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Offshoring Automotive Engineering: Globalization and Footprint Strategy in the Motor Vehicle Industry

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Overview of Automotive Engineering

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Employment of US Auto Engineers

Footprint Strategy for Automotive Engineering

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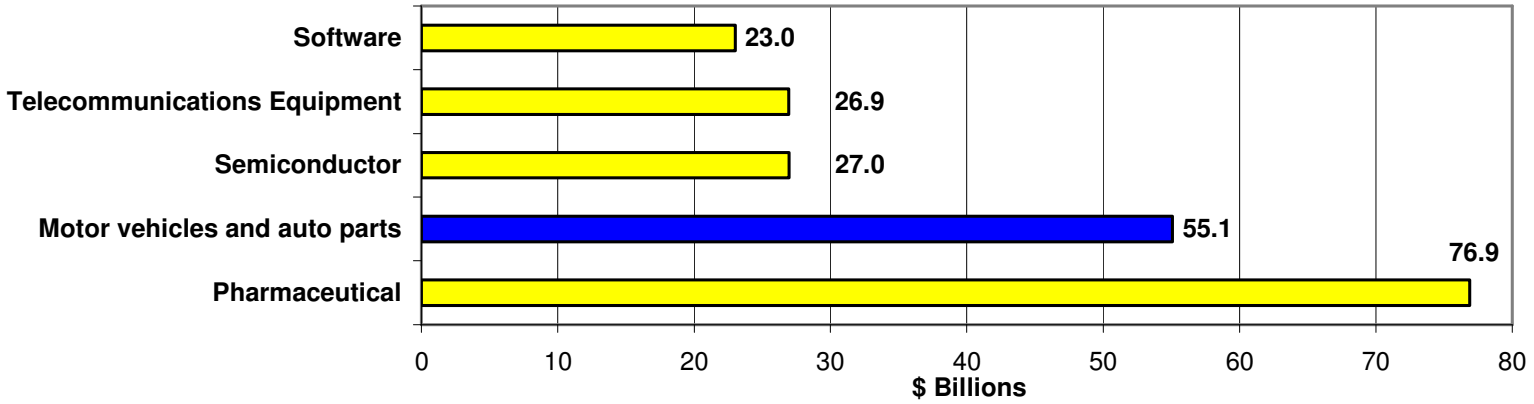
Two types of automotive engineers:

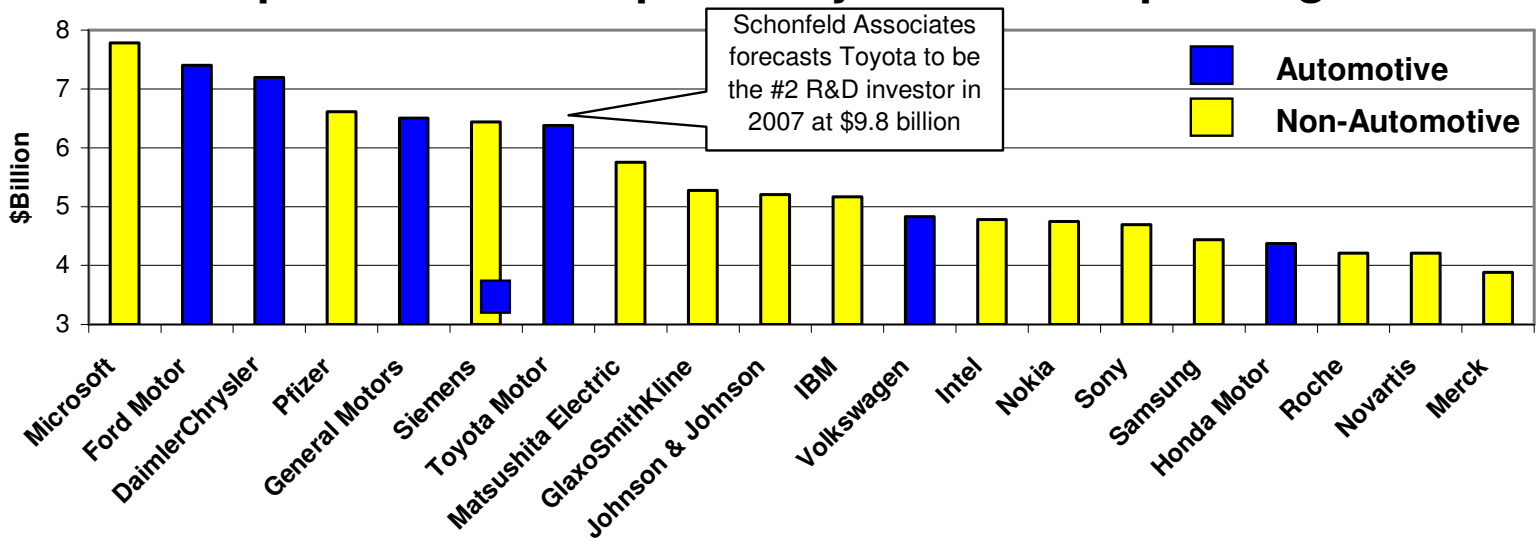
- **Manufacturing Engineers** (location tied to production facilities)
- **Product Engineers**
  - Product Design Engineers
  - Development Engineers
  - Test Engineers
  - Advanced Engineering
- Many engineers work for the supply base
  - Tiered supply base
  - 20-30 thousand parts in a typical automobile
  - Most (all?) OEMs spend more than half their revenue buying from their suppliers

Automotive industry is #2 for R&D spending

Top Industries by 2006 Estimated R&D Spending



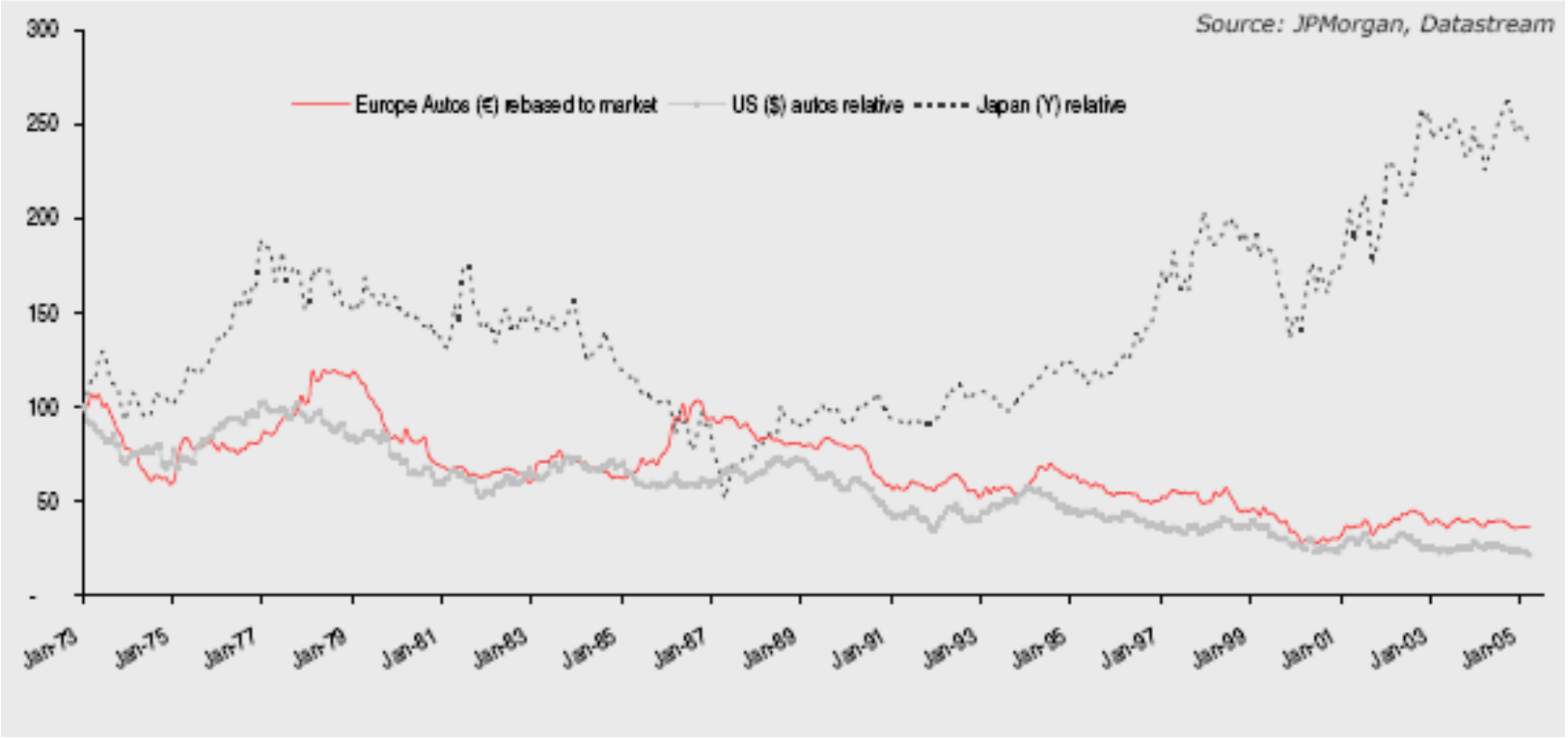
Top 20 Global Companies by 2004 R&D Spending



