Innovation in Global Networks – The Challenge for Technical Standards and Related Policies

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Questions raised by globalization…

1. Do we have sufficient data to map important changes in the international standards landscape?
2. What new challenges does globalization create for interoperability standards?
3. What do we know about China's distinct approach to standardization?

Appendix - Questions for Policy & Research

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1. Do we have the data to map changes in the international standards landscape?

When I prepared for this talk, I was hoping (admittedly somewhat naively) to get some rough proxies from SDOs & standards consortia to illustrate how **globalization has increased the number of standards** , say between mid-1950s and today.

I got this idea from WIPO's nice exercise that demonstrates that

- Patent filings worldwide surged from ca 1m (1995) to > 2.57 m (2013)
- Internationalization of patenting is the main driver of the patent surge → The share of inventions being patented in more than one country (*subsequent filings*) increased from 39% (1983-1990) to 52% (1995-2007)

2. All I have right now are widely quoted rough estimates:

- IEEE estimates 500,000 standards exist in the world today that form the technology foundation of the global marketplace*.
- IEEE estimated that it costs approximately $1.5 billion (US) to maintain these standards*.
- The semiconductor industry is estimated to have over 1000 standards, most of which are non-product." **

→ But these widely quoted rough estimates are no substitute for meaningful standards data

*Donald E. Purcell, 2006, Presentation at USTR; ** Greg Tassey, 2015,The economic nature of knowledge embodied in standards for technology-based industries

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What we have and what we'd need

We have definitions, taxonomies of standards and their benefits

→ But we lack meaningful data on the surge, value & increasing diversity of standards

- fragmentation of data sources
- "rule of thumb" proxies are no substitute

→ We need better data & consolidated data collection to assess how globalization affects standardization

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What we know about standards – Definitions/NIST

Standards are: "Specifications that establish the fitness of a product for a particular use or that define the function & performance of a device or system. Standards are key **facilitators of compatibility & interoperability**."

Interoperability: "the capability of two or more networks, systems, devices, applications, or components to exchange & readily use meaningful, actionable information—securely, effectively, & with little or no inconvenience to the user.

Interop standards "define specifications for languages, communication protocols, data formats, linkages within & across systems, interfaces between software applications & between hardware devices, and much more." → They must **accommodate** future applications and technologies.

http://www.nist.gov/smartgrid/upload/Draft-NIST-SG-Framework-3.pdf

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Interoperability standards are needed to ensure…

- effective communication between digital components like devices, networks or data repositories
- improved connections & knowledge sharing along
  - the **supply chain**
  - **across borders**, within global networks of production & innovation

European Commission, *A Digital Single Market for Europe*, May 6, 2015: pages 15 & 16

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We have sophisticated typologies of standards

- **Proprietary** (owned by a company which may license it to others) vs **Open** (available to all potential users, with or without a fee) *
- **The elusive concept of "open standards":** *"The computer industry needs as many words for 'open' as Eskimos need for snow."* *(Libicki et al, 2000, RAND study)*
- ***De facto*** (adopted thru standards competition among rival standards consortia) vs ***De jure*** (by consensus, thru industry committees or formal standards organization)*
- **Product** (define key attributes or elements) vs **Non-product** (include process standards; measurement & test methods; interop; science & engineering data bases; standard reference materials) *(Tassey, 2015: p.192)*

* e.g., Tassey, 2007; Stango, 2004; Steinfield, 2007

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Benefits – Standards can …

- Improve & simplify terminology, databases, measurement, installation & testing
- Increase manufacturing efficiency, reduce costs →Reduce risks for implementers & users
- Improve quality, safety & reliability → expand market share thru performance assurance & reduced transaction costs
- Improve interoperability among system components & portability of software across technology platforms
- Enhance efficiency of R&D & accelerate product development & commercialization
- Foster competition →enhance entry opportunities for SMEs

e.g., Tassey, 2015

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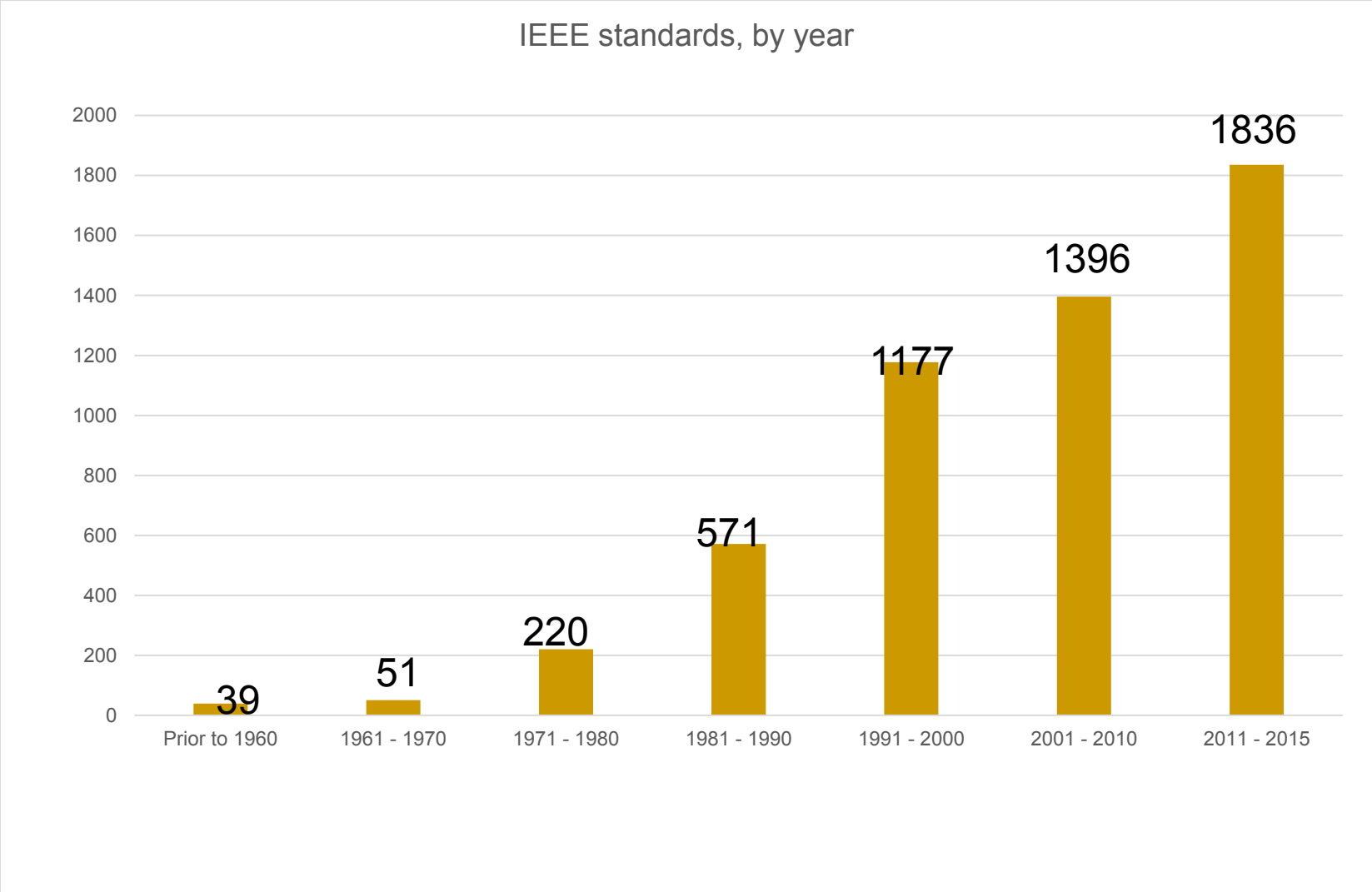

