Trade and Macroeconomics

Lectures 3: Offshoring and the Gains from Globalization

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July 9, 2014

Disintegration of Production

- improvements in transportation and communication have led to a new form of exchange:
  - trade in value-adding tasks performed in different locations
  - offshoring in manufacturing and business functions
  - global supply chains
- contrasting views on offshoring
- offshoring as an opportunity:
  - standard GFT
- offshoring as a threat:
  - could workers in US be worse off?
- what is offshoring? what is special about offshoring?

The Rise of Offshoring

- offshoring:
  - sourcing of input goods or services from a foreign country
- not a new phenomenon:
  - already in the 1970s, IKEA established production facilities in Poland
  - already in the 1980s, Swissair had moved many accounting tasks to India
- recent boom triggered by
  - economic transformation in East Asia
  - advances in ICT

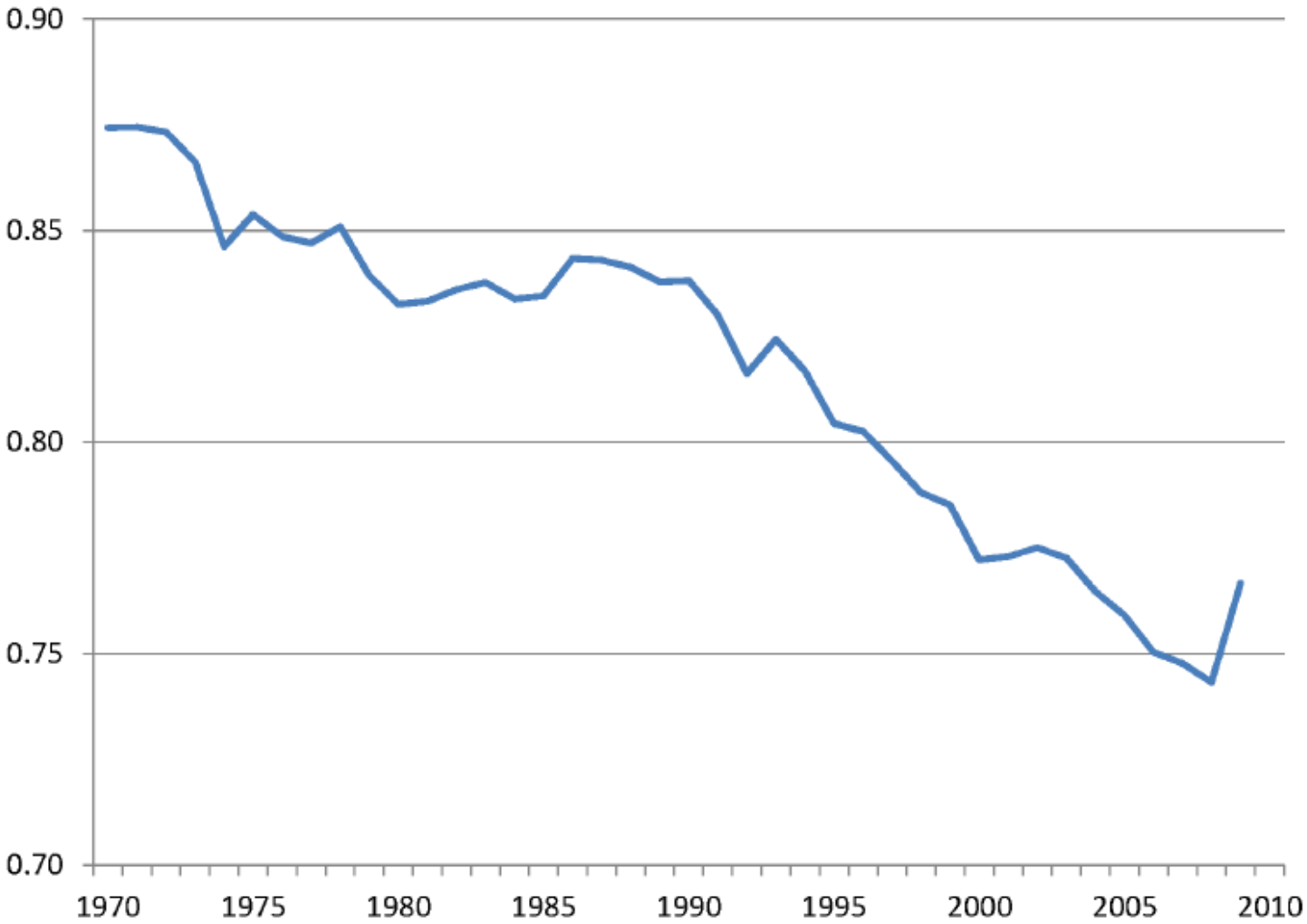
Measuring Offshoring

- 2/3 of world trade is in intermediate products
- Feenstra & Hanson (1996):
  - share of imported inputs in total US input purchases (from US I-O tables)
  - from 6% in 1980 to 27% in 2006
- Johnson and Noguera (2012):
  - use global I-O tables to compute

$$\text{VAX ratio} : \frac{\text{value added}}{\text{gross value}} \text{ of exports}$$

