A New Geography of Knowledge? From Global Production to Innovation Networks

by

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Storyline

1. What does the literature tell us about the prime movers and defining characteristics of Global Production Networks (GPNs)?
2. What distinguishes Global Innovation Networks (GINs)? And what drives their increasing diversity and complexity?
3. The New Geography of Knowledge is not a Flatter World

1. What does the literature tell us about the prime movers and defining characteristics of Global Production Networks (GPNs)?

- Ernst, D., 1997, *From Partial to Systemic Globalization: International Production Networks in the Electronics Industry*, Berkeley Roundtable on the International Economy (BRIE) Working Paper 98, April: 113 pages
- *Ernst, D. and Linsu Kim, 2002,* "Global Production Networks, Knowledge Diffusion and Local Capability Formation", *Research Policy, special issue in honor of Richard Nelson and Sydney Winter*.
- Ernst, D. (2012). “Production and innovation networks, global”, in *Encyclopedia of Global Studies*, Sage Publications (pp. 1393-1397). Thousand Oaks, CA:,

Global Production Networks (GPNs) – from Partial to Systemic Globalization

Limits to Partial Globalization:

- MNCs invest in a loose patchwork of stand-alone affiliates, joint ventures, and suppliers, that
  - are scattered across the globe
  - co-exist without much interaction and coordination across functions and locations
- The MNC cannot reap the full benefits of international specialization.

Ernst, D., 1997

Global Production Networks (GPNs) – from Partial to Systemic Globalization, cont'd

Systemic Globalization:

- A firm (a "network flagship") proceeds to integrate its dispersed operations and inter-firm relationships worldwide, both across functions and locations.
- Cost-effective coordination of these interactions enables the firm to internalize & combine resources and capabilities without running into the constraints of excessive centralization.

Ernst, D., 1997

GPN = a major organizational innovation which enables 'flagships' to combine fragmentation & integration.

- Fragmentation → separates labor-intensive processes (that move to low-cost locations) from capital- and knowledge-intensive processes.
- Integration of the dispersed production, supplier and customer and knowledge bases is necessary to reduce the high coordination costs and risks of cross-border exchanges of products, people, information and knowledge.

Ernst, D. (2012). "Production and innovation networks, global"

Asymmetry

- MNCs dominate as **network flagships** & define network organization and strategy.
- Control over network resources plus coordination of information flows & decision-making enables the flagship to directly affect the growth, strategic direction, and network position of lower-end participants (e.g., specialized suppliers and subcontractors).

Variable governance includes…

- loose linkages, formed to implement a particular project & that are dissolved after the project is finished ("virtual enterprises")
- highly formalized networks("extended enterprises") with clearly defined rules, common business processes, & shared information infrastructures → with or without common ownership.

Ernst, 2012

Outsourcing is the main driver

- By outsourcing volume manufacturing & related support services to lower-cost locations (Mexico, China), the flagship expects substantial cost savings.
- Over time, the focus of outsourcing has shifted from assembly-type manufacturing to knowledge-intensive support services (supply chain management, engineering services & new product introduction).
- Network flagships increasingly rely on the skills and knowledge of specialized suppliers to enhance their core competencies.

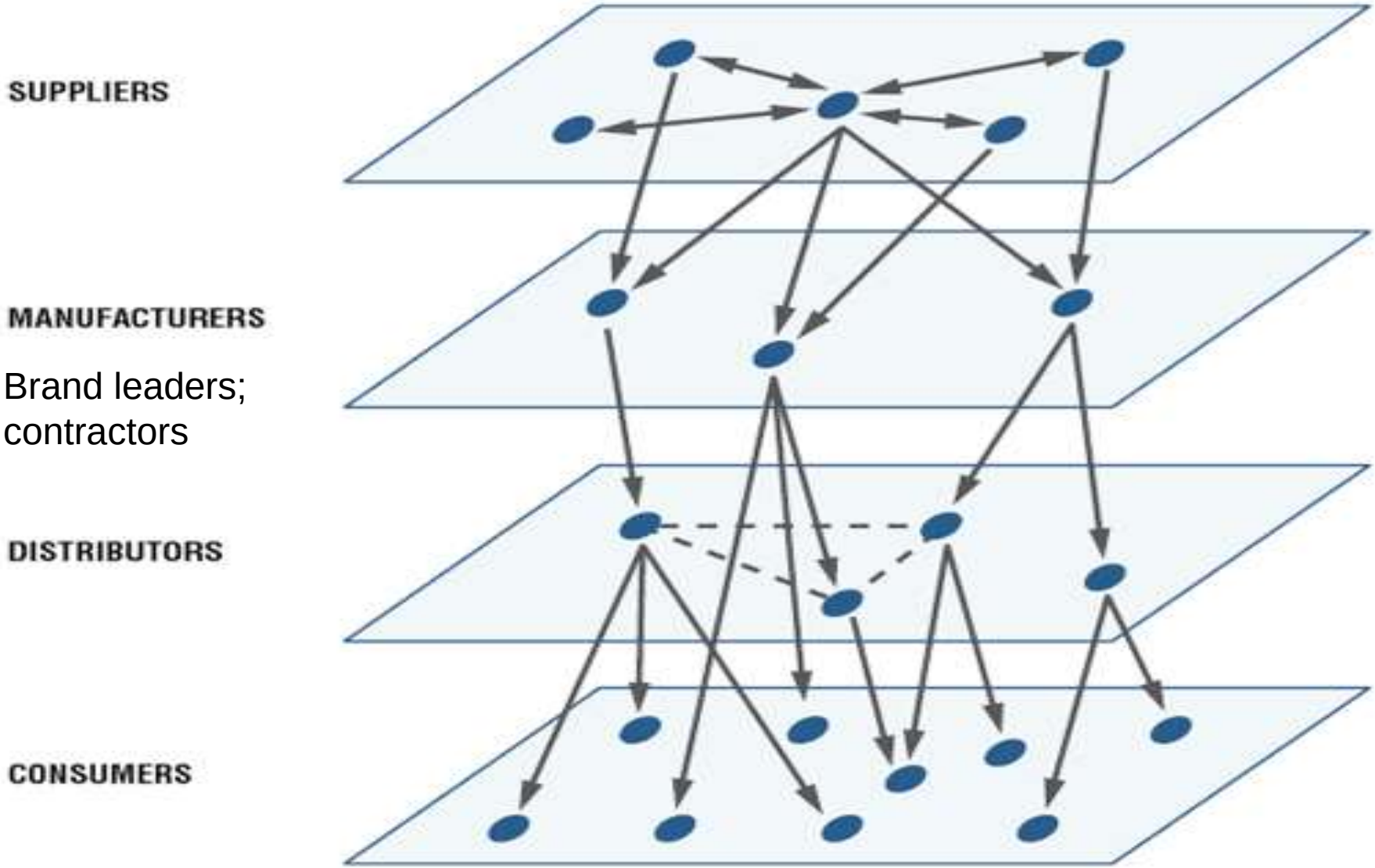
Ernst, D. (2012). “Production and innovation networks, global”

