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Making cars smarter: The growing role of electronics in automobiles

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Electronics make up nearly 40% of the content of today's average new automobile, and their share will continue to grow. On June 2, 2011, as part of the eighteenth annual Automotive Outlook Symposium (AOS), the Chicago Fed hosted a panel of experts at its Detroit Branch to examine the current and future roles of electronics in motor vehicles.

Panel presentations are available at www.chicagofed.org/webpages/events/2011/automotive_outlook_symposium/index.cfm.

Today an average new automobile includes more than 40 electronic controllers, five miles of wiring, and more than 10 million lines of software code. Are cars becoming more like computers on wheels? What factors are behind the increasing use of electronics in automobiles? And what should we expect in the future? For example, will motor vehicles drive themselves one day? A panel of auto industry experts at this year's AOS[1] explored these and related questions. This *Chicago Fed Letter* summarizes the presentations and discussion of the panelists, who were Thomas Kurfess, professor and BMW Chair of Manufacturing at Clemson University; James Buczkowski, Henry Ford Technical Fellow and director of electrical and electronics systems research and advanced engineering at Ford Motor Company; Michael Smitka, professor of economics at Washington and Lee University; and Thomas Klier, senior economist at the Federal Reserve Bank of Chicago.

Functions supported by electronics

The panelists explained that vehicle performance and connectivity are the two primary functions supported by the increasing use of electronics in automobiles. The panel members said they considered the growing role of electronics in improving vehicle performance to be consistent with other long-term trends in motor vehicle production, whereas they noted the rising use of electronics in enabling connectivity in vehicles would likely cause substantial shifts in long-standing industry practices.

Vehicle performance

Most of the electronic content of motor vehicles supports their performance. Motor vehicles are made up of four principal systems: powertrain (the engine and transmission); chassis (the frame, including axles, wheels, and steering); exterior (the body); and interior. For several decades, automakers have assembled these four systems with large integrated modules or subsystems, which are supplied by independent parts manufacturers. In each of these four systems, one can observe that the role of electronics has been growing. For example, electronic parts have replaced mechanical levers for adjusting seat positions in the interior. More recently, electronics have begun to replace hydraulics in steering components of the chassis.

Electronics have been especially important in improving two aspects of vehicle performance: 1) refining the powertrain to reduce emissions and improve fuel consumption and 2) refining the chassis, exterior, and interior to improve vehicle safety and comfort (see figure 1). Most

of this growth in the use of electronics has been hidden from the driver's view.

The growing role of electronics in making motor vehicle performance better has had little effect on the traditional relationships between vehicle assemblers and parts suppliers.[2] That is, the development of performance-related electronic parts and subsystems continues to follow the traditional industry model, with the automaker atop the supply pyramid, long lead times prior to product launch, and vehicle specifications that last about four years. As electronics have become more prevalent, traditional suppliers of motor vehicle parts (e.g., producers of seats) have adapted to provide electronic capability in their products.

Connectivity

In contrast to electronics' increasing role in enhancing vehicle performance, the greater use of electronics to provide more in-car connectivity is more likely to lead to fundamental changes in the auto industry. Long gone are the days when the radio in the dashboard was the only connection to the outside world while driving. Portable electronic devices that provide connectivity, like smartphones and tablet computers, have become nearly ubiquitous. So consumers have come to expect the ability to stay connected via wireless phone or Internet while driving safely and lawfully. Such expectations for in-car connectivity have begun to shape the way automobiles are being used, designed, and marketed.

Until recently, entertainment was the principal purpose of in-car electronics. Kurfess reviewed the history of in-car entertainment. Galvin Manufacturing Corp., which became today's Motorola, introduced a fitted car radio in the 1930s. Blaupunkt first offered FM receivers for cars in 1952. The 8-track tape player was introduced as an option for in-car entertainment in 1965, followed by the cassette player in the 1970s, the compact disk player in the 1990s, the DVD player in 2002, and the MP3 player and satellite radio in 2003.

Entertainment continues to be one of the main reasons why people want technology in their vehicles, according to a survey by the Consumer Electronics Association (CEA), which Buczkowski summarized. For example, the ability to connect a digital media player to the car stereo was cited by many consumers as one of their top wishes for in-car entertainment. However, the top two in-car electronics items that consumers said they most wanted were not entertainment related: Topping their wish lists were voice-activated wireless communications and a dashboard display of real-time local information.