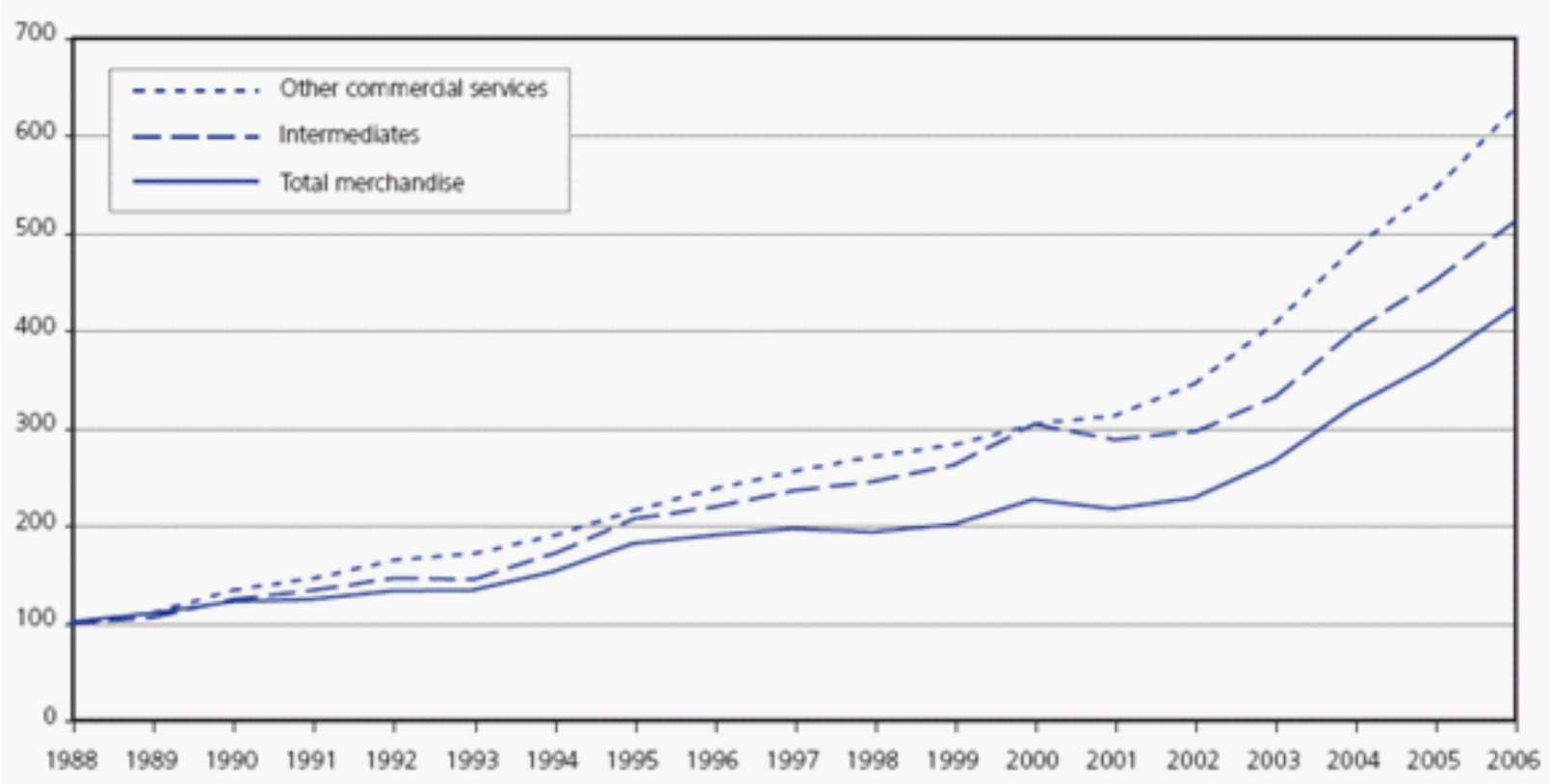
  - inverse measure of vertical specialization in the world production
  - value added content of trade declined, particularly in manufacturing

Value Added to Gross Export



Source: Johnson and Noguera (2012b)

