UNIWERSYTET WARSZAWSKI
Wydział Nauk Ekonomicznych

International Economic Geography – Location theory II

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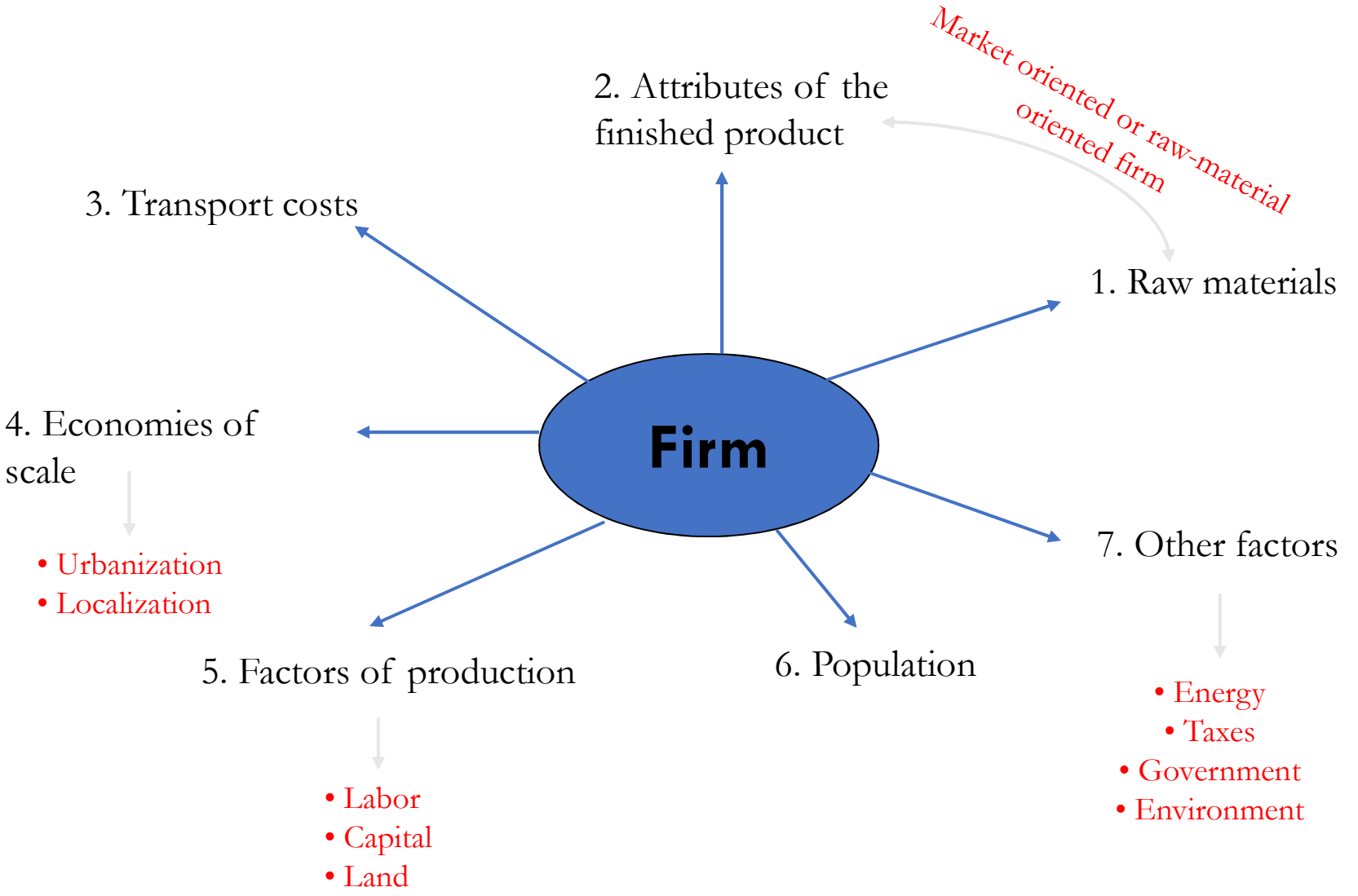
Industrial location theory

- Von Thünen model focused on the allocation of **land areas to different agricultural activities**
- Now we explore the theory of Webber that addressed the optimal location of plants at **points (nodes) in space**
- Here, we will consider different types of firms in terms of their characteristics
- However, in general Weber model refers to firms belonging to the manufacturing sector

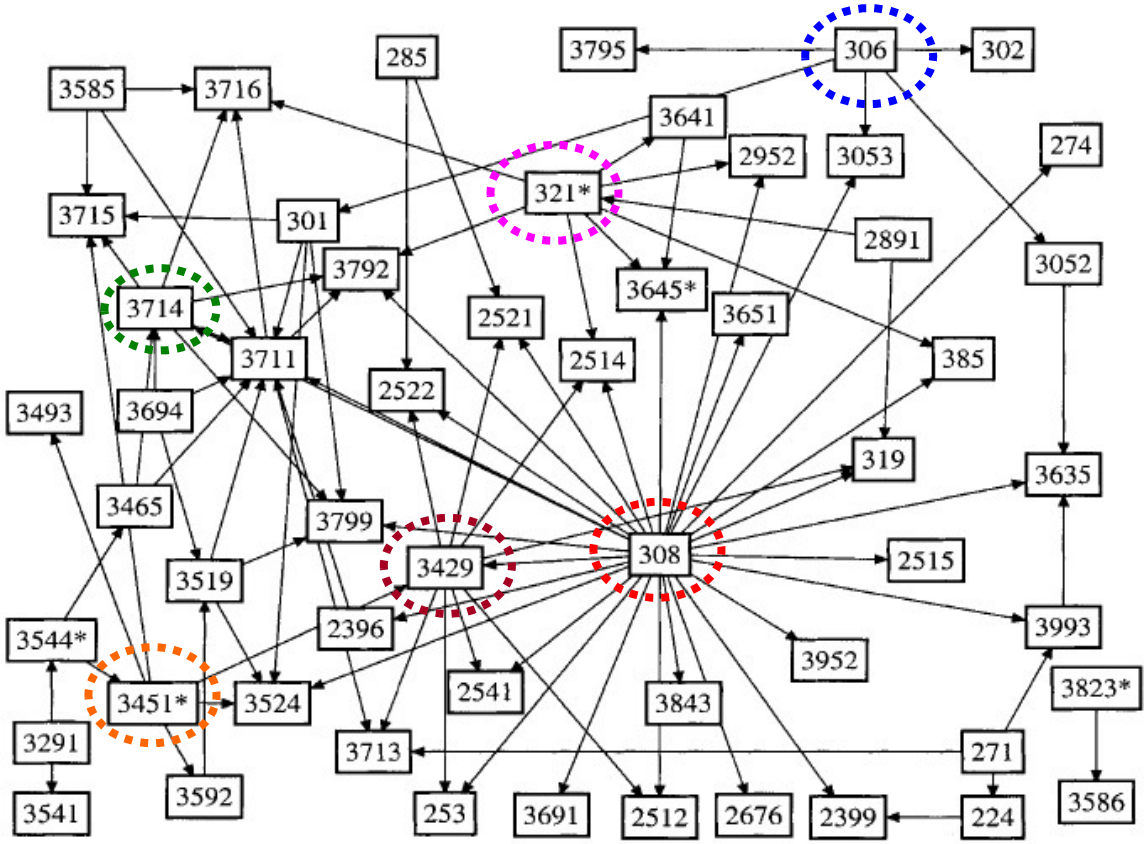
What are the factors that affect location decisions of firms?



Industrial clusters and raw materials

- When the industries locate closer to their raw materials? Creation of industrial clusters.

Intracluster purchasing linkages within vehicle manufacturing

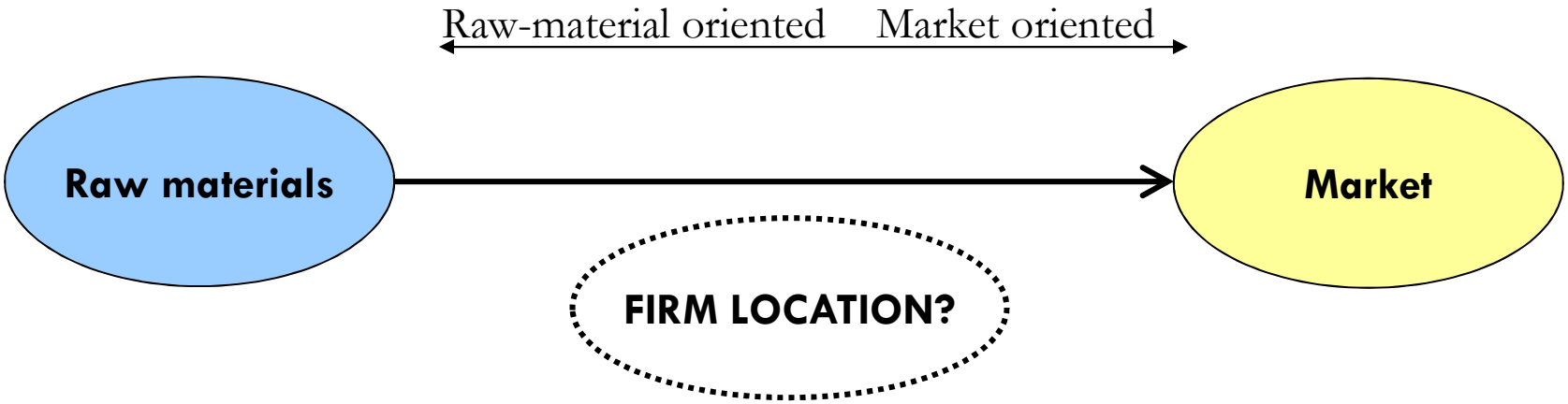


Source: Feser, E. J. & E. M. Bergman. (2000). National industry cluster templates: A framework for applied regional cluster analysis. *Regional Studies 34, 1-19*.

Key basic suppliers

- 308: Miscellaneous plastics products
- 306: Fabricated rubber products
- 3714: Motor vehicle parts and accessories
- 321: Wood product manufacturing
- **3429: Hardware**
- **3451: Screw machine products and bolts**

Raw-material or market oriented firms?