Estimates, courtesy IEEE-SA, May 2015

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IEEE Documents in Semiconductor Technology

IEEE provides standards through the IEEE *Xplore* digital library.

- CMOS 190,000+ documents
- RRAM/MRAM 3,800+ documents
- Optoelectronics/OEIC applications 75,200+ documents
- Semiconductor Lasers 43,400+ documents
- Silicon Wafer 27,100+ documents
- Carbon Nanotubes 14,400+ documents
- 3D IC 2,600+ documents
- Computational Intelligence 58,600+ documents

http://www.ieee.org/publications_standards/publications/subscriptions/semiconductor_industry_sheet.pdf Counts are accurate as of May 2014 and include IEEE/IET content

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Ambiguity – "Document" is not equal to "Standard"

- There are many other deliverables such as guiding documents, explanatory documents, workshop agreements, roadmaps, instructions, etc.
- Many standards will show up under different owners but with (more or less) identical content, e.g. ISO, EN/ISO, DIN/EN/ISO, BSI/EN/ISO, GB, JIS, ASTM. *
- Especially for consortia, the border between standard and simple instructions is often blurred.
- ***What would be needed to standardize the standardization data?***
- ***How to go about separating the wheat from the chaff?***

*Klaus Ziegler, China Representative, DIN German Institute for Standardization, email to author, May 4, 2015

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From quantitative growth to quality

- Many standards become obsolete very fast → Much of standardization work today focuses on **replacing or upgrading** existing standards.
- The IEEE estimate of 500K standards may well be exaggerated. Many of those standards are probably obsolete, unused, or variations of other standards*.
- **Quality of standards is the buzzword, and higher value.**
- **The Good news**: Some progress in harmonization of standards has let to a considerable reduction in the number of standards → **But do we know enough?**

* Klaus Ziegler, China Representative, DIN German Institute for Standardization, email to author, May 4, 2015

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Standard-essential patents (SEPs) are…

- necessary to produce any product that meets the specifications defined in the standard →Patents are "essential" to a standard when it is not possible to comply with the standard without infringing that intellectual property right.
- used as a strategic weapon to prohibit, delay, or obstruct standardization processes (Blind et al, 2004)

Challenges:

- **How "essential" are patents which are "alleged or believed to be essential"?**
- **What precisely are FRAND licensing terms?**
- **Under what conditions should owners of SEPs be entitled to exercise an injunction?**
- **Patent thickets complicate management of SEPs**

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How "essential" are patents "alleged or believed to be essential"?

- **2011 estimate**: WCDMA (1000 patent families), LTE (1000 patent families), MPEG-2 and MPEG-4 (800 patents in 160 patent families), optical disc drive standards (2200 patent families), and DVB-H (30 patent families)*
- **RPX Litmus test**: How do alleged & declared SEPs fare in litigation proceedings? → **Overall, Alleged and Declared SEPs were <u>relatively unlikely to succeed</u>. Plaintiffs won on slightly more than a quarter of Alleged and Declared SEPs across district court and ITC proceedings**.**

*Blind et al (2011); ** RPX 2015, SEPs: How do they fare?

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SEPs – Current Status & Prospects

Court decisions have …

- created a bit more clarity on what precisely are FRAND commitments
- also clarified the scope for injunctions.

SDOs: IEEE-SA's amendments & VITA's earlier *ex ante* disclosure requirement have been strengthened by **DoJ Business Review Letters**

- Competition policy thus plays an important role for standard development

Unresolved question: How will globalization affect SEP-related conflicts?

→ Fierce resistance of owners of large SEP portfolios

→ **What role will China play?**

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Patent thickets – laptops

- Over 500 interoperability standards are used in a prototypical laptop computer
- Of the identified 251 interoperability standards, 44% were developed by consortia, 36% by formal SDOs, and 20% by single companies

Biddle, White and Woods, 2010

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Patent thickets – smart phones

- In 2010, an average smartphone was covered by at least 250,000 different patents, up from only 70,000 in 2000**
- In 2013, the royalty stack for a hypothetical $400 smart phone was $120 (excluding the value of cross-licenses & other nonmonetary compensation), or 30 % of the overall product price***

** RPX Corp., Registration Statement on Form S-1. Jan. 21, 2011; *** Armstrong, Mueller & Syrett, 2014

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We need meaningful data to assess how globalization affects standardization

- *The standards community lacks robust quantitative measures of* ***useful*** *standards → "Absent any meaningful data, we'll never make this a viable subject for study."* *(Carl Cargill, 4/29/2015)*
- *No one is systematically looking across the landscape & collecting & examining standards → The "literature" is scattered in so many places and often it is not well articulated.*
- Timing is critical → *"Standards have to evolve in concert with the technology system. Different types of standards have different roles and therefore need to be available at different points in the technology life cycle."* *(Greg Tassey, May 4, 2015)*

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2. What new challenges does globalization create for interoperability standards?

- Knowledge sharing is the glue that keeps the increasingly diverse and complex global networks of production & innovation growing*
- Complex technology systems with almost indefinite levels of interconnectivity (e.g., Industrial Internet; Smart Grid; Integrated Healthcare; autonomus car; Internet of Everything) require cooperation among heterogeneous businesses with very different standards & different approaches to standardization.
- Needed: Universally accepted & implemented interop standards for the format & content of messages that flow between participants of global networks & complex technology systems**

Current status: Global network integration is either inefficient or incomplete

*Ernst, D. and Linsu KIM (Research Policy, 2002)

** http://www.nist.gov/director/planning/upload/report04-2.pdf

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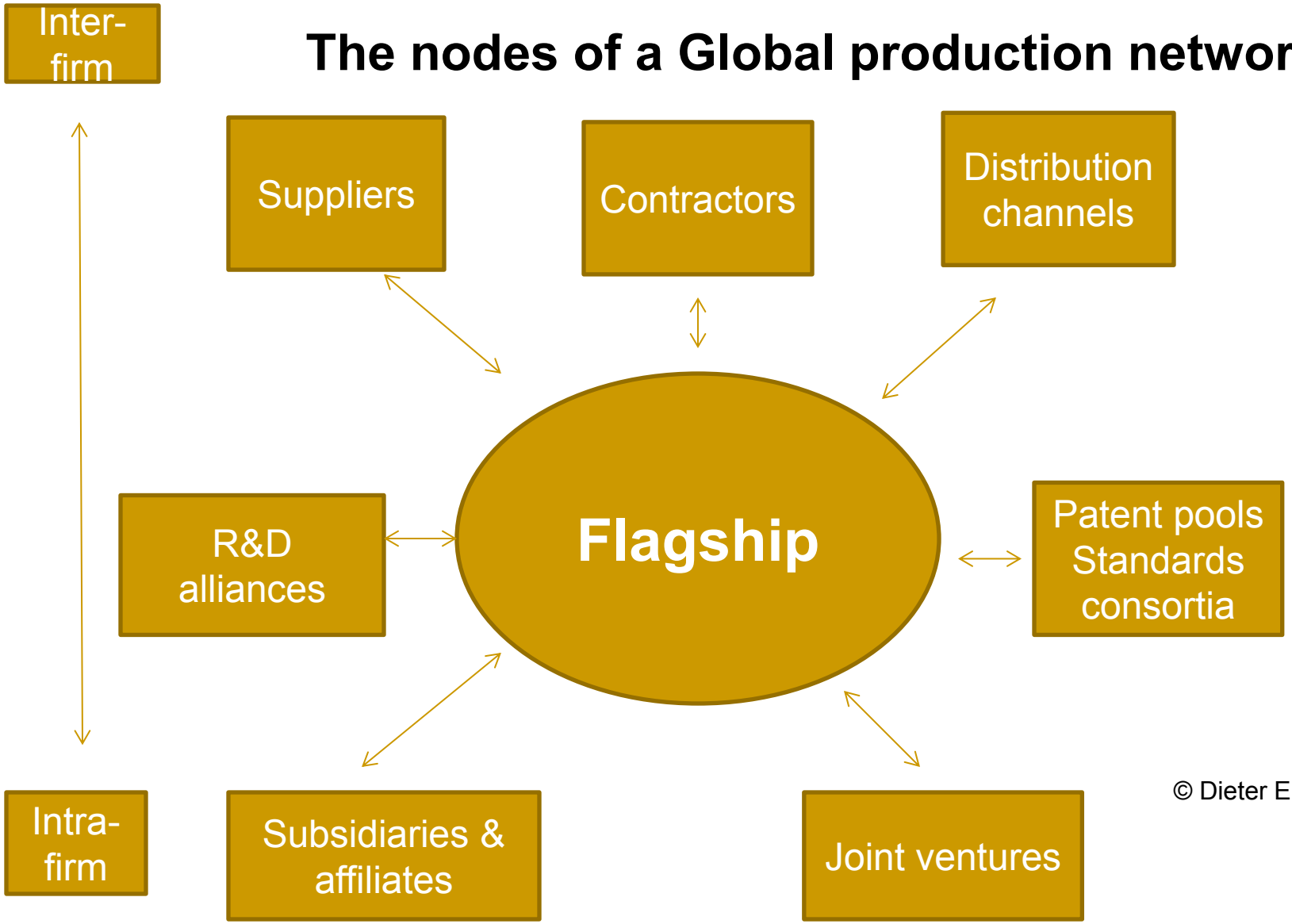
The nodes of a Global production network



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Knowledge sharing requires interoperability standards

Ernst, D. and Linsu Kim, 2002

Global innovation networks – increasing diversity

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Hierarchical

- **Intra-firm networks -** Global companies "offshore" stages of innovation to Asian affiliates
- **Inter-firm networks -** Global firms "outsource" stages of innovation to specialized Asian suppliers
- **Asian firms** construct their own GINs (**Huawei**)

International public-private R&D consortia

- **ITRI** – global knowledge sourcing from the erstwhile periphery

From hierarchical to splintered GINs

- **Foxconn** – contractors can shape strategic direction as junior network flagships

Plus: **Informal social networks (students, knowledge workers)**

Adapted from Ernst, D., 2009, *A New Geography of Knowledge?*

Increasing diversity and complexity of GINs

- GINs now involve multiple actors and firms that differ substantially in size, business model, market power & nationality of ownership, giving rise to a **variety of networking strategies and network architectures**.
- New network flagships from emerging economies, especially from Asia, construct their own GINs.
- Asian countries are also quite active now in global sourcing through cross-border public-private partnerships.
- **Splintered GINs** with diverse network flagships which increasingly complement the erstwhile dominant hierarchical networks.

