

WHY AUTOMOTIVE RESEARCH & DEVELOPMENT MATTERS

— 2016 —

AAPC
AMERICAN AUTOMOTIVE POLICY COUNCIL

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EXECUTIVE SUMMARY

At their R&D facilities in Auburn Hills, Dearborn, and Warren, Michigan, FCA US, Ford, and General Motors together employ 45,000 workers. The engineers and scientists working at these facilities — busy developing alternative fuels, advanced powertrains, new materials, and enhanced safety equipment — are just part of the companies' \$19 billion annual investment in R&D. In fact, FCA, Ford, and General Motors rank among the world's top producers of R&D. Each invests more per year than Facebook, HP, DOW, or ExxonMobil.

Why do FCA, Ford, and General Motors invest so much?

First, automaking is a technology-intensive business. A new car or truck contains about 60 microprocessors, and in-vehicle electronics represent as much as half the vehicle's total cost. Those microprocessors are producing enormous improvements in fuel economy, safety, and performance. For example, over the past decade, braking technology has evolved from anti-lock brakes (which help a driver brake faster) to electronic stability control (which keeps a vehicle moving safely when the driver has lost control), to automated emergency steering systems (which control brake, steering, and throttle).

Second, automakers operate the world's largest supply chains, and it takes a lot of engineers to keep those supply chains functioning. A car or truck contains between 8,000 to 12,000 parts. Designing, manufacturing, and integrating those parts is one reason why automakers and suppliers employ nearly 1 in 10 U.S. scientists and engineers working in the private sector.

Third, FCA, Ford, and General Motors are leading a global race to develop alternative fuels, advanced materials, and autonomous vehicles. Over the past five years alone, FCA, Ford, and General Motors have collectively applied for more than 15,000 U.S. patents.

Why does FCA, Ford, and General Motors R&D matter to the U.S.?

First, the U.S. continues to lead the world in R&D, but our lead is shrinking — and it depends more each year on how much companies like FCA, Ford, and General Motors invest in their U.S. labs. Thanks to big increases by the private sector, U.S. R&D increased 55% from 2003 to 2013. Today, corporations like FCA, Ford, and General Motors invest more than twice as much each year as the federal government.

Second, manufacturing R&D drives more value and employs more people than other R&D in the U.S. In fact, manufacturers employ 60% of U.S. R&D employees and account for two-thirds of R&D volume. In 2013 and 2014, manufacturers accounted for roughly 75% of the growth in U.S. R&D.

Third, automotive R&D sparks a job-creating cycle: FCA, Ford, and General Motors R&D drives U.S. sales, which drives greater U.S. production, which drives new hiring and investment in factories and assembly plants. As FCA, Ford, and General Motors invest more in the U.S., it encourages their suppliers and other automakers to hire and invest more here. Six of the world's other largest automakers and 46 of the world's top 50 automotive suppliers have opened R&D facilities near FCA, Ford, and General Motors research labs. These economies of scale are critical to the U.S.'s economic competitiveness.

KEY POINTS

- 1. The U.S. continues to lead in R&D, but its advantage is shrinking.** Thanks to big increases by the private sector, U.S. R&D increased 55% from 2003 to 2013, but global spending on R&D doubled during that same period. Today, corporations invest more than twice as much as the federal government.
- 2. The auto industry ranks second in global R&D spending and invested approximately \$20 billion in U.S. R&D last year.** Because cars are a high-tech business, and because the automotive supply chain is so big, automakers and their suppliers employ nearly 1 out of 10 corporate scientists and engineers working in the U.S.
- 3. FCA, Ford, and General Motors are among the world's top investors in R&D.** Each invests more in R&D than Facebook, HP, DOW, or ExxonMobil. Together, they have applied for nearly 15,000 patents in the last five years.
- 4. FCA, Ford, and General Motors R&D is driving new sales, production, and jobs across the U.S. — and this success is attracting their suppliers and competitors to invest more here as well.** This job-creating cycle is critical to the U.S.'s economic competitiveness.

INTRODUCTION

The National Science Foundation (NSF), President's Council of Economic Advisors, and the European Union each recently published their annual reports on R&D. Once again, FCA, Ford, and General Motors rank among the world's largest investors in R&D, each spending substantially more than many of the U.S.'s most famous tech companies and most respected government labs. Together, these reports explain what smart R&D can mean for the U.S. — and for the American companies competing in our increasingly competitive global economy.