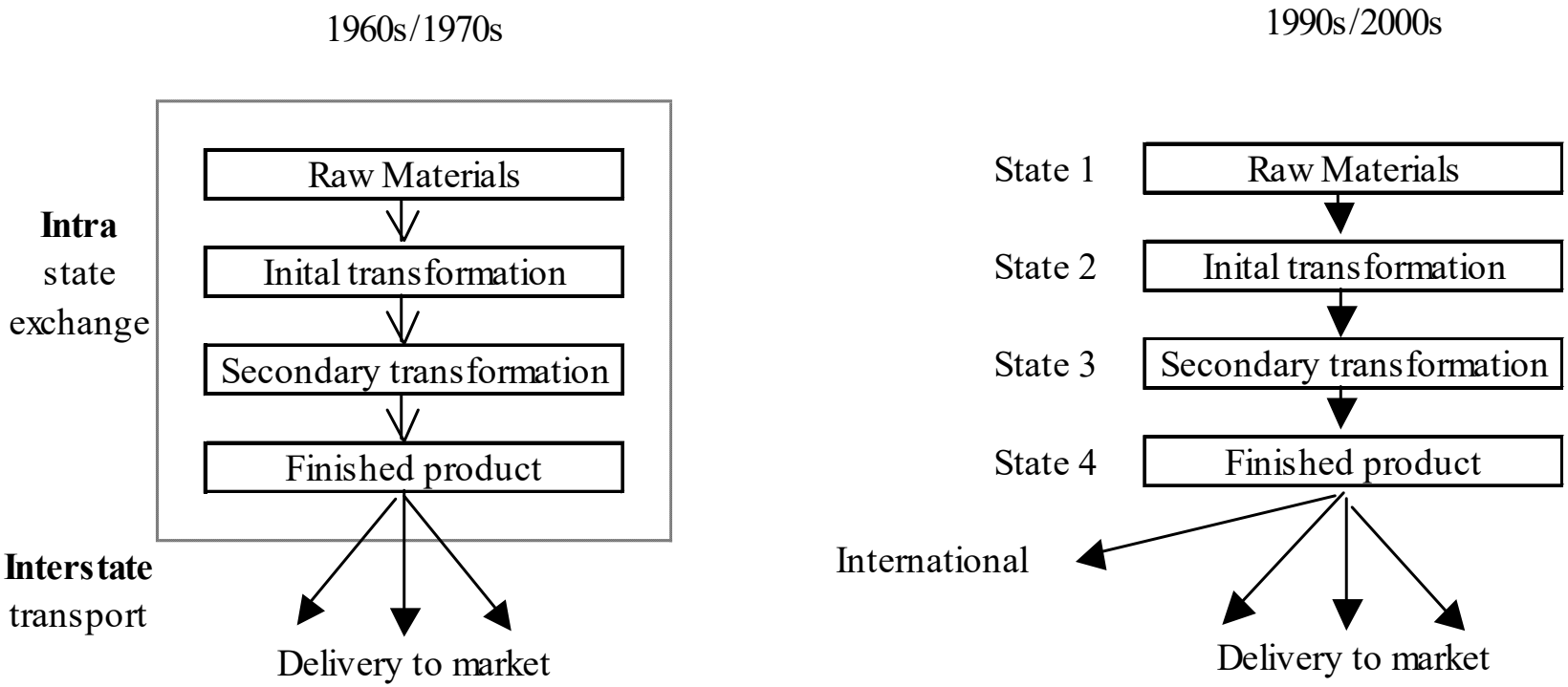
- Soft-drink industry?
- Bakery industry?
- Dairy industry?
- Fruit canning and preserving industry?
- Watches vs. cement: value per unit of weight?
- Automobile and furniture industries?

Attributes of the finished product

- When the final product weight much more than the raw materials, the firm is located closer to the markets (e.g. bakery industry).
- When the production process involve a loss of weight, bulk or perishability then we can talk about a raw material oriented industry (e.g. dairy industry).
- How sensitive is the product to the transport costs? (ex. watches vs. cement).
- Are the transport costs increasing with distance?
- Factors that affect the transport costs:
  - Mode of transportation.
  - Size of shipment.
  - Perishability.
  - Product value.
  - Competition.

Transport costs

- Since 1960 (until recently) real transportation costs have declined by 5-6 times.
- A consequence: increased locational fragmentation



Economies of scale

Internal

The cost of producing a unit of output decreases with increasing plant size

External

Those that are external to the individual firm

Urbanization

Benefits for being located in large cities (larger labor force, lower transport costs, large number of services).

Localization

When firms in the same industry cluster in the same location (shared research, suppliers, services, etc).

Diseconomies of scale

Factors of production

- **Labor**: quality of labor and cost of labor.
- When the cost of labor is low?
  - When labor supply is greater than labor demand.
  - When the economic opportunities are decreasing.
  - When only a subset of the population has employment opportunities.
  - When the cost of living is low.

- **Land**: extension, proximity to water, land values, distance to the city and accessibility.

- **Capital**: fixed capital vs. financial capital (for small firms, loans are more easily obtained from local banks).

Weber model

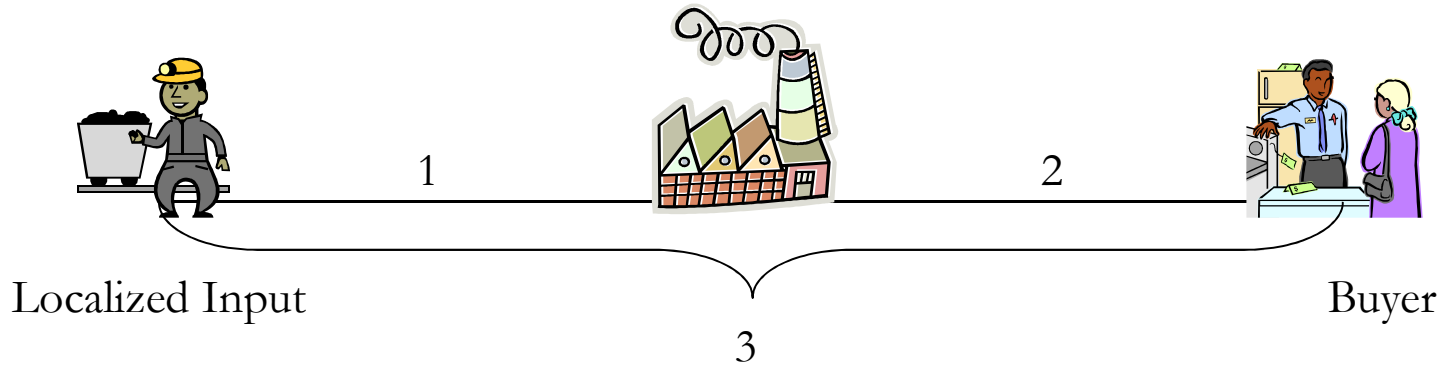
- Dealing with a partial equilibrium approach – only the location of one firm considered
- Focus on:
  - ✓ Transport costs – for inputs and moving the finished good
  - ✓ Location of key suppliers
  - ✓ Size and location of the buyers
- Also can consider the variance in labor costs, community factors (e.g. taxes, public goods, services), etc.

Weber model - main assumptions

- Perfect competition … a fixed price
- No spatial variance in other factors (e.g. labor, tax, land price etc.)
- Transport costs = Distance * Weight
- Two types of raw materials (transportation implications):
  - **Ubiquitous**: universally distributed and no transport cost (e.g. water, electricity)
  - **Localized**: must be moved (e.g. coal)
- Two types of raw materials (process):
  - **Pure**: lose no weight in processing (e.g. automobile transmission)
  - **Gross**: lose weight in processing (e.g. fuel)
- Material index: Raw material (localized) weight / Finished product weight

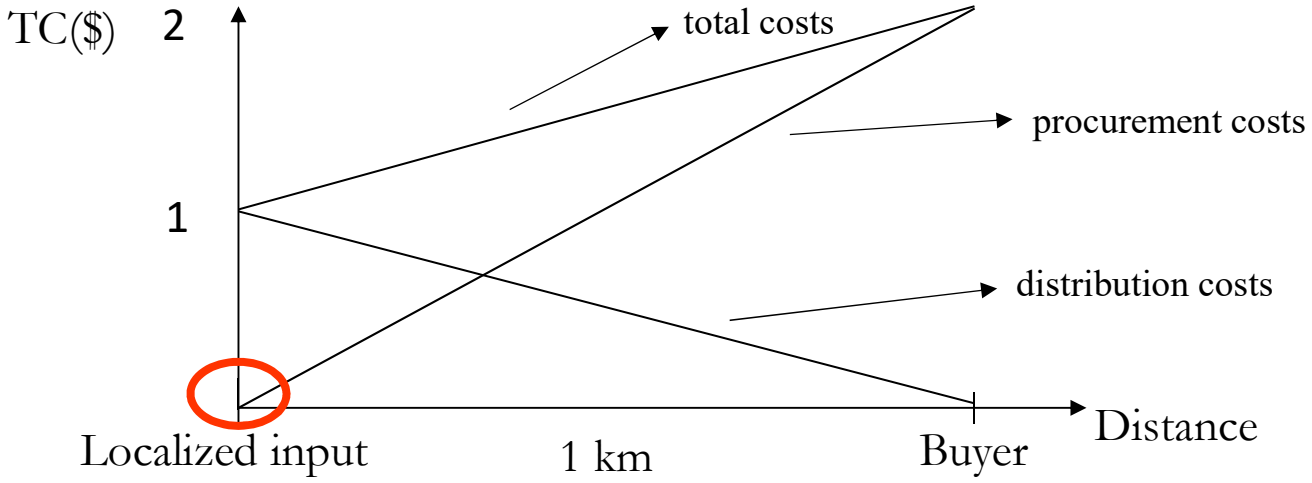
Transport costs in Weber model

- Compute transport costs for the cases (on next slides)
  1. Transport costs of input materials (procurement costs)
  2. Transport costs of the products (distribution costs)
  3. Total transport costs (=1+2)
- Finding optimal location involves consideration of **substitution over space** – in simple case between input costs and delivery costs



Weber model - examples

- Case 1: Weight-losing industry with one *localized gross (1)* input
  e.g. Ethanol, Orange juice, etc.
  - *Material index: 2*
  - *Production: 2 tons of the localized input to produce 1 ton of products*
  - *Transportation costs: $1 per ton/km*

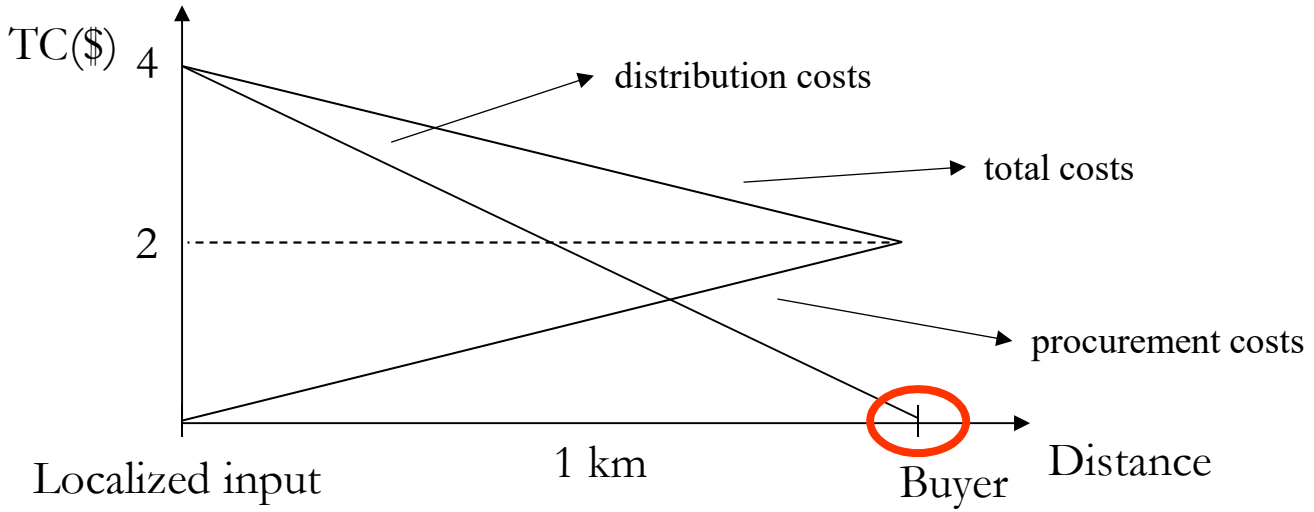


Material index > 1 (raw material weight greater than final product weight)

Weber model – examples (2)

- Case 2: Industries using a *localized weight-losing (gross)* input plus *ubiquitous inputs*
  e.g. Brewers: barley and hops, etc.

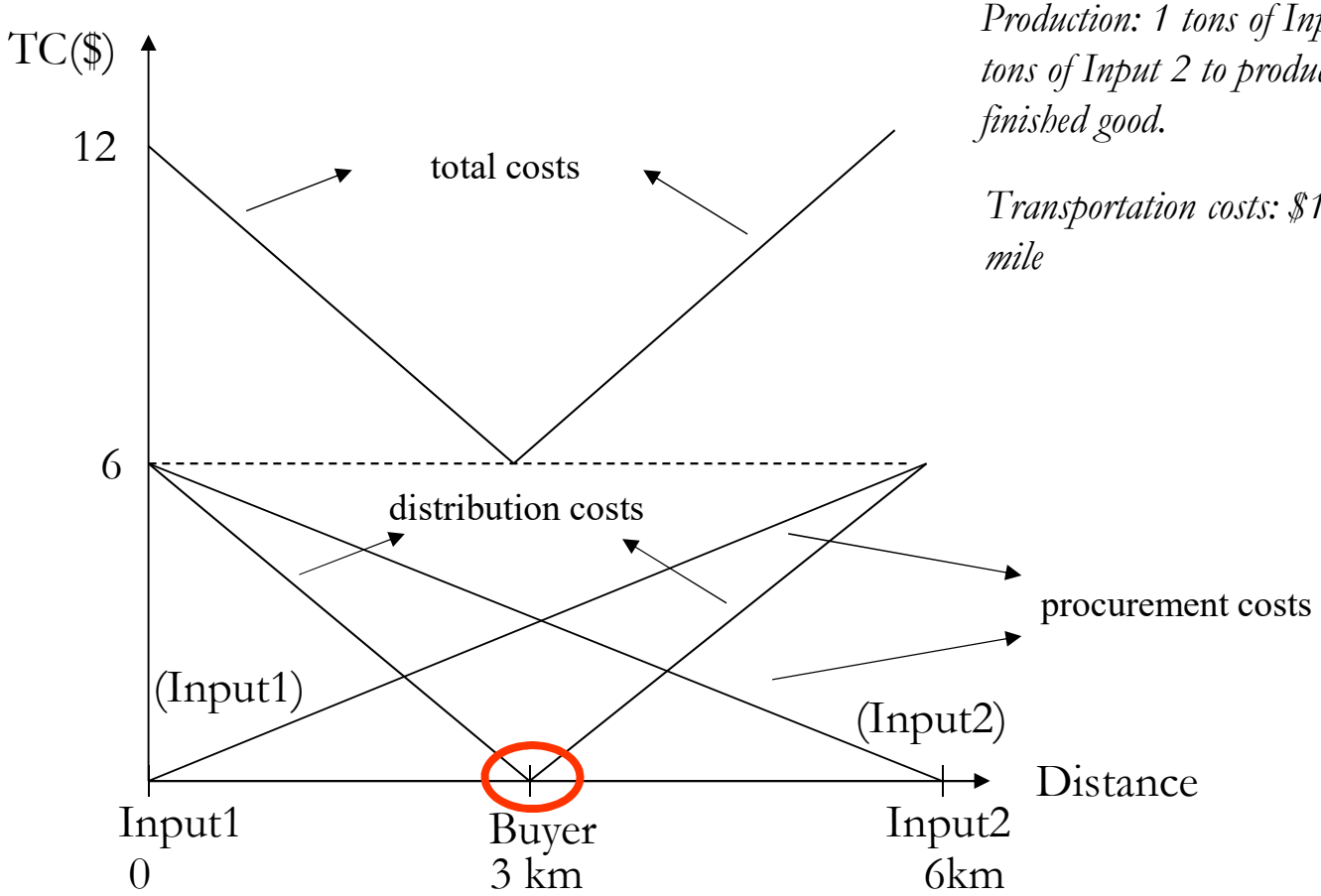
- *Material index: 1/2*
  - *Production: 2 tons of the localized input and 3 tons of ubiquitous inputs to produce 4 tons of products*
  - *Transportation costs: $1 per ton/km*



Weber model – examples (3)

- Case 3: Industries using two *localized pure* materials

• Material index: 1



Production: 1 tons of Input 1 and 1 tons of Input 2 to produce 2 tons of finished good.

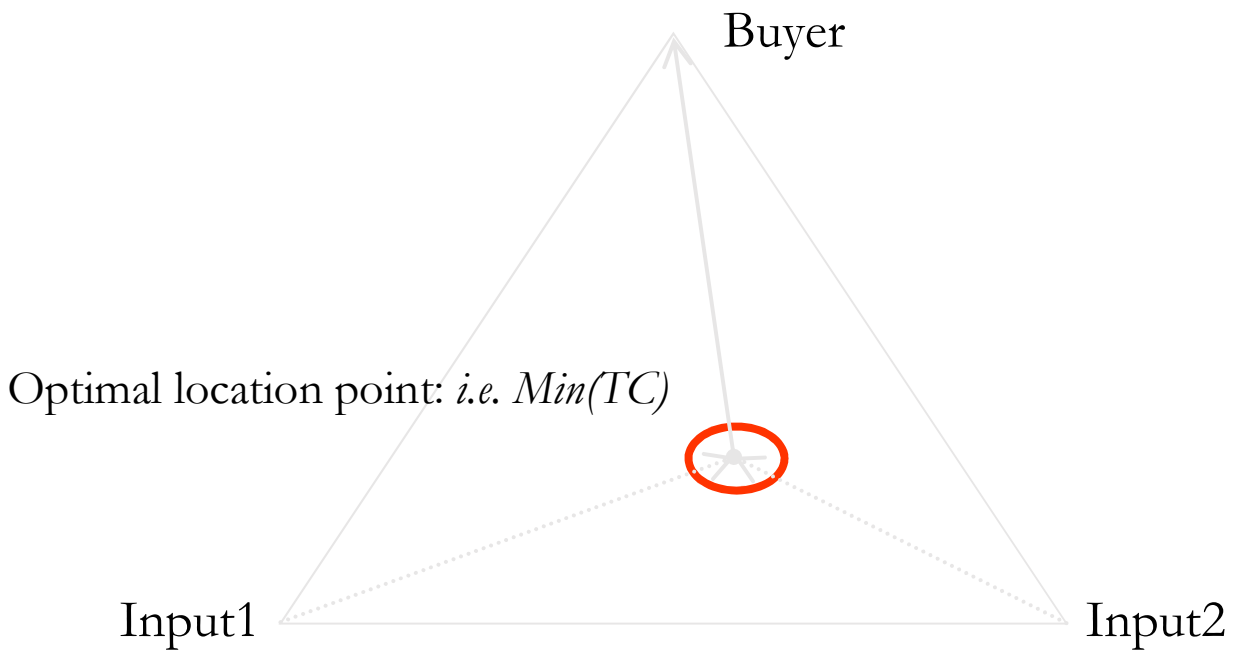
Transportation costs: $1 per ton-mile

Weber model - questions

- General findings from the simple analyses
  - Weight-loss production will tend to locate near the source of inputs
  - Weight-gain production (e.g. sing the ubiquitous inputs) will tend to locate at the location of buyers
  - The problem becomes more complicated, when multiple localized inputs and buyers exist.
- Additional … what if? (in Case 4)
  - What if the location of the single buyer is changed?
  - What if the industry needs to purchase *1 tons of Input 1 and 2 tons of Input 2 to produce 3 tons of finished good* for its production?
  - What if there are two inputs and material index is higher (than 1)?