Knowledge sharing is the glue that keeps GPNs growing

- Network flagships transfer both explicit and tacit knowledge to local suppliers through formal and informal mechanisms
- This is necessary to upgrade the local suppliers' technical and managerial skills so that they can meet the flagships' specifications
- Once a network supplier successfully upgrades its capabilities, this creates an incentive for flagships to transfer more sophisticated knowledge, including engineering, product and process development"
- This process is NOT automatic → To stay on the GPN, local suppliers must constantly upgrade their capabilities
- **Upgrade or perish!!**

Ernst and Linsu KIM (Research Policy, 2002)

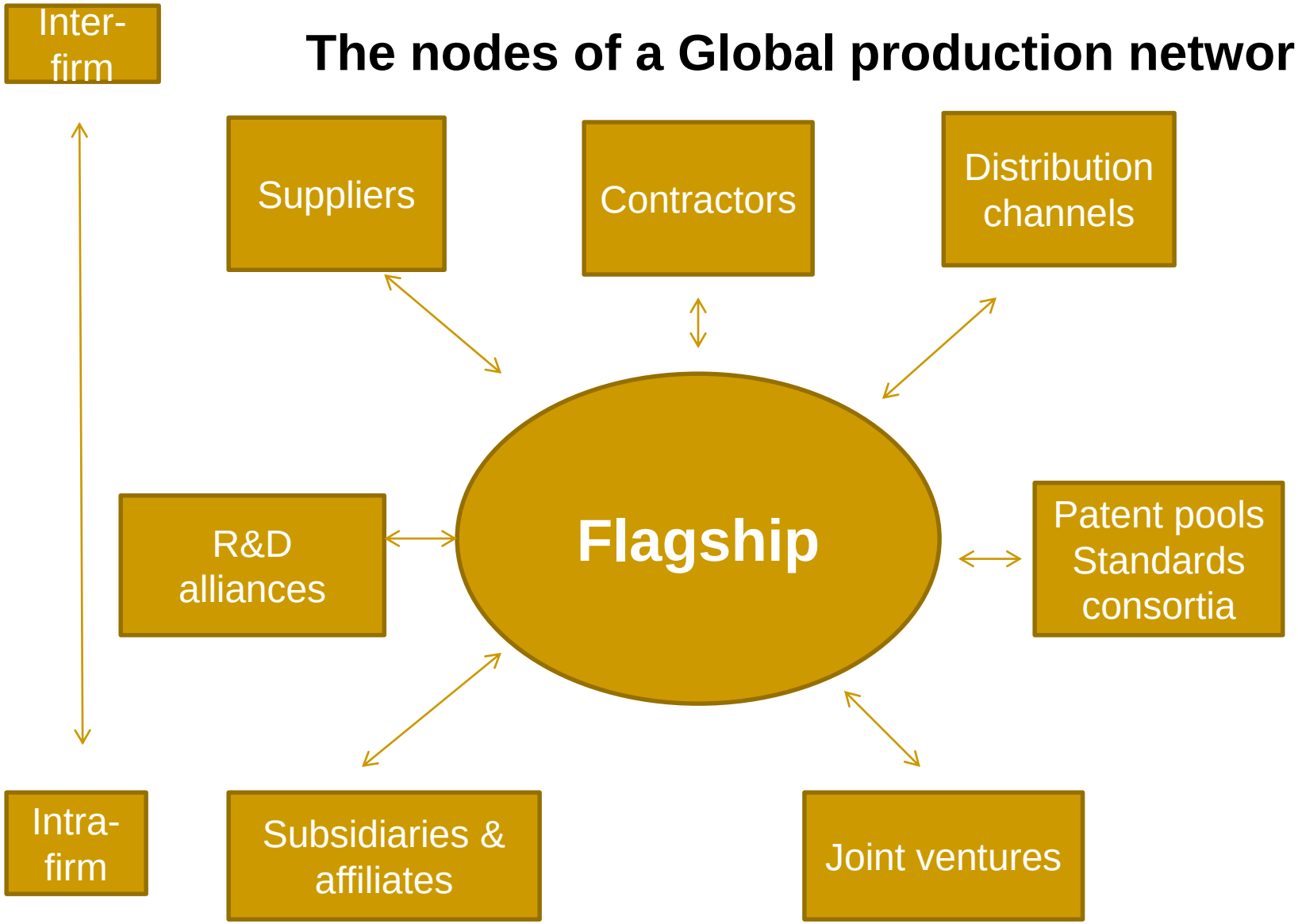
Three-dimensional model of a GPN



Brand leaders; contractors

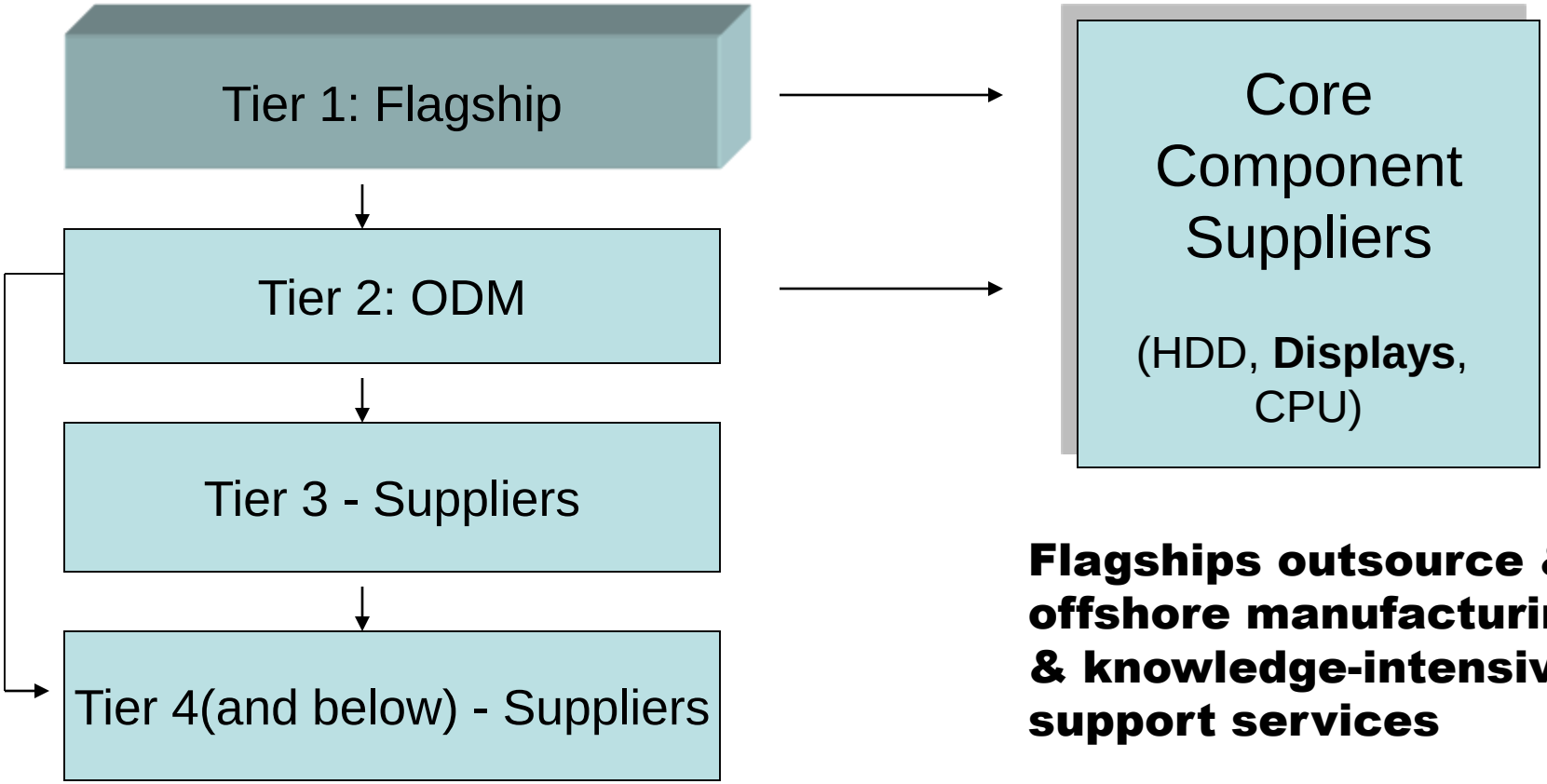
Lazzarini, Chaddad, and Cook, “Integrating Supply Chain and Network Analyses.”