SCALE AND IMPORTANCE OF AUTOMOTIVE R&D

Automakers and their suppliers are the world's second biggest investor in R&D. Automakers and their suppliers invest more than \$115 billion in R&D each year, or more than \$1,300 of R&D for each vehicle sold last year (worldwide).¹

This \$115 billion represents approximately 16% of the world's R&D: more than the hardware, software, electronics, chemicals, aerospace, defense, or oil & gas sectors. Automakers and their suppliers rank second out of 41 industries. (Only pharmaceutical companies invested more.) Autos moved to second place from third in 2014, in part, because they increased their R&D by 9.9% over the prior year, versus an industry-wide increase of 6.8%. (Chart A).²

Automakers and their suppliers invest more than \$115 billion in R&D each year.

Importance of manufacturing R&D to the U.S.'s economy. Manufacturing R&D drives more value and employs more people than other R&D in the U.S. In fact, manufacturers employ 60% of U.S. R&D employees and account for two-thirds of R&D volume. In 2013 and 2014, manufacturers accounted for roughly 75% of the growth in U.S. R&D.³

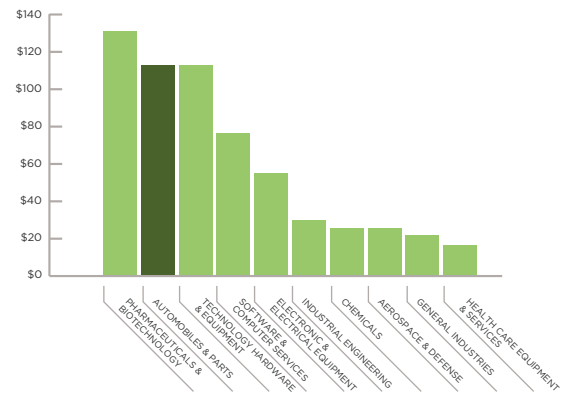
Importance of automakers to manufacturing R&D. In the U.S., automakers and suppliers invested nearly \$20 billion in R&D last year, much of that developing alternative fuels, advanced powertrains, new materials, and better sensors.⁴ As a result, automakers and their suppliers employ nearly 1 in 10 U.S. engineers and scientists working in the private sector.⁵

Nearly 1 in 10 of the U.S.'s engineers and scientists in the private sector are employed by an automaker or one of its suppliers.

Automakers are tech companies, too. Why are automakers such an important player in American innovation? One reason is that much of auto R&D is focused on in-vehicle electronics, which can represent as much as half of the cost of a new vehicle. To appreciate the scale and significance of auto R&D, consider several findings from the Center for Automotive Research (CAR): A new smart phone contains one microprocessor, while a new car or truck contains about 60. These microprocessors manage 100 or more sensors located throughout the vehicle, connected

Top Ten Industries for R&D Spending (2014, in billions)

CHART A



by as much as a mile of wiring. Just as important, a microprocessor in a smart phone is expected to last about three years, while autos are expected to last 12 years or more.⁶

Auto engineers are using these sensors and microprocessors to make cars safer. Over the past decade, automaker R&D has driven braking technology from anti-lock brakes (which help a driver break faster) to electronic stability control (which keeps a vehicle moving safely when the driver has lost control), to experimental automated emergency steering systems (which control brake, steering, and throttle).⁷

Engineering the U.S.’s largest supply-chain. Because each vehicle contains between 8,000 and 12,000 parts, designing and producing autos is a massive engineering challenge. Tens of thousands of engineers and scientists at automakers and their suppliers work to develop, produce, ship, and improve automobile parts and components.

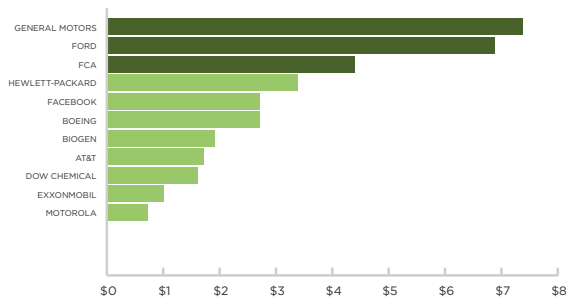
FCA, FORD, AND GENERAL MOTORS R&D

General Motors, Ford, and FCA each invest more in R&D than many of the world’s leading IT, defense, biotech, and energy giants, including Facebook, HP, DOW, Biogen, and ExxonMobil (Chart B).