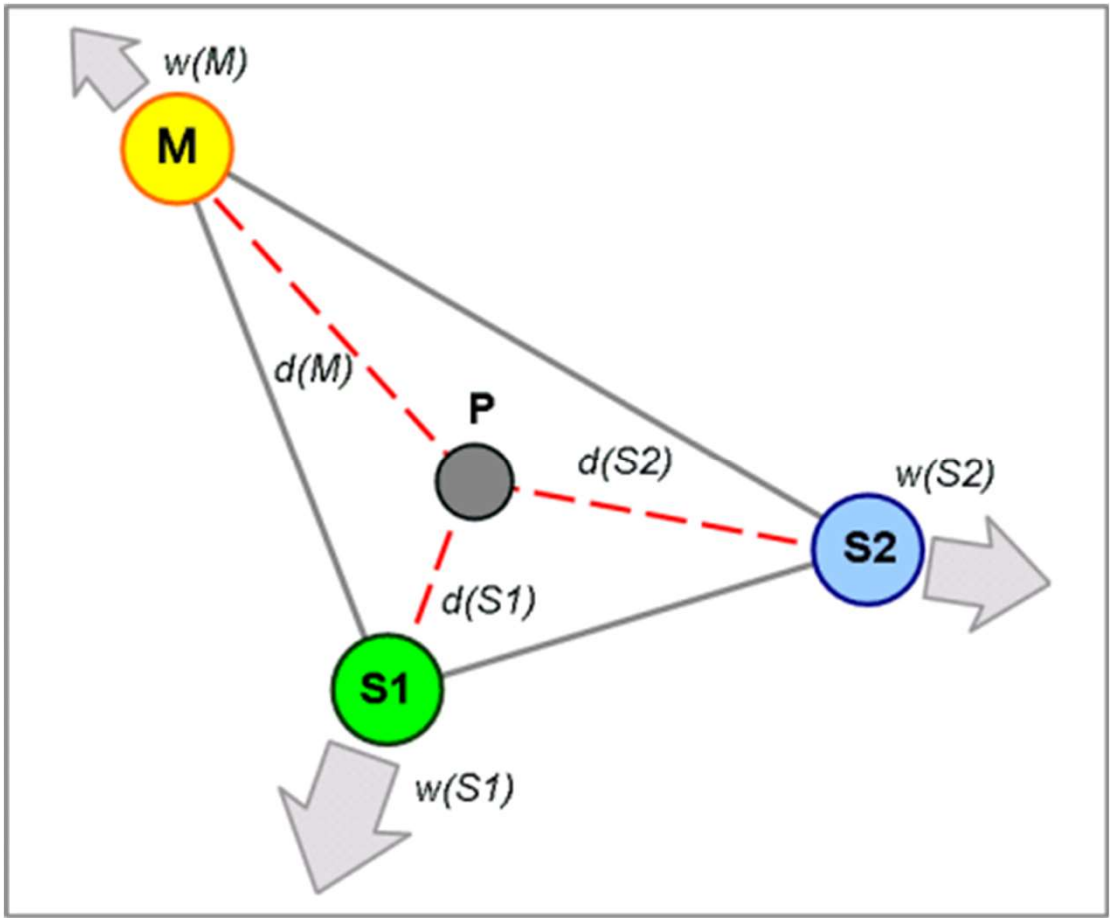
Weber's location triangle - a more generalized case

- … Two inputs to be shipped and a buyer
- Two-dimensional analysis



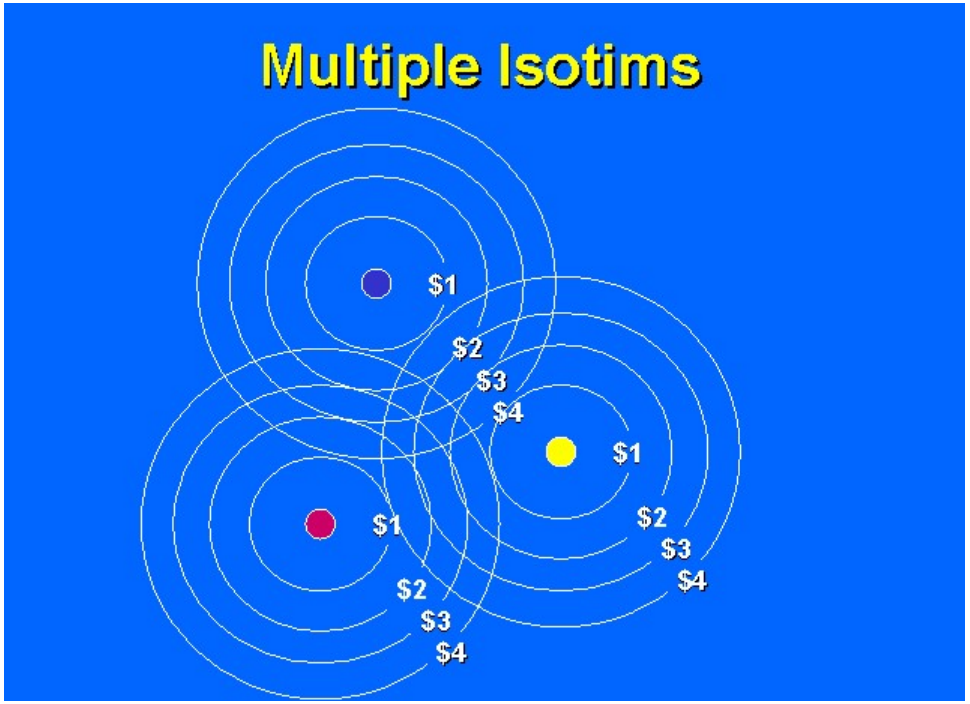
Weber's location triangle – change in weights

- Here, the arrows indicating the direction of the "force" exerted by the weight of the inputs and a finished product.



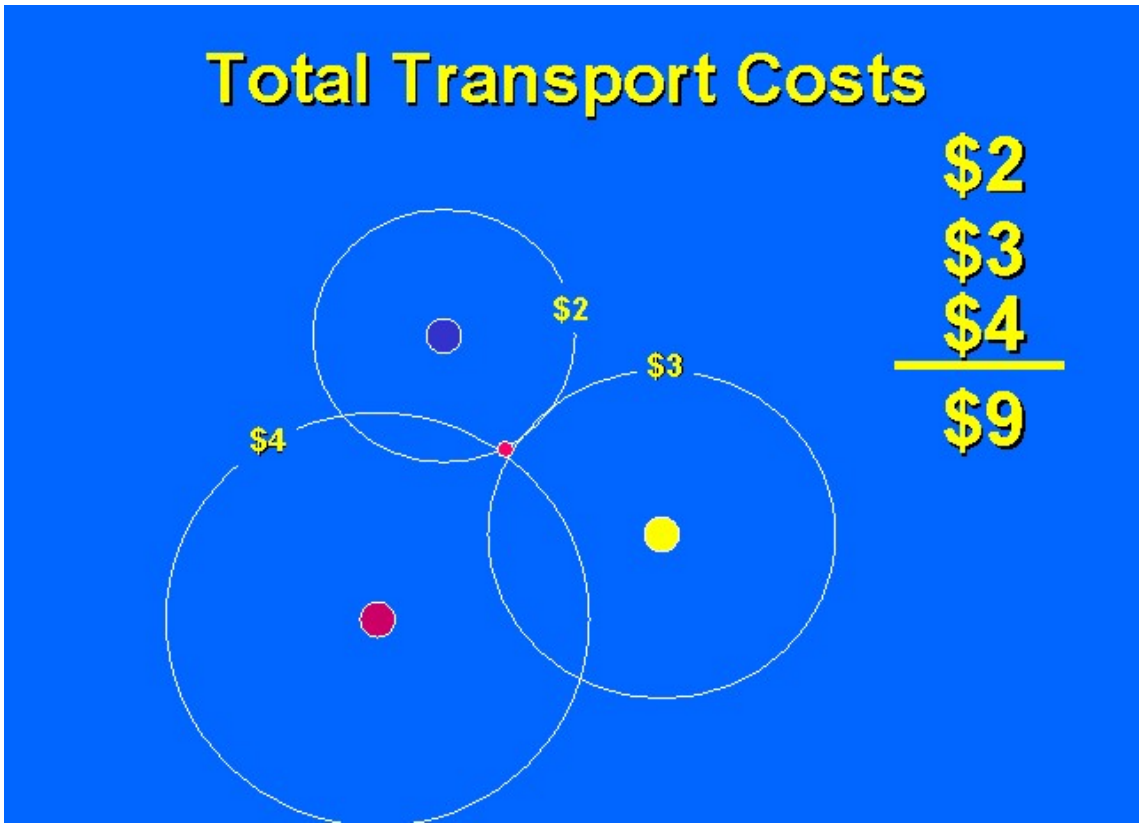
Weber model – alternative analysis

- Another way of analysis – Isotims and Isodapanes



Isotim: line of equal transport cost from a location

Weber model - Isotims and Isodapanes

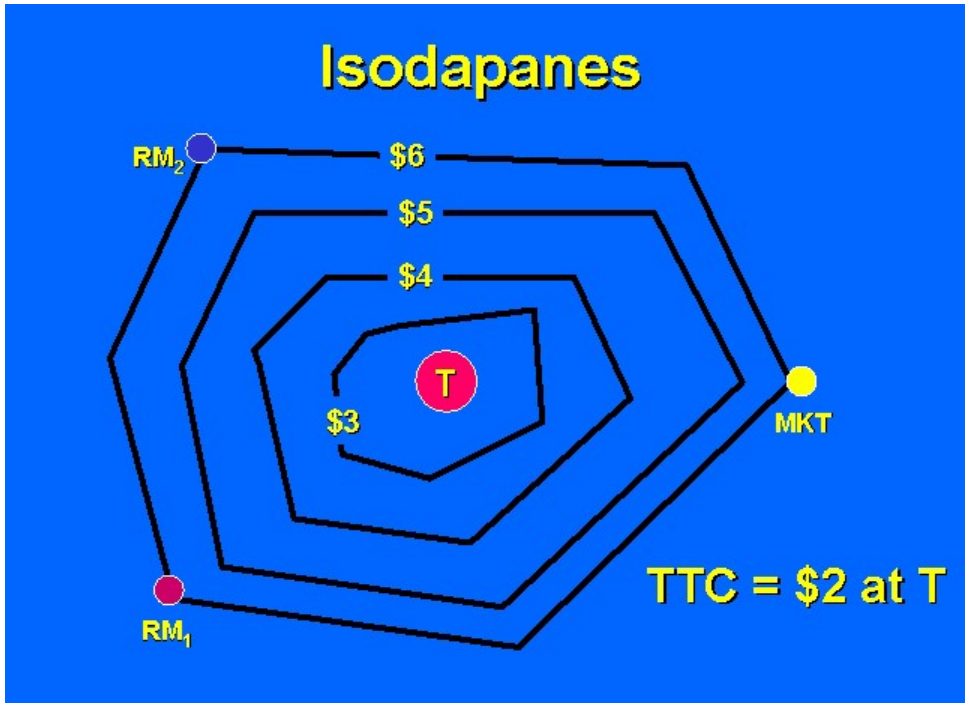


We can calculate total transport costs for each location by summing values to move two inputs to the location and then ship the finished product to a buyer

Weber model - Isotims and Isodapanes (2)

Minimum transportation costs

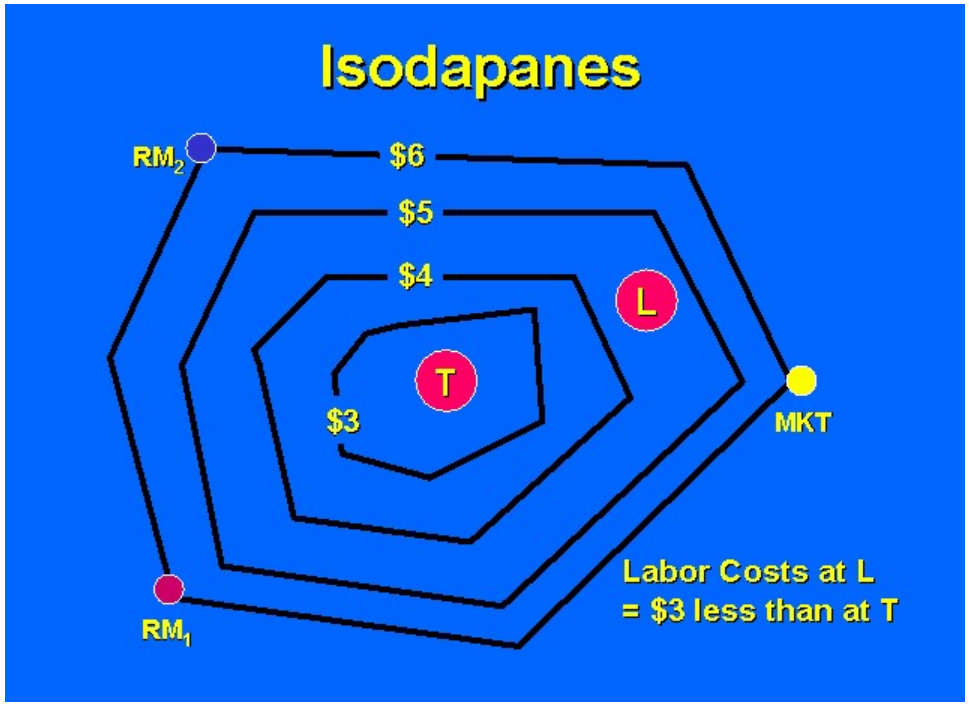
Isodapane: line of equal **total** transport cost from a location



Other issues – e.g. cheaper labor

Consider alternatives to T – point of minimum total transport costs

Weber model - Isotims and Isodapanes (3)

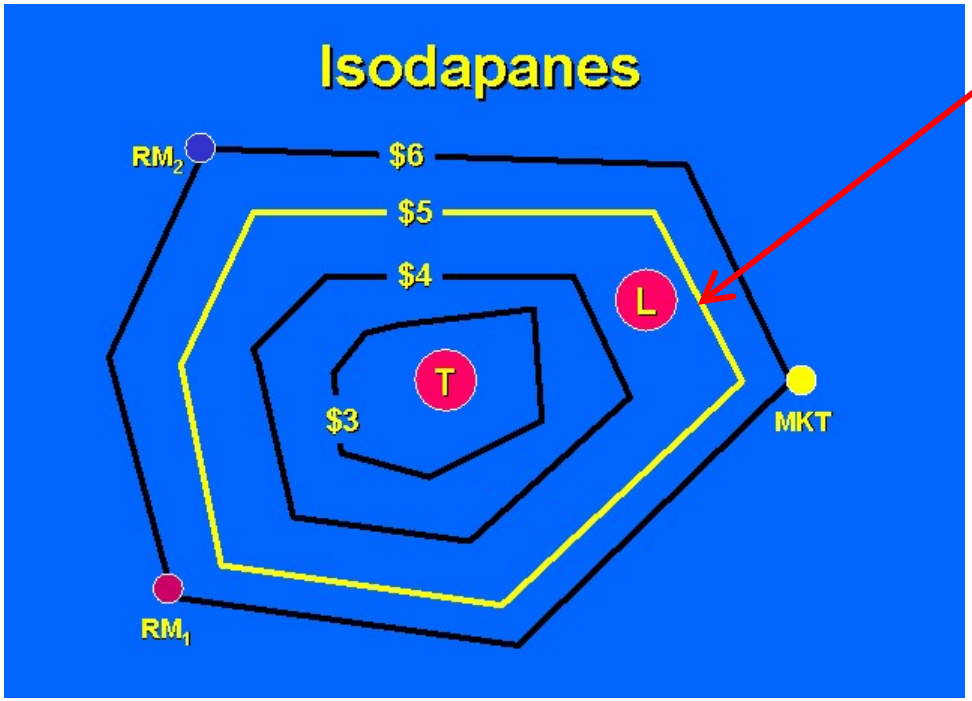


Will firm relocate to cheaper labor site, *L*?

Identify critical isodapane – value of transportation costs at *T* plus differences in labor costs i.e $2 (TTC at *T*) plus $3 (difference in labor costs between *T* and *L*)

Weber model - Isotims and Isodapanes (4)

- Isodapanes [8]



Critical isodapane – in this case, savings in labor at $L >$ increase in transportation costs over T – firm will relocate

Example: textiles moved from New England to SE in 1950s, 1960s (and then to Asia) – cheaper labor costs offset higher transport costs

Weber model - agglomeration

Agglomeration benefits

- Weber and more recent scholars focused on role of agglomeration forces
- In similar fashion to the consideration of cheaper labor costs, can evaluate the benefits from locating in same market – e.g. access to skilled labor that knows production process or cheaper material inputs because many firms buying them
- Here the critical isodapane would reflect the benefits from locating near other, similar firms and, like the cheaper labor cost case, may result in firms relocating
- But what about competition…….?

Weber model - dynamics

Dynamics & Real Complexity: An example

Given conditions

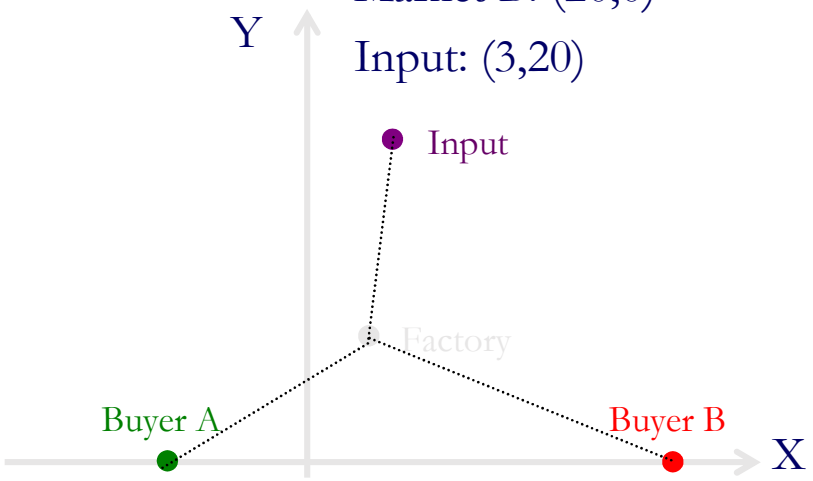
- Production Process: 2 ton (Input) → 1 ton (Product: to 2 Buyers)
- Transport cost per distance
  - Input: 2 ($/ton)
  - Product: 7 ($/ton)
- Evolving Markets
  - Buyer A: Constant Demand (100ton from year = 1~10)
  - Buyer B: Growing Demand (100ton at year = 1; then 10% increase every year)

Location (X,Y):

Market A: (-10,0)

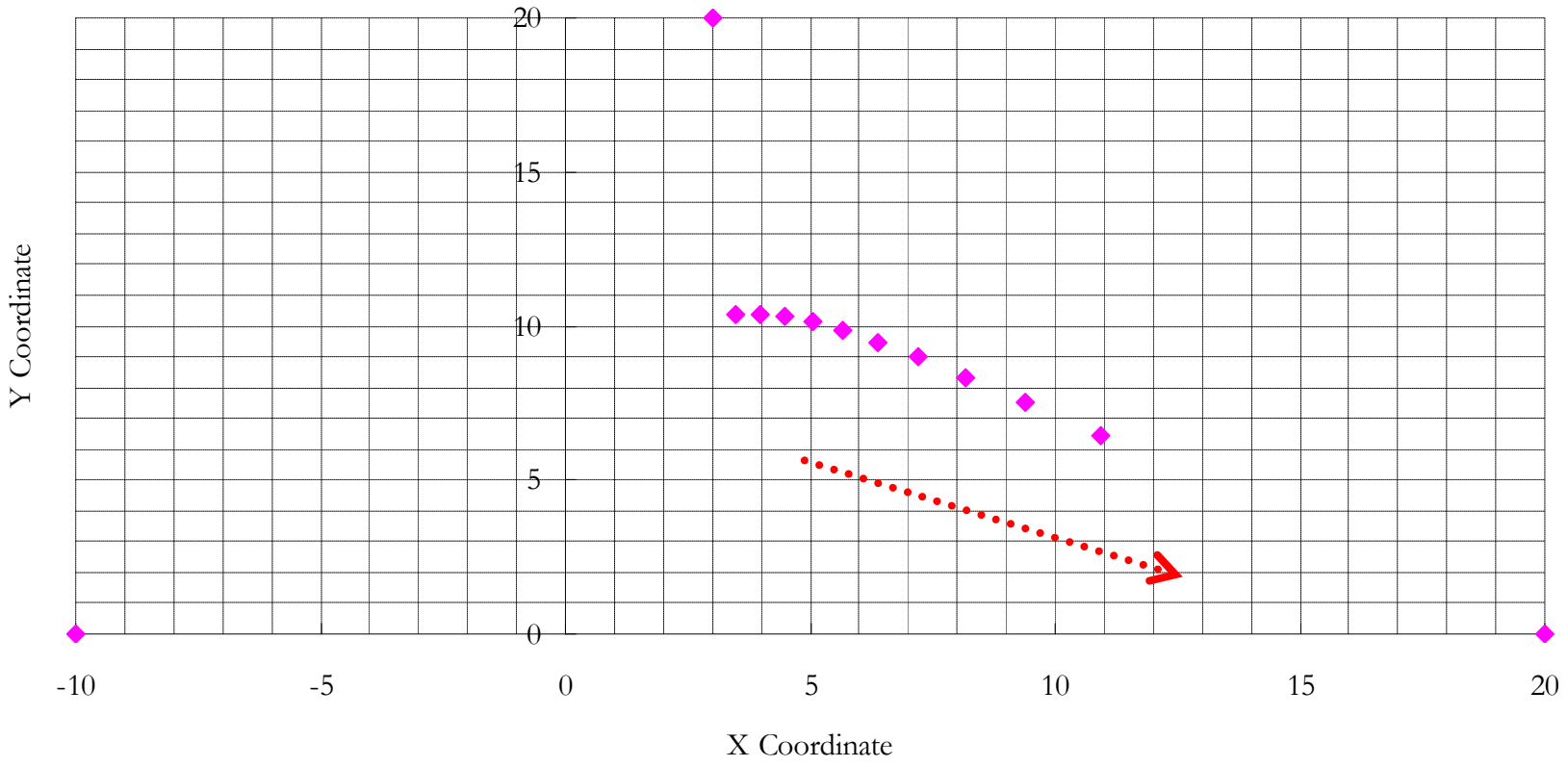
Market B: (20,0)

Input: (3,20)



Weber model – dynamics (2)

- Dynamics & Real Complexity: Optimization Outcome



Is this company going to relocate every year?; When?; How frequently?; Why?