The nodes of a Global production network



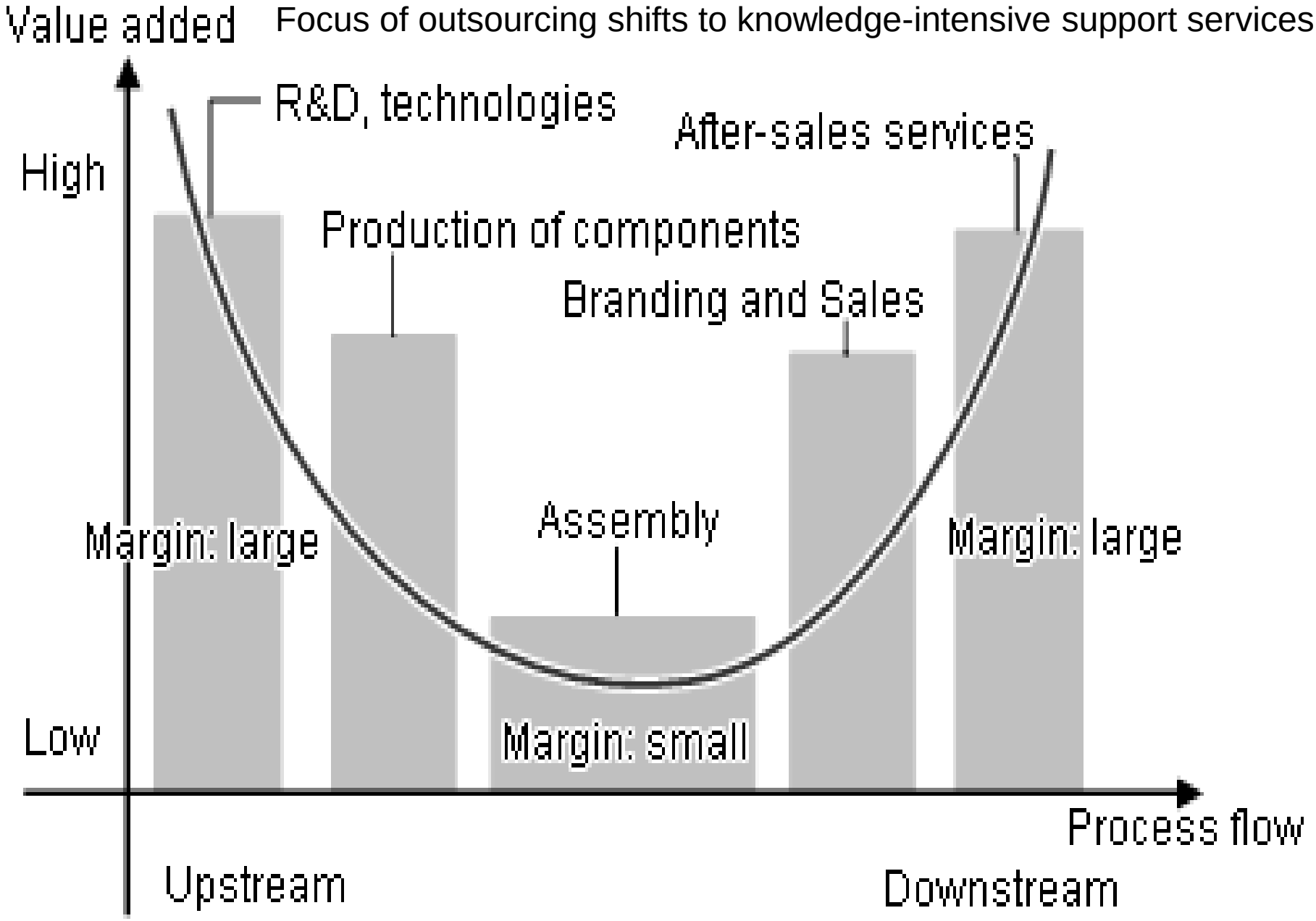
Ernst, D. and Linsu Kim, 2002,

Inter-Firm Networks - Notebooks



Flagships outsource & offshore manufacturing & knowledge-intensive support services