Sources: Schonfeld Associates; Corporate R&D Scorecard, *Technology Review*

Automakers are under enormous pressure to reduce costs …

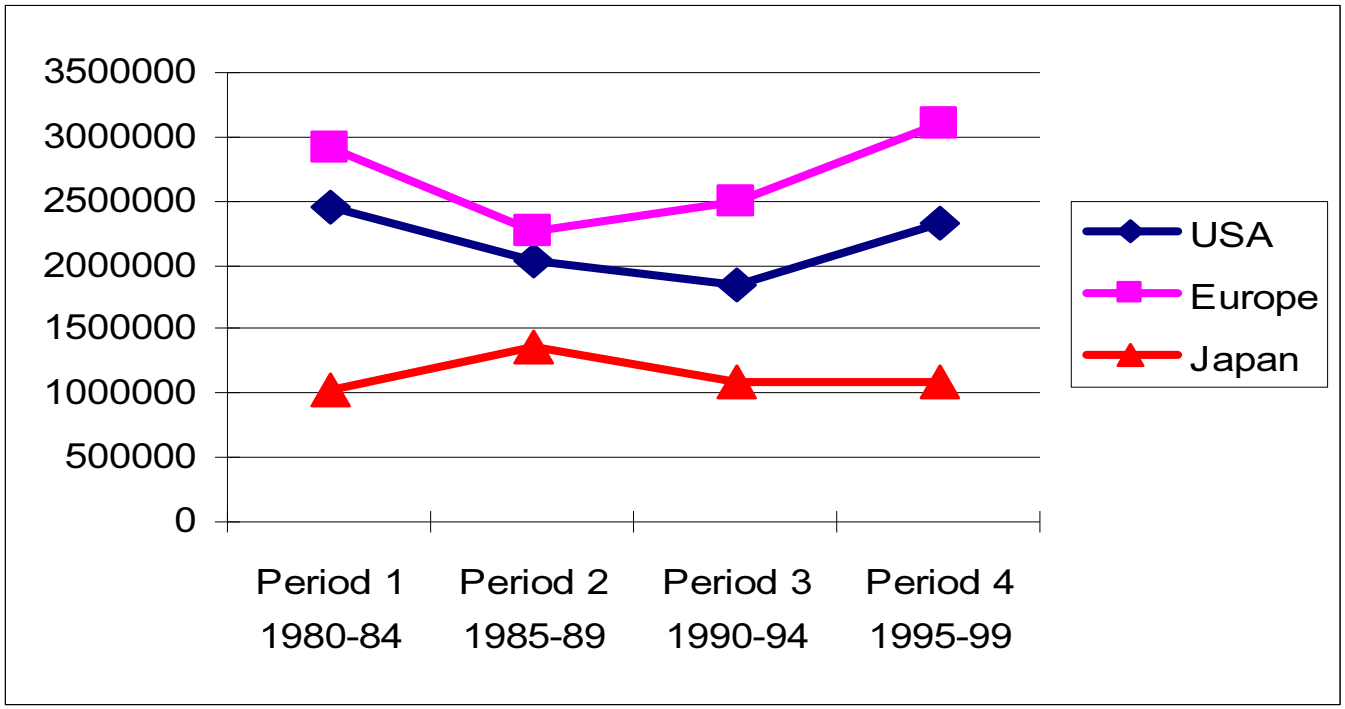
Automotive Proportion of Market Capitalization for US, EU, Japan



… including engineering costs.

Significant differences in engineering efficiency remain among automakers

Adjusted Product Engineering Hours for OEMs in US, EU, Japan



Source: Takahiro Fujimoto, University of Tokyo

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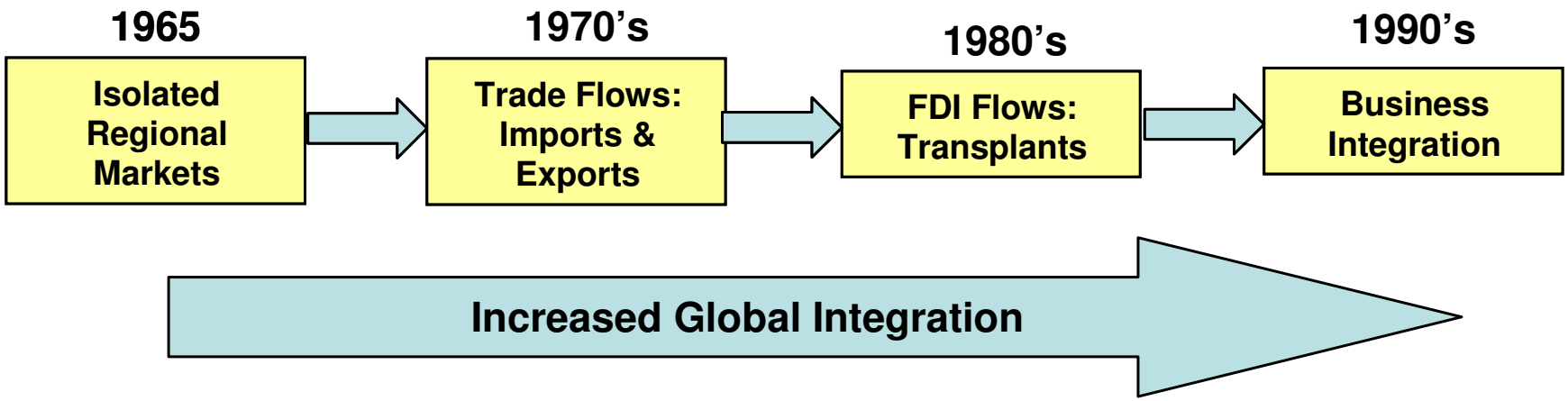
Globalization is not new to the auto industry

Offshore CKD Assembly Plants of Ford, GM & Chrysler up to 1928

Company	Number of Plants	Location of Plants (Year opened)
Ford Motor Company	**24**	Canada (1904); England (1911); France (1913); Argentina (1915); Argentina (1919); Spain (1919); Denmark (1919); Brazil (1919); Belgium (1919); Sweden (1922); Italy (1922); South Africa (1923); Chile (1924); Japan (1924); Spain (1925); Germany (1925); France (1925); Australia (1925); Brazil (3 locations, 1926); Mexico (1926); India (1926); Malaysia (1926);
General Motors	**19**	Canada (1907); England* (1908); Australia (1923); Denmark (1923); Belgium (1924); England (1924); Argentina (1925); England (1925); Spain (1925); Brazil (1925); Germany (1926); New Zealand (1926); South Africa (1926); Uruguay (1926); Indonesia (1926); Japan (1927); India (1928); Poland (1928); Sweden (1928)
Chrysler	**3**	Germany (1927); Belgium (1928); England (1928)

Source: Rhys, D. G. Maxcy, George. Sturgeon & Florida, *Globalization and Jobs in the Automotive Industry*.

