CAPACITY CRISIS IN THE UNITED STATES TRUCKING INDUSTRY, A CONCEPTUAL MODEL FROM A THEORY OF CONSTRAINTS PERSPECTIVE

by

Callie B. Montgomery

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Project Approved:

Travis Tokar, Ph.D.
Department of Information Systems and Supply Chain Management
(Supervising Professor)

Laura Meade, Ph.D.
Department of Information Systems and Supply Chain Management

Brian Pinkham, Ph.D.
Department of Management, Entrepreneurship, and Leadership

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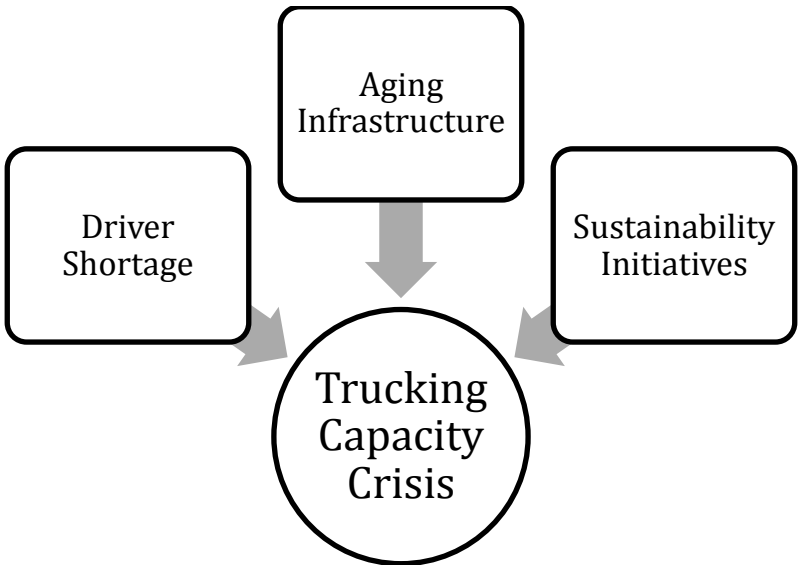

INTRODUCTION

Contrary to popular belief, trucking is considered one of the leading economic indicators in the United States. This is important because economic indicators allow us to analyze current economic performance as well as make predictions regarding future economic performance. Commercial motor vehicles, or CMVs, are responsible for the majority of freight movement over land, carrying raw materials, work-in-progress goods, and finished goods. In fact, it is estimated that these trucks carry approximately three-fourths of the total domestic cargo by value and two-thirds of the total domestic cargo by weight; therefore, trucks are carrying more value and weight than any other mode of transportation (USA Freight Transport Report, 2013). As a result, 'trucking' is often seen as synonymous to 'the backbone of the American economy.' However, at the current rate demand is exceeding capacity, the trucking industry cannot sustain growth and is thus experiencing a domestic capacity crisis.

In operations management, capacity is usually expressed in terms of either resource availability or potential output rate. In turn, capacity limits are often expressed in two different ways: maximum capacity and effective capacity. Maximum capacity is the highest output rate that an activity or process can achieve under ideal conditions in the short term (Swink et al. 2011, pg. 58). This assumes that all equipment and workers are fully operational for the maximum amount of available time (Swink et al. 2011, pg. 58). Usually, producing at a rate of maximum capacity can only be sustained for a relatively short time, because things do not always operate perfectly (Swink et al. 2011, pg. 59). When operations managers take into account the potential for disruptions, they can estimate the effective capacity that the process can sustain (Swink et al. 2011, pg.

59). To further explain capacity, utilization is defined as the percentage of process capacity that is actually used. Very low utilization rates suggest that equipment or employees are being underused, while extremely high utilization rates suggest overuse and a corresponding danger that problems may occur if demand continues to exceed available capacity (Swink et al 2011, pg. 59). For either external or internal reasons processes are often not able to achieve desired levels of capacity utilization (Swink et al. 2011, pg. 59).

The Theory of Constraints was first developed by Eliyahu M. Goldratt, (Goldratt 1984); this theory will be used as the lens through which this crisis in the trucking industry will be viewed. The principles offered by the Theory of Constraints apply universally; therefore, I will be applying these principles to the drivers of the capacity crisis currently affecting the domestic trucking industry. The Theory of Constraints is the overall management system that strives to improve system performance by identifying, focusing on, and managing constraints (Swink et al. 2011, pg. 59). The principles serve to simplify process management by focusing managers' attentions to the important constraints that limit the performance of a process (Swink et al. 2011, pg. 59). There are five basic principles at the heart of TOC: 1.) Every process has a constraint. 2.) Every process contains variance that consumes capacity. 3.) Every process must be managed as a system. 4.) Performance measures are crucial to the process's success. 5.) Every process must continually improve. Overall, I will be using this theory to guide understanding of this issue and make predictions about the drivers of this domestic capacity crisis (Swink et al. 2011, pg. 60).

The goal for any organization within any industry is to make profit now as well as in the future. Anything that limits the performance of a system towards its goal is a constraint. If there is not enough capacity, customer demand will not be met. If even one link of the supply chain does not have enough capacity, the whole chain can be affected (Swink et al. 2011, pg. 126). Some resources can be changed faster than others. Consequently, capacity changes can be short term, medium term, or long term in nature (Swink et al. 2011, pg. 128). For this paper, the process activity is Transportation; the associated resources that limit capacity will vary.

CONCEPTUAL DEVELOPMENT

The Theory of Constraints

In order to understand the current capacity crisis affecting the trucking industry within the United States, we propose a conceptual development model based on the Theory of Constraints (TOC) perspective. In the following sections, we discuss the principles of the Theory of Constraints (TOC) in greater detail.