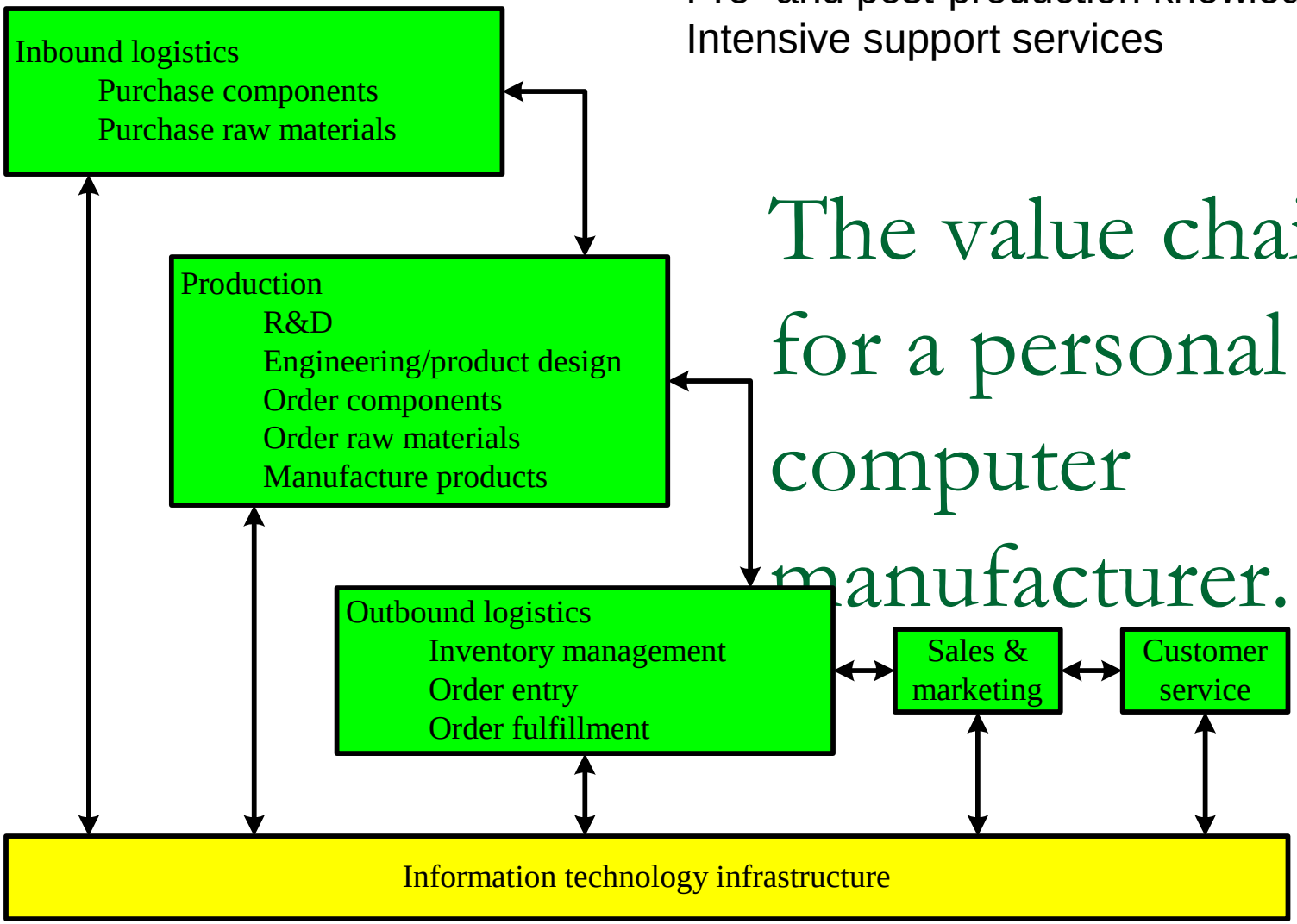
Focus of outsourcing shifts to knowledge-intensive support services

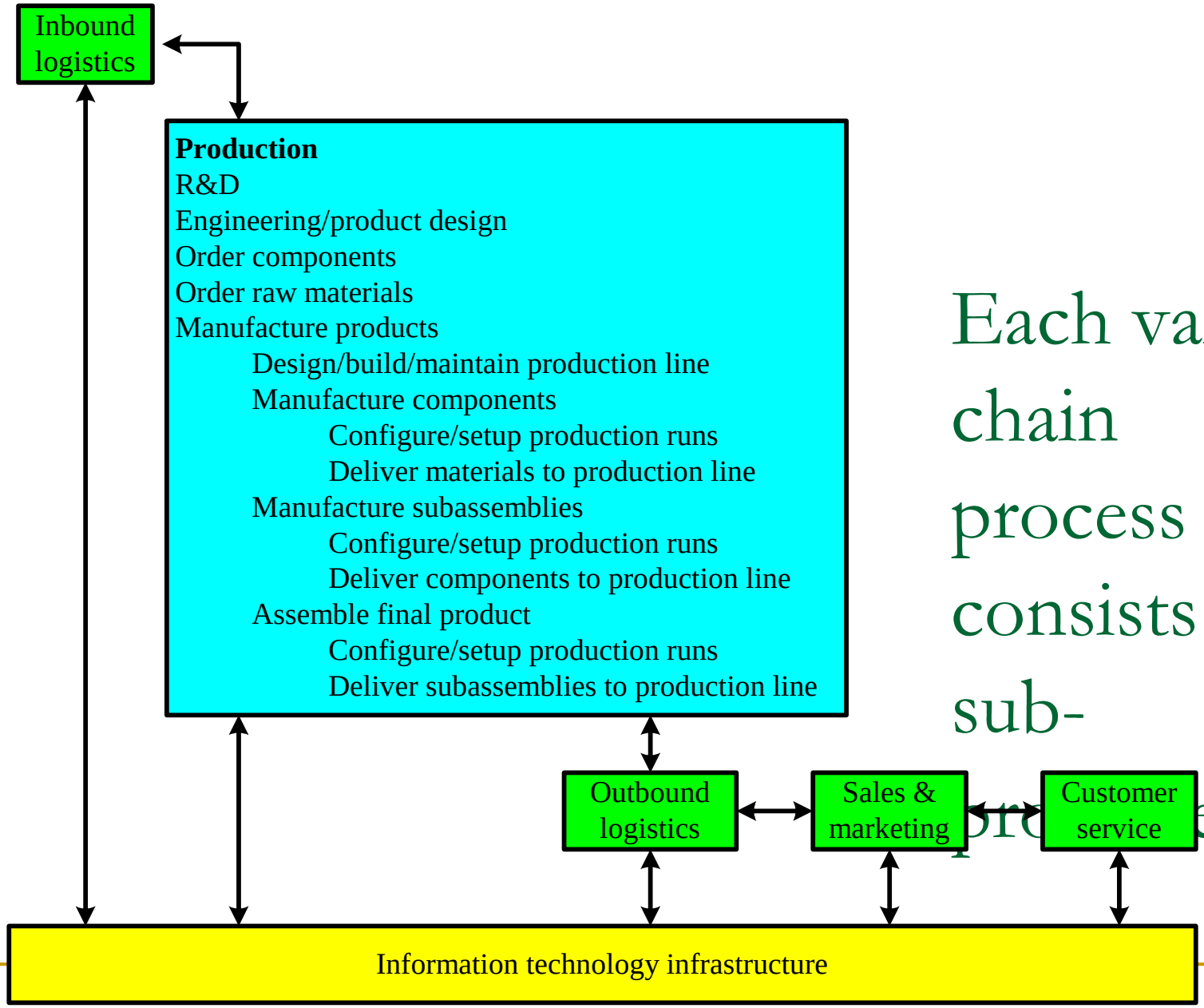


RIETI, 2010

Pre- and post-production knowledge-Intensive support services

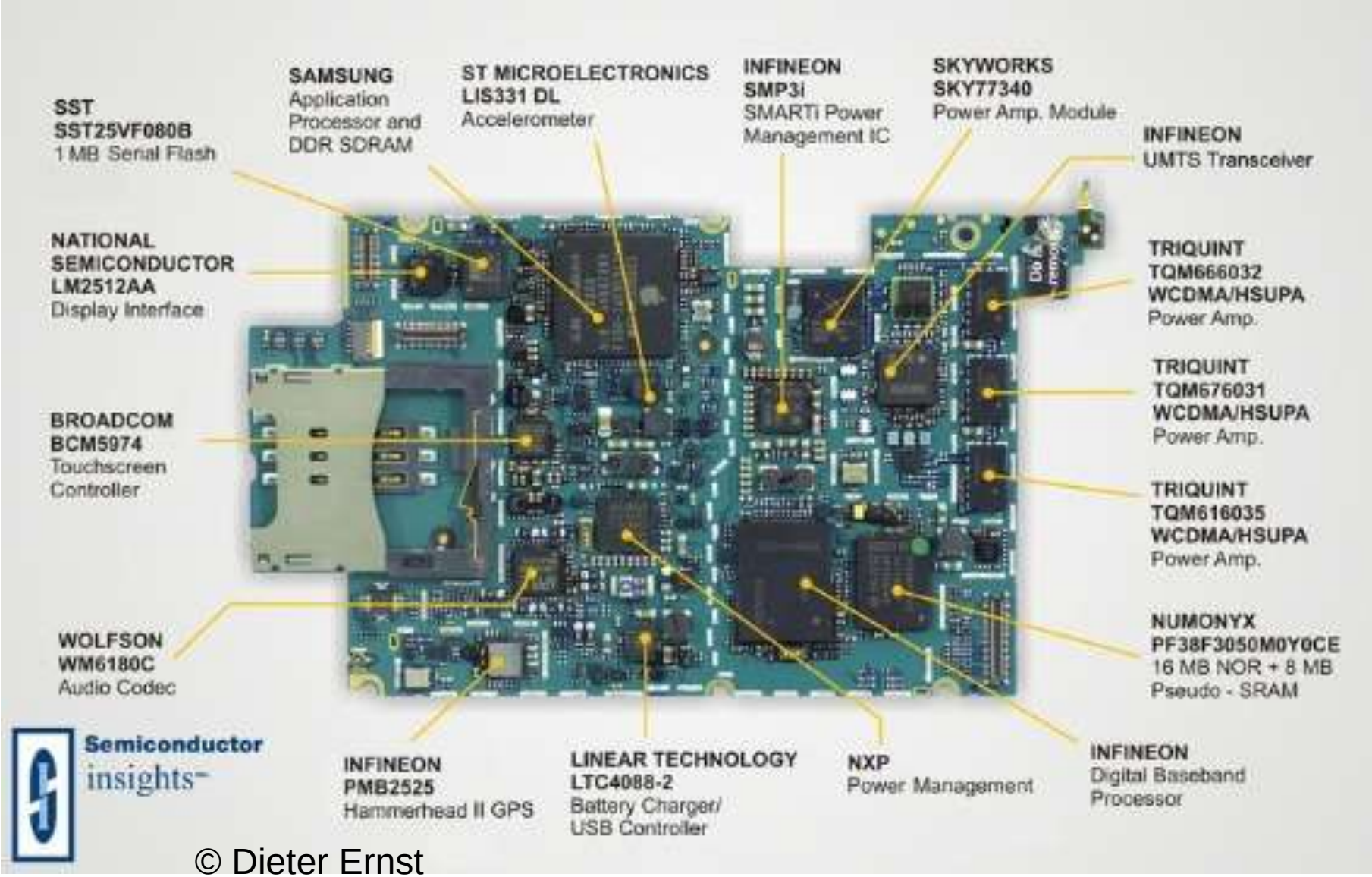
The value chain for a personal computer manufacturer.

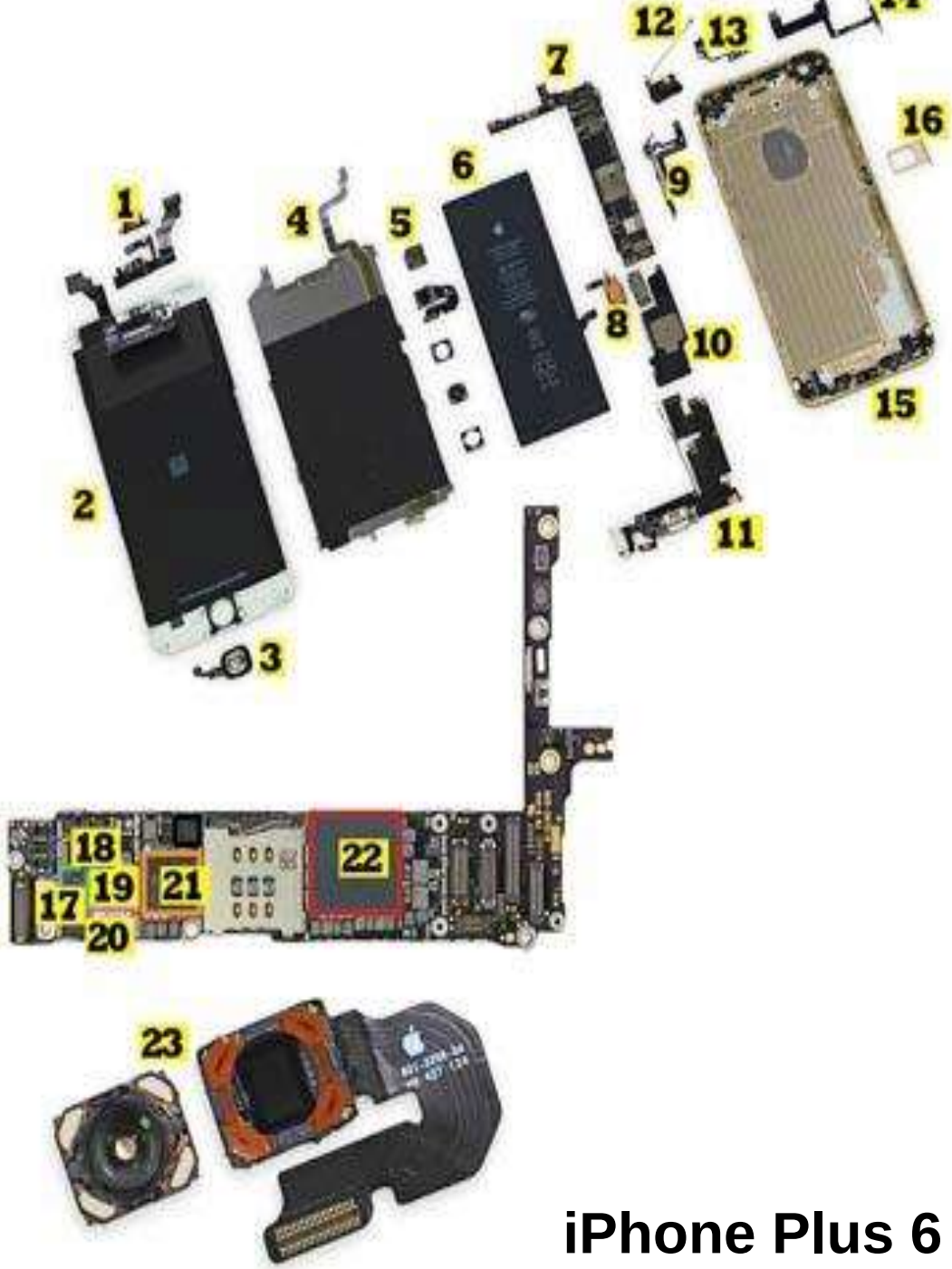




Each value chain process consists of sub-processes.