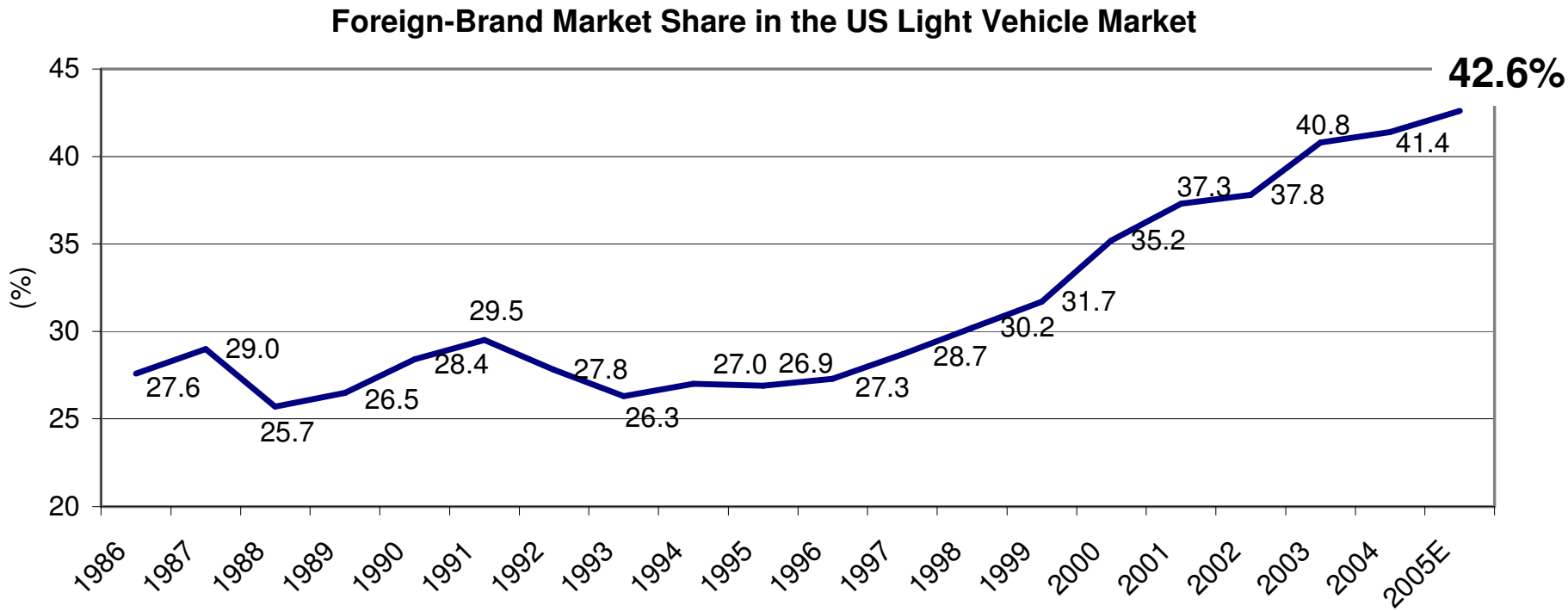
… But the industry has undergone a second wave of globalization since the 1960's



→ Globalization of sales (by brand, by owner)

→ Globalization of production and employment

Foreign-brand market share has steadily increased in the United States to nearly 43% in 2005

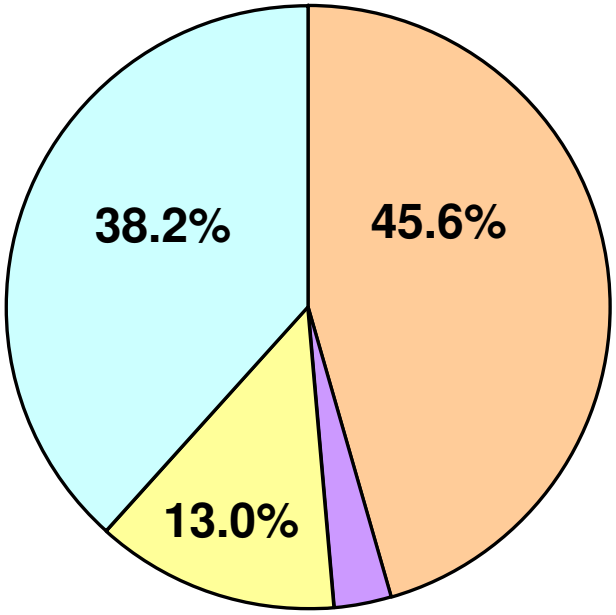


Source: Automotive News, Univ. of Michigan

But **foreign-owned** firms now account for more than half the US market

Foreign-Owned, Foreign-Brands:
BMW, Mini, Rolls Royce, Mercedes Benz, Maybach, Ferrari, Acura, Honda, Hyundai, Kia, Isuzu, Lamborghini, Lotus, Maserati, Mitsubishi, Infinity, Nissan, Porsche, Subaru, Suzuki, Lexus, Scion, Toyota, Audi, Bentley, Volkswagen

2004 Total Sales = 16,912,613 units



Domestic-Owned, Domestic-Brands:
Ford, Lincoln, Mercury, Buick, Cadillac, Chevrolet, GMC, Hummer, Oldsmobile, Pontiac, Saturn

Foreign-Owned, Domestic-Brands:
Chrysler, Dodge, Jeep

Domestic-Owned, Foreign-Brands:
Aston Martin, Jaguar, Land Rover, Volvo, Saab, Mazda

Source: IMVP, Automotive News 2004 data

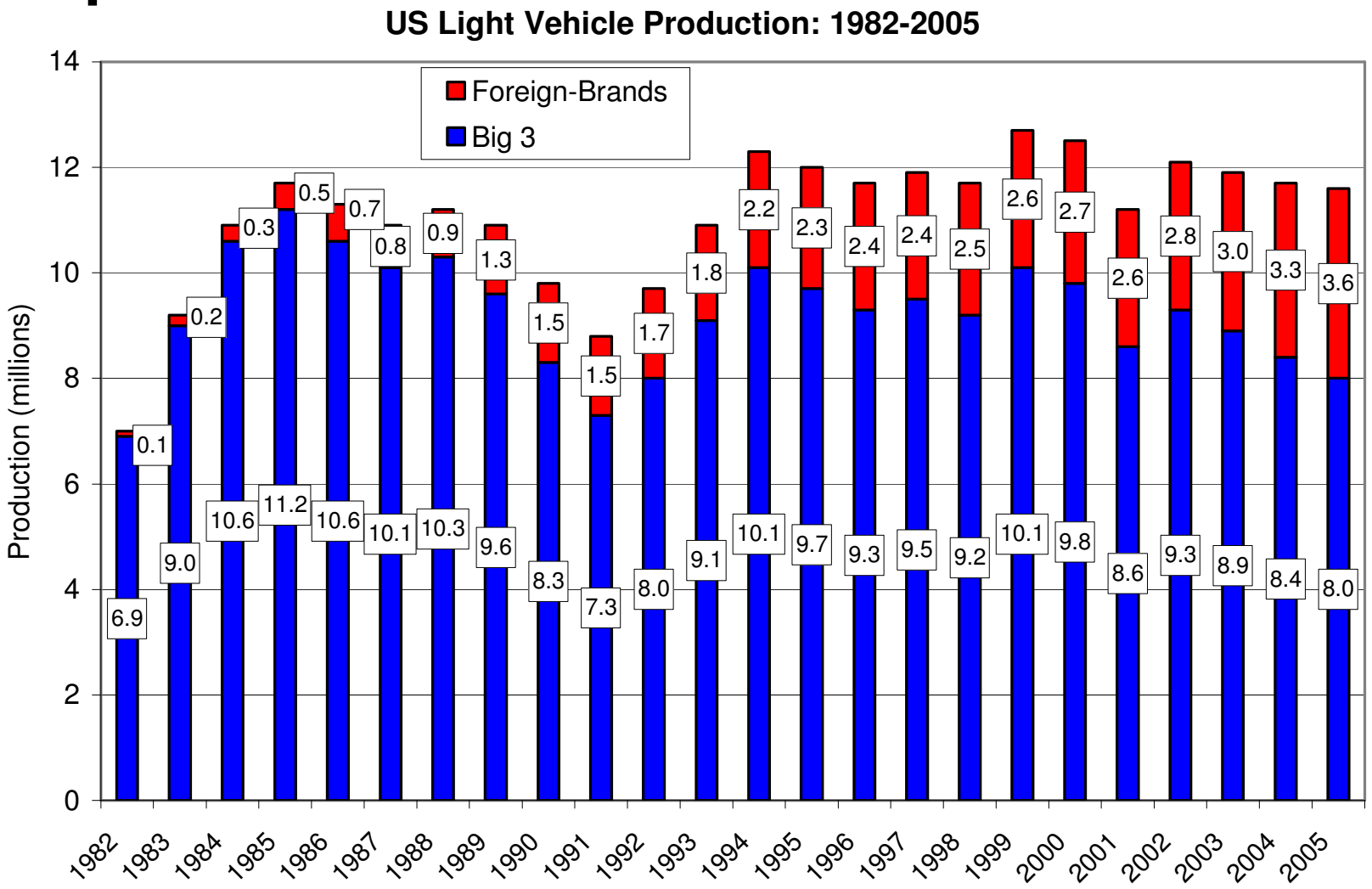
US vehicle market is the most "open" to foreign brands …

