Historical Geography of the Semiconductor Industry

Prepared for for NBER/CRIW pre-conference on "Technology, Productivity, and Growth"

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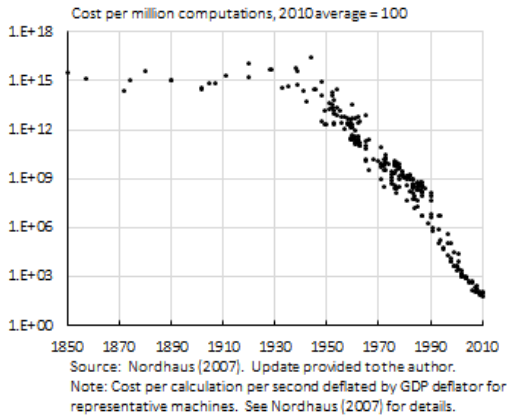
Agenda

- Broader project: data processing value chain database
  - coverage by function / business process, not industry or product
  - data processing == collection, storage, transformation, transmission and reporting of data (raw quantitites)
  - one layer in the information processing function stack
- Key questions
  - Size of data processing performance gains over time?
  - How (and how fast) are those performance gains leveraged by the economy, showing through to productivity?
  - How does evolution of the global value chain inform the first two questions? Which countries contribute to the productivity gains? Which countries use the performance gains to boost aggregate productivity?
- This paper is a first step: a global semiconductor industry database

Motivation 1: Consistency Over Time

Technical change plays out over decades.

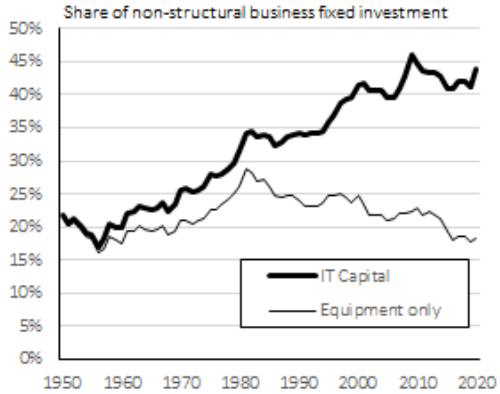
Computation Cost



Source: Nordhaus (2007). Update provided to the author.
Note: Cost per calculation per second deflated by GDP deflator for representative machines. See Nordhaus (2007) for details.

Computing cost has fallen steadily since mid-20th century.

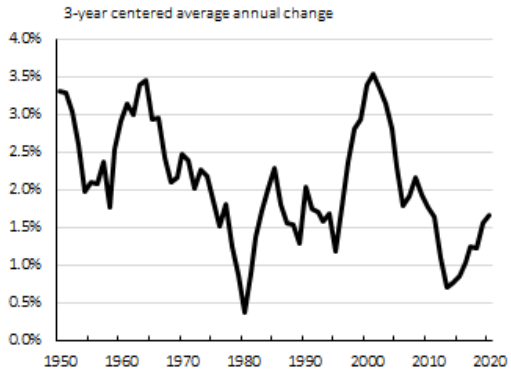
IT Investment



Source: Bureau of Economic Analysis.
Note: Computing and communications equipment, software, and R&D in IT capital and IT service producing

IT share of business investment rising throughout the period.

Labor Productivity



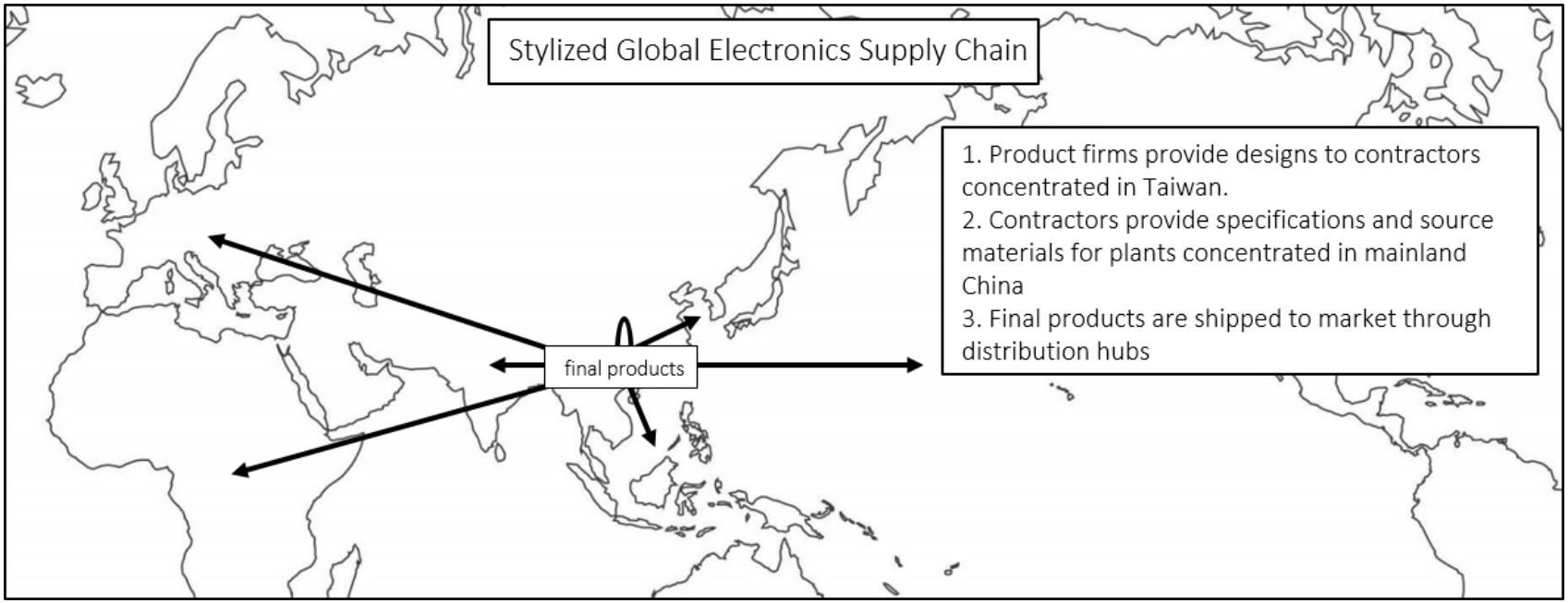
Source: Bureau of Labor Statistics.

Leading to an IT-driven productivity surge in late 1990s.

Measurement consistency over time is crucial for understanding sources of economic growth.

Motivation 2: Consistency across Geography

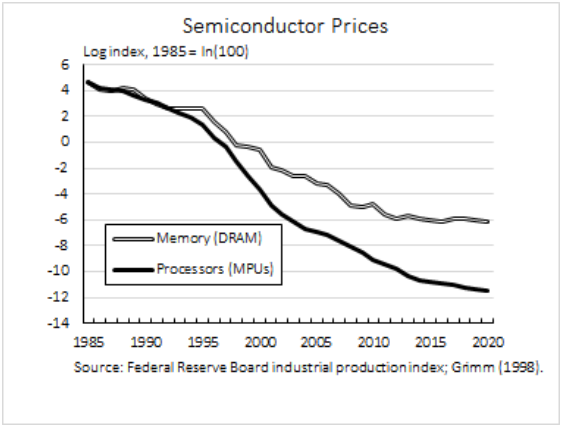
The electronics value chain sprawls across many locations, raising the stakes for harmonization of statistics. (And exposing the chain to differing political, public health, and climate risks.)

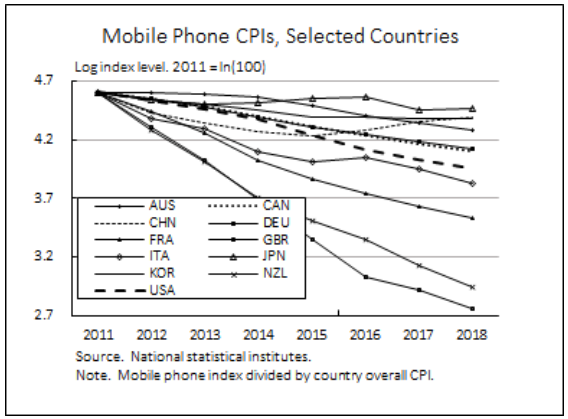


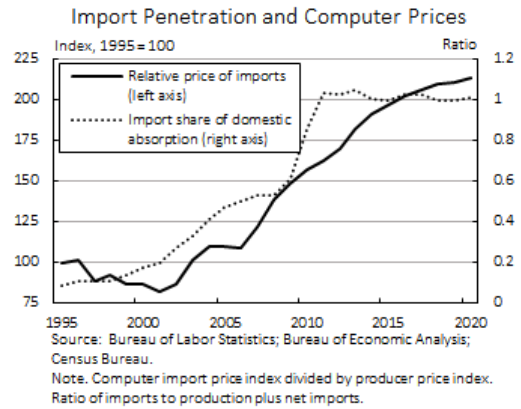
Measurement consistency across countries is critical, both for crisis analysis (where might COVID-19 outbreaks disrupt the supply of electronics?) and for studying industrial organization (what share of global value added is captured by China?)

Motivation 3: Consistent Price Measurement

Adjustment for quality change differs wildly across products and over time. Price measurement is Balkanized.







Prices differ across products within the industry.

Product prices that should (nearly) match can differ markedly across national accounts.

Statistics *within* national accounts can seem inconsistent.

Consistency across products and sufficient product detail is critical for measuring output, trade, and productivity.