1. Performance-related automotive applications of electronics

Category	Examples
Passive safety restraints	Multiple airbags Tensioning seat belts Sensors (e.g., measuring tire pressure)
Active safety systems	Electronic stability control Adaptive cruise control Blind spot detection Lane departure detection
Drivetrain controls	Multiple sensors linking engine and transmission Electrically activated turbocharging
Fuel efficiency	Electronic steering Rapid start/stop systems

Source: Michael Smitka, 2011, "Vehicular electronics: Supplier issues," presentation at Automotive Outlook Symposium, Detroit, MI, June 2, available at www.chicagofed.org/digital_assets/others/events/2011/automotive_outlook_symposium/smitka_0602211.pdf.

In reaction to consumer surveys like the one conducted by the CEA, automakers have had to redesign the dashboard. The radio is still there, but communications and information functions, including navigation, have taken up more of the dashboard's space. Designing and integrating these connectivity functions have been especially challenging for automakers. Instead of going it alone, automakers have forged partnerships with established players in consumer electronics. For example, Ford has worked with Microsoft to create a connectivity system called Ford Sync.[3] According to Buczkowski, 70% of Ford vehicles sold in 2011 were equipped with Sync.

Four principles underlie Ford's connectivity strategy, Buczkowski explained. First, Ford has decided to leverage existing technology standards and formats rather than invent unique electronics systems for its vehicles. Second, the company will "ride along" with technology changes, such as the switch from 3G to 4G mobile phone technology. Third, Ford will provide consumers with a wide range of options so that they can express their preferences—such as the ability to reconfigure and personalize displays. Fourth, Ford's in-car connectivity must operate seamlessly with the consumer's home, office, and portable electronics. Automakers increasingly market their vehicles on the basis of their distinctive approaches to connectivity. Ford Sync is designed to differentiate Ford's vehicles from the competition, said Buczkowski, especially among younger buyers who expect to continue mobile phone calls as they enter their vehicles and search for nearby restaurants online while driving.

The increasing use of electronics to meet the rising demand for in-car connectivity presents many difficult challenges for automakers beyond those of the initial design and integration of new dashboards. Consumer electronics evolve at a pace that is much faster than what is typical for automobiles: Consumer electronics companies introduce new versions of their products every year or two, whereas auto manufacturers make major changes in their vehicles only once every four to six years. Furthermore, despite the fact that most of the connectivity hardware and software applications reside in the vehicle's dashboard, they tend to originate from a group of suppliers outside the traditional realm of automotive parts manufacturers. Consequently, automakers need not only to fundamentally restructure their internal electronics capabilities, but also to interact with electronic hardware and software companies that change their products at a much faster rate than auto companies are used to.

Given the disparity in product cycles for motor vehicles versus consumer electronics, automakers will likely need to make some difficult adjustments in

their approach to production. Chief among them should be to build greater flexibility into their vehicles' consumer electronics interfaces so that consumers can swap in successive generations of electronic devices. Achieving flexibility in the consumer electronics interfaces will address not only the disparity in product cycles, but also the fact that consumers typically keep their cars for much longer than their personal electronics. Because of such factors, automakers are now hard pressed to avoid obsolescence and to anticipate future trends in personal electronics.

At this time, it is unclear whose brands will come to the fore in tomorrow's automotive value chain. Competing with the auto assemblers (like Ford and Toyota) are the traditional suppliers (like Visteon and Renesas), as well as nonautomotive electronic hardware companies (like Pioneer and Apple) and software companies (like Microsoft and QNX). In the past, the branding power of the automakers triumphed over that of the parts makers. For example, Chevrolet, Chrysler, and Ford remain popular brands to this day, whereas Delco radios, Bosch antilock brakes, and Hydramatic transmissions have long since disappeared from most consumers' minds. In the past, parts makers' products changed from novel, branded technology to generic parts. It is too early to tell if in-car consumer electronics will share the same fate. For example, if consumer electronics brands remain prominent inside an automobile, ultimate control of automotive branding and marketing may change from automakers to consumer electronics firms. In the future, we may even see advertisements for an "iCar."

What drives the growth of vehicle electronics?

Smitka recapped the origins of performance-related electronics in motor vehicles, which go back to 1970. Regulation turns out to be the most important factor behind the increased use of electronics in automobiles. This trend started with the Clean Air Act, which was first passed in 1963 and then significantly amended in 1970. Motivated by the recurrent smog experienced in the Los Angeles basin, legislators, through the act, prescribed that cars be equipped with catalytic converters to control their emission of pollutants. Yet the three-stage catalytic converter necessary to control emissions to mandated levels required the oxygen level to be within a rather narrow range in order for the vehicle's exhaust control to function well. Such precise calibration of the oxygen level could only be achieved through the use of electronic sensors.

Vehicle performance and connectivity are the two primary functions supported by the increasing use of electronics in automobiles.

A few years later, in 1973, vehicle safety regulation required passive restraint systems. By the mid-1980s, airbags had become the safety technology of choice to supplement seat belts.[4] Today's airbags include a number of sensors not only to assure fast and accurate deployment, but also to prevent unnecessary deployment.

Fuel efficiency regulation was put into effect following the passage of the first law on corporate average fuel economy (CAFE) of new vehicles in 1975. What transpired after implementing this regulation represents another example of how the standards required by law could ultimately only be met by using electronics. Automakers employed technology such as fuel injectors and electronic engine control units to achieve CAFE standards. The use of these types of technology was possible because of the progress made in electronics—e.g., the development of early integrated circuits, as well as solid-state sensors (sensors without any moving parts).

In contrast to the increasing use of performance-related electronics, the current expansion of connectivity-related electronics in vehicles is being driven by consumer demand, rather than government regulation. In fact, regulation may be complicating the ability of automakers and their suppliers to increase in-car connectivity with electronics. For example, the rapid expansion of in-car connectivity has raised a number of safety concerns. Thus, the National Highway Traffic and Safety Administration considers driver distraction from in-car electronics to be a key policy issue.[5] While consumer demand for in-car connectivity is likely to grow, the auto industry may have to clear new regulatory hurdles to meet this demand.

What is ahead?

In general, the panelists agreed that the share of electronic content in vehicles would continue to grow for some time. For example, Kurfess said that the number of processors in cars would double over the next five years. What will the additional electronic capability likely be used for? Current testing and product trials suggest rather futuristic applications—such as vehicle-to-vehicle communication that reduces the chance of collisions; advanced navigation systems that adjust a car's engine to features of

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the terrain according to information on the route traveled; and systems that find and reserve parking, as well as place vehicles into tight parking spaces. Ultimately, cars may drive themselves (one possible application of this capability would be "platooning," where self-driving vehicles travel in tightly spaced groups on highways).[6] The importance of such applications will rise as traffic congestion and urbanization increase in both developed and developing economies.

While such applications offer a large potential for automakers to differentiate their products from the competition, the rising use of electronics in vehicles also presents a set of organizational and management challenges for them. For example, what best represents the core competency of vehicle producers when some of their automobiles' key features are defined by electronics? Will it continue to be mainly mechanical engineering? Or should automakers strive to define themselves as technology companies to complement their identities as engineering and design firms? And by accepting the strategic importance of electronics to automobiles, how can automakers most effectively integrate electronic capabilities into their organizations? These are just some of the tough questions automakers will have to answer in the coming years.

In addition, the growing presence of electronics in vehicles will likely lead to changes in the automotive supply chain—in particular, the auto assemblers' well-established relationships with their independent parts suppliers. Automakers have already started to interact directly with computer hardware and software providers, circumventing their traditional parts supplier networks. The growing role of electronics in automobiles will ultimately require lots of complex innovation, which in turn will lead to the development of new skill sets for both automakers and independent parts suppliers, as well as more partnerships with consumer electronics manufacturers.

[1] The rest of the AOS is summarized in William A. Strauss and Norman Wang, 2011, "Economy to keep cruising along in 2011 and 2012," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 289a, August.

[2] Since 1980, the share of a vehicle's content that is provided by independent parts suppliers has grown substantially, but not because of the increased use of electronics. See Thomas Klier and James Rubenstein, 2008, *Who Really Made Your Car? Restructuring and Geographic Change in the Auto Industry*, Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.

[3] The system's full name is SYNC powered by Microsoft. Sync is part of Ford's electronic interface called MyFord Touch.

[4] In the United States, airbags did not become mandatory until the late 1990s.

[5] See www.distraction.gov.

[6] See also John Markoff, 2011, "Google lobbies Nevada to allow self-driving cars," *New York Times*, May 10, available at www.nytimes.com/2011/05/11/science/11drive.html.