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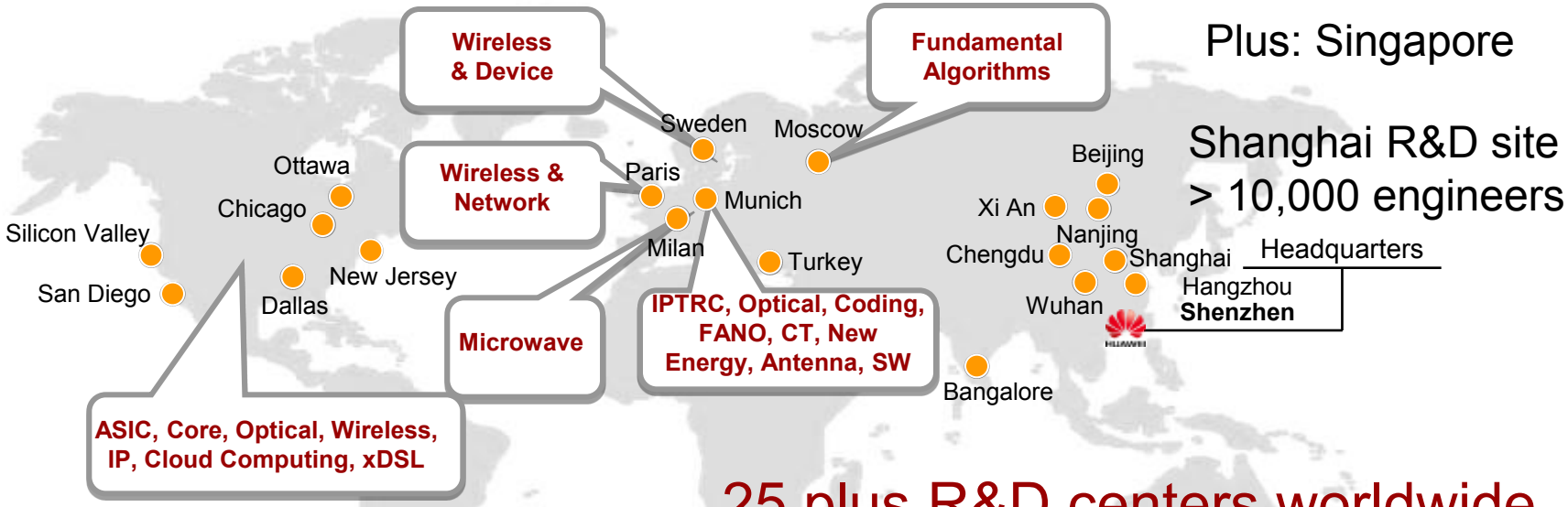
Huawei's Global Innovation Network

Plus: Belgium (close to IMEC); Ireland (software) & Finland (mobile devices)



25 plus R&D centers worldwide

San Diego, USA

Dallas Texas, USA

Moscow, Russia

Bangalore, India

Stockholm/ Gothenburg, Sweden

Munich, Germany

Paris, France

Milan, Italy

Knowledge sharing requires interoperability standards

Sources: company website and interviews

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ITRI's global knowledge network – U.S. (select examples)

Universities: Carnegie Mellon; Case Western Reserve; Columbia; Cornell; Georgia Tech; Harvard; Johns Hopkins; Lawrence Berkeley National Laboratory; MIT Media Lab; MIT-CSAIL; MIT-Harvard Clinical Consortium; National Renewable Energy Laboratory; Ohio State University; Purdue University; Rensselaer Polytechnic; Texas Tech University; UC Berkeley; UCLA; UC San Diego; UC Santa Barbara; University of Central Florida; University of Cincinnati; University of Illinois; University of Missouri; University of Washington, Seattle; Virginia Polytechnic

Companies: Corning; DuPont; e-Meter Corporation; Eastman Kodak; Exactech; IBM; InVisage; Johnson & Johnson; Qualcomm MEMS Technologies; Texas Instruments; etc

- ITRI's network interacts with & complements Taiwanese corporate GINs (e.g., TSMC)

ITRI website & interviews

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Honhai/Foxconn Global production & innovation network

Canada: co-develop Blackberry 4G smart phone

US
Harrisburg
Carnegie Mellon (robots)
MIT-CSAIL (AI)
Florida, Indiana, Texas, Arizona

EU: Hungary, Slovakia, Czech Rep, Finland, Turkey Denmark

China: 15 mega-locations

Korea

Japan: Display R&D Osaka

India
Chennai

Taiwan HQ

Malaysia, Vietnam

Brazil
Manaus
Indaituba
Jundiai
Sorocaba
Santa Rita do Sapucai

EMS, ODM & R&D services for Acer, Amazon, Apple, Blackberry, Cisco, Dell, Google, HP, Microsoft, Motorola, Nintendo, Nokia, Sonay, Toshiba, Vizio, Micromax Mobile (India), and many more customers

HonHai Precision, the **network flagship**, controls > 230 holding companies, affiliates, subsidiaries and divisions; expands R&D cooperation with top universities

Sources: Company website & interviews

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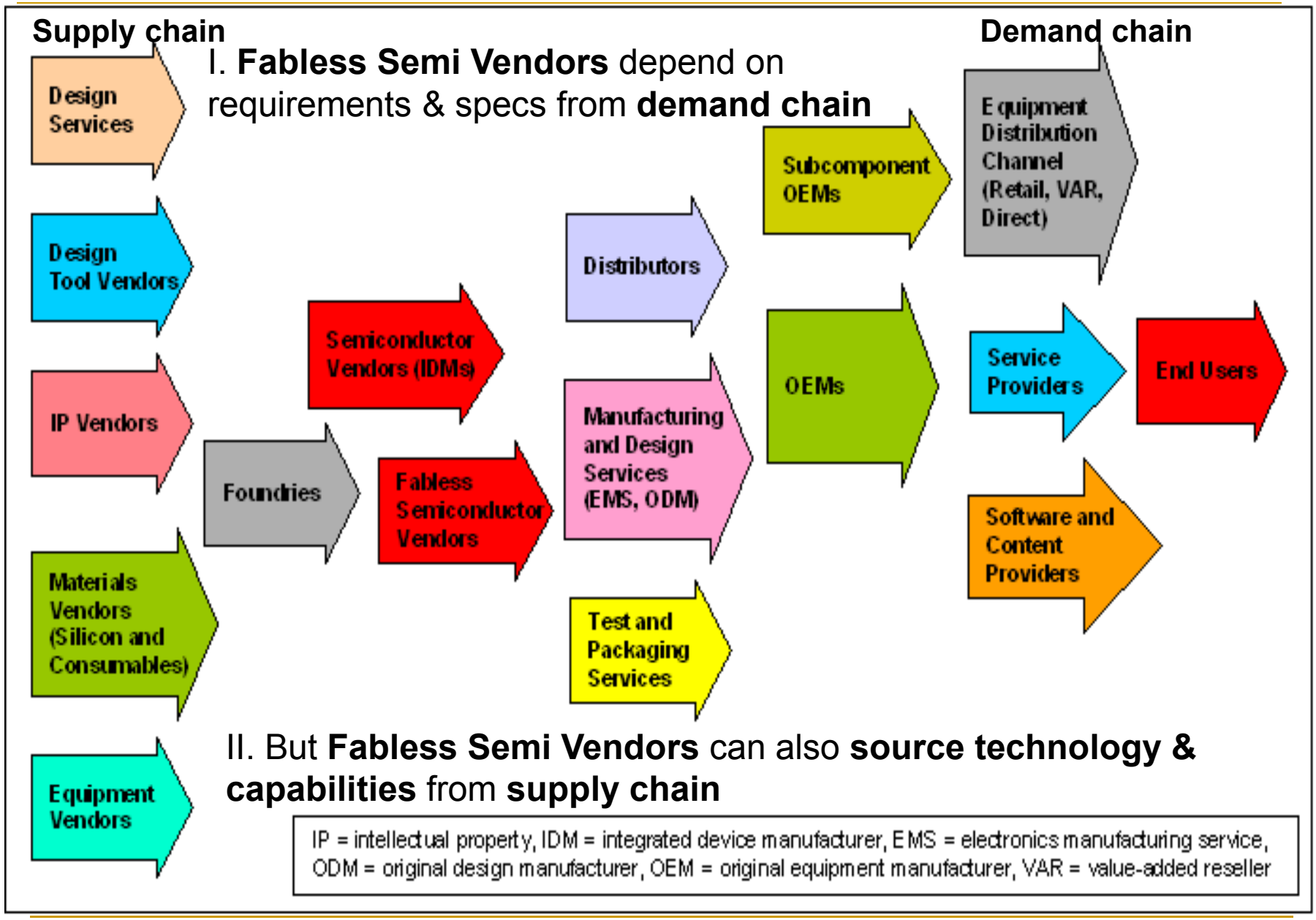

Adapted from Gartner, 2006

For Smart Grid to work, interoperability standards are a must

http://www.hitachi.com/environment/showcase/solution/energy/smartgrid.html

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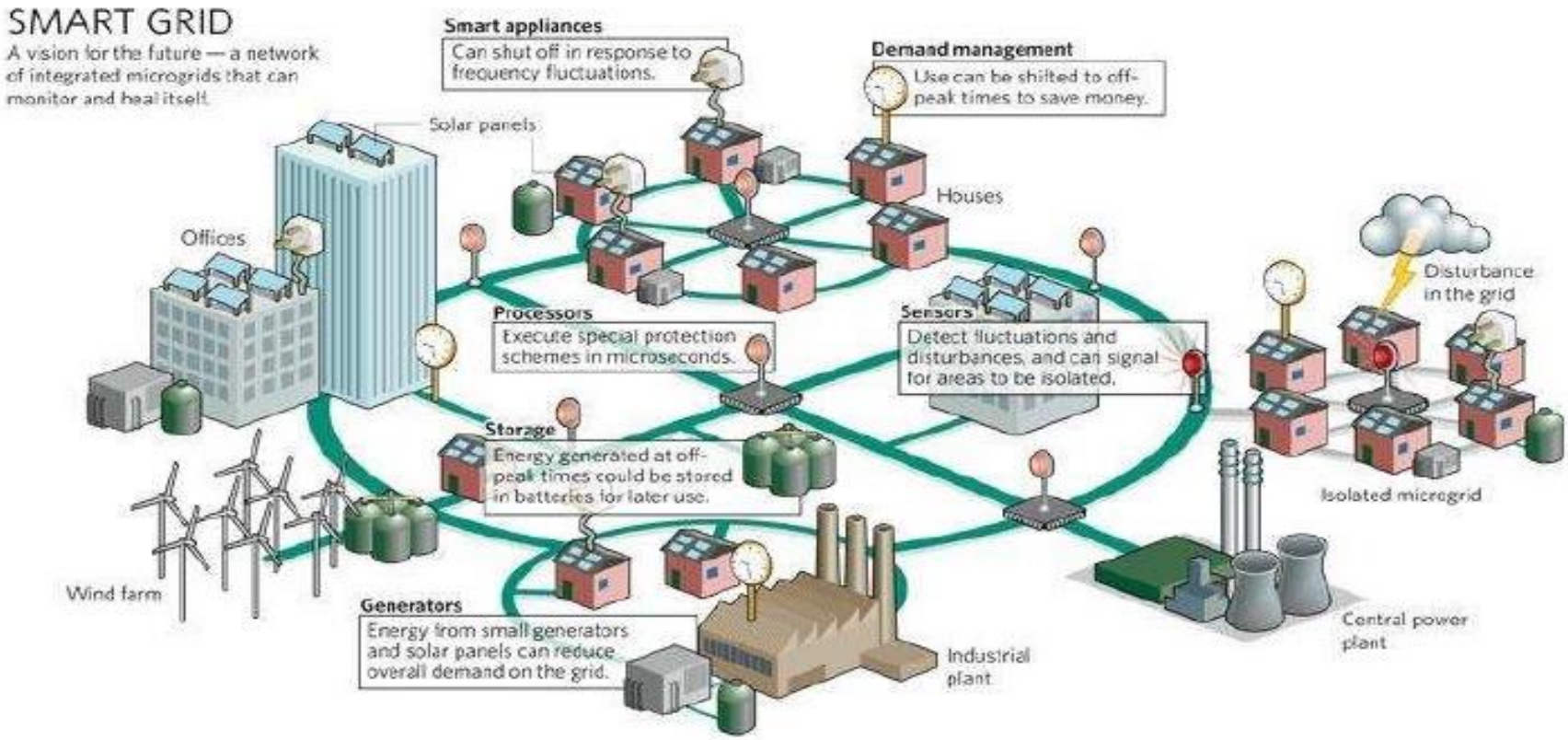
How the smart grid works



[http://www.nature.com/news/2008/080730/images/454570a-6.jpg]

Interoperability standards are needed to enable cooperation among heterogeneous businesses with very different standards & different approaches to standardization. © Dieter Ernst

The current status of GN integration …

- is messy, & in most cases, GN integration is either inefficient or incomplete*:
- Under ***inefficient*** integration, systems are put in place to automate information inputs & flows, but the unavailability of a suitable standards infrastructure leads to excessive capital investment, duplication of effort, higher than optimal staffing and support levels, & inadequate organizational flexibility.
- In the case of ***incomplete*** integration, key elements of a comprehensive system are missing, or improved systems are only implemented for a subset of GN participants. In the latter case, the GN as a whole still experiences costs well above optimal levels, & many of the gains from integration remain unrealized.

* Adapted from http://www.nist.gov/director/planning/upload/report04-2.pdf

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High cost of ineffective or incomplete global network integration – NIST 2004 estimate

"The total annual costs of inadequacies in supply chain infrastructures to be in excess of $5 billion for the automotive industry, and almost $3.9 billion for the electronics industry. These figures represent about 1.2% of the value of shipments in each industry."

→ ***We need updated cost estimates!!***

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RosettaNet – a global network integration standard for Information Technology

- The RosettaNet consortium has identified **more than 100 separate business processes** between network participants for which standard protocols, called Partner Interface Processes (PIPs), are necessary within the electronics sector.
- PIPs fit into **seven clusters, or groups of core business processes**, that represent the backbone of the network.

http://www.service-architecture.com/articles/web-services/partner_interface_process_pip.html; https://supplier.intel.com/static/B2Bi/RosettaNet.htm

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RosettaNet Clusters

0. Network support → 1. Partner product & service review → 2. Product information → 3. Order Management→

4. Inventory management - Enables inventory management, including collaboration, replenishment, price protection, reporting & allocation of constrained product → 5. Marketing Information Management → 6. Post-sales service & support →

7. Manufacturing - Enables the exchange of design, configuration, process, quality & other manufacturing floor information to support the "Virtual Manufacturing" network.

http://www.service-architecture.com/articles/web-services/partner_interface_process_pip.html; https://supplier.intel.com/static/B2Bi/RosettaNet.htm

Implementation issues for global network interoperability standards

1. Inventory management : Vertical disintegration thru GPNs has raised the challenges → Timing is critical for costly core components.

2. Time-to-market: As prices erode quickly, a large percentage share of the life cycle profit is made within the first few weeks after product introduction. To accelerate time-to-market, close interaction is required between design & manufacturing (i.e. design-for-manufacturability).

→ However, vertical specialization has separated design from manufacturing, requiring robust interop standards for sharing design data across the network.

3. Conflicts about standards between Network flagships (OEMs) and suppliers

OEMs have historically been reluctant to engage in industry-wide standardization. They typically request reliance on "my processes, my systems, my EDI methods, my reports"

Suppliers, on the other hand, require robust interop standards.

4. Broad-based support is critical

Interop standards can only succeed if they have support from customers and multiple layers of suppliers. Without it the best standards are useless. → Hence, the critical importance of industrial dialogues. "The involvement of a lead firm and key business partners is not sufficient to create efficient integration."

Interviews in mobile device industry, 2014

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3. What do we know about China's distinct approach to standardization?

- Is standardization in China still prone to the "Galapagos Island Syndrome"?
- Improved data document growth of standards & a shift to voluntary ("recommended") standards
- Achievements & unresolved challenges
- How might fundamental changes in China's growth model affect the development and use of standards in this country?
- Pragmatism continues to shape China's policy
- *But China is not headed for the American Decentralized Voluntary Standards System*

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Is standardization in China still prone to the "Galapagos Island Syndrome"?

China's insular focus on the development of indigenous technology standards has engendered a "Galapagos Island Syndrome", "isolating its ICT technologies and markets from global norms" (ITIF, *The Middle Kingdom Galapagos Island Syndrome: The Cul-De-Sac of Chinese Technology Standards*, 12/2014)

↕

China pursues a distinct, hybrid standardization strategy that seeks to reconcile its efforts to catch up with the productivity & income levels of the US with its leading role in international trade & global networks (Ernst, D.,2011, Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy)

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China's development model shapes its standardization system – Key features until ca 2012

Innovation push: Massive investments in the country's R&D infrastructure & higher education have been fast-tracking the speed of learning & capability development. → Since 2000, China has increased R&D spending roughly 10% each year.

High GPN integration: Two-thirds of China's production of goods & services are intermediates, which is substantially higher than the world average*

High GIN integration: China is the largest "net importer" of R&D, and it is the third most important offshore R&D location (after the US and UK) of the 300 top R&D spending multinationals**.

*Baldwin and Lopez-Gonzales 2013

** Ernst, 2011 Testimony to US-China Economic& Security Commission

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Demand Pull from mobile devices & standardization

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 mobile telecom standards

- Both TD-SCDMA and TD-LTE standards have fostered the development of technical capabilities in Greater China IC design companies (MTK; SPRD; RDA)

→ As a result, global device vendors & leading IC companies are all searching for ways to ensure long-term access to the China market.

- Global market share of mobile phones produced in China has almost doubled from 44% (2008) to 81% (2013) *