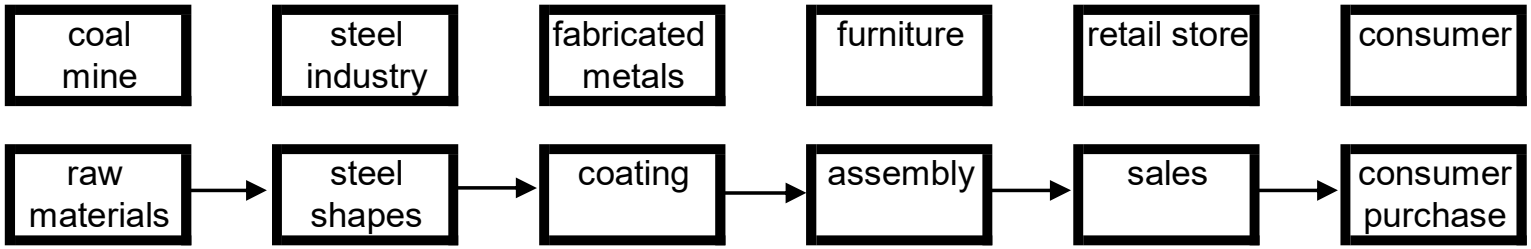
von Thünen vs. Weber

- von Thünen
  - ✓ Allocation of land to specific uses
  - ✓ Allocation accomplished by consideration of maximizing location rent
- Weber ... *Industrial Location*
  - ✓ Explicit consideration of "substitution over space"
  - ✓ Focus on finding specific location where transportation costs can be minimized
- Both theories concerned with movement minimization but
  - ✓ von Thünen focused on areas
  - ✓ Weber focused on location of points

Manufacturing: Some Stylized Facts

Compared to other sectors, manufacturing:

- Heavily depends on intermediate inputs and purchases through the supply chain, for example:

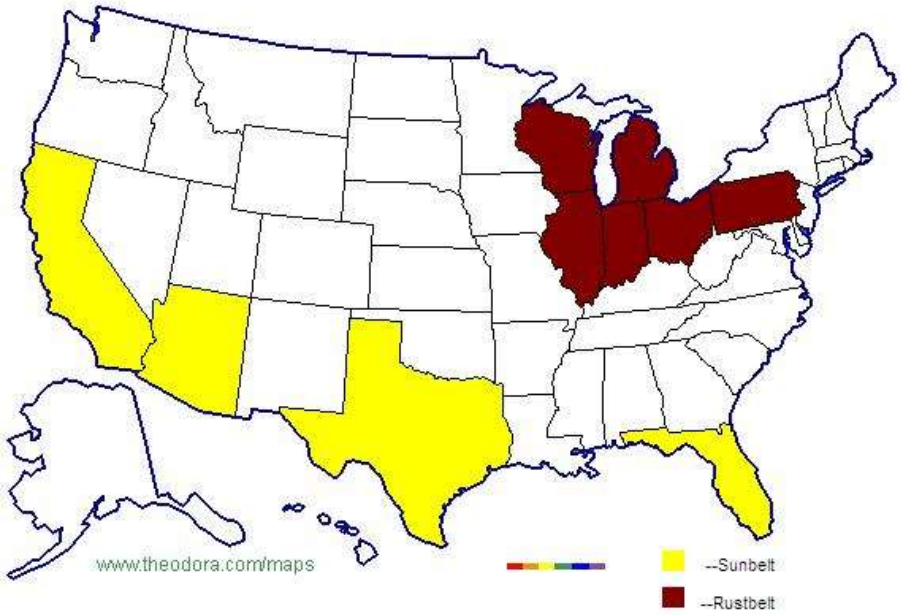


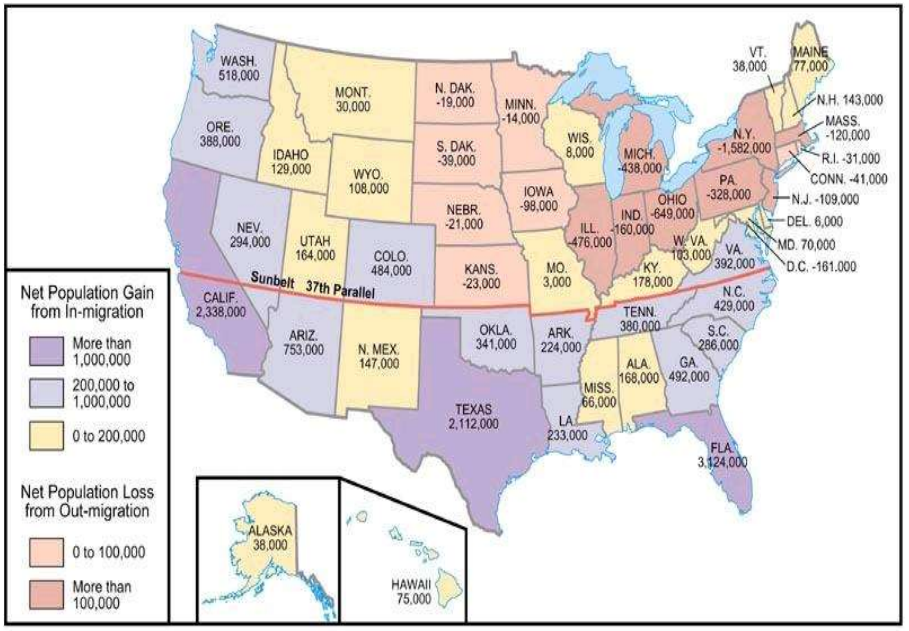
- The locations of key suppliers and buyers are important, in addition to the availability and quality of production factors.

Why different spatial evolution in different manufacturing industries?

- The economic region known as the Manufacturing Belt became known as the Rust Belt by the 1970's, as manufacturing and **heavy industry declined** due to **high energy costs and foreign competition**. Cities in the Rust belt were subject to unemployment, underemployment in low-paying service jobs, "white flight" to the suburbs, and general out migration as manufacturing jobs moved south and abroad.
- Meanwhile, Sun Belt states in the West and Southwest continued to enjoy the economic growth trend spurred by **Cold-War defense spending** and an **influx of retirees**. The South profited from a booming agribusiness industry and California's Silicon Valley became the hub of the technology industry. As population in the Sunbelt increased, so did the region's political influence.

Rust belt and Sun belt





Migration to the Sunbelt, 1970–1981

Economic structure based on input-output tables

Input-Output table for the U.S. economy (2006)

	1	2	3	4	5	6	Household	Governments	Capital & Inventory	Exports	Total
1 Extractive (Ag, Mining, etc)	97.3	42.0	6.7	405.6	0.4	27.5	53.1	6.1	61.4	55.1	755.1
2 Utilities & Transportation	16.2	94.7	27.0	232.1	66.1	214.2	346.4	83.8	10.8	63.0	1,154.4
3. Construction	1.1	3.8	1.3	12.9	8.8	78.3	0.0	321.7	975.0	0.1	1,403.0
4 Manufacturing	92.4	103.9	315.7	1,950.0	82.6	537.7	1,385.3	380.1	640.8	865.6	6,354.1
5 Wholesale & Retail Trade	14.5	18.7	123.6	394.4	54.7	153.1	1,482.0	36.0	132.8	66.6	2,476.4
6 Service & Government	90.3	134.8	185.5	927.0	583.6	3,190.0	5,247.4	1,756.4	247.6	268.8	12,631.4
Value-Added	380.8	687.4	643.4	1,611.5	1,650.2	8,221.5					
Imports	60.9	67.5	98.7	808.9	26.8	183.1					
Others	1.7	1.6	1.1	11.8	3.3	25.8					
Total	755.1	1,154.4	1,403.0	6,354.1	2,476.4	12,631.4					

Source: IMPLAN | Unit: Billion Dollars

The main supplier and buyer of the manufacturing sector is the manufacturing sector. Why?

Manufacturing inputs (the US case)

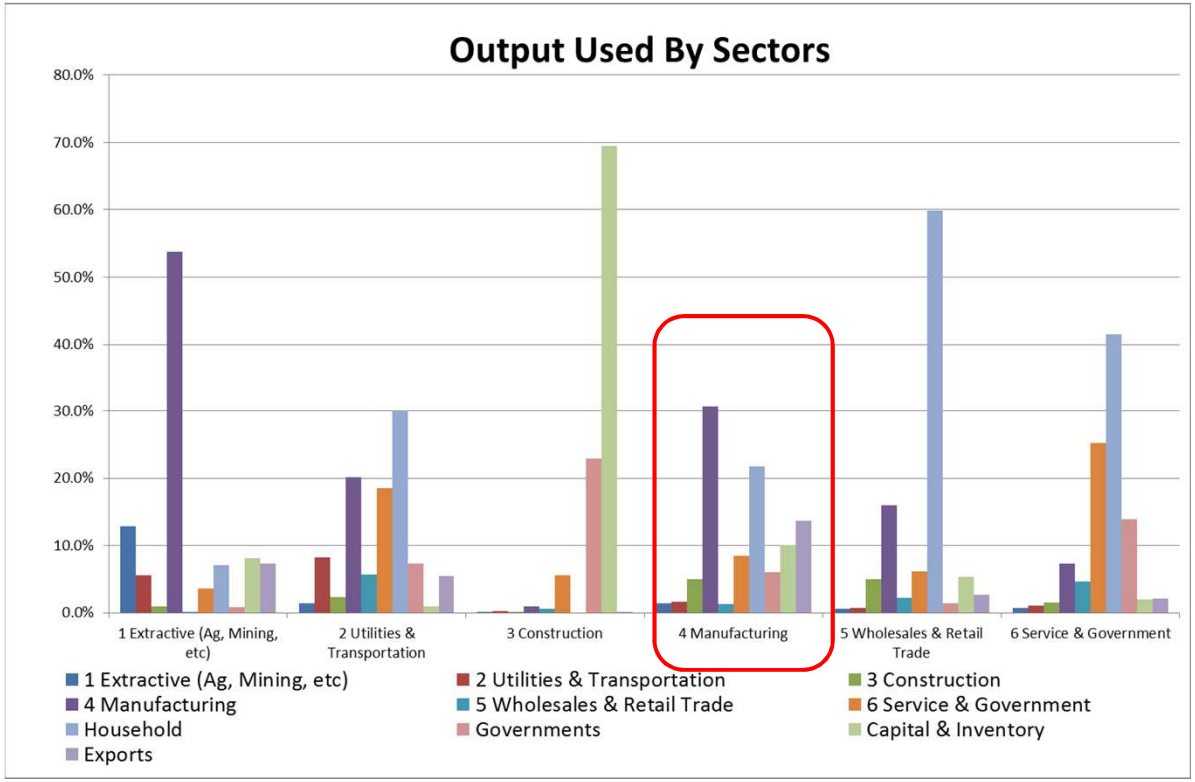
What do they buy for their production?