Features of the Broader Data Processing Database

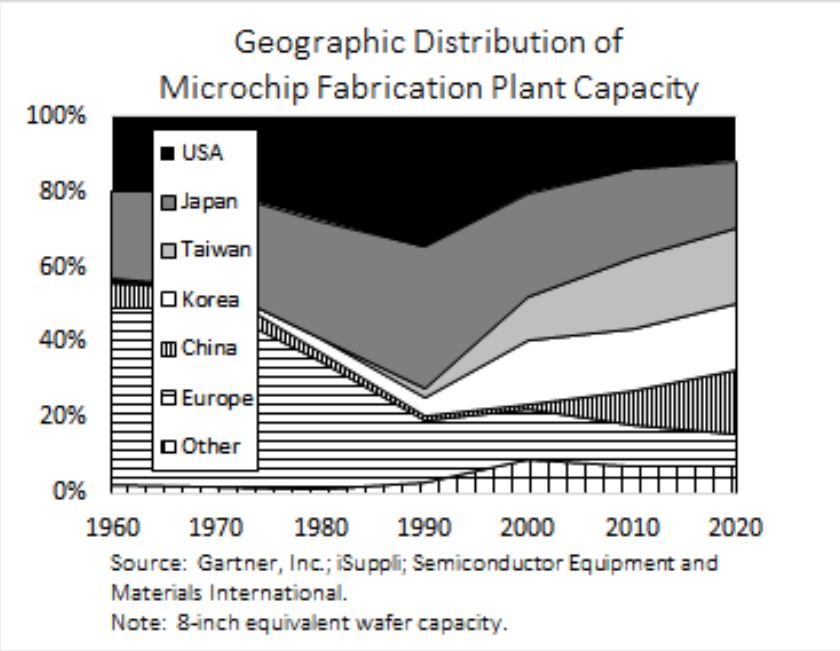
- functional scope: data processing
  - data processing == collection, storage, transformation, transmission and reporting of data (raw quantitites)
  - all technologies (initial focus on electronics, but also electro-mechanical, etc.)
  - entire value chain: design, component manufacturing, equipment manufacturing, investment (business and household), capital services (consumption and intermediate use)
- global scope: country-level detail and linked value-added trade
- deep product detail
  - more granular than national accounts
  - consistent accounting for technical change
- long history: c. 1950 to the present, with eventual extension
- regular updates in a trusted repository

Phased Development

1. semiconductor manufacturing (this paper)
   - output by country
   - product mix: memory, processors, other
   - value-added stages: design, fabrication, test
   - prices by country-product-stage
2. subassembly and equipment manufacturing
3. investment and capital services
4. real value-added trade

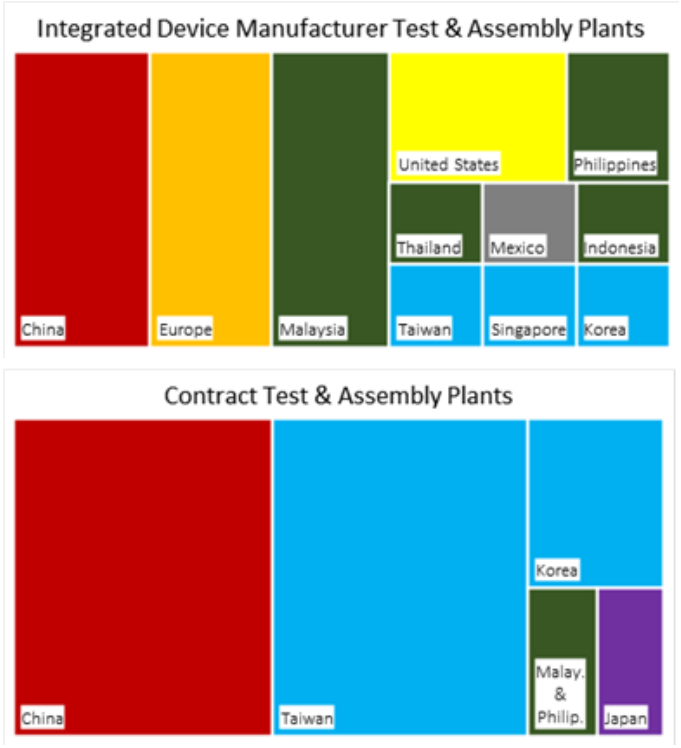
Initial Results: Lessons for the Current Chip Crisis

Fabrication Geography



Capacity is *less concentrated* than widely understood.
(Though Taiwan dominates the bleeding edge at the moment.)

Testing Geography



Source: Author's elaboration of company financial reports. As widely noted, testing takes place in Malaysia, *but in many other places as well*.

Comments, questions?

Project goal: Joining, augmenting, and consolidating research and official statistics to create a database functional in scope, consistent over time, and linked across the global value chain for data processing equipment and its capital services.



Source: Public domain. United States Library of Congress's Prints and Photographs division via Wikipedia. From The Pennsylvania gazette, 9 May 1754. Attributed to James Turner (silversmith) for Benjamin Franklin.

Existing Work

- NSI national accounts
- World KLEMS
- Total Economy Database
- World Input-Output Database
- Penn World Tables
- OECD, World Bank data