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May 2, 2018

Mr. Peter Cipriano
Special Assistant to the Administrator
U.S. Department of Transportation
Docket Operations, M-30
West Building Ground Floor
Room W12-140
1200 New Jersey Avenue, SE
Washington DC 20590

Docket Number FRA-2018-0027

Dear Mr. Cipriano:

On behalf of the Information Technology and Innovation Foundation (ITIF) I am pleased to submit the accompanying ITIF report in response to the Federal Railroad Administration's Request for Information on Automation in the Railroad Industry (Docket Number FRA-2018-0027) published March 29, 2018. ITIF was recently recognized as the world's leading think tank for science and technology policy.

The report, *How Regulatory Reform Can Advance Automation in the Freight Transportation Sector,* looks at advances in automation in several freight industries, including railroads. It argues that automation on balance can deliver strong benefits to society in the form of lower costs and increased safety. It calls for regulators to encourage the development of this new technology while still protecting public safety and suggests a set of principles for regulators to follow.

Thank you for the opportunity to submit this report.

Sincerely yours,

Robert D. Atkinson
President and Founder
Information Technology and Innovation Foundation

How Regulatory Reform Can Advance Automation in the Freight Transportation Sector

BY JOE KENNEDY | JUNE 2017

In industries such as railroads, trucking, and commercial drones, regulators are struggling with rapid advances in automation that promise significant safety and efficiency benefits to society.

Although technological advancements are creating the potential to increase automation in many industries, regulations often prevent companies from capitalizing on these opportunities, in part because regulators often give less emphasis to productivity and innovation than they deserve. Intelligent regulatory reform can remove barriers to innovation and significantly increase economic growth. Unfortunately, regulatory reform is much more difficult to accomplish than other major initiatives, such as tax or health-care reform, because change requires a detailed knowledge of the forces shaping each individual industry. The transportation sector offers a good case study of these opportunities and challenges. In industries such as railroads, trucking, and commercial drones, regulators are struggling with rapid advances in automation that promise significant safety and efficiency benefits to society. Examining how different regulators have encouraged or hindered this automation offers important lessons for other sectors.

INTRODUCTION

Regulatory reform offers tremendous benefits to society in a number of economic sectors. Bad regulation often imposes unnecessary costs on the economy without producing corresponding social benefits. In highly innovative industries, these costs can slow or even stop the introduction of productivity-enhancing technology.[1] But, perhaps even more important, wise regulation can actually speed valuable innovations by reducing uncertainty,

strengthening market incentives to improve performance, and easing public acceptance of new technology. Market innovations bring many benefits, but they also affect important public goals, such as safety and the environment. While it is always important to regulate wisely, it is especially important in highly innovative sectors. Regulators have to find the right balance between encouraging unproven, but promising, technologies and protecting the public interest.

The complexity and interdependence of modern economies often demands some degree of regulation, because markets failures, lack of competition, and imperfect knowledge can allow some parties to take advantage of others. As a result, regulatory action touches virtually every sector of American society. However, the specifics of regulation are governed by many statutes and agencies, making central decision-making very difficult. The Administrative Procedures Act makes it difficult to impose new regulations by requiring agencies to build a public record supporting any new rules and engage in an extended process of public notification, comment, and agency response to proposed decisions;[2] however, the same requirements slow the process of revising or removing old regulations, even if they are clearly outdated. Perhaps the greatest barrier to reform, however, is that sensible regulation requires a detailed knowledge of all the major forces influencing a particular industry or market, as well as a clearly articulated vision of what the market should look like, not only now but far into the future.

It is also important for regulators to be consistent, especially when different industries compete with each other. Industries that face more onerous regulation will have a tougher time competing against less regulated ones, distorting competition. The challenge is especially acute when each industry is regulated by a different agency. It is even more difficult when each industry is facing different technological challenges and opportunities.

The freight transportation sector is a good example of the challenges modern regulators face. Industries such as trucking, airlines, railroads, and, in the future, drones all compete against each other in the delivery of physical goods across land. At the same time, they all cooperate with each other to coordinate hand-offs and minimize the total cost of delivery. Each industry is also struggling to integrate new technology. In particular, technology is allowing for a much greater degree of automation in each industry. Done right, such automation could increase productivity, reduce accidents, ease labor shortages, and reduce pollution. Interestingly, trains, aircraft, and trucks are each subject to a different regulator, allowing for a comparison of different approaches to the common problem.

This paper reviews how federal regulation of the transportation sector has changed over the last 50 years. This is followed by a set of principles that should guide regulators as they approach their task. With regard to safety or any other variable, regulators should try to classify issues into a two-by-two matrix according to, first, whether regulatory goals such as safety are prominent or not and, second, whether or not the industry is experiencing rapid innovation. Efficient regulation is especially important in cases where regulatory goals are

prominent and the potential for innovation is high. The report closes with a brief comparison of how each transportation regulator has handled automation technology.

The premise of this report is that automation technology offers significant benefits to society in the form of lower costs, greater safety, reduced fuel use and emissions, and faster delivery times. Regulators should assume that much greater automation is not only inevitable due to technological improvements, but it is also desirable. The challenge is to aid its development in a way that protects safety.