Country or Region	Foreign-Brand Penetration (2004)	Foreign-Ownership Penetration (2004)
United States	41.3%	51.2%
Western Europe	26.6%	38.2%
Japan	4.2%	9.0%
South Korea	2.3%	26.2%

… But Foreign Penetration Continues to Increase in All Markets and Foreign-Ownership Penetration Exceeds Foreign-Brand Penetration in All Markets

Note: All Data for 2004
Source: IMVP, ACEA, JAMA, KAMA

Transplant production accounted for 30.9% of US production in 2005



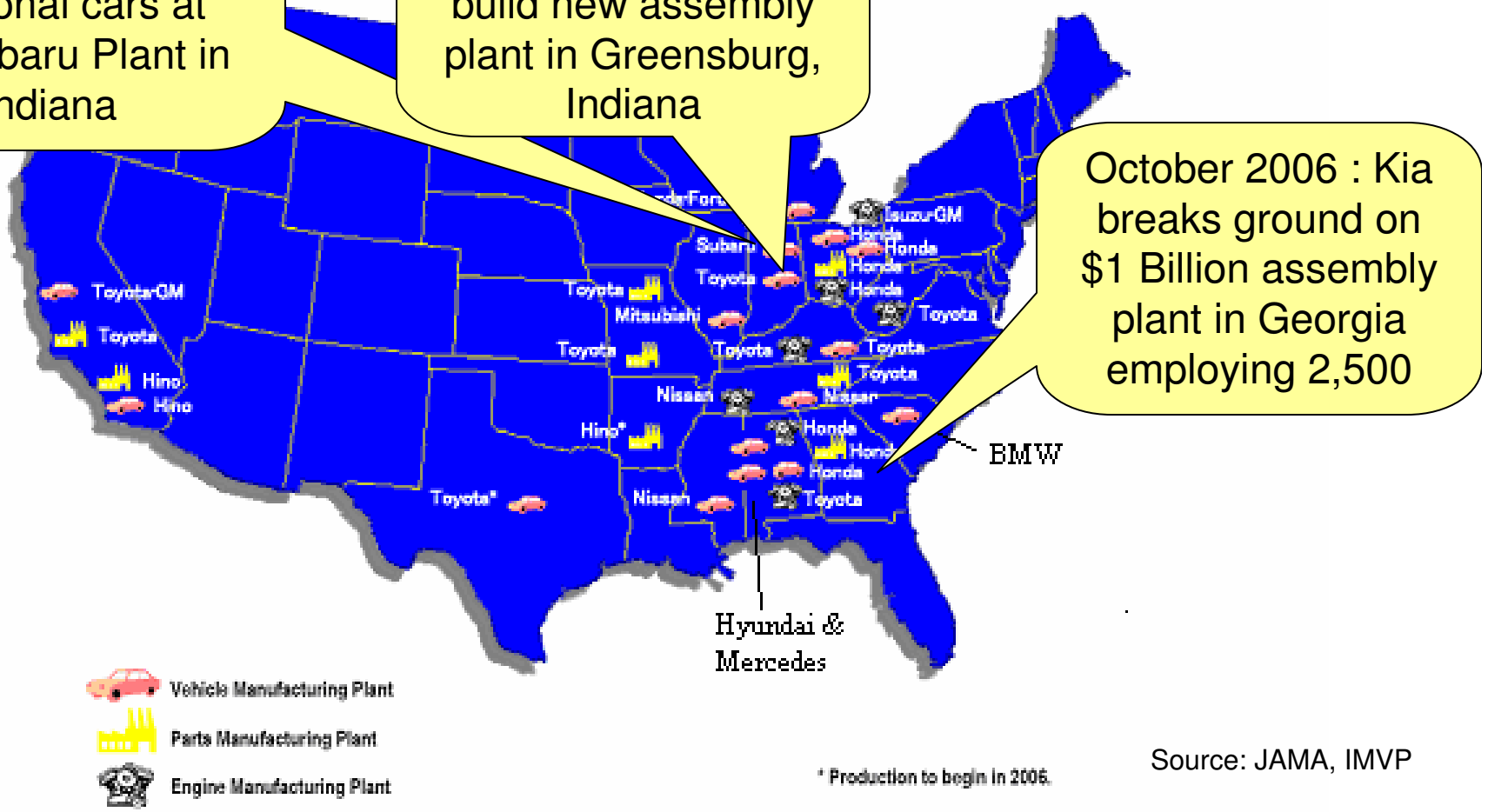
Source: IMVP, Automotive News

The transplants have a different (and expanding) footprint from domestic US production

March 2006: Toyota it will build 100,000 additional cars at Fuji/Subaru Plant in Indiana

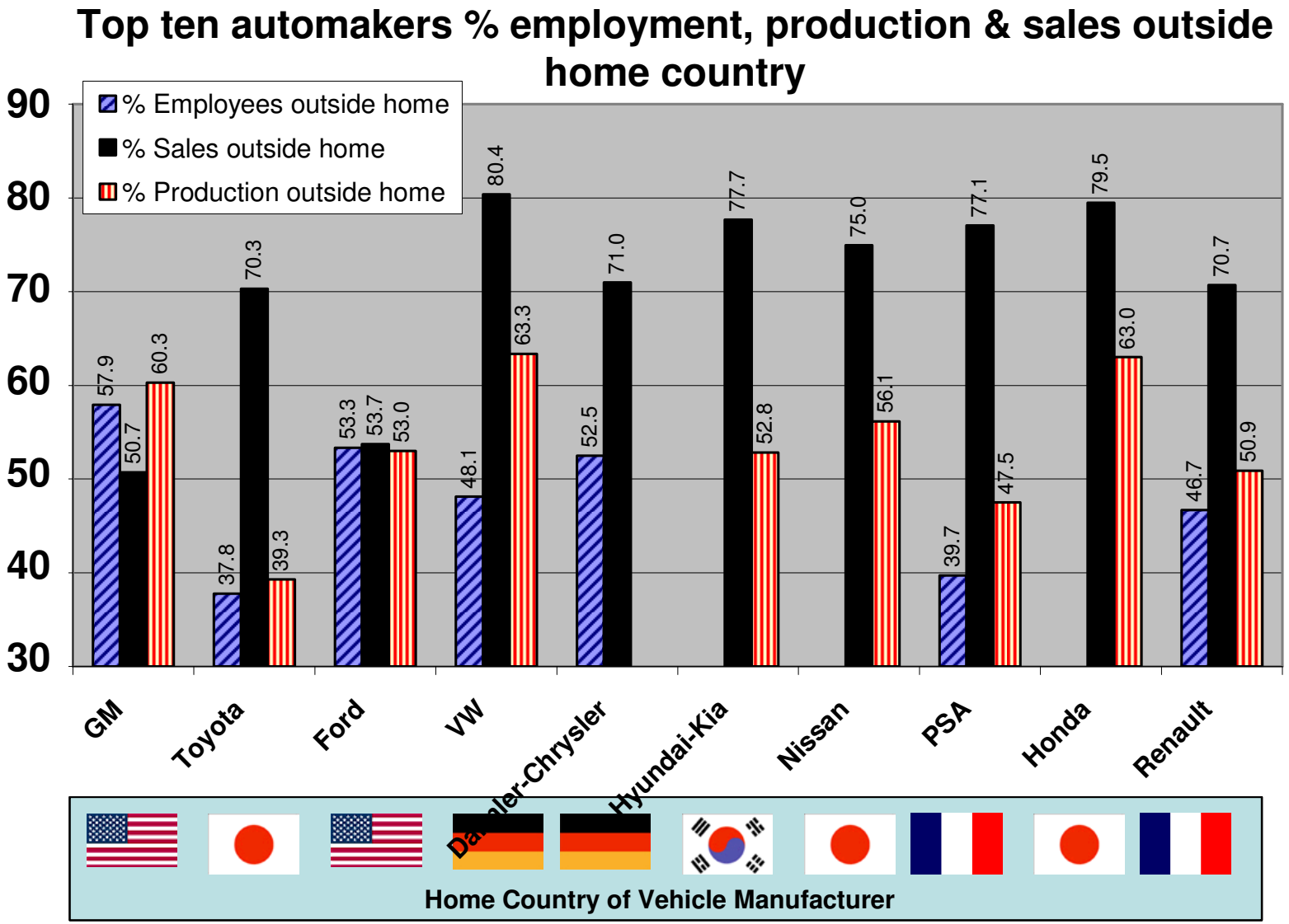
June 2006: Honda announces it will build new assembly plant in Greensburg, Indiana

October 2006 : Kia breaks ground on $1 Billion assembly plant in Georgia employing 2,500



Source: JAMA, IMVP

Employment, sales and production have globalized



Source: company annual reports, except Ford data from Automotive News

Automotive Supplier Industry Is Also Global

- Suppliers “shop at the global mall”
- Foreign suppliers (e.g., Denso) follow their customers (e.g., Toyota) to USA
- US suppliers (e.g., Lear) pursue business with foreign customers entering the US (e.g., Hyundai)
- In 2004, 41% of the combined sales of the top 35 North American suppliers were to customers outside North America

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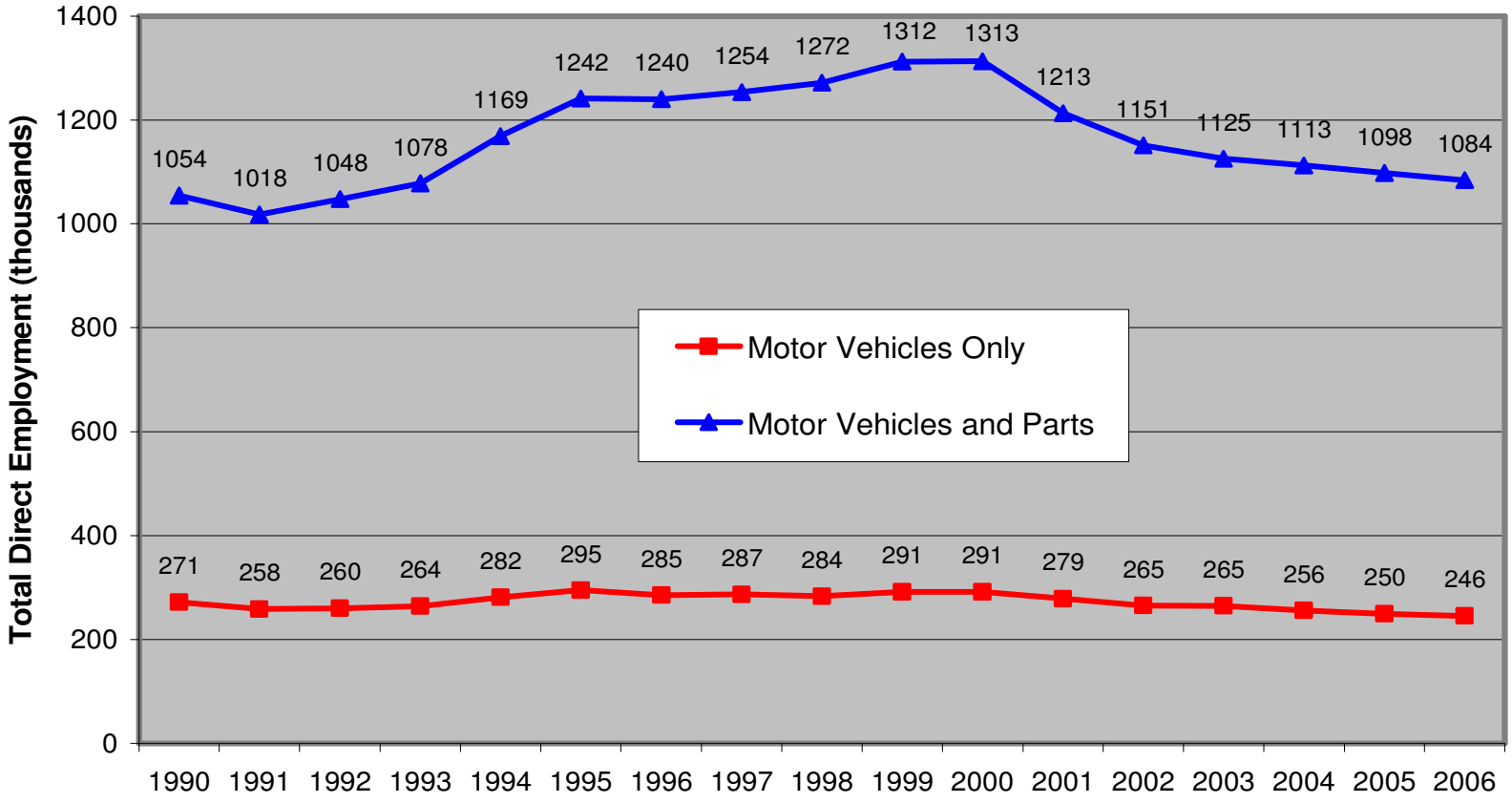
Overall US automotive direct employment has declined to about 1.1 million



Source: US Bureau of Labor Statistics

BLS data indicates about 45,000 automotive engineers in the US …

Occupational Code	NAICS 3361: Motor Vehicle Manufacturing	NAICS: Motor Vehicle Body and Trailer Manufacturing	NAICS 3363: Motor Vehicle Parts Manufacturing	Total of All Three NAICS Codes
Engineering Manager	610	570	3,960	5,140
Industrial Engineer	3,390	1,240	14,460	19,090
Mechanical Engineer	1,920	1,360	9,300	12,580
Electrical Engineer	150	110	910	1,170
Engineers, All Other	n/a	180	7,200	7,380
Total	**6,070**	**3,460**	**35,830**	**45,360**
All Occupations	**256,700**	**168,840**	**693,120**	**1,118,600**

… but this does not include most product engineers!

Source: US Bureau of Labor Statistics

A bottom-up estimate yields about 34,000 engineers and technicians for OEMs ONLY

Company	**Current Number of Engineers & Technicians**	**Projection**
General Motors	11,500	Decreasing
Ford Motor Company	12,000	Decreasing
DaimlerChrysler	6,500	Steady
Japanese	3593	Increasing Rapidly
Korean (Hyundai-Kia)	200	Increasing Rapidly
German (BMW)	150	Increasing
Total	About 34,000	

Source: Company interviews and literature

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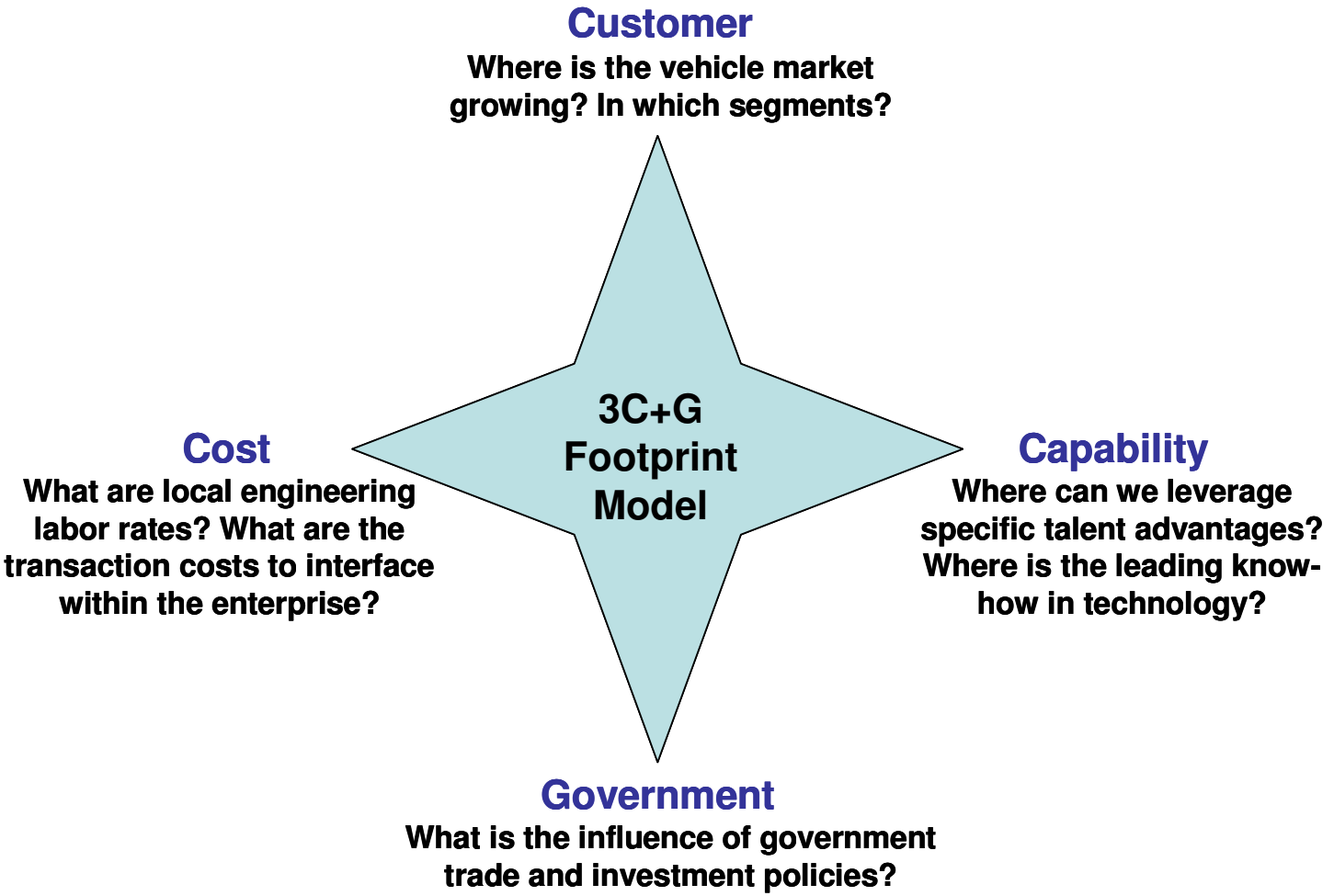
Interviews suggest four key factors that affect automotive engineering footprint:



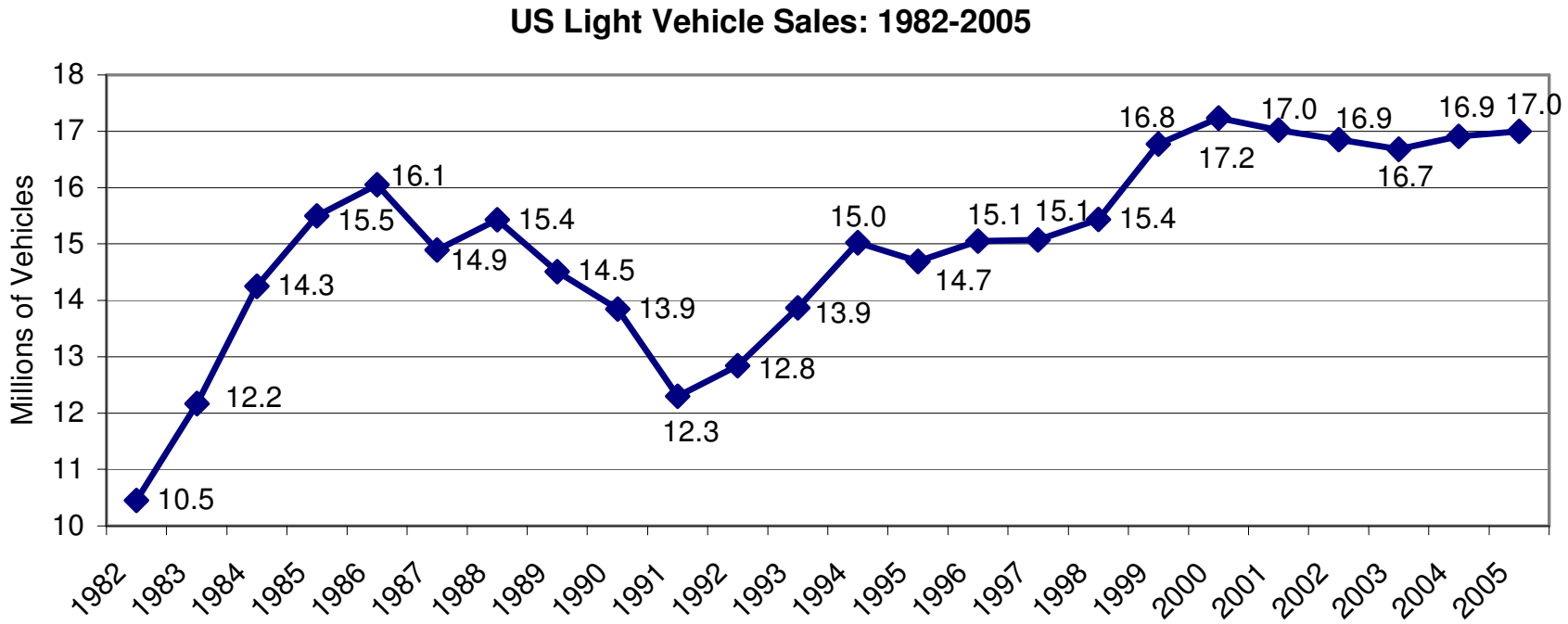
Different weighting of the four factors for product and manufacturing engineering

Factor	Influence on Manufacturing Engineering Footprint	Influence on Product Engineering Footprint
Customer	High	Medium
Cost	Medium	Medium
Capability	Low	High
Government	High	Low