Apple iPhone *3G* 2008





Main exploded view
1 Front camera assembly
2 Exterior case (front)
3 Home button
4 Main front panel
5 Rear camera assembly
6 Battery
7 Motherboard
8 Vibrator
9 Volume button assembly
10 Speaker
11 Lightning connector assembly
12 Antenna
13 Antenna
14 Power button assembly
15 Exterior case (rear)
16 SIM tray

Motherboard
17 High band PAD
Avago

18 Power amplifier Sg
Avago

19 Power amplifier
Skyworks NL

20 Power amplifier
Triquint

21 LTE Modem
Qualcomm

22 Apps processor TSMC, Tw
Apple SoC stacked on Elpida RAM

Rear Camera
23 8MP camera with optical image stabilisation and phase-detection autofocus

iPhone Plus 6 tear-down, *E&T,* 11/10/14

Apple iPhone 6 Estimated Key Vendors and Parts - In Descending Order of Component Value

September, 2014 iHS

Foxconn, Tw = Tier-2:ODM

Manufacturer	Part Number	Description	
LG Display Kr		Display / Touch-screen Module - 4.7" Diagonal, 16.7M Color In-Cell Touch IPS LCD, 1334x750 Pixels, 326ppi	JDI
Apple (TSMC, Tw)	APL1011	Apps Processor - Dual-Core ARMv8 64-bit CPU, 20nm, PoP	
Qualcomm	MDM9625M	Baseband Processor - Multi-Mode	
		Enclosure, Main, Chassis - Machined Aluminum	
		Fingerprint Sensor Module - w/ Sapphire Crystal Cover	
		Primary Camera Module - 8MP, BSI CMOS, Auto Focus Lens	
SK Hynix Kr	H9CKNNN8KTMRWA-NTH	SDRAM - Mobile DDR3, 1GB	Mult
SK Hynix Kr	H2JTDG8UD1BMS	Flash - MLC NAND, 16GB	
Desay Electronics China		Battery - Li-Polymer, 3.8V, 1810mAh	Mult
Murata Jp	339S0228	BT / WLAN Module - IEEE802.11ac, Contains Broadcom BCM4345	
Qualcomm	WTR1625L	RF Transceiver, Multi-Mode, Multi-Band	See
Dialog Semiconductor D	338S1251-AZ	Power Management IC	
Qualcomm	WFR1620	RF Receiver	See
Qualcomm	PM8019	Power Management IC	
NXP NL	PN65V	NFC Controller - w/ Secure Element	
Skyworks	SKY77802-23	Transmit Module	
Avago Sg	ACPM-8010	Transmit Module	
Avago	ACPM-8020	Transmit Module	
Triquint	TQF6410	Transmit Module	

2. Global Innovation Networks (GINs)

- Ernst, D., “Complexity and Internationalization of Innovation: Why is Chip Design Moving to Asia?", *International Journal of Innovation Management*, March 2005, special issue in Honour of Keith Pavitt
- Ernst, D., "The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks", in: Latham, R. and S. Sassen (eds.), *Digital Formations: IT and New Architectures in the Global Realm*, Princeton University Press, 2005
- Ernst, D., *A New Geography of Knowledge in the Electronics Industry? Asia’s Role in Global Innovation Networks*, Policy Studies #54, August 2009, East-West Center, Honolulu, USA

What distinguishes Global Innovation Networks?

- Offshore outsourcing also includes product development, design and research.
- There is an important element of continuity – GINs emerge as a natural extension of GPN and hence share most of their characteristics.
- Until recently, the lack of good data gave rise to the perception that GINs "are still limited in number and mostly concentrated with big firms" (OECD,2008)

Measurement problems

- Econometric analysis dominates policy debates & focuses on highly aggregated data that are often lagging by a number of years.
  - "imperfect macroeconomic proxies provide a surprisingly low level of R&D globalization" (Mowery et al, 2008)
- But even those imperfect proxy indicators document the scattering of the innovation process across borders
- IMF Balance of Payment data → rapid growth of international payments, especially for patent licensing & copy right.
- Surveys of innovation offshoring by leading MNCs

EWC- GIN research

- Interviews with > 150 ICT companies (US, Japan, Asia, EU)
- Diverse sample (size, ownership, business model):
  - large global brand leaders
  - specialized technology suppliers and service providers
  - trans-pacific VC funded start-ups
  - international public-corporate R&D consortia
- Drivers and characteristics of GINs
- Impacts on learning, capability formation and innovation at diverse locations in China, Taiwan, Korea, Malaysia and India.

Systemic pressures to internationalize innovation

- ROI → contain rising cost, complexity and uncertainty of innovation
- Rapid growth of emerging markets → move R&D and product management close to lead customers in these markets
- Shorter product-life-cycle → speed-to-market
- Surging demand for low-cost knowledge workers → new sources in emerging markets
- New competitors and emerging centers of excellence
- Regulatory arbitrage = exploit differences in IPR regimes, incentives, tax laws [transfer pricing], regulations [finance; environment; health]

Ernst, 2009 & 2011

Enablers

- Modular design enables vertical specialization (slicing & dicing of innovation value chain)
- Liberalization/privatization → 'deregulated' markets
- ICT-enabled information management
- Globalizing markets for technology, knowledge workers and innovation finance
- Growing innovative capabilities in emerging economies
- Globalization of IP protection & standards (TRIPS-Plus; ITA; TISA; TPP; TTIP)

Ernst, 2009 & 2011

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.