A SHORT HISTORY OF FEDERAL REGULATION IN THE TRANSPORTATION SECTOR

The rapid growth of the regulatory state after the New Deal resulted in a heavily regulated transportation sector. Each industry faced extensive rulemaking that governed company structure, routes, prices, and firm entry and exit. In essence, regulators took on the job of optimizing the market, ensuring that competitors enjoyed a sufficient rate of return, and that supply matched demand, not only nationwide but also in numerous local and regional markets.

Freight automation offers significant benefits to society in the form of lower costs, greater safety, reduced fuel use and emissions, and faster delivery times.

During the Carter and Reagan administrations, a number of academic papers suggested that regulation might actually be increasing prices and reducing innovation in each of these industries. Regulation was being used to prevent competition and guarantee incumbents an adequate profit rather than to respond to clear market failures. The result was reduced innovation and efficiency. A series of deregulation bills returned a great deal of power to the private sector and even eliminated some agencies, such as the Civil Aeronautics Board. During the intervening decades, transportation industries have undergone a profound shift, including robust productivity growth, lower prices, reengineering around modern supply chains, industry consolidation and, more recently, automation.

Today, federal regulation is primarily concerned with public safety, the environment, and market competition. The various regulators enforce a number of safety and recordkeeping requirements on companies within their jurisdiction. Together with the Department of Justice and the Federal Trade Commission, they also review the impact of mergers within their industries. The concern over public safety has forced regulators to deal with technologies that promise to automate various aspects of operators' duties. In some cases, such as positive train control and electronic logging devices, regulators have required the adoption of technology in order to improve safety. In other cases, such as the use of one-person crews on trains and drones generally, they have used safety concerns to delay the introduction of new technologies and methods, perhaps at the cost of losing huge public benefits. The next section offers regulators a framework for evaluating this challenge.

SIX PRINCIPLES FOR REGULATING PRODUCTS

One could excuse regulators for feeling besieged in the current political climate. Their budgets are stretched and often subject to last-minute political stalemates. Companies and interest groups constantly press them for more or less regulation in this or that area, often appealing to Congress or the courts when the agency disagrees. Should a significant safety lapse occur, the public is sure to wonder why the regulator did not do its job. Meanwhile,

technological change continues, demanding ever deeper knowledge of how it might affect society.

Part of the problem, however, does lie in the mindset and approach of regulators. Regulators often make two common mistakes in how they approach their job. The first is to concentrate too much on the process by which business should operate in order to accomplish regulatory goals, rather than the outcomes themselves. The latter approach leaves it up to the industry to find the optimal technology and business practices to meet the desired outcomes of the regulation. Ideally, outcomes-based regulation does more than just reduce the cost of attaining a certain level of safety: It also encourages innovation that strikes a better balance between cost and performance over time.[3]

The second mistake is a lack of data-driven, evidence-based decision-making in developing regulations. In recent years, it has become increasingly easy and cheap to gather massive amounts of data on any industry. The real challenge has been to decide which data is important and then integrate the data into the regulatory process to improve the regulator's understanding of the industry and produce better regulatory decisions.

Regulatory performance can be significantly improved by following six main principles. These principles do not apply only to regulators. They should also guide the actions of Congress and the industry itself. Regulators deserve broad support because they can help achieve social goals and address market failures. But they can also significantly increase industry innovation and productivity by reducing uncertainty, speeding decision-making, and reassuring the public that the introduction of new technology will not compromise safety or other social values.

1. Welcome Technology

Regulators should start with the premise that technological progress can solve many problems. They should therefore welcome technological development, and act to speed the process of making it safe and reliable and introducing it into markets, rather than act as gatekeepers who slow the pace of innovation. This process is seldom helped by adopting the precautionary principle, as the Europeans do, which holds that new technology should not be introduced until it has been proven not to present any risks to society.[4] Instead, regulators need to acknowledge that innovations always involve failures and mistakes, some of them serious. The ultimate question is whether the technology, once fully developed, would deliver significant benefits to society. If it would, then regulators should try to facilitate its development, while still ensuring public safety and other important goals. The mere presence of obvious risks, even if serious, should not in itself condemn a new technology to a snail's pace, at best, of progress.

2. Acknowledge the Other Forces Encouraging Companies to Act Responsibly

Regulators should only act when there is a clear market failure. Some policymakers incorrectly assume that, absent regulation, companies would lack an incentive to protect the public, but this is not always the case. Many market and legal forces reign in company behavior even absent regulation. This is especially true in the transportation sector. For one

thing, planes and trains are extremely expensive. Any accident that destroys one or shuts down service has a direct effect on a company's profitability. Tort law also holds firms liable for any damage that their negligence causes to others. In product liability, negligence is defined broadly. Finally, the net worth of a company is increasingly tied up in its brand and the loyalty of its most valuable workers. Both can suffer quickly if the company makes mistakes. In the age of Twitter and smartphones, bad incidents can have an immediate impact on the company's value. When United Airlines recently asked airport police to take a passenger off a plane, the incident became national news within a day.[5] Airports around the country announced that their police would no longer intervene in disputes between airlines and passengers. United issued refunds to all passengers on the plane and settled a lawsuit by the removed passenger. It also announced that in the future it would pay up to $10,000 to passengers who are bumped from a flight. The stock price fell almost 10 percent over the next week (although it has more than recovered since then), and the CEO lost a promotion to board chairman. At this point, regulatory action seems like an afterthought. Significant injuries due to the premature or inept introduction of automation technology would create a similar public-relations disaster. Companies have many incentives to avoid this on an individual level, as well as to create norms and best practices to prevent this among their peers.

Regulators should not possess a strong bias for the status quo, but instead should welcome the possibility of dramatic improvements in performance and price.

3. Allow for Different Futures

When regulators create rules for an industry, they should avoid policies that favor a particular technology or business model. Every industry changes over time. In cases where technology, markets, or economic forces are changing rapidly, industries may look dramatically different a decade or two from now. Regulators should not possess a strong bias for the status quo, but instead should welcome the possibility of dramatic improvements in performance and price. They should also be agnostic on the exact way in which social goals are met. In the past, agencies regulated the prices and routes within industries in an attempt to balance profitability, availability, and affordability. Then they discovered that the market could handle these decisions. In the same way, companies are often capable of discovering better technology and management practices on their own. The freer they are to implement them, the faster the industry can progress. A good example is Uber's vision of flying cars.[6] It is possible that the technology will never advance far enough. Even if it does, the economics of flying cars may not justify the large investments that are required. Finally, for one reason or another, public acceptance may be too low. But the regulator should view such possibilities with interest and hope. Efforts to revive supersonic air travel present a similar opportunity. In fact, by setting out clear safety standards for getting regulatory approval, agencies can dramatically reduce the cost of developing new technology.

4. Distinguish Between Substantially Different Technologies

Regulators should recognize the diversity of technological solutions and tailor regulation to specific technologies, rather than treating substantially different technologies the same. Technology tends to advance in stages, and not every stage needs the same level of

regulation. For instance, a passenger car's level of automation is often rated on a zero-to-five scale developed by the Society of Automated Engineers. A level-zero car has no automation. At level one, technology helps in steering or acceleration and deceleration, although the driver remains in full control. Only at level five is the driver not needed. Federal policy has drawn a distinction between technology that assists drivers while they are in control and technology that largely replaces drivers, subjecting the former to relatively little regulation. The Federal Aviation Administration has made a similar distinction between micro-drones and larger ones that could create more damage if they were to fail. Such distinctions in regulation allow a technology to be introduced gradually, as firms work out the technology's more complicated and sensitive aspects.

5. Provide Regulators the Necessary Resources

Congress should provide regulators the necessary resources to make timely and correct decisions. Agencies need the financial resources and staff sizes to be able to monitor and understand how the industry is evolving. Unfortunately, the growing squeeze of mandatory spending programs has placed increased pressure on all discretionary programs, including the budgets of most regulatory agencies. Human talent is especially important. Regulators need to be able to attract and retain people who are experts in both current and emerging technology. That means they must be able to pay wages that are competitive with those in the private sector. Too often, the agencies serve as training grounds from which their best employees leave for more lucrative salaries in the regulated industry. The gap between private and federal compensation generally increases for more educated workers, making it harder to retain them.[7] Regulated firms need to become effective advocates for their overseers to ensure that Congress gives the regulators sufficient resources but also makes sure that they are spent efficiently. Otherwise, regulatory actions will be delayed and uninformed.

6. Make Timely Regulatory Decisions

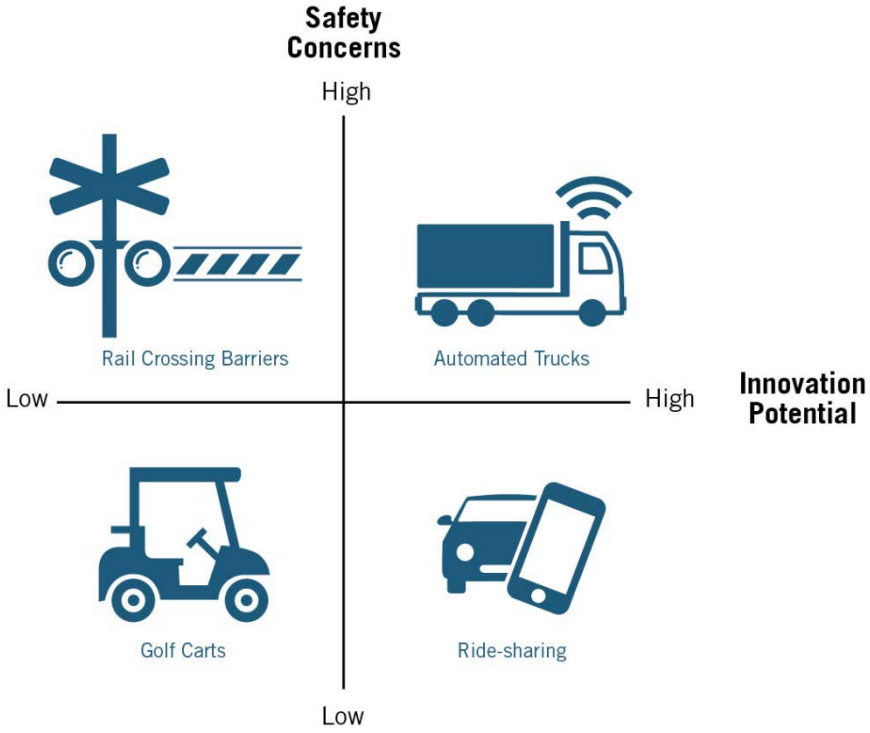
Regulators should make timely decisions to keep up with the pace of innovation. The formal regulatory process of announcing preliminary regulations, accepting public comments, and issuing a final rule can take over two years. Even then, the final rule may be held up in court challenges for several more years. This makes it hard to adapt regulatory rules to an industry experiencing rapid changes. Regulators can do two things to address this problem. The first is to try and write rules that set broad safety and other standards that firms need to comply with, but avoid stringent rules that constrain how a business achieves a particular regulatory goal. While a regulator might want to establish a safe harbor, holding a firm harmless if it uses specific technology, it should also allow for the ability to meet the standards in a better, more efficient way. Specifically, firms need to know the regulatory requirements for using new technology. Where this cannot be set in advance, the agency should be in constant dialogue with the industry about how existing regulations apply to new technology and how those regulations can be rewritten or reinterpreted to allow a better outcome.

BALANCING PUBLIC SAFETY WITH INNOVATION

Smart regulation matters most when the stakes are highest. The stakes can be high when either an important public priority, such as safety, is clearly affected or when the potential for innovation is especially high. Not every regulatory decision is equally important. It can help to classify situations according to a two-by-two matrix that takes into account the implications for a certain public good, in this case safety, and the innovation potential of an industry (see examples in figure 1).[8] Some aspects of regulation only have a limited effect on safety or do not affect it at all. Others, such as proper train maintenance, affect safety quite a lot. Similarly, some industries or aspects of a particular industry are ripe for significant innovation, while others are not.

The potentially fast pace of innovation increases the cost of poor regulation, since bad rules can significantly delay the implementation of new technology and business methods.

Figure 1: Innovation and Safety Matrix for Regulation in the Transportation Sector



In the quadrant representing low safety concerns and low innovation potential, a regulatory agency is dealing with issues that have minimal impact on safety and show little promise of innovation. A good example would be golf carts, which pose little safety risk but are also experiencing little automation. Regulators should generally refrain from rulemaking and let markets guide firm behavior. Firms still have an incentive to both innovate and maintain public safety. However, because safety concerns are low, the cost of any mistakes is also likely to be low. In these cases, the proper reaction can be left to tort law and, if necessary, regulatory adjudication after the fact, such as a fine or recall. The threat of legal liability should generally be enough to provide firms with the necessary motivation to give due regard to safety. The slow pace of innovation minimizes the chance that any industry changes will have unexpected negative effects.

The quadrant where safety concerns are low and innovation potential is high is perhaps the most promising for reform. Good examples are micro-drones, ride-sharing, and fuel efficiency. The fact that safety concerns are minor removes much of the justification for regulation. At the same time, the potentially fast pace of innovation increases the cost of poor regulation, since bad rules can significantly delay the implementation of new technology and business methods. Sensible deregulation can therefore increase productivity at little risk to other goals, such as safety. Here again, most issues should be left to the market to sort out. The regulator's role should be limited to scrubbing existing rules to make sure that they are not imposing unnecessary barriers to innovation.

The opposite corner of the matrix is where the risk to safety is high, but the pace of innovation is low. Two good examples are road barriers at railroad crossings that prevent cars from crossing a track when a train is coming and weight limits on existing planes. While the regulator should still try to set general goals and leave companies as much freedom as possible to find the best way to accomplish them, the cost of setting specific standards that leave very little room for discretion is much less than in the two quadrants with high innovation potential. First, the benefits of achieving specific safety standards are by definition high in these cases. Second, if the regulator does set overly restrictive standards, the cost in terms of foreclosed innovation is by definition low. Even in the absence of regulation, firms are unlikely to introduce new ways to dramatically improve the safety/cost ratio. In contrast, the potential for negative unintended consequences is high. It makes sense for the regulator to err on the side of caution.

The most difficult tradeoffs occur in the last quadrant, where both the potential for innovation and the safety concerns are high. In the long-term, these areas offer the greatest opportunity for higher productivity because we can find much better (as opposed to marginally better) ways to achieve very important goals (as opposed to minor goals). Automation in a number of transportation industries falls into this category.

In this quadrant, regulators should set strong safety standards but also give firms a lot of discretion about the best way to meet them. Markets and the tort system are less able to effectively deal with high safety risks, especially when they involve serious injury or death, without introducing an unacceptable margin of error. However, the high pace of innovation holds out the hope of achieving greater levels of safety than are available today and at a significantly lower price. Overly prescriptive regulations will impose a large, but often unnoticed cost on society in terms of innovation and even safety. It is always possible to increase safety by installing more equipment, running more tests, slowing speeds, and more, but an industry can only sustain itself if there is a wise trade-off between safety and other important goals such as reasonable profitability (which ensures a healthy supply), affordability (which ensures a robust demand), and innovation.

The regulator should find the right balance between encouraging promising technology and assuring an appropriate level of safety. Agencies should make sure that regulations are

not imposing unnecessary costs, but are achieving their goals. They should also keep current on new technology and its implications for safety. This typically requires a heavy investment in data collection, analysis, and the personnel and procedures necessary to make timely decisions. General standards continue to be the best approach, but it is just as important that companies have a clear idea of the criteria for successfully implementing new innovations. Regulators need to be in constant communication with the industry regarding the promise that future innovations offer and how current laws and regulations would apply to them.