The Value of Proximity

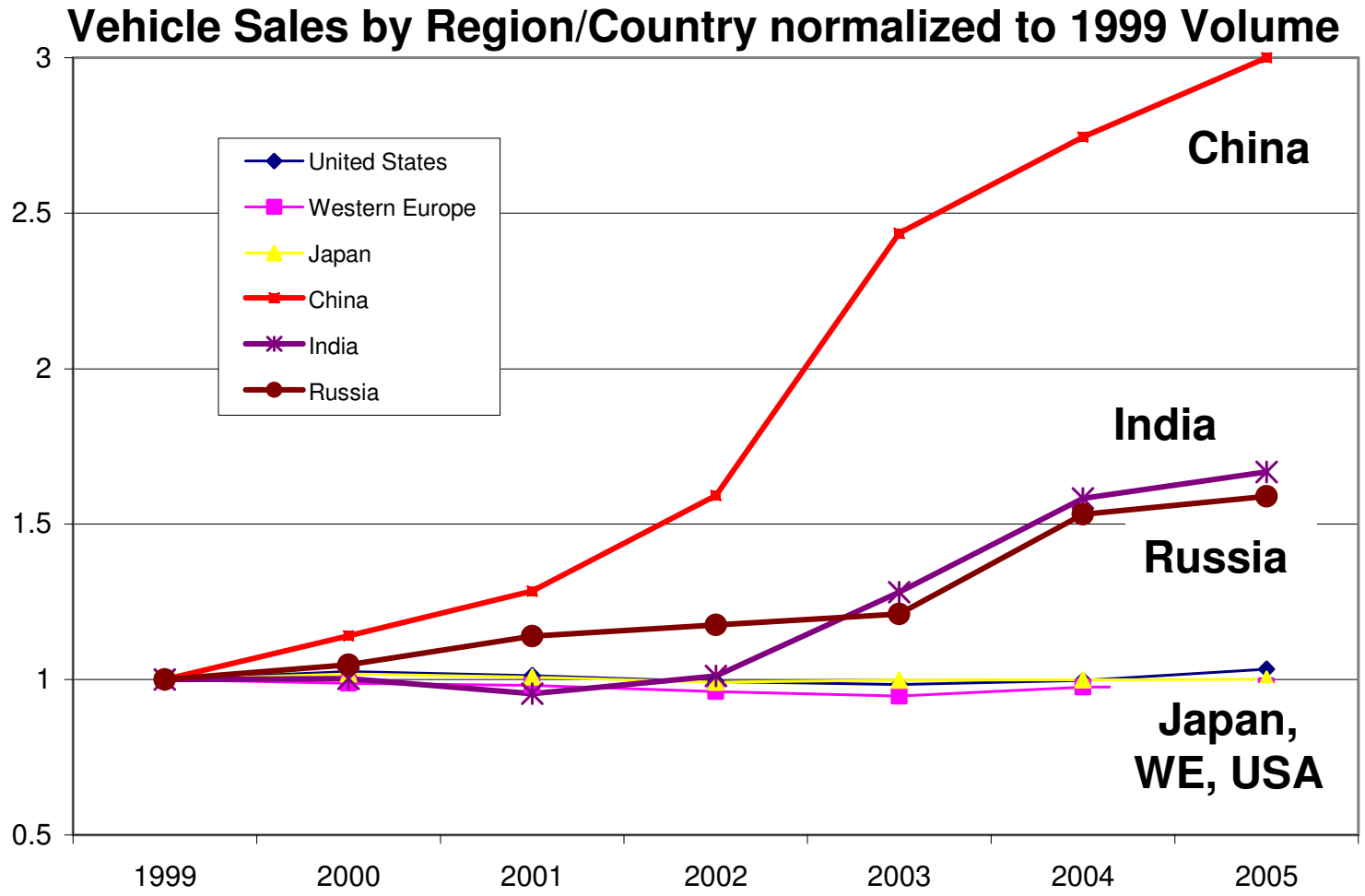
	Manufacturing Engineering (Production)	Production Engineering (R&D)
OEM-Customer Proximity	*Build where you sell* Lower Transport Cost Trade Policy Political/Reputation Gain Reduce Currency Risk	*Engineer where you sell* Localization Engineering local vehicles
Supplier-OEM Proximity	*Supply close to assembly plant* Bulky (fuel tanks) Assembly sequence (seats) Integral (bumpers)	*Engineer close to OEM customer* Integral systems/ components

Historically cyclical, the US vehicle market has been flat for the past six years



Source: Automotive News data

China, India and Russia are growing; US, WE and Japan are stagnant



Source: Automotive News data

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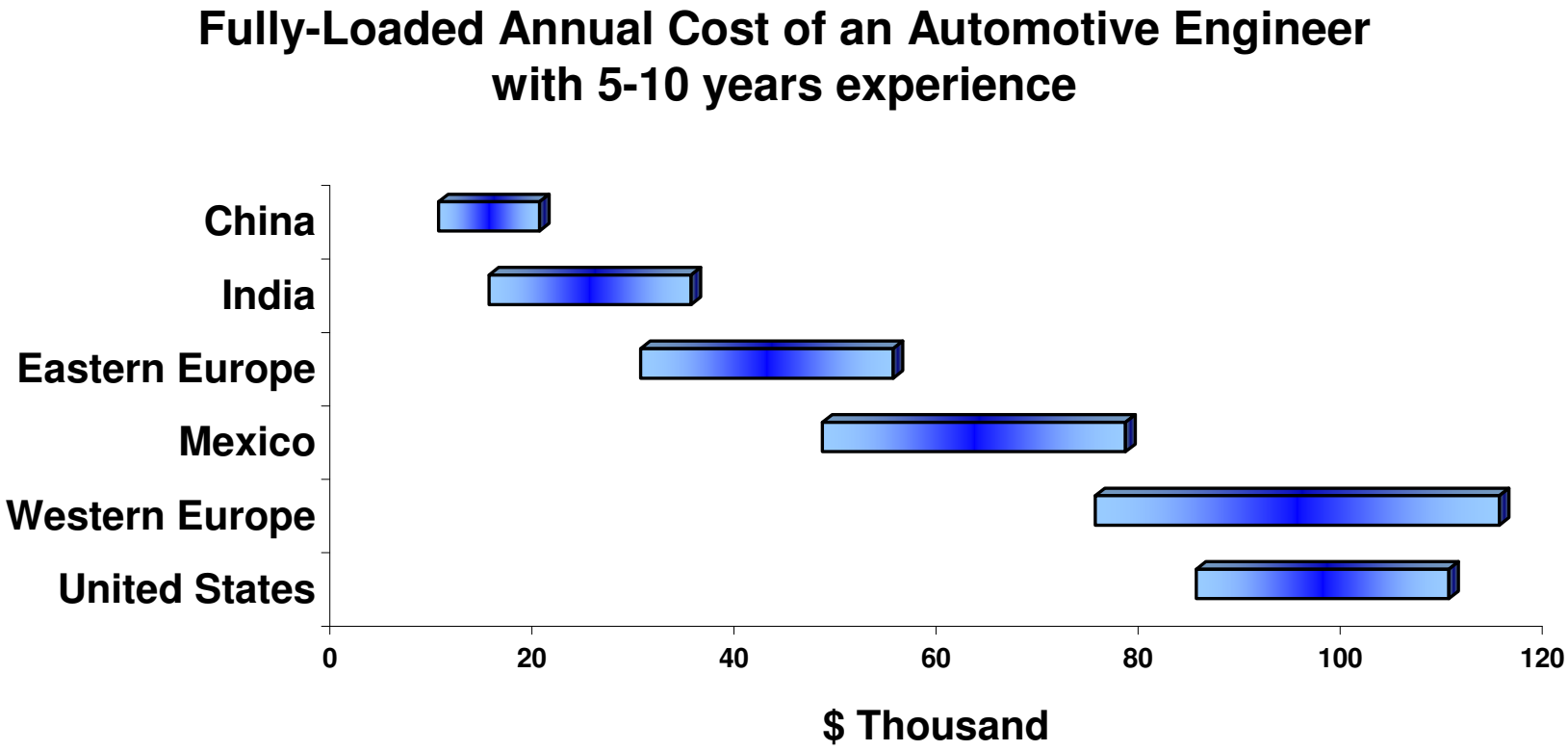
Engineering labor rates vary widely