Together, Ford, FCA, and General Motors invest nearly twice as much each year as NASA (\$18.7 billion vs. \$10.5 billion) (Chart C).⁸

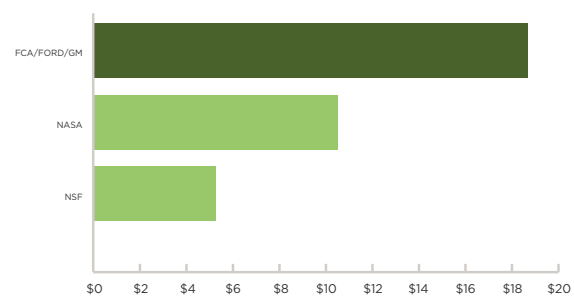
General Motors, Ford, and FCA’s Annual R&D vs. Other Leading Innovators (2014, in billions)

CHART B



General Motors, Ford, and FCA’s Annual R&D in Context (2014, in billions)

CHART C



Another way to understand the magnitude of automaker R&D is to compare it to federal programs established to solve similar priorities. For example, from 2009 through 2015 the federal government directed \$6.1 billion toward research on and deployment of next generation automotive batteries, advanced biofuels, plug-in hybrids, and battery-electric vehicles (BEVs). The federal government also built the infrastructure necessary to support those technologies (such as installing charging stations for BEVs).⁹ During that same period, FCA, Ford, and General Motors invested approximately \$110 billion on R&D (about 18 times as much), with much of it going toward those same priorities.¹⁰

WHAT INNOVATION LOOKS LIKE

FCA. At the Chrysler Technology Center in Auburn Hills, MI, 14,000 employees work among eight design studios, a 170,000-square foot pilot plant, a wind tunnel, emissions lab, powertrain test center, noise and vibration lab, and electromagnetic capability lab. The complex, connected to FCA's Chrysler World Headquarters, is big enough to have its own fire station.

Chrysler Technology Center



Ford. At the Ford Research & Engineering Center in Dearborn, MI, 12,000 employees work among 34 buildings on a 720-acre campus that includes research labs, design studios, a test track, wind tunnel, crash sleds, dynamometers, and a major data center. Ford is so committed to conducting its R&D here at home that it is transforming its Dearborn campus to further drive innovation and collaboration.

General Motors. At the General Motors Technical Center in Warren, MI, 19,000 employees work out of 38 buildings across a 326-acre campus that includes a design center, research development operations, and an advanced engineering center lab. In 2015, General Motors announced \$1 billion in capital improvements and 2,600 new jobs at the site.

Ford Research & Engineering Center



General Motors Technical Center



CONNECTION BETWEEN R&D AND JOBS

R&D drives innovation. Automakers and their suppliers are significant drivers of patents. Each year, automakers, auto suppliers, and auto entrepreneurs from around the world file for nearly 60,000 patents with the USPTO.¹¹ Filings for autonomous and hybrid vehicles have increased by almost 300% in the last ten years (Chart D).¹²

In 2014, FCA, Ford, and General Motors filed for more than 3,400 patents. For example, Ford earned or applied for more than 100 new patents for a single one of its new models: the 2015 F-150 pickup.¹³

Innovation drives sales. U.S. auto sales increased 67% from 2009 to 2015 (from 10.4 million to 17.5 million). They increased 5.7% last year alone, with Americans buying about 950,000 more cars and light trucks in 2015 than they did in 2014. Sales are expected to increase another 3.4% (from 17.5 million to 18.1 million) in 2016 and another 2.2% in 2017 (to 18.5 million).¹⁵

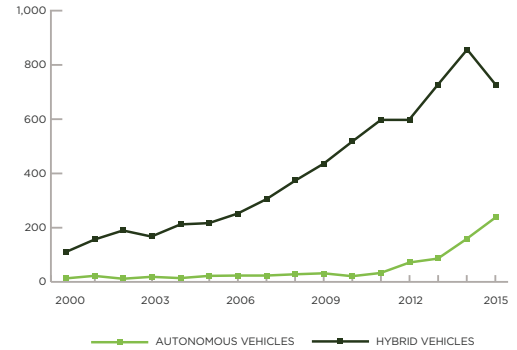
Sales drive production and jobs. Automotive production in the U.S. has more than doubled over the past five years (from 5.6 million to 11.9 million vehicles) (Chart E). Production is expected to increase 1.7% in 2016 and 0.8% in 2017.¹⁶

Part of this change relates to reductions in the U.S.'s labor and energy costs, but an industry-wide move toward global model platforms is also a factor. Throughout the automotive industry, automakers are reducing their research, development, and production costs by building their models from a smaller number of body platforms. They are also centralizing production of those platforms. In such cases, more efficient and innovative markets, like the U.S., can gain volume by exporting the same body frame or major component to assembly facilities around the world.¹⁷

Virtuous cycle driving production, job growth, and R&D. R&D does more than drive near-term job growth: it sparks a reinforcing cycle of greater innovation leading to more production, jobs, and R&D. As FCA US, Ford, and General Motors hire workers and build their supply chains, the cost of doing business in the U.S. drops. As those costs drop, new firms move into the market, driving business costs down further. Here in the U.S., economies in the 14 states with automotive assembly plants are contributing to recent increases in automotive production, employment, and R&D. At a time when most other manufacturing sectors are declining, automotive investment and