Global innovation networks – increasing diversity

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)**

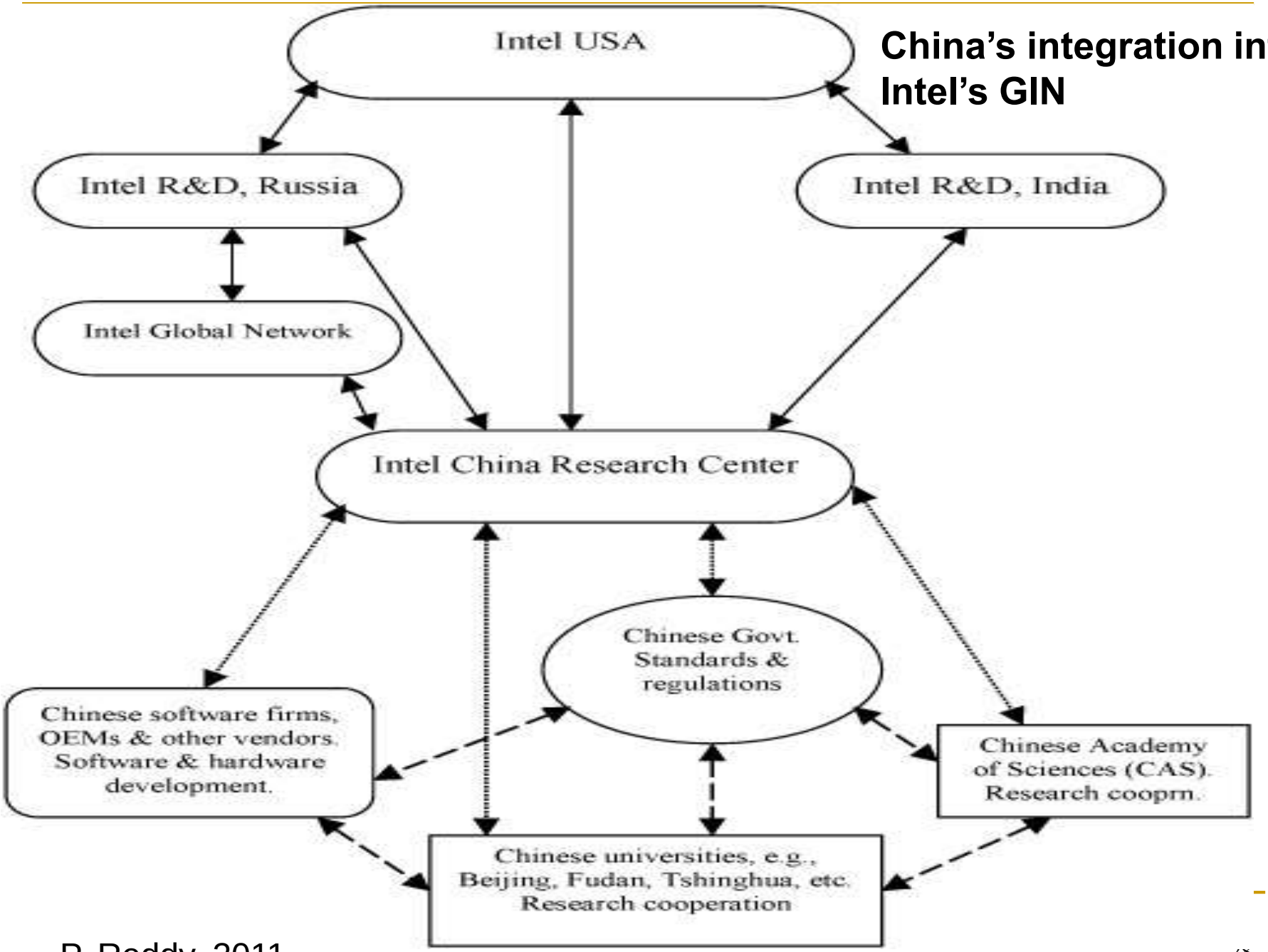
Adapted from Ernst, D., 2009, *A New Geography of Knowledge?*

Hierarchical GIN - Intel's integrated product development

- **US** (>11 R&D labs)
- **Europe** (> 12 R&D labs)
  - **Israel** (Haifa: 2400, since 1974), processor research
  - **Russia**: Nizhny Novgorod (450++): software
- **Asia** (7 labs, more planned)
  - **Bangalore (1998, 2,700 + = largest lab outside US), leading-edge processor & platform development**
  - **Penang** (500), component design; **Shanghai** (100++) Linux based solutions for telecom; new applications for emerging markets; **Beijing** (50++), platform and architecture lab

Sources: company website and interviews

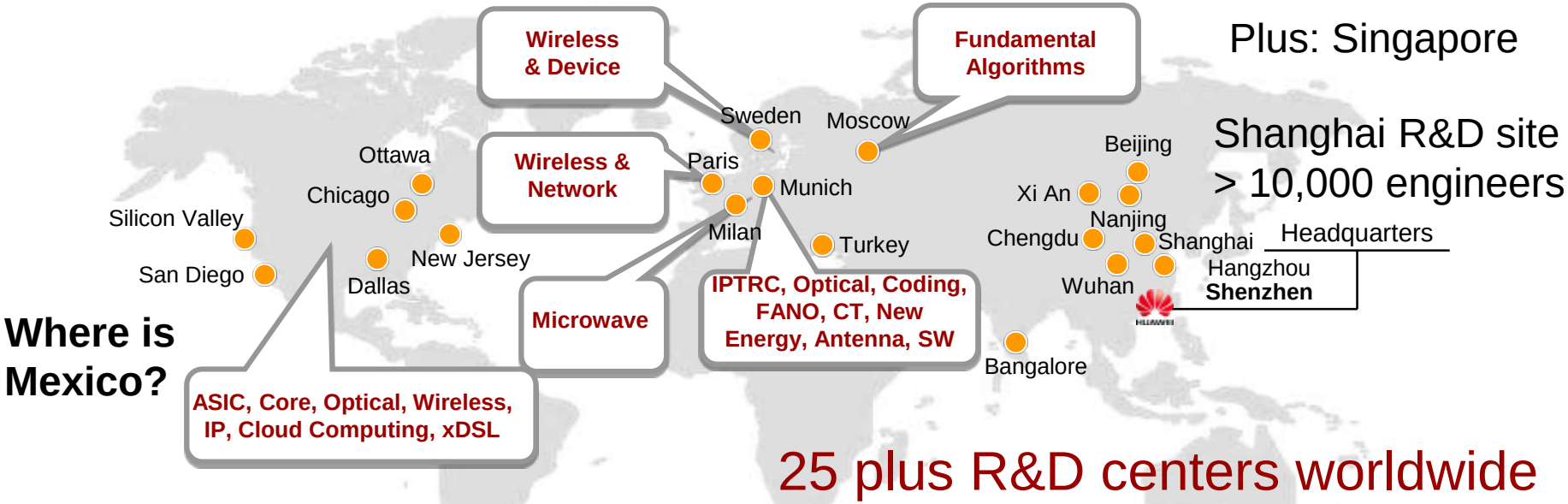
China's integration into Intel's GIN



P. Reddy, 2011

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

> 800 R&D specialists across 14 R&D sites in 8 EU countries

Sources: company website and interviews

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

Universities: Carnegie Mellon; Case Western Reserve; Columbia; Cornell; Georgia Tech; Harvard; Johns Hopkins Kent State; 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

Power shift? From hierarchical to splintered GINs

Hierarchical GINs: Brand leaders like Apple act as network flagship which …

- controls key resources and shapes strategic direction;
- uses its purchasing power to force corrosive price concessions on suppliers (production & R&D) and distributors.