* CSIA, MIIT, Gartner

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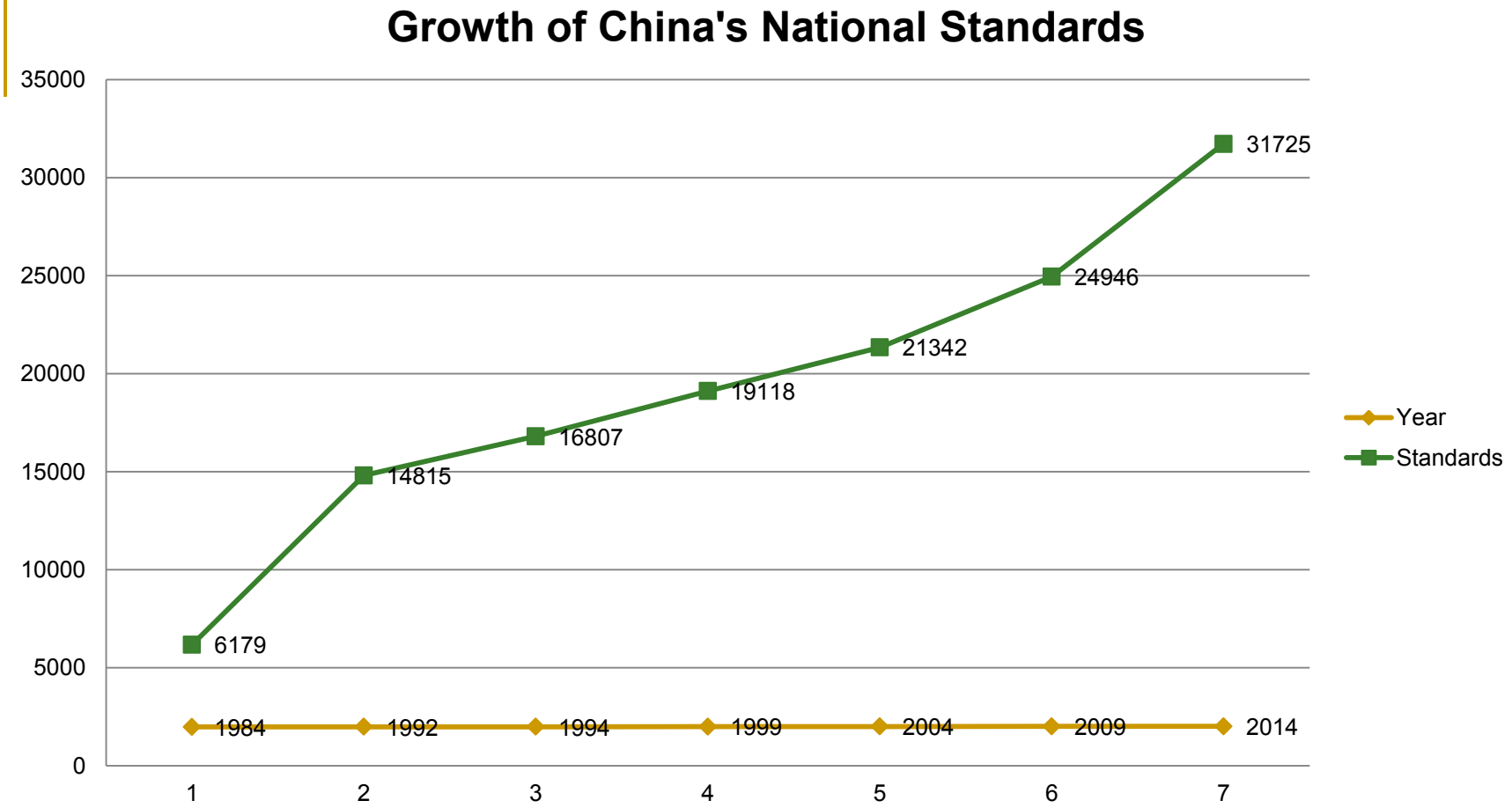

Between 2004 and 2014, a period of high GDP growth, ca 10,000 new national standards have been created → China's standardization bodies received Gov funding for setting voluntary standards → *Ditto for Korea, Taiwan* → ***What is the current funding situation in the US (ANSI; industry SDOs)?***

Courtesy of Standardization Administration of China (SAC), May 2015

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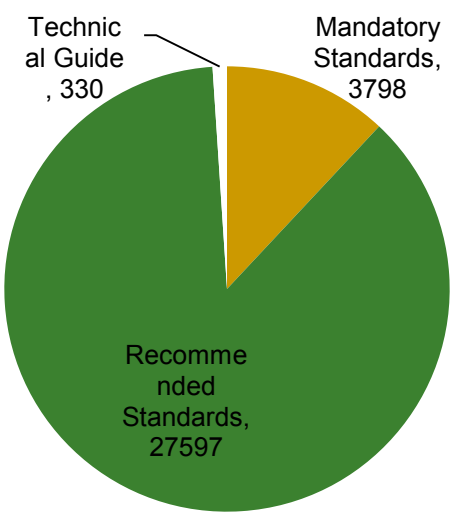
Growth of China's standards

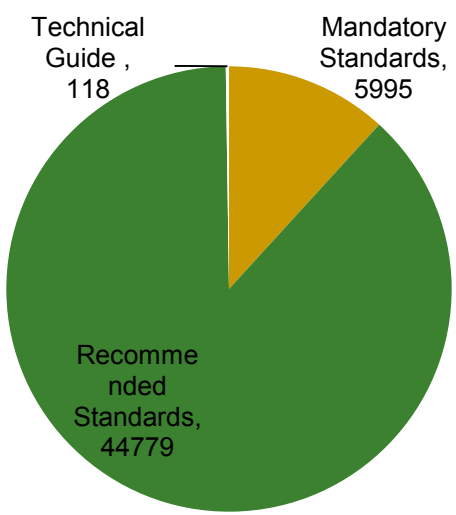
2009 estimates*: 25,000 National Voluntary Standards; → 3,000 to 4,000 National Compulsory Standards; → between 40,000 & 100,00 sector/industry/ministerial standards; → a few Association standards; → ca. 20,000 provincial standards.

2014 official data**:

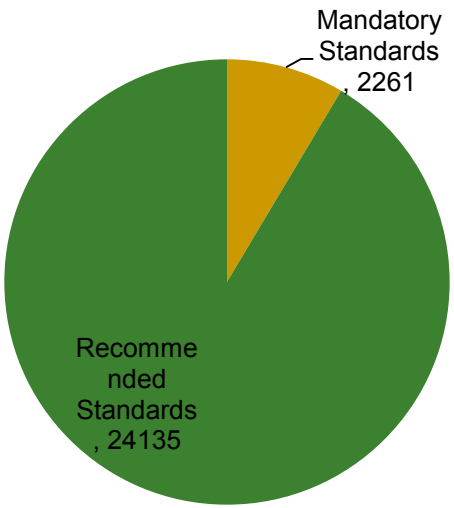
Total National Standards
31,725



Total Sector Standards
50,892



Total Local Standards
26,396



Sector standards, recorded (5,324) →new established (3,453) →reviewed (1,871) [recommended:5,143] → **mandatory standards are of less importance**

* Ernst, 2011, *Indigenous Innovation…* ** Standard Administration of China, May 2015

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Will China's ongoing reform of its standardization system improve data availability?

- Proposals for the revised standardization law seem to point all in the right direction, especially the focus on globalization & greater coherence of the system.
- Overall this reform is expected to lead to a much stronger position of SAC & to enhanced practices in standardization & data collection in China.

Author's interviews

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China's distinct Standardization System – ca 2010

Objectives

- Enhance technology absorption; reduce licensing fees; foster indigenous innovation
- Develop/upgrade national industries; opening markets for Chinese companies
- Support national security interests (cyber-security)
- Reduce huge gap in safety, health and environmental standards

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Governance

- Government mandates standards & is the ultimate arbiter in standards decisions
- Standard development bodies are government-controlled organizations
- Chinese standardization is shaped by ministries and not by industry → However, Chinese standards consortia are gradually strengthening their decision autonomy and also are involving foreign companies
- Inter-agency rivalries constrain coordination and create fragmented standardization system

Achievements

- Quick mobilization of resources for massive investments in standardization infrastructure
- Rapid growth of standards → China is by far the most prolific standardization country
- Rapid pace of learning – the Chinese system has matured in a short period of time

Ernst, D.,2011, Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy

Participation of foreign firms in Chinese standards-setting bodies

US firms "complain that may be prohibited from participating in core aspects of standards-setting bodies in China. (Mark Cohen, prepared testimony before the U.S.-China Economic and Security Review Commission, January 28, 2015: p.28.)