Source: Company interviews

Interviews: Chasing labor is not a good idea

- Low labor productivity can cancel out low engineering cost per hour
- Low engineering labor rates are not sustainable
- Labor accounts for about half of total automotive engineering cost

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Interviews: Capability matters

- Many offshore engineers lack basic automotive domain knowledge
- Offshore the routine/repetitive/low-value-added tasks: e.g., FE meshing, engineering bill of materials, component FMEA (not system), generating a tool design from a part specification
- Offshore ramp-up time (and cost) is frequently underestimated

US Firms Offshoring R&D Tech Centers

GM Technical Center

Bangalore, India

Opened Nov. 2003

Employment: 240 professionals in 2005 increasing to 400 in 2006

Vehicle design tools, virtual manufacturing, control systems, materials

GM-SAIC Pan Asia Technical Automotive Center (PATAC)

Shanghai, China

Opened June 1997

Employment: 660 Designers, Technicians, Engineers

50-50 joint venture between GM and SAIC provides automotive engineering services including design, development, testing and validation of components and vehicles.

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Foreign Firms Onshoring R&D Tech Centers

Nissan Technical Center

Farmington Hills, Michigan

First Established 1989

2005 Employment:1056 (540 engineers)

In March 2005, Nissan added a $14M design studio to this site, following a $38M expansion in 2002..

Total vehicle development for US market.

Toyota Technical Center

Ann Arbor, Michigan

First established 1977 (multiple expansions)

2005 Employment: 750

Toyota's New $150 Million R&D Facility will join this facility in Ann Arbor, Michigan and add 400 technical jobs.

TTC is engaged in engineering design, engine unit design, prototype development, vehicle evaluation, evaluation and design of parts and materials, regulatory affairs, emission certification, and technical research.

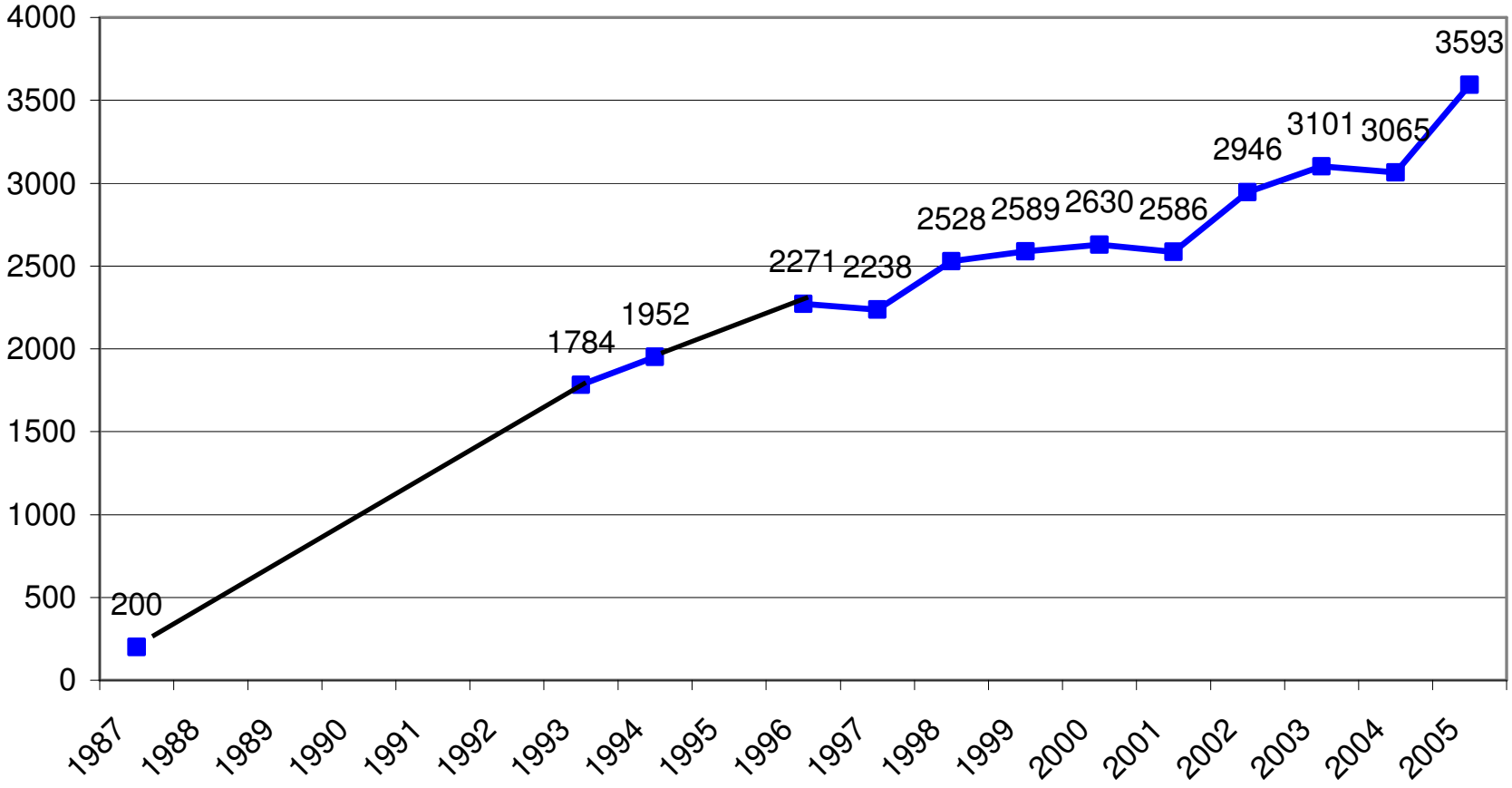
Foreign-brand R&D and design facilities in the United States employed nearly 4,000 people in 2006

Company	Location(s)	Established	Employees
BMW	Spartanburg, NC; Woodcliff Lake, NJ; Oxnard, CA; Palo Alto, CA	1982	150
Honda	Torrance, CA; Marysville, OH	1975	1300
Hyundai	Ann Arbor, MI	1986	200
Isuzu	Cerritos, CA; Plymouth, MI	1985	100
Mazda	Irvine, CA; Ann Arbor, MI; Flat Rock, MI	1972	100
Mercedes-Benz	Palo Alto, CA; Sacramento, CA; Portland, OR	1995	50
Mitsubishi	Ann Arbor, MI	1983	130
Nissan	Farmington Hills, MI	1983	980
Subaru	Ann Arbor, MI; Lafayette, IN; Cypress, CA	1986	30
Toyota	Gardena, CA; Berkeley, CA; Ann Arbor, MI; Plymouth, MI; Lexington, KY; Cambridge, MA; Wittmann, AZ;	1977	950

Source: Japan Automobile Manufacturers Association (JAMA), Automotive News, IMVP

Onshore engineering has been growing

Number of engineers and designers working for Japanese OEMs in the United States



Source: Japan Automobile Manufacturers Association (JAMA)

Concluding thoughts

- Finding good data is difficult; Industry viewpoints converge on some issues and diverge significantly on others
- The automotive world is not flat; proximity does have value for both manufacturing and product engineering
- Growth in manufacturing engineering (production) will continue to be driven by local market growth and government policies
- Growth in product engineering is driven by a complex balance of local cost, capability and customer; US vehicle manufacturers are striving to optimize global engineering footprint rather than offshore US engineers