It is important to note that issues may move from one quadrant to the other. In particular, regulators' attitude toward innovation can shift the pace of innovation itself. Firms are unlikely to invest in new approaches if a regulator has a reputation of preventing them from being implemented. On the other hand, a more welcoming approach can motivate companies to spend more money on research, thereby increasing the pace of innovation. Similarly, smart efforts to encourage the right type of innovation might result in discoveries that can lower the relevant safety concerns.

As mentioned above, each transportation industry is currently experiencing significant innovation related to automation. Automation increases productivity, and therefore lowers costs and increases national income. While it threatens some jobs in the short-term, overall it results in the same number of jobs at higher wages.[9] The combination of ubiquitous sensors, massive computing power, rapid communications, and improving artificial intelligence will continue to shift the boundary between those tasks that can successfully be automated and those that still require a human operator. Over time, these systems will become even better than the most experienced human operators. Since the technology is not going away and the benefits are so promising, regulators must figure out how to integrate it safely into the industry. The push for automation is playing out differently in each sector, and each regulator has adopted a different approach to the challenge. The following case studies try to extract common lessons from these experiences. They cover the introduction of one-person train crews, fully autonomous trucks, and commercial drones. The emphasis is on movement of freight over land, but similar technology is affecting marine and commercial travel, and private automobiles.

RAILROADS AND THE FEDERAL RAILROAD ADMINISTRATION

The primary issues regarding automation in the railroad industry involve the installation of positive train control (PTC) and the implementation of single-person crews. Class I railroads (used to transfer most railway freight) currently face a congressional mandate to implement PTC technology by the end of 2018, although further extensions are available until the end of 2020 to allow testing.[10] PTC is an integrated set of information technologies to monitor and control train movement. According to the Association of American Railroads, PTC systems must be able to "determine the precise location, direction, and speed of trains; warn train operators of potential problems; and take immediate action if the operator does not respond to the warning provided by the PTC system."[11] A PTC system could, for example, impose a maximum speed when a train

approaches a curve, avoid collisions by stopping trains on the same track, and prevent a train from entering tracks on which repair work is being done. In the United States, at the end of 2016, railroad companies had installed PTC equipment on 38 percent of route miles and 63 percent of freight-car locomotives, and they had put in place 77 percent of base-station radios (used to communicate between command centers and field users).[12] Similar systems are widely used in Europe and should make train operations safer. They should also significantly reduce the demands on human operators.

Although PTC implementation is proceeding apace, it has recently become intertwined with the movement to single-person crews. PTC performs many safety checks and reduces reliance on the engineer, thus making it less important to have a second crew member in the locomotive cab. As a result, some railroads have gradually been implementing single-person crews on more of their lines.[13] The Federal Railroad Administration (FRA) recently issued a Notice of Proposed Rulemaking (NPRM) that would require FRA approval for each line planned to be staffed by a one-person crew.[14]

At first glance the proposed rule looks reasonable. FRA states that its primary concern is public safety. It details the benefits of having a second crew member in the locomotive or nearby to assist the engineer. FRA proposes allowing most existing one-person lines to continue to operate, provided the railroad notifies FRA of their existence. For new lines, the proposed rule would require the railroad to show how its use of technology and operating procedures would compensate for the loss of a second crew member.

A closer look, however, raises concerns about whether FRA is unnecessarily delaying the use of new technology that could reduce costs and possibly increase safety. A primary motive for going to one-person lines is to reduce operating costs. But the automation needed to accomplish this could have the secondary effect of producing technologies that also improve safety. Looked at another way, companies have a continuous incentive to improve safety, but it may not be profitable to develop automation that increases safety unless companies are allowed to reduce other operating costs, including labor, as they become unnecessary. One key factor will be the general attitude a regulator adopts when applying its new rule. But even looking at the language of the rule, there is cause for concern. The widespread implementation of PTC should itself reduce much of the need for a second crew member, yet the FRA gives little analysis to this issue except to say that it is not convinced that PTC, by itself, will be sufficient to justify one-person crews.[15]

The FRA's interest in the issue seems to be motivated by two railroad accidents that occurred in 2013.[16] However, neither of these accidents involved a moving train being controlled by a one-person crew. The first involved the failure to correctly set the brakes on a stopped train, and the second involved an accident where the FRA determined that the presence of multiple crew members was helpful in responding to the accident after the fact. The agency also expressed surprise at the degree to which one-person crews were already operating on railroad lines.[17] In its notice accompanying the proposed rule, FRA admits it lacks safety data regarding the choice of one- versus two-person crews.[18] Given the

conclusions of the Oliver Wyman study discussed below, it appears this was due to a lack of effort rather than a lack of data.