The Growth of Offshoring



Data are normalized at 100 in 1988

- material and service offshoring have grown faster than merchandise trade

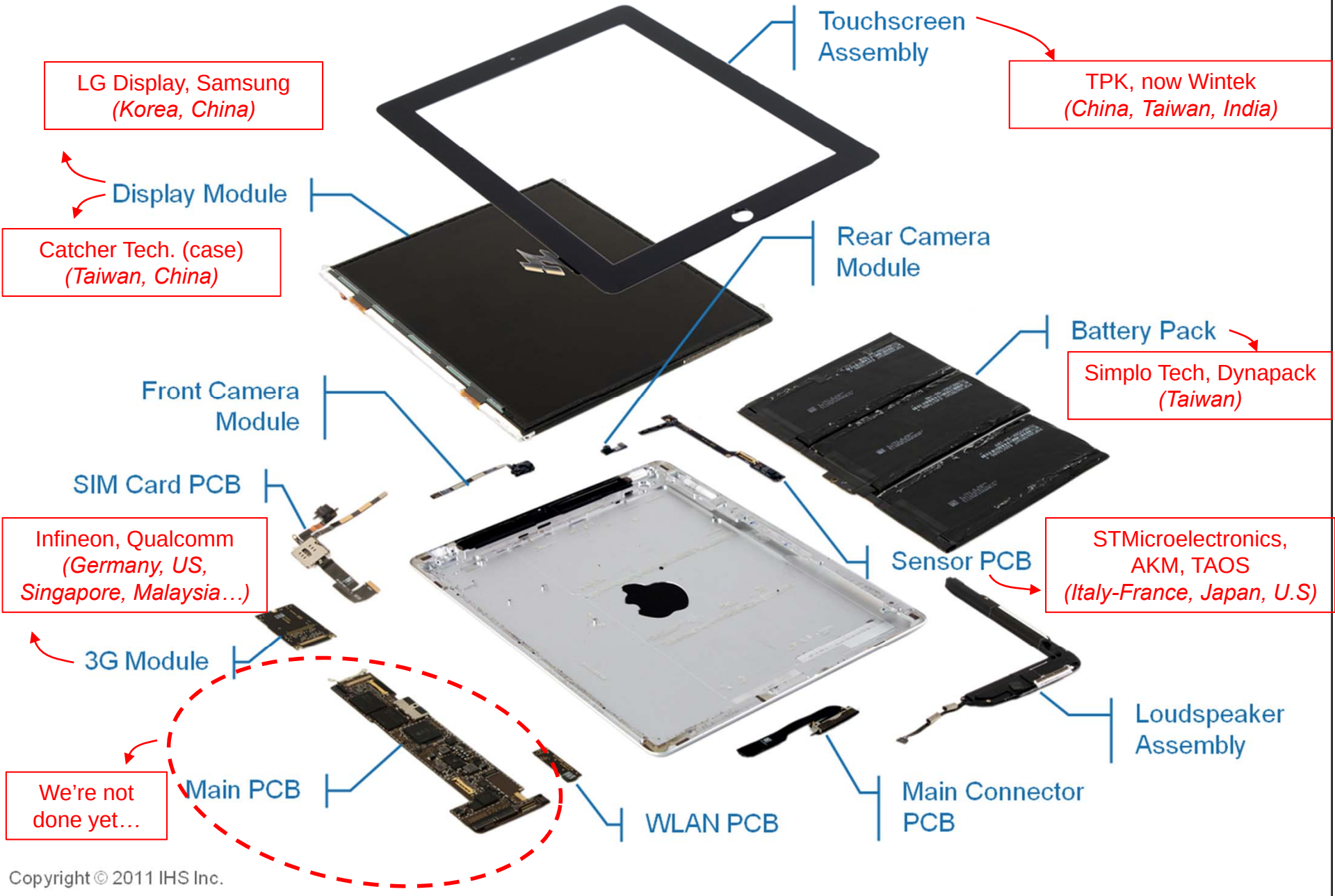
An Example: the iPad 2

- Assembled in China (and soon in Brazil) by Taiwan-based Foxconn

Apple iPad 2 32GB (Wi-Fi + 3G)

Exploded View

iSuppli®
Teardown Analysis



Apple iPad 2 32GB (Wi-Fi + 3G)

Disassembly – Main PCB, Bottom

iSuppli Teardown Analysis

Firms with R&D centers in developed countries and manufacturing plants worldwide

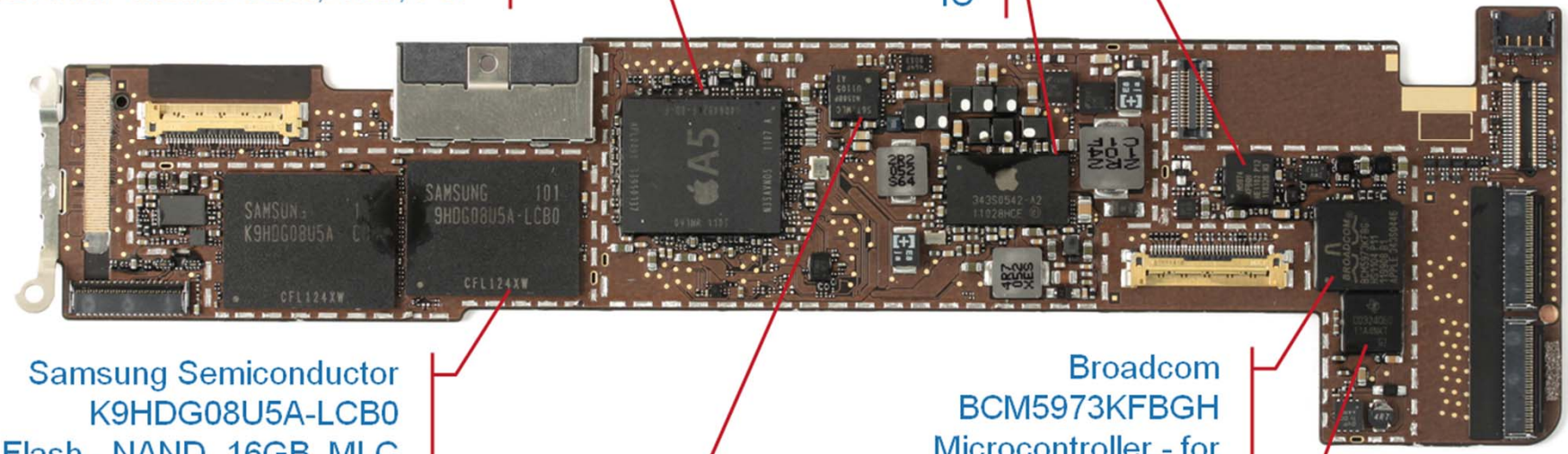
Samsung Semiconductor
APL0498
Applications Processor - 45nm, PoP

Elpida
B4064B2PF-8D-F
SDRAM - Mobile DDR, 4Gb, PoP

Broadcom
BCM5974CKFBGH
Multitouch Controller

WLAN PCB

Power Management IC



Samsung Semiconductor
K9HDG08U5A-LCB0
Flash - NAND, 16GB, MLC (x2)

Broadcom
BCM5973KFBGH
Microcontroller - for Touchscreen

Samsung Semiconductor
S6T2MLC
ASIC - LCD Timing Controller

Texas Instruments
CD3240A1
Touchscreen Driver

The iPod Value Chain: Jobs

- Apple's Video iPod:
  - sold at $299 on the US market
  - $163 to American companies
  - $132 to part makers in other Asian countries
  - $4 to Chinese workers
- iPod-related jobs by country and category in 2006:

	Production	Retail and other non-professional	Engineering and other professional	Total
U.S.	30	7,789	6,101	13,920
China	11,715	*	555	12,270
Philippines	4,500	*	250	4,750
Japan	700	*	1,140	1,840
Singapore	825	*	100	925
Korea	600	*	600	1,200
Thailand	750	*	50	800
Taiwan	70	*	270	340
Other	0	4,825*	300	5,125
Total	**19,190**	**12,614**	**9,366**	**41,170**

*Includes all non-U.S. retail and other non-professionals.

  - more jobs abroad than in the US
  - US specialized in engineering and retail

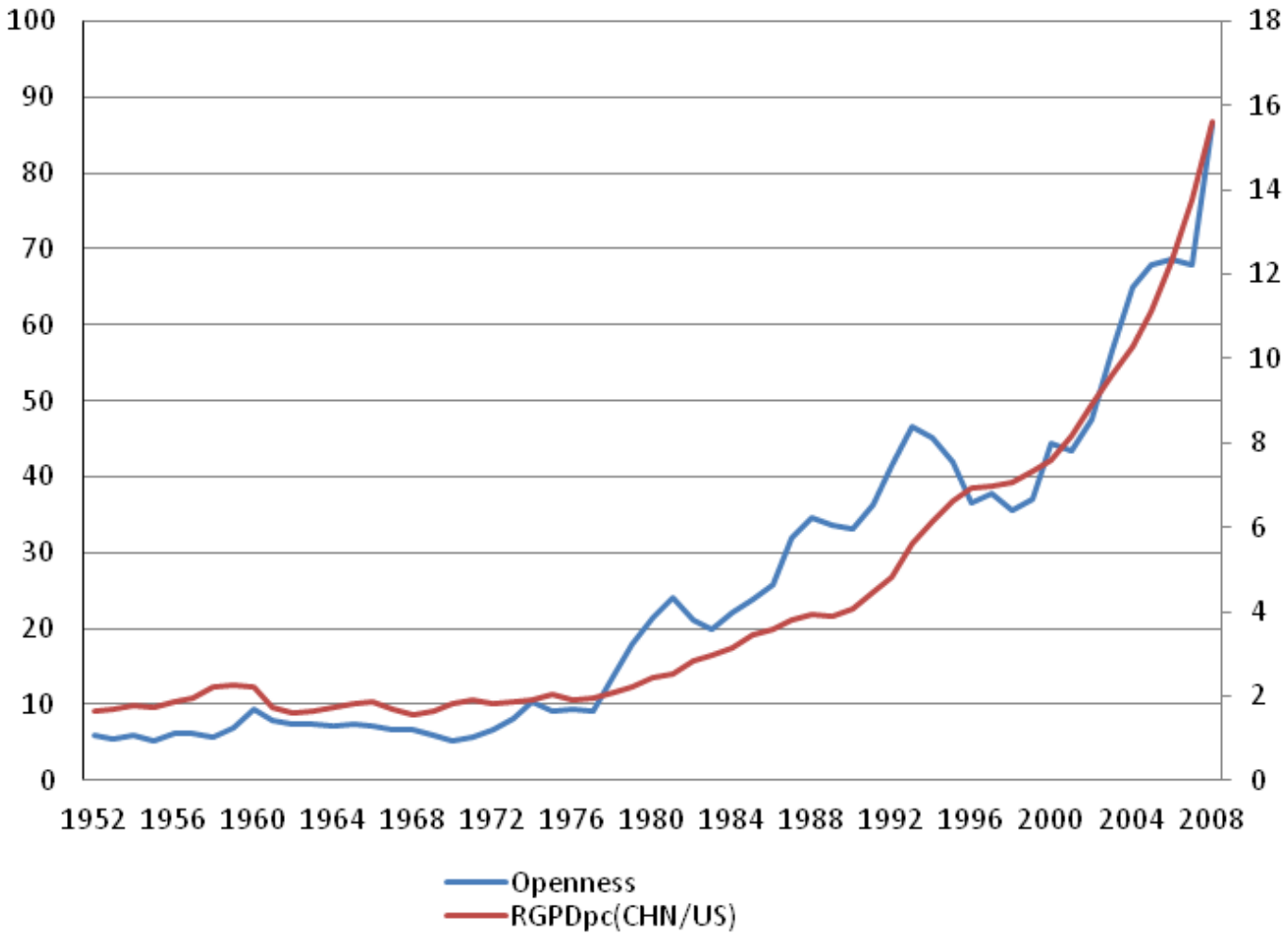
The iPod Value Chain: Earnings

- average annual employee earnings by job category in 2006:

	Production	Other non-professional	Engineering and other professional
U.S.	$47,640	$25,580	$85,000
Japan	$40,400	$20,000	$65,000
Korea	$29,440	$15,000	$30,000
Taiwan	$12,860	$7,000	$20,000
Singapore	$17,110	$9,000	$20,000
Philippines/Thailand	$2,140	$1,500	$15,000
China	$1,540	$1,000	$10,000

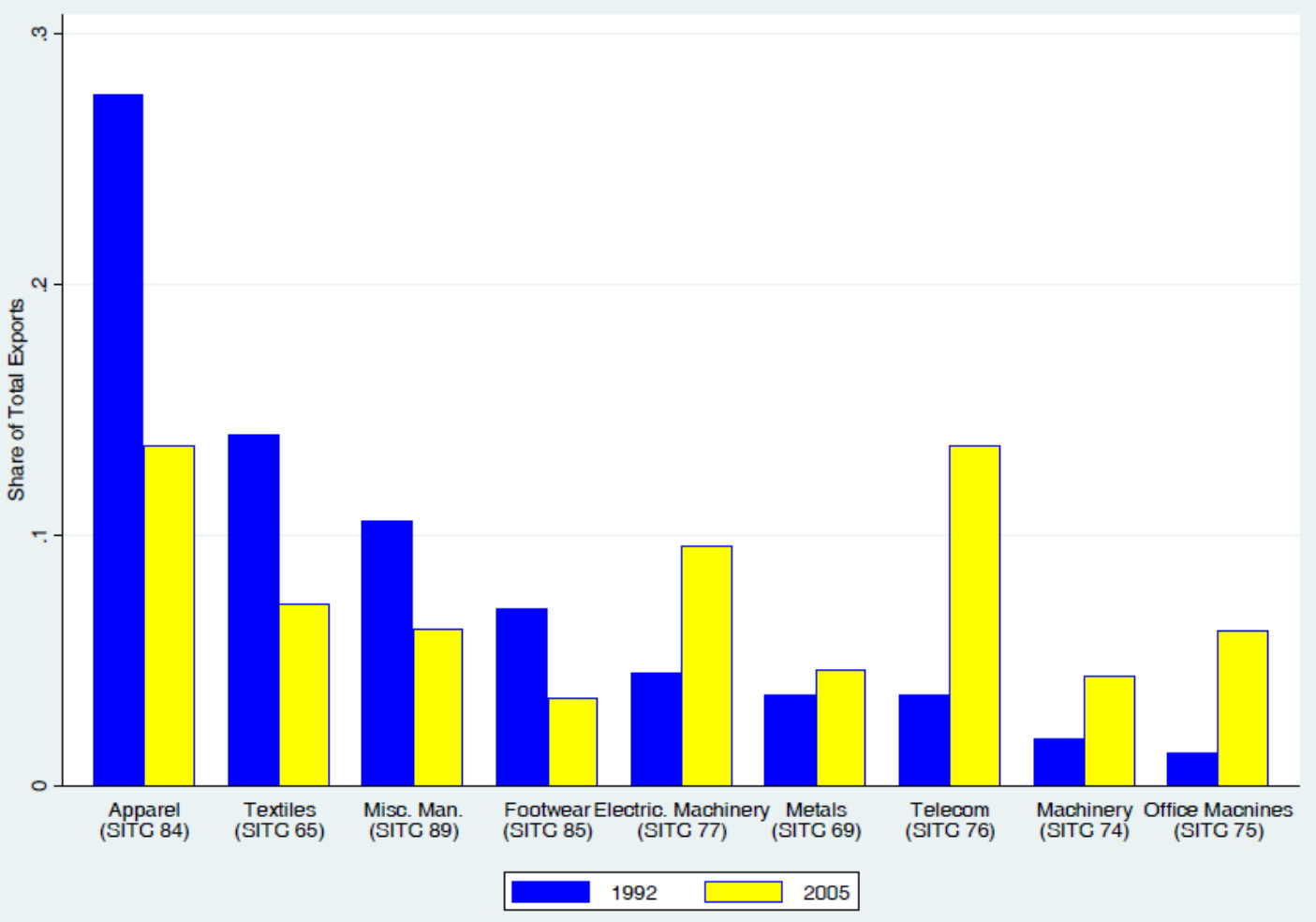
  - high-wage jobs are in the US
  - yet, high-skill workers are relatively more expensive in China