- Extractive: 6.38%
- Utilities & Transportation: 3.65%
- Construction: 0.20%
- **Manufacturing: 30.69%**
- Wholesale & Retail Trade: 6.21%
- Service & Government: 14.59%
- **Value added: 25.36%**

Manufacturing outputs (the US case)

Where their production is sold?

- Extractive: 1.45%
- Utilities & Transportation: 1.64%
- Construction: 4,97%
- **Manufacturing: 30.69%**
- Wholesale & Retail Trade: 1.30%
- Service & Government: 8.46%
- **Households: 21.80%**
- **Exports: 13.62%**

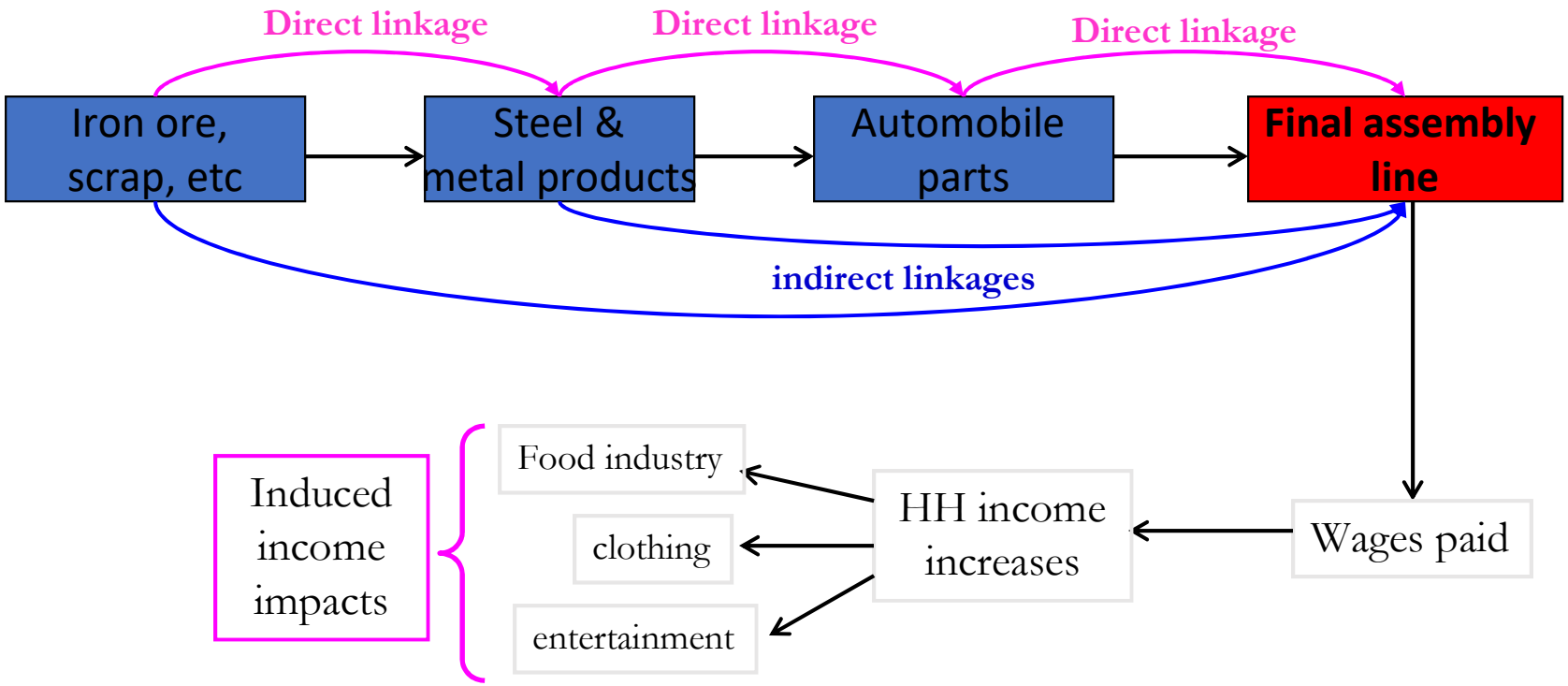


Manufacturing sector

- Durable goods
  - Primary metals, Fabricated metal products, Machinery, Computer and electronic products, Communications equipment, Semiconductors and electronic components, Electronic instruments, Electrical equipment and appliances, Transportation equipment, Motor vehicles and parts, Furniture and related products, Miscellaneous manufacturing
- Nondurable goods
  - Food manufacturing, Beverages and tobacco products, Textile product mills, Apparel, Leather and allied products, Paper and paper products, Printing and related support activities, Petroleum and coal products, Chemicals, Plastics and rubber products

Direct, indirect and induced impact effects in the manufacturing sector

Impacts of the vehicle assembly line in the economy



Manufacturing heterogeneity

- Income growth between 1970 and 2000 of manufacturing sector in the US as a whole: 586.2%
  - Leather and leather products: 134.8%
  - Apparel and other textile products: 251.3%
  - Primary metal industries: 291.1%

  vs.

  - Instruments and related products: 1,321.0%
  - Rubber and miscellaneous plastics products: 868.8%
  - Chemicals and allied products: 860.0%
  - Printing and publishing: 792.5%
  - Motor vehicles and equipment: 780.4%

Heterogeneity within the sector

Manufacturing heterogeneity (2)

- **Income Growth** | Share Change (1970~2000) by State

U.S. as a whole: 586.2% | Share: 28.0 → 26.5%

- New York: 319.4% | Share: 23.9 → 10.7%
- West Virginia : 335.8% | Share: 25.8 → 14.7%
- Rhode Island: 368.7% | Share: 30.2 → 16.4%
- Pennsylvania: 394.6% | Share: 34.8 → 20.6%

vs.

- Nevada: 2,627.4% | Share: 4.0 → 4.7%
- South Dakota: 1,551.8% | Share: 7.5 → 14.3%
- Arizona: 1,498.3% | Share: 16.0 → 13.1%
- New Mexico: 1,402.9% | Share: 5.8 → 7.6%

Heterogeneity among states

The Globalization of manufacturing

- Since 1960, manufacturing output has increased sharply in lower-wage industrializing countries
- The deindustrialization of advanced economies in 1970s and 1980s.
- East and South Asia vs. Latin America, “Flying Geese Formation vs. Sitting Ducks”
  - Japan - leader, South Korea, Taiwan, Hong Kong, Singapore - followers
- China, the world factory
- Why do different industries have different globalization patterns?

Textiles and Garments

- The leading industry in manufacturing globalization, why?
  - Labor intensive, low technology, small firms, modest economies of scale
  - Continuously looking for new source of cheap labor
  - Very fluid geography over time

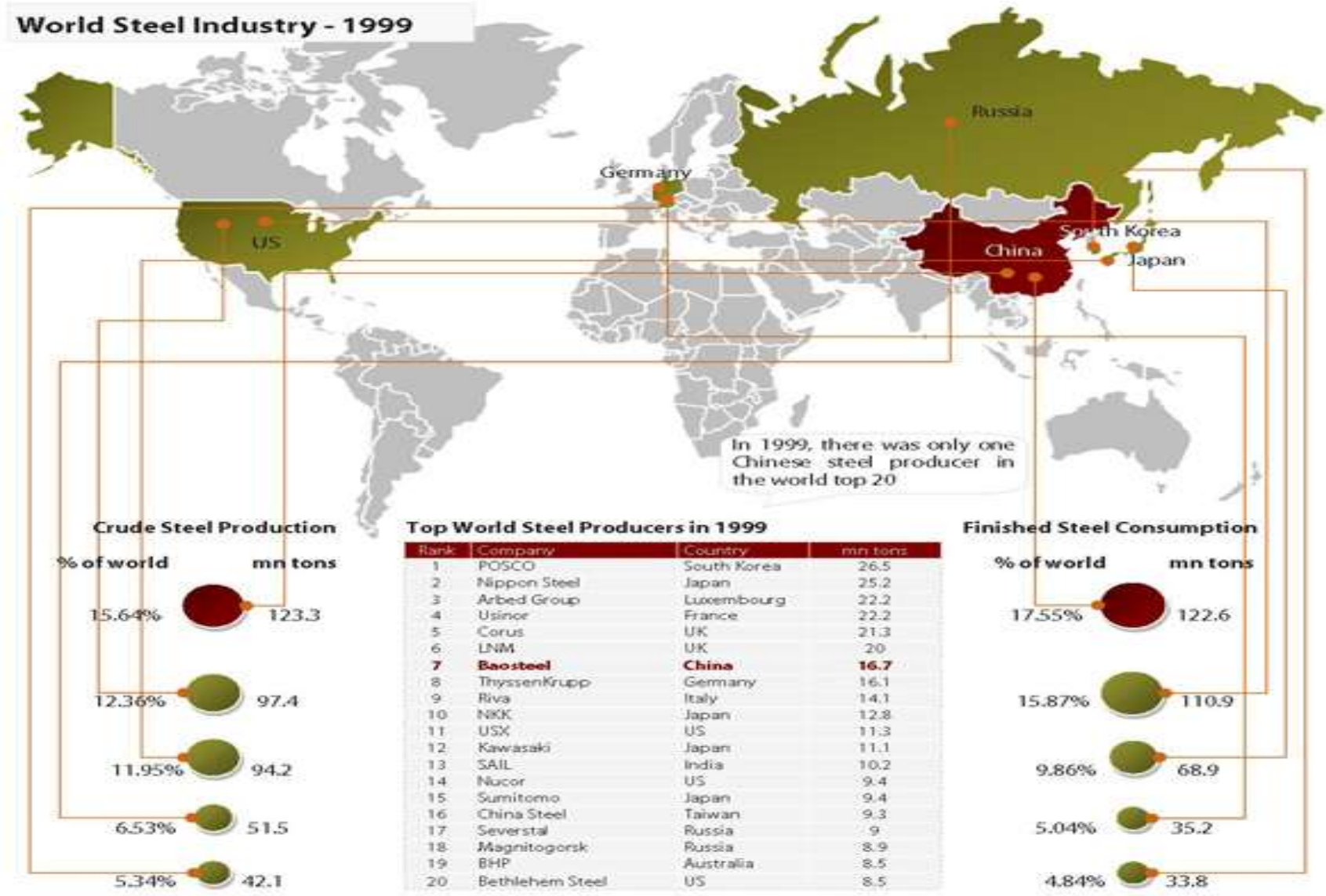
Steel

US produced 63% of world steel output after WWII, and only 8.3% in 2005

Pittsburgh 1960

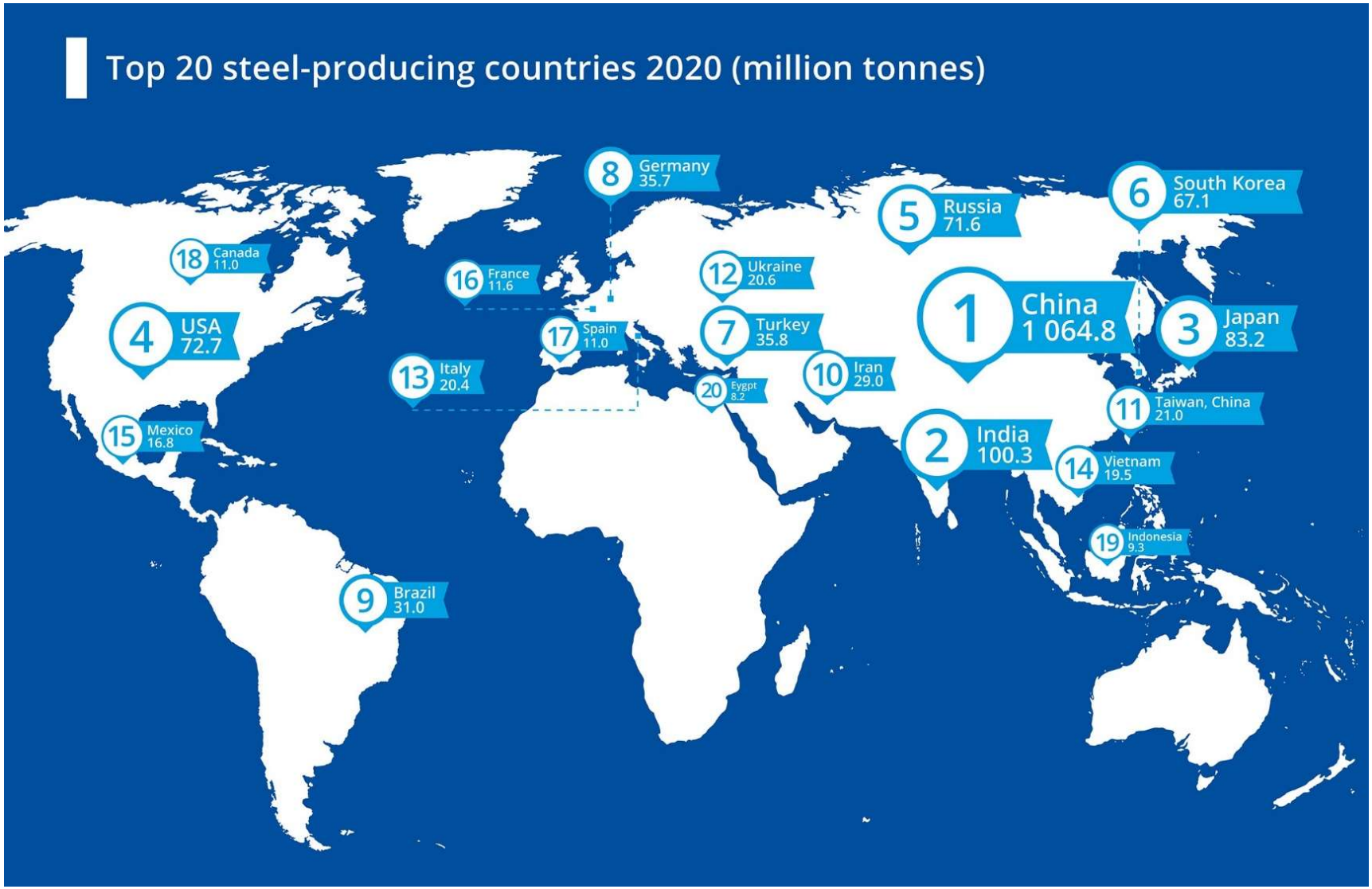
Pittsburgh 2010

Steel Production 1999



Rank	Company	Country	mn tons
1	POSCO	South Korea	26.5
2	Nippon Steel	Japan	25.2
3	Arbed Group	Luxembourg	22.2
4	Usinor	France	22.2
5	Corus	UK	21.3
6	LNM	UK	20
7	**Baosteel**	**China**	**16.7**
8	ThyssenKrupp	Germany	16.1
9	Riva	Italy	14.1
10	NKK	Japan	12.8
11	USX	US	11.3
12	Kawasaki	Japan	11.1
13	SAIL	India	10.2
14	Nucor	US	9.4
15	Sumitomo	Japan	9.4
16	China Steel	Taiwan	9.3
17	Severstal	Russia	9
18	Magnitogorsk	Russia	8.9
19	BHP	Australia	8.5
20	Bethlehem Steel	US	8.5

Steel Production 2020



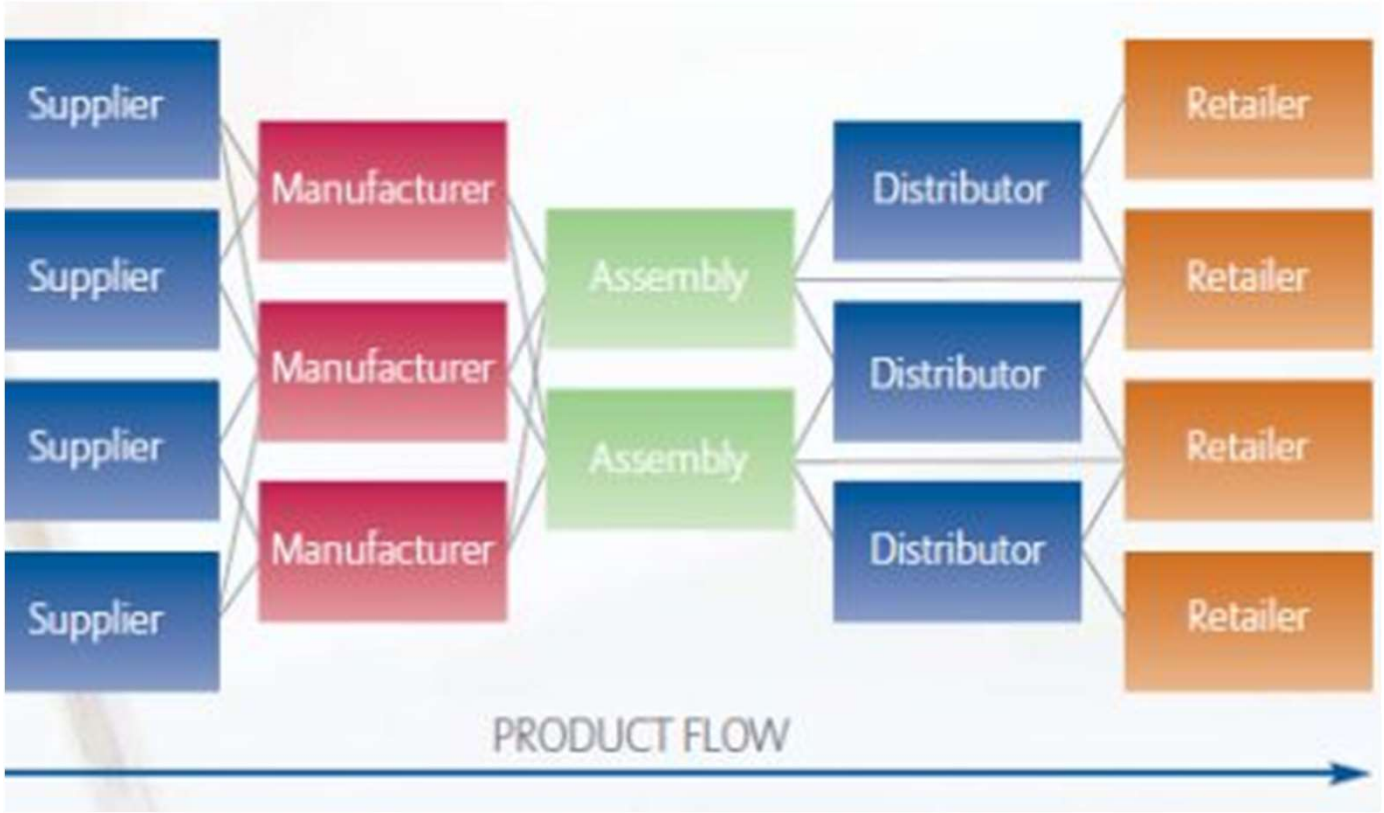
Automobiles and Globalization

- Giant transnational corporations, why?
  - High capital intensive
  - High start-up cost
  - Long history of oligopolization (top 10 companies produce 70% of output)

Recent Developments in Globalization

- Driven by lowering trade cost
  - Advances in transportation technology lower the shipping costs (container shipping)
  - ICT (Information and communication technology) lower the coordination costs
- On-shoring/Re-shoring
  - Chinese wage rates increasing 10-12% p.a.
    - In 3 years equivalent to Eastern Europe
    - In 5-6 years, on par with the US and Western Europe
- Advanced Manufacturing/3-D Printing
  - Technology changing to make it competitive to produce locally, on-demand (e.g. distributor caps)
  - Re-industrialization of developed economies

Supply Chains: Potential Changes



NOW: Dispersed------- Concentrated----------Dispersed

3-D: Concentrated…. Concentrated…….Dispersed.

COVID-19???