The FRA seems very concerned that the introduction of PTC could have unintended consequences on the locomotive engineer's cognitive requirements. It seems to largely discount the significant safety impacts that were used to justify the investment of tens of billions of dollars in these systems. The agency seems to view PTC systems as presenting unknown risks rather than clear benefits that will significantly improve public safety. It also appears to claim that, because its safety regulations were written with the unstated expectation that nearly every train would have at least two crew members, it is justified in making that expectation explicit, even absent any evidence of a safety problem.[19]

The freight rail industry opposes the proposed rule.[20] As part of its response to the NPRM, the Association of American Railroads commissioned a safety study by management consulting firm Oliver Wyman of single-person crews in both the United States and Europe.[21] The study alleges that "By its design, PTC-based monitoring will render redundant the additional person in multiple-person train crews on affected routes."[22] It also reports that "the use of single person crews for trains is widespread in developed markets similar to the United States in size and complexity. In Europe and Australia for example, the use of single-person crews is the dominant practice on many freight railroads, including those in Germany, France, Sweden, Australia, the United Kingdom, and Queensland/New South Wales."[23]

The combination of positive train control and one-person crews may be able to deliver reduced costs and potentially enhanced safety.

The study first compared the experience of one-person and two-person crews within the United States between 2007 and 2013 and concluded that "single-person train crew operations were as safe as multiple-person train crew operations."[24] It then analyzed the record against Europe, where trains operate with PTC systems. Its analysis of the relative safety records showed there was little evidence that the European systems were less safe. In fact, by many measures they seemed to outperform American railroads.[25] Finally, the Oliver Wyman study attempted to measure the cost savings that might accrue from implementing one-person crews. It determined that, under conservative assumptions, the industry could save as much as $900 million in 2020, rising to $1.9 billion by 2029.[26] Given the competitiveness of freight delivery, a substantial share of these savings would be passed on to shippers in the form of lower shipping costs.

The study provides evidence that the combination of PTC and one-person crews may be able to deliver reduced costs and potentially enhanced safety. If its findings are true, and FRA admits that it lacks sufficient information regarding the impact of larger crews on public safety, then FRA's approach to automation should be more welcoming. This is especially true since, even in the absence of regulation, railroads face strong pressure from customers, local governments, and the general public to operate safely and efficiently. Although FRA portrays its rule as merely ensuring that "each railroad implementing one-person operations has adequately identified potential safety risks and taken mitigation measures to reduce the chances of accidents, as well as the impact of any accident that may

still occur," it has actually given itself the power to second-guess those decisions even though it has no evidence of a safety problem and even though it lacks the situation-specific knowledge to make those determinations.[27] Although FRA "does not foresee that any particular existing or start-up operation could not meet the appropriate level of safety standard with some conditions added," the proof will be in how often FRA requires additional conditions and whether these conditions are reasonable.[28] FRA's general approach to the issue of automation will also play an important role in how fast the safety benefits of automation advance.

TRUCKS AND THE FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

MIT's *Technology Review* listed self-driving trucks as one of its 10 breakthrough technologies earlier this year.[29] Its progress benefits from similar research for passenger cars. In the car market, large Internet platforms such as Google and Amazon are both cooperating and competing with established auto manufacturers and specialty companies such as Tesla and Mobileye (recently purchased by Intel) to develop the information platform controlling the car of the future.

Heavy and tractor-trailer freight trucks carry roughly 70 percent of the freight that factories and consumers use. The American Trucking Associations (ATA) forecasts that freight tonnage will grow by 27 percent over the next decade.[30] The industry is regulated by the Federal Motor Carrier Safety Administration (FMCSA), which specifies basic safety requirements. Individual states also impose their own requirements in some areas such as vehicle size and weight. In both cars and trucks, developers of automation technology have been able to move their research to states with friendly regulation.

In some respects, automation in the trucking industry has progressed further than it has in personal cars.[31] This is partly because the technological challenge is easier: A higher portion of truck miles is driven on highways, where the presence of pedestrians, intersections, and detours pose less of a problem. Moreover, the economic case is stronger. Autonomous technology costs are a smaller share of total vehicle costs for trucks than for cars. And to the extent the technology allows some elimination of drivers, it can save money for trucking companies, thereby justifying the automation expense.

In 2015, the nation's largest heavy-duty truck manufacturer, Freightliner, received permission to test its prototype 18-wheeler, the Inspiration Truck, in Nevada. Its automation system allows the truck to take over steering, braking, and accelerating from the driver. If the software detects that it cannot handle upcoming conditions, it begins a 20-second transition back to the human driver, who must remain behind the wheel at all times.[32] Last year a truck from Uber's self-driving truck division drove 120 miles from Fort Collins to Colorado Springs to deliver a load of beer.[33] Although a driver was in the cab, he was not in the driver's seat during the highway portion of the trip. Uber's division, Otto, launched in January 2016 and developed its first prototype that May. Its technology can be retrofitted to existing trucks.

There is some debate about the degree to which truck automation will replace human drivers. Current technology improves the quality of driving. A recent presentation by FMCSA points out that automation is not an all-or-nothing deal. Trucks already can implement components of it, including forward-collision warning, lane-departure warning and smart cruise.[34] The Obama administration issued a report forecasting that 1.3 million to 1.7 million heavy and tractor-trailer truck drivers might eventually be replaced by automation, although the report did not give a time line.[35] However, during a recent congressional hearing, a representative from the trucking industry testified that he did not foresee significant driver replacement for the foreseeable future.[36] These jobs have a lower automation score than the national average for the total workforce.[37]

Autonomous trucking would produce large safety benefits.

More probably, automation will help the industry deal with an existing shortage of drivers that experts forecast will grow over the next decade. The American Trucking Associations estimates the current shortfall at 48,000 drivers and predicts it could reach 175,000 by 2024.[38] The shortfall is made worse by difficult working conditions, including safety risks, and in many cases, relatively poor wages.[39] Current speculation is that automation will be confined largely to grade-separated highways. Drivers will monitor and fix the system's onboard computers and handle in-city driving. A driver might take a truck to the highway, punch in an automated trip to its destination city, and hop out. Once there, the truck might sit in a trucking station until another driver takes it to its final destination. In addition, some companies are experimenting with platooning, where vehicle-to-vehicle communication allows a convoy of trucks to follow each other at closer distances than human drivers can safely maintain. Current platooning allows the front truck to use 4.5 percent less fuel and trailing trucks to use 10 percent less fuel, with a corresponding decline in emissions.[40] In platoons, only the first truck would be manned by a human driver. Widespread platooning is more likely in the medium-term than full automation of all trucks.

Autonomous trucking would produce large safety benefits. There are roughly 400,000 truck crashes each year, resulting in about 4,000 casualties. Almost all of these are due to human error, many of them caused by driver fatigue.[41] To date, FMCSA has not been actively involved in regulating automation technology. The Transportation Research Board devoted a panel discussion to the topic at its annual meeting in January this year. During the discussion, ATA's president argued for a federal role, partly to ward off the possibility of conflicting state requirements. FMCSA also held a public listening session concerning highly automated commercial vehicles on April 24, 2017.[42] But it has yet to take any affirmative action on specific rules.

In 2016, years after widespread testing by Google and other companies, the National Highway Traffic Safety Administration (NHTSA) issued a policy report setting out a possible basis of regulation for the automation of passenger cars.[43] The agency currently sets out Federal Motor Vehicle Safety Standards, and manufacturers self-certify that the vehicles they sell comply with these standards. As long as a car meets all existing standards,

no federal law prevents offering an automated vehicle for sale.[44] NHTSA made clear that its report applies to trucks as well as passenger cars.

The policy document focused on three realities: The rise of autonomous vehicle technology is inevitable; the government can increase safety improvements by setting out early guidance; and we will continue to get more knowledgeable about the technology as it advances. The document identified the government's task as being "to ensure public safety while establishing a strong foundation such that the rules of the road can be known, understood, and responded to by industry and the public."[45] The report noted that "the speed with which [highly automated vehicles] are advancing, combined with the complexity and novelty of these innovations, threatens to outpace the agency's conventional regulatory processes and capabilities."[46] It also pointed to a shortage of suitable candidates to meet the agency's critical hiring needs.[47] NHTSA strongly encouraged states to cede all regulation of automated vehicles' performance to the Department of Transportation.[48]

The NHTSA also committed to issuing simple automated vehicle-related interpretations of existing law within 60 days and ruling on simple exemption requests in six months.[49] Although the document is not mandatory, it does request that companies voluntarily provide reports on how they are following the guidance. NHTSA plans on making safety assessments mandatory in the future. FMCSA is developing a separate document to address the needs of the trucking industry. In comments to NHTSA, the Center for Data Innovation, a research center affiliated with the Information Technology and Innovation Foundation (ITIF), noted that automated vehicles can offer many social and economic benefits and commended the agency for issuing its policy report.[50] The center urged the agency to encourage data collection and sharing, so that the industry and regulators could create a rapid-learning network resulting in higher performance standards across the board. But it did caution the agency against regulating privacy in autonomous vehicles, arguing that the current FTC and voluntary industry frameworks are more than adequate.

DRONES AND THE FEDERAL AVIATION ADMINISTRATION

It might surprise people to know that the flying of commercial airlines is already highly automated, with pilots usually involved only for a few minutes during takeoff and landing. This high degree of automation in airplanes has existed since the early 1980s. Currently, government agencies are experimenting with replacing the copilot, or perhaps both pilots, on cargo planes with either robots or remote operators.[51]

Automated airlines have been significantly advanced by strong support from both the military and the National Aeronautics and Space Administration (NASA). Both institutions regularly spend billions of dollars on both basic and applied research related to flying and to keeping pilots safe. Their willingness to develop and test the technology reduces the burden on the Federal Aviation Administration (FAA). The Defense Advanced Research Projects Agency (DARPA) is currently testing a robot that can act as the copilot on military aircraft. Meanwhile NASA is exploring having a remote copilot serve for

multiple flights on commercial routes. The debate mirrors the one that occurred in the 1970s when airlines went from three persons to two in the cockpit. As in trucking, part of the impetus for automation stems from an anticipated pilot shortage, especially at regional airlines.[52]

One promising commercial innovation is drones. These highly automated flying vehicles are controlled by humans on the ground. A number of companies, including Amazon, are trying to develop sophisticated drones that could be used for a variety of important tasks. Amazon would like to use drones to cover the last few miles of package delivery, allowing it to deliver many orders within an hour of placement. Other important uses are likely to include crop inspection, infrastructure inspection, and traffic reporting. In 2013, one report estimated the total potential economic impact at $82 billion between 2015 and 2025.[53]

The FAA's delay in creating permissive drone rules has had real consequences.