The Rise of China



- since the 1980s, spectacular growth of GDP and trade volumes

China's Export Growth



- main 2-digit manufacturing industries (1992-2005 growth: +500%)

Offshoring and Welfare: Samuelson (2004)

- can offshoring of production to low-wage countries (South) reduce welfare in high-wage countries (North)?
- Samuelson (2004):
  - eventually YES, if offshoring implies technology transfer from North to South
- why?
  - because the North will eventually lose its comparative advantage and thus the gains from trade
- we illustrate this point in a Ricardian model inspired to:
  - Acemoglu, Gancia & Zilibotti (2014), Rodriguez-Clare (2010) and Krugman (1979)
- yet, the model will suggest that *some* offshoring is mutually beneficial

A Simple Ricardian Model

- two country: North and South$^{(*)}$
- one factor, labor, in fixed supply: L and L^*
- all markets are competitive
- world output:
  - CES function of a continuum of freely-traded intermediates/tasks:

$$Y = \left(\int_0^1 x_i^{\alpha} \, \mathrm{d}i \right)^{1/\alpha}, \quad \alpha \in (0,1)$$

  - tasks enter symmetrically, but are imperfect substitutes
- the North can produce all intermediates, the South only a subset $[0, \kappa]$
  - offshoring: $\uparrow \kappa =$ more jobs go South

Demand for Intermediates

- profit maximization:

$$\max_{x_i} \left\{ \left(\int_0^1 x_i^{\alpha} \, \mathrm{d}i \right)^{1/\alpha} - \int_0^1 p_i x_i \, \mathrm{d}i \right\}$$

  - p_i = price of intermediate x_i

- FOC, $\frac{\partial \{\cdot\}}{\partial x_i} = 0$:

$$\begin{aligned} p_i &= \left(\int_0^1 x_i^{\alpha} \, \mathrm{d}i \right)^{\frac{1-\alpha}{\alpha}} x_i^{\alpha-1} = Y^{1-\alpha} x_i^{\alpha-1} \\ \rightarrow \quad x_i &= p_i^{\frac{1}{\alpha-1}} Y \end{aligned}$$

  - demand has a constant price elasticity

Production and Prices

- production:
  - 1 unit of x_i requires 1 unit of labor (in any country)
  - but the South can only produce a subset $[0, \kappa]$ of intermediates
  - assume: $\kappa < \bar{\kappa} = \frac{L^*}{L+L^*}$
- perfect competition:
  - price = marginal cost

$$p_i = w \quad \text{if produced in North}$$

$$p_i = w^* \quad \text{if produced in South}$$

- where will a good be produced?

Specialization, Offshoring and Relative Wages

- given $\kappa < \bar{\kappa} = \frac{L^*}{L+L^*}$:
  - the South will specialize in intermediates $[0, \kappa]$
  - the North will produce the rest $[\kappa, 1]$
- thus:

$$x^* = \frac{L^*}{\kappa} \quad \text{and} \quad x = \frac{L}{1-\kappa}$$

- why?
  - using $p_i = Y^{1-\alpha} x_i^{\alpha-1}$, compute relative prices:

$$\frac{p}{p^*} = \left(\frac{x}{x^*}\right)^{\alpha-1} = \left(\frac{L^*}{L}\frac{1-\kappa}{\kappa}\right)^{1-\alpha} > 1$$

  - since $p > p^*$, North cannot compete on intermediates from South
  - since $p_i = w \longrightarrow p > p^*$ implies $w > w^*$

Offshoring and Efficiency

- substitute x_i into Y:

$$\begin{aligned} Y &= \left[(1-\kappa)\, x^{\alpha} + \kappa\, (x^*)^{\alpha}\right]^{1/\alpha} \\ &= \left[(1-\kappa)^{1-\alpha}\, L^{\alpha} + \kappa^{1-\alpha}\, (L^*)^{\alpha}\right]^{1/\alpha} \end{aligned}$$

- offshoring (κ) and output:

$$\frac{\partial Y^{\alpha}}{\partial \kappa} = (1-\alpha)\left[\left(\frac{L^*}{\kappa}\right)^{\alpha} - \left(\frac{L}{1-\kappa}\right)^{\alpha}\right] > 0$$

  - moreover:

$$\lim_{\kappa \to 0} \frac{\partial Y}{\partial \kappa} = \infty \quad \text{and} \quad \lim_{\kappa \to \bar{\kappa}} \frac{\partial Y}{\partial \kappa} = 0$$

- intuitive:
  - moving production where labor is cheaper raises aggregate efficiency, the marginal effect is infinite when $w^* = 0$ and disappears at $w = w^*$

Offshoring and Wages: South

- real wage in South:

$$\begin{aligned} w^* &= p^* = Y^{1-\alpha}\left(x^*\right)^{\alpha-1} = Y^{1-\alpha}\left(\kappa/L^*\right)^{1-\alpha} \\ \frac{\partial \ln w}{\partial \kappa} &= (1-\alpha)\left[\frac{\partial Y}{\partial \kappa}\frac{1}{Y}+\frac{1}{\kappa}\right] > 0 \end{aligned}$$

- two effects of offshoring:
  1. efficiency effect $(+)$
  2. more demand for labor in South $(+)$
- offshoring raises real wages in the South