Splintered GINs: diverse network flagships:

- **core component suppliers** (Intel, MS; ARM; QCM; TSMC) control platforms
- **Mega-contractors** (Foxconn) can **co-shape** strategic direction & provide integrated solutions
- **Mega- distributors** (e.g.,Arrow Electronics; Avnet) can provide integrated solutions

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

Mexico
Chihuahua
Juarez
(ex-Motorola; Ex-Cisco)

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

3. An unequal distribution of innovation gains defines the New Geography of Knowledge

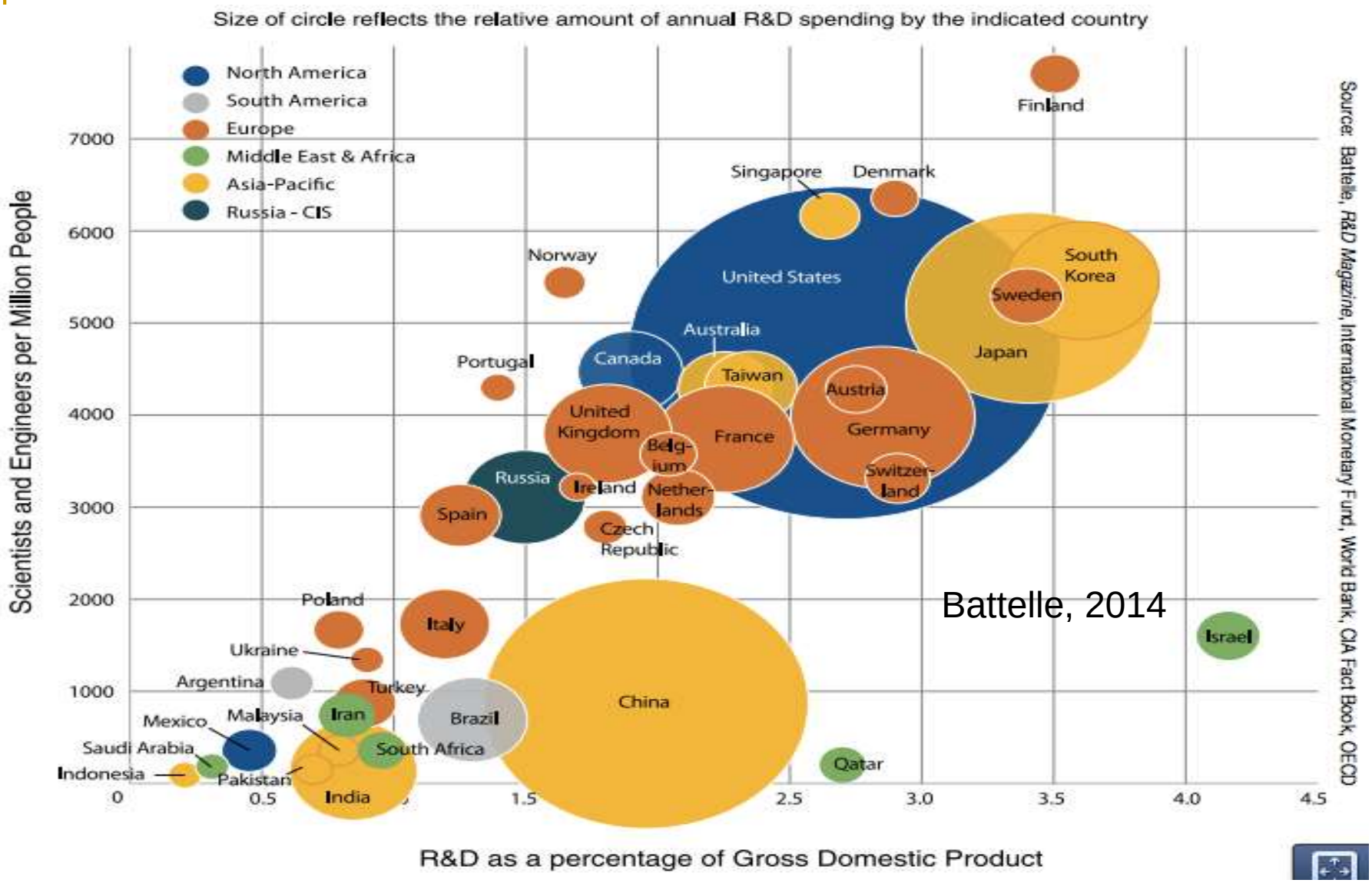
- Asia's role in GINs is increasing (from initially low level)
- new (large) Asian players develop their own networks and unique ('hybrid') networking strategies
- established centers in the US, Europe and Japan retain their dominance
- Asia competes within a new global hierarchy of innovation hubs

A new global hierarchy of innovation hubs

- **Global centers of excellence** (US, Japan, EU)
- **Advanced locations** (Israel, Korea, Taiwan, [Ireland], [Russia])
- **Catching-up locations** (Beijing, Shanghai, Shenzhen in China; Bangalore, Chennai, Hyderabad, Delhi in India) → rapid learning; intense competition for talent pool; experience gap
- **'New frontier' locations** (lower-tier cities in China & India, plus Romania, Armenia, Bulgaria, Vietnam, etc)
  - low-cost, highly motivated and trainable engineers and technicians
  - weak infrastructure, widespread market imperfections and limited exposure to modern US-style management system

Ernst, 2009

World of R&D 2013



Population 2015; Mexico=125,235,587 ; Malaysia =30,432,000

Established innovation centers retain dominance

- all 15 leading companies with the best record on patent citations are based in the United States (9 in the IT industry)
- The 700 largest R&D spenders (mostly large U.S. firms) account for 50% of the world's total R&D expenditures and >2/3 of the world's business R&D
- > 80 percent of the 700 largest R&D spenders come from only five countries (United States dominates, followed by Japan, Germany, United Kingdom, France)

Who controls ICT standard consortia?

- about 50 global corporations determine what 250 ICT standard consortia do, and more importantly, how they do it.
- Incumbent leaders: IBM, Microsoft, Fujitsu, Intel, Hewlett Packard, Hitachi, Nokia, Ericsson and Texas Instruments.
- Of the 50 major players, 25 are from the US, 12 from the EU, and 8 from Japan.
- Only 5 companies from emerging countries (all from Asia) are members (Samsung, Huawei, LG, Lenovo, ZTE)

Last thoughts

- The New Geography of Knowledge is not a Flatter World
- Concentrated dispersion of capabilities through GPNs and GINs results in an unequal distribution of innovation gains
- **What does this imply for industrial & innovation policies?**
- **What does this imply for Mexico?**

Q&A