Commercial drone development has been slow. One major cause of this delay in the industry's development is that FAA took a long time to develop regulations and, once it did create rules, the agency imposed a number of strict limitations on the technology. The FAA Modernization and Reform Act of 2012 gave the agency a deadline of September 30, 2015, to publish regulations allowing the use of commercial drones. The act deferred to the FAA for commercial operations, but allowed noncommercial flights to occur if they followed special rules for model aircraft.[54] Prior to creating licensing rules for commercial activity involving drones weighing less than 55 pounds, the FAA took the position that commercial drone operation was illegal and required that all commercial drone operators apply for a special exemption to operate their devices.[55] The exemption process was costly and time consuming, with attorney fees ranging from $5,000 to $50,000, depending on the complexity of the exemption.[56]

In early 2016, in the face of political criticism and rapidly growing drone use, FAA enacted regulations governing operations of small drones (under 55 pounds).[57] The rules allow small-drone operators to apply for licensing for commercial activity. Some of the basic rules for smaller drones include:[58]

- Flying below 400 feet,
- Maintaining visual sight of the aircraft at all times,
- Not flying within five miles of an airport,
- Avoiding people, and
- Operating during daylight.

However, the FAA's rules are not permissive enough to meet the needs of the private sector. Some of these restrictions impose significant constraints on the ability to use drones optimally, such as for delivering packages, inspecting crops or infrastructure in a rural setting, or performing aerial photography. Commercial users seeking an exemption from the rules must apply for a special waiver and take a written test.[59] FAA's approach appeared to be motivated more by the perceived risks, especially with drones flying near airports, than by an appreciation of the economic potential of commercial drones.[60] The FAA's

delay in creating permissive drone rules has had real consequences. For example, Amazon, which wants to make drone deliveries a routine occurrence, recently declared plans to open a 60,000-square-foot center in the United Kingdom focused on artificial intelligence and drone-delivery research.[61] Amazon originally located this activity in the United Kingdom because the U.S. government was blocking its tests.[62] Canada also has benefitted from looser regulations.[63]

In addition, the FAA created rules in late 2015 that require private owners of drones weighing over 0.5 pounds to register with the government.[64] Within the first month, nearly 300,000 drone owners registered their aircraft, reflecting the strong interest in the technology.[65] In May 2017, these rules were struck down by the U.S. Court of Appeals under the grounds that the FAA did not have the statutory authority to require private owners to register their noncommercial drones.[66] As of May 30, 2017, the FAA has not appealed this decision.

Overly restrictive regulations can damage both U.S. competitiveness and productivity. They can also delay the market benefits that new technologies bring in the form of lower prices, more convenient products, and even increased safety.

FAA has designated six test sites around the nation for future drone research. But this likely restricts companies' ability to rapidly develop their technology in realistic conditions. The delay in writing regulations for commercial use, combined with the FAA's overly stringent policies and lack of resources, has slowed the development of commercial drones as well as that of the businesses that might use them.[67] Rather than setting clear safety standards that apply to all drone users and then letting manufacturers and users introduce any innovations that meet those standards, the agency has drawn an artificial line between hobby and commercial use, even though there is not necessarily any difference in the risks they pose. For instance, it might be important for an amateur flying a simple plane to maintain visual sight of the drone at all times. But the requirement makes little sense for a commercial drone equipped with automatic navigation or a camera view and operated by an experienced professional, especially in an unpopulated area.

FAA should be much more welcoming of the future offered by drones. Without minimizing the obvious safety risks, it should acknowledge that there are many ways to address these concerns. It should encourage manufacturers to find different ways to improve safety, making it clear exactly what criteria will govern final approval. Finally, it should do all of this much more quickly than has been the case so far, even if this requires devoting more resources to the technology.

CONCLUSION

The economy could experience an uptake in innovation in a number of important technologies, including those related to autonomous operation of machines. In the case of public safety, new technologies will present different kinds of risk than current practice but hold out the hope of increasing overall safety at a lower cost, while significantly boosting economic productivity.

There are two reasons why regulators need to get the balance between innovation and safety right. The first is to maintain our national competitiveness in leading industries. It is important that the United States remain at the forefront of developing these new

technologies in order to maintain the competitiveness of both the industries that produce technology and the industries that use it.[68] The second reason is that automation increases productivity and living standards. Overly restrictive regulations can damage both U.S. competitiveness and productivity. They can also delay the market benefits that new technologies bring in the form of lower prices, more convenient products, and even increased safety. The fast pace of technology would likely challenge regulators even in the best of times. In the face of budget cuts, the task will be even harder.

In the case of transportation automation, technology has developed differently in each industry, partly due to market differences and the technological challenges posed by each industry, but also due to the attitude of the specific regulatory agency involved. In each case, automation promises significant economic benefits, but also poses new safety challenges, especially as the technology is developing and being integrated into regular industry practices. The regulator's job should be to encourage technological development while ensuring public goals such as safety. This will require a detailed knowledge of both the industry and the technology, and the promulgation of flexible rules that accommodate new ways of doing things.

ENDNOTES

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15. The FRA cites research that concludes that "although PTC technology is likely to have a positive impact on overall risk of accidents, these new sources of cognitive demand can contribute to errors and accidents." Ibid., 13, 927. Elsewhere it has pointed out that PTC is "designed to override human error in controlling the speed and movement of trains." U.S Department of Transportation, Federal Railroad

Administration, "FRA to Issue Proposed Rule on Minimum Train Crew Size," news release, April 9, 2014, http://www.fra.dot.gov/eLib/Details/L04999.

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