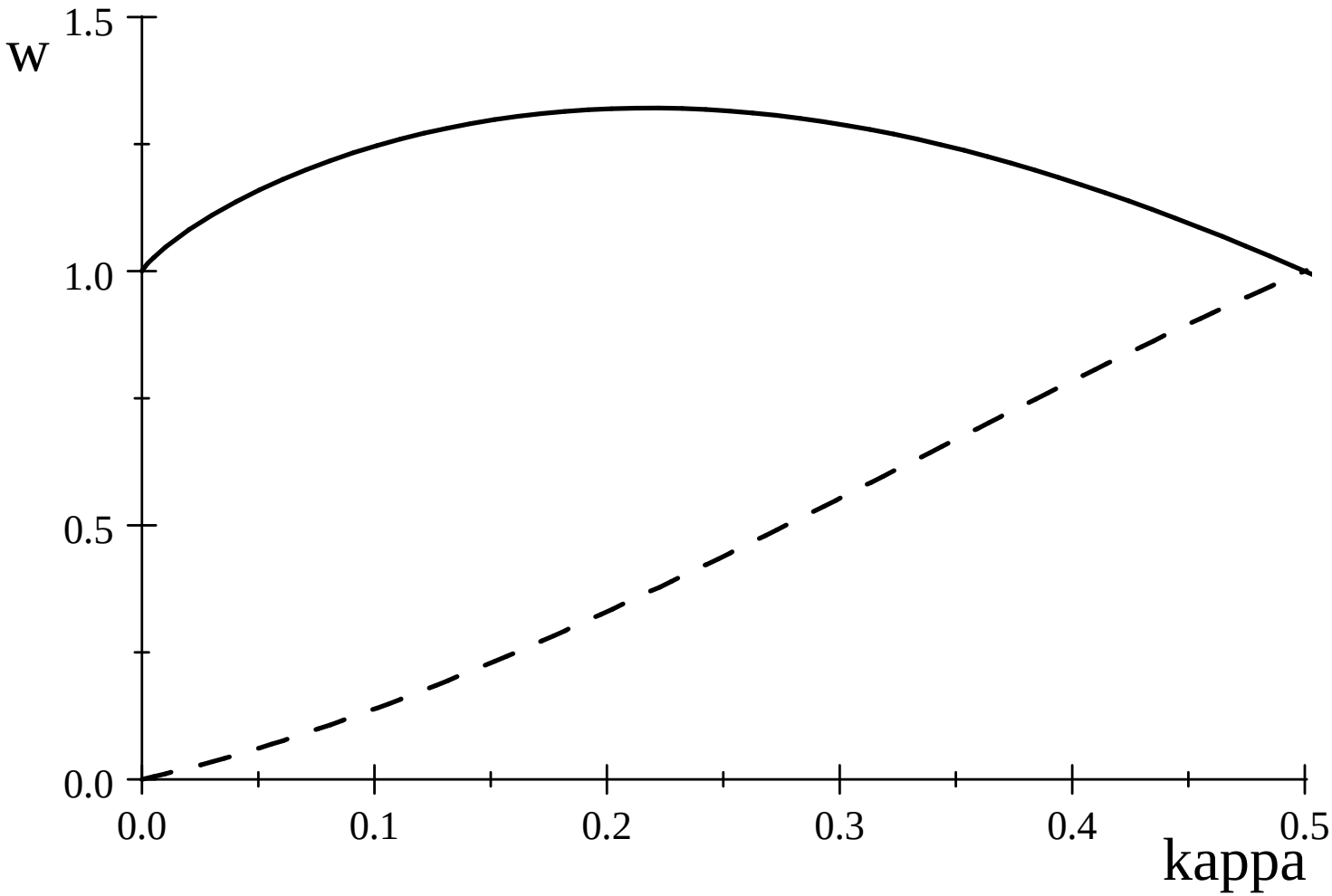
Offshoring and Wages: North

- real wage in North:

$$\begin{aligned} w &= p = Y^{1-\alpha} x^{\alpha-1} = Y^{1-\alpha} \left[(1-\kappa) / L \right]^{1-\alpha} \\ \frac{\partial \ln w}{\partial \kappa} &= (1-\alpha) \left[\frac{\partial Y}{\partial \kappa} \frac{1}{Y} - \frac{1}{1-\kappa} \right] \end{aligned}$$

- two effects of offshoring:
  1. efficiency effect $(+)$
  2. less demand for labor in North $(-)$
- at $\kappa \longrightarrow 0$, (1) dominates $(\frac{\partial Y}{\partial \kappa} = \infty)$
  - for low κ : $\frac{\partial \ln w}{\partial \kappa} > 0$
- at $\kappa \longrightarrow \bar{\kappa}$, (2) dominates $(\frac{\partial Y}{\partial \kappa} = 0)$
  - for high κ : $\frac{\partial \ln w}{\partial \kappa} < 0$

Offshoring, Wages and Welfare



Solid: North, Dashed: South

Offshoring, Complexity and the Wage Gap

- North-South wage gap:

$$\frac{w}{w^*} = \frac{p}{p^*} = \left(\frac{L^*}{L} \frac{1-\kappa}{\kappa} \right)^{1-\alpha}$$