In Technical Committees under China's standards bodies, "…[**f]oreign firms are not barred from voting membership**. However, while able to vote and contribute technology, foreign enterprises still have no direct voice in the final direction and adoption of the standard or selection of individual technologies to incorporate into specific protocols." (Breznitz, D. & M.Murphree, *The Rise of China in Technology Standards: New Norms in Old Institutions*, report to the U.S.-China Economic and Security Review Commission, January 2013)

Planned revision of the Chinese standards system

- Foreigners are welcome to participate in all standardization activities for voluntary standards
- Full transparency in selecting TC members among the applicants, the planned list of members for new committees is published for comments. The principle of inclusion of all stakeholders, plus dominant force of industry apply, especially for voluntary standards
- Foreigners will have restricted access only to compulsory standardization: The practice is not yet clear – it looks like observer status only
- Not mentioned but assumed: Foreigners remain excluded from standard-setting in areas of concern of national security. (China-based standardization expert who has requested anonymity)

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China's distinct Standardization System – Unresolved Challenges

- Focus on technical issues of standards development ('hard' capabilities) → neglects standards implementation (Are customers willing to pay for this technology?)
- Fragmentation (competing standards within China; inter-agency rivalries)
- Conformity assessment rules which control market access tend to precede standardization
- Huge gap in standardization capabilities between a few Chinese global players and the rest
- Chinese standards are largely ignored in foreign markets
- A huge gap exists between the speed of China's resurgence as an economic power & the country's capacity to develop appropriate policies and institutions. →It will take time for China's standards system to adjust to globalization requirements.
- As globalization increases uncertainty & the speed of change a, attempts to "pick winners" & to promote national champions may fail.
- Top-down policies are not conducive to open standards; such policies also may constrain learning from foreign sources of knowledge (LIU Chuanzhi, Lenovo Founder: "Standing on the shoulders of giants")

Ernst, D.,2011, Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy

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How might fundamental changes in China's growth model affect the development and use of standards?

"China has long been the top destination of foreign investment in the developing world but foreign invested firms account for a declining share of the economy."*

- Foreign investment share of China's total fixed investment has fallen from a high of 12 % in 1996 to 4.4 % in 2003 to only 0.9 percent of total investment in 2013.
- The share of FIEs of all registered capital in China has shrunk by half from 21% in 2003 to 11.2% in 2014.
- Total trade was equivalent to 65 % of China's economy at its peak in 2006, & that figure has consistently fallen to less than 42 % in 2014.
- Exports from foreign-invested firms are still substantial, 45.9% of total exports in 2014, but this number is also destined to continue falling. → As a sizeable portion of "foreign" investment & trade is with Hong Kong, & masks domestic firms who simply funnel capital through the city, the true share of foreign investment & trade is even lower.

*Scott Kennedy, statement before the U.S.-China Economic and Security Review Commission, 1/28/2015

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Pragmatism continues to shape China's policy

- "China is not averse to intervening, but it has done that against the background of a lot of liberalization. It's paying off." (Peter Petri, Brandeis University & EWC)
- "Pragmatism has been a hallmark of China's reforms over the past 30 years, as Chinese leaders have not flinched from a realistic view of their challenges. They typically experiment with various approaches before deciding on the best ways to address major concerns." (Ken Lieberthal, Brookings Institution)
- "In the next ten years, there will be a large amount of M&A cases in China, but many of them will fail…But it is better than nothing. China enterprise will gain experience." (Chen Datong, HCM chairman)

➢ But China is not headed for the American Decentralized Voluntary Standards System

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Appendix – Questions for policy & research

Questions for Policy

1. What combination of private solutions, law, legal practice, and public policy might be needed to keep both the process of standardization and the standards open, flexible, and extendable?
2. How important is the role of competition policy, and what adjustments might be needed in patent law?
3. What forms of public-private partnerships and cooperation between NIST, ANSI and SDOs might help to …

- improve access to robust quantitative measures of useful standards, their quality & value?
- reduce uncertainty about how "standard-essential" those patents really are which are alleged or believed to be essential?
- standardize key concepts used in standards development, such as guiding documents, explanatory documents, workshop agreements, roadmaps, instructions, public company processes;
- reduce double counting of standards which show up under different owners but with (more or less) identical content, e.g. ISO, EN/ISO, DIN/EN/ISO, BSI/EN/ISO, GB, JIS, ASTM;
- create the interoperability standards needed to improve the integration of increasingly complex global networks and technology systems?

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Questions for Policy, cont'd

4. As national standards systems and policies continue to differ, what might be realistic approaches to trade diplomacy and international cooperation to gradually enhance the "harmonization" of international standards? And what might be promising priority areas for efforts to reduce the current Balkanization of standard-setting?

5. What changes in the governance and procedures of standard development organizations & private standards consortia would help to reduce the use of standard-essential patents (SEPs) as entry deterrents? Specifically, how will the recent IEEE policy amendments affect the implementation of "fair, reasonable and nondiscriminatory (FRAND) licensing terms? Will other standard-setting organizations like for instance the European Telecommunications Standards Institute (ETSI) follow suit? What role can competition policy play?

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Questions for Research

1. Case studies to determine how "standard-essential" patents really are which are alleged or believed to be essential.
2. As many standards become obsolete very fast, what are realistic estimates of required investments needed to maintain & upgrade existing standards?
3. Develop a taxonomy of tasks & capabilities required for developing open, flexible & extendable standards and standardization processes.
4. Case studies of success & failure of diverse approaches to develop interoperability standards for complex technology systems (such as Smart Grid, Integrated Health system).
5. Develop updated cost estimates of ineffective or incomplete global network integration, drawing on NIST's 2004 estimate.
6. Comparative case studies of standards consortia which seek to develop & implement global network integration (e.g. RosettaNet; IBM's Open industry standards for global supply chains; etc)
7. In-depth comparative case studies of diverse standards systems & policies, in OECD countries as well as in emerging economies & developing countries.

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