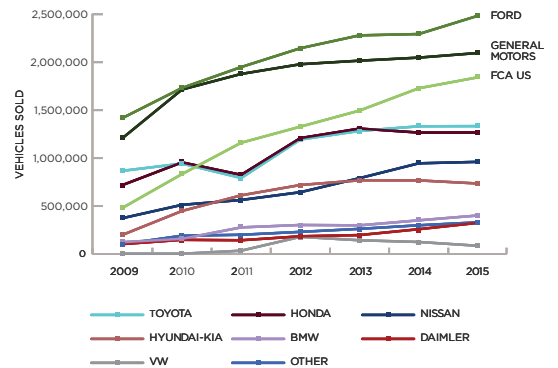
Filings by Fiscal Year

CHART D



Total U.S. Production: 2009-2015

CHART E



employment is growing. For example, one-half or more of both Ford and FCA US's new U.S. jobs in 2014 were science and engineering positions.

And, when new production leads to new labs, those labs encourage other automakers and suppliers to follow. Automakers and 46 of the world's top 50 global automotive suppliers have opened R&D facilities near FCA US, Ford, and General Motors's R&D centers.¹⁸

SOURCES

- ¹ Approximately 88 million vehicles were sold, worldwide, in 2015. \$115 billion in global R&D divided by 88 million vehicles sold equals \$1,307 R&D per vehicle sold.
- ² European Commission Joint Research Centre, *2015 EU Industrial U R&D Scoreboard*. This increase is particularly impressive because the automotive industry's revenues increased only 5.9% during that same period.
- ³ White House Council of Economic Advisors, *2016 Economic Report of the President* (February 2016), p. 222-223.
- ⁴ The National Science Foundation (NSF) estimates U.S. auto industry R&D totaled \$13.2 billion in 2012. Since that time, global auto R&D has increased by 9.9% each year. Assuming U.S. automotive research matched the global rate, baseline auto research totaled \$17.5 in 2015. New entrants into the automotive industry (including Apple, Google, Lyft, Tesla, and hundreds of start-ups) represent billions more in auto R&D.
- ⁵ National Science Board, *Science and Engineering Indicators 2016*.
- ⁶ Center for Automotive Research (CAR), *Just How High-Tech Is the Automotive Industry?* Hill, Kim, MPP, Bernard Swiecki, Debra M. Menk, and Joshua Creeger (January 2014).
- ⁷ CAR, *Just How High-Tech Is the Automotive Industry?* Hill, Kim, MPP, Bernard Swiecki, Debra M. Menk, and Joshua Creeger (January 2014).
- ⁸ National Science Board, *Science and Engineering Indicators 2016*.
- ⁹ White House Council of Economic Advisors, *A Retrospective Assessment of Clean Energy Investments in The Recovery Act* (February 2016), pp. 44-46. Recovery Act investments included \$2.4 billion on advanced batteries, \$600 million on biofuel research, and \$300 million on alternative fuel vehicles and alternative fuel vehicles for the federal government.
- ¹⁰ Assumes FCA, Ford, and General Motors's collective 2015 spending is equal to the yearly average of their collective spending from 2009 through 2014 (EU R&D Scoreboard).
- ¹¹ CAR, *Just How High-Tech Is the Automotive Industry?* Hill, Kim, MPP, Bernard Swiecki, Debra M. Menk, and Joshua Creeger (January 2014).
- ¹² United States Patent and Trademark Office, March 2015.
- ¹³ United States Patent and Trademark Office, March 2015. CAR, *Just How High-Tech Is the Automotive Industry?* Hill, Kim, MPP, Bernard Swiecki, Debra M. Menk, and Joshua Creeger (January 2014).
- ¹⁴ United States Patent and Trademark Office, March 2015. CAR, *Just How High-Tech Is the Automotive Industry?* Hill, Kim, MPP, Bernard Swiecki, Debra M. Menk, and Joshua Creeger (January 2014).
- ¹⁵ CAR, *The US Economy and CAR's US Automotive Forecast* (January 2016). Slide 33.
- ¹⁶ CAR, *The US Economy and CAR's US Automotive Forecast* (January 2016). Slide 34.
- ¹⁷ CAR, *Economic Contribution of the Ford Motor Company Michigan Assembly Plant to the Michigan Economy* (March 2013). Kim Hill, Bernard Swiecki, Deb Menk, Joshua Creeger, and Michael Schultz.
- ¹⁸ CAR, *Economic Contribution of the Ford Motor Company Michigan Assembly Plant to the Michigan Economy* (March 2013). Kim Hill, Bernard Swiecki, Deb Menk, Joshua Creeger, and Michael Schultz.