- offshoring ($\uparrow \kappa$) reduces the North-South wage gap
  - more demand for labor in South, less in North
- more complementarity between tasks ($\downarrow \alpha$) increases the wage gap
  - more "complexity" in production makes the technological advantage of the North more important

Sequential Production and Supply Chains

- production processes often consist of many sequential stages
  - today's vertical supply chains span multiple countries specializing in different stages
- Costinot, Vogel & Wang (2013)
  - production of final good requires a continuum of intermediate stages
  - each stage uses labor and intermediate good from previous stage
  - production is subject to mistakes (Sobel 1992, Kremer 1993)
  - countries differ in terms of failure rate
- key result:
  - more productive countries (lower mistakes rate) specialize in later stages of production, where mistakes are more costly
  - why? value added grows after each stage $\longrightarrow$ mistakes are more costly at more advanced stage
- study changes in number of stages and in mistake rates

Costinot, Vogel & Wang (2013): Assumptions

- basic environment:
  - multiple countries $c \in \{0, ..., C\}$
  - one factor, labor, in fixed supply L_c, wages w_c
  - perfect competition
- technology:
  - to produce the final good, a continuum of stages $s \in (0, S]$ must be performed
  - at every stage performed in c, output is lost at a Poisson rate λ_c
  - combining $q(s)$ units of intermediate good s with $q(s)ds$ units of labor, the output of intermediate good $s + ds$ is

$$q(s + ds) = (1 - \lambda_c ds)q(s)$$

- order countries so that λ_c is decreasing in c
  - from less to more productive countries

Equilibrium: Vertical Specialization

- free trade equilibrium:
  - output levels $Q_c(s)$, wages w_c and prices $p(s)$ such that
  - price = unit cost

$$p(s+ds) = (1+\lambda_c ds)p(s) + w_c ds \quad \text{iff} \quad Q_c(s') > 0 \quad \forall s' \in (s, s+ds]$$

    - ⋆ obtained from $p(s+ds) = \frac{p(s)+wds}{1-\lambda_c ds}$ and ds infinitesimal
  - good and product markets clear
- vertical specialization:
  - there exists a sequence of stages $S_0 = 0 < S_1 < ... < S_C = S$ such that $Q_c(s) > 0$ iff $s \in (S_{c-1}, S_c]$
  - in words, more productive countries specialize at later stages
- why? more productive countries leverage their productivity on more valuable inputs

Equilibrium: Allocation and Production

- notation:
  - $Q_c \equiv Q(S_c)$ and $p_c \equiv p(S_c)$ (export quantity and price of country c)
- to find Q_c and S_c:
  1. intermediates get lost at a constant rate when produced in c

$$Q_c = e^{-\lambda_c (S_c - S_{c-1})} Q_{c-1}$$

  2. using labor market clearing, $\int_{S_{c-1}}^{S_c} Q_c(s)\, ds = L_c$, and (1) above:

$$L_c = \frac{Q_{c-1} - Q_c}{\lambda_c}$$

- solution:
  - solve (1) and (2) as two difference eq. with boundary conditions $S_0 = 0$ and $S_C = S$

Equilibrium: Prices and Wages

- prices:
  - cost of producing the cutoff good S_c must be equal in c and $c+1$ from $(1+\lambda_c ds)p_c + w_c ds = (1+\lambda_{c+1} ds)p_c + w_{c+1} ds$

$$w_{c+1} = (\lambda_c - \lambda_{c+1})\, p_c + w_c$$

  - from $p = MC$:

$$\frac{dp(s)}{ds} = \lambda_c p(s) + w_c$$

    with boundary conditions $p_0 = 0$ and $p_C = 1$
- some properties:
  - countries with lower mistake rates have higher wages: $w_{c+1} > w_c$
  - prices grow along the value chain: $p_{c+1} > p_c$
  - rich countries tend to import and export goods with higher prices (and from similar income countries)
  - longer value chain ($S \uparrow$) $\longrightarrow$ more inequality
  - uniform decrease in all failure rates $\longrightarrow$ less inequality

Further Readings

- vertical specialization and sequential production:
  - Hummels, Ishii & Yi (2001), Yi (2003)
- quantitative Ricardian models of multinational production:
  - Arkolakis, Ramondo, Rodriguez-Clare & Yeaple (2013)
  - Ramondo & Rodriguez-Clare (2013)
- contracts and the international organization of production:
  - Antras (2005)
  - Antras & Helpman (2004)
  - Antras & Chor (2013)
- some surveys (theory and empirics):
  - Antras & Yeaple (2014)
  - Crino' (2009)

What Did We Learn?

- offshoring:
  - allows firms to take advantage of low wages
  - often involves the transfer of technology from more to less advanced countries
- technological superiority generates rents:
  - the loss of technological superiority due to offshoring may eventually reduce welfare in the country that had the initial lead
  - yet some offshoring is Pareto efficient
  - the worse scenario is to lose the GFT, so protectionism is NOT a solution
  - China is not (yet) a threat
- in dynamic models, offshoring may lead to more innovation
  - may restore technological lead (Acemoglu, Gancia & Zilibotti, 2014, Rodriguez-Clare, 2010)
- rents from technological superiority are higher if products are more "complex"