Principle 1: Every Process Has a Constraint

As described by the first principle of TOC, the overall operating capacity of a process is limited by one or more constraints (Swink et al. 2011). The trucking industry is undermined by both physical and non-physical constraints. The limited availability of truck drivers and the aging infrastructure both serve as physical constraints. The legislative focus surrounding sustainability initiatives for the trucking industry as a whole serves more as a non-physical constraint to a certain extent. In this sense, the process or process activity becomes transportation within the trucking industry. These constraints place limits on the overall output of the process, also known as bottlenecks. The overall output is the value added to the end customer, the company, and/or the economy. It is important to recognize that over time the output of a process can be no greater than the output of its bottleneck activity (Swink et al. 2011, pg. 60).

This bottleneck principle can be applied further to calculate the maximum capacity in a process, whereby capacity is strongly influenced by the structure of the process. The structure of a process can be serial/sequential or parallel. In the U.S. trucking industry, we have a parallel structure, where there are two or more resources performing the same task simultaneously (Swink et al. 2011). If we add capacity to one

of these resources, it does not help the overall supply chain, as it will always be limited by the capacity of the other resources (Swink et al. 2011). In applying this same concept to the drivers, if we increase the rated or design capacity of the infrastructure, it does not help the overall supply chain if we still have a shortage of human capital to transport goods across this infrastructure, and vice versa. In sum, the total capacity of the set of parallel activities simply equals the sum of the individual resource capabilities.

Principle 2: Every Process Contains Variance That Consumes Capacity

The second principle of TOC incorporates variance, as it exists in outputs, inputs, or in the process activities themselves. Variability of different sorts introduces complexity and uncertainty into processes, which in turn increases the difficulty of efficiently and fully utilizing resources (Swink et al. 2011, pg. 62). Variance and utilization interact in such a way whereby as utilization levels are increased, the impact of variability is worsened; therefore, as demand continues to exceed available capacity, the variances are magnified and consume capacity (Swink et al. 2011). This is true for the trucking industry, which overuses its available resources resulting in extremely high utilization rates.

Each of the three drivers is impacted by variability, often by the same variance at the same time. Common variances include, but are not limited to: economic recovery, congestion, fuel, government regulations, and the economic viability of companies. Additional resources must be dedicated to managing complexity and uncertainty, even if those resources are not directly contributing to the total productive capacity of the process (Swink et al. 2011). In addition to consuming capacity, variance increases

process congestion and increases flow times (Swink et al. 2011). This is important because transportation to customers is a critical aspect of overall lead-time performance.

Principle 3: Every Process Must be Managed as a System

Awareness of the bottlenecks within the system is critical. In this case, awareness of each individual driver as a bottleneck is critical to understanding how each one constrains capacity within the transportation process. However, we cannot myopically view these drivers in complete isolation of one another. This is difficult for varying interests because they have direct control over their individual part of the supply chain hence they are likely to be focused on this (Simatupang, Wright, and Sridharan 2004, pg. 7). Decisions tend to be made on an individual basis without considering supply chain-wide implications. Because of interdependencies in the system, variances tend to be amplified throughout the system; thus, the resulting capacity crisis in the U.S. trucking industry (Swink et al. 2011). Levels of capacity constantly fluctuate, preventing us from determining which driver has the lowest capacity or which driver serves as the biggest bottleneck. By applying TOC, this forces us to take a "big picture" approach to the problem, with the potential to transforming the issue from a zero-sum game to a win-win game in the process.

Principle 4: Performance Measures are Crucial to the Process's Success

The goal of the fourth TOC principle is to establish collaborative performance metrics that motivate the chain members to improve the supply chain as a whole. However, with changes in the environment of the supply chain and within the supply chain itself, these policies and metrics often become unsuitable for motivating desired decision-making behavior and thus result in negative impacts on supply chain

performance (Simatupang, Wright, and Sridharan 2004, pg. 14). People are comfortable with regular habits and predictable outcomes, and hence often continue to use outdated policies and inappropriate metrics in making decisions even though supply chain technologies or the business environment has changed (Simatupang, Wright, and Sridharan 2004, pg. 14).

Principle 5: Every Process Must Continuously Improve

This is difficult to achieve when we consider that quality is usually the first victim of insufficient capacity. How can we continuously improve if our current state does not even meet acceptable standards? The activities of the processes must be evaluated and changed when the level of value they provide is no longer acceptable (Swink et al. 2011, pg. 66). The drivers, then, can either be modified or replaced. Unfortunately, the time frame for capacity changes to these drivers is longer-term in nature and requires significant long-term planning through a collaborative effort of supply chain members. Isolated investments in capacity can be ineffective as far as the overall supply chain is concerned (Swink et al. 2011, pg. 61). Investments should be strategic in that they create processes that can quickly react to unplanned situations so that the detrimental effects of variation are kept to a minimum (Swink et al. 2011).

Based on our understandings of these principles, we can begin to identify some of the specific drivers of the capacity crisis. This paper, through examination of the Theory of Constraints, proposes that there are three main drivers of significance: 1.) The Truck Driver Shortage 2.) Infrastructure and to a lesser extent 3.) Sustainability Initiatives. Figure 1 illustrates a model for how these particular drivers are negatively contributing to capacity in the trucking industry. The five principles of the Theory of Constraints (TOC)

have been applied to understand how these three drivers of significance are linked to capacity. I will now present a literature review of the three proposed drivers.

REVIEW OF LITERATURE

Drivers of the Capacity Crisis

In the following sections, each of the three drivers identified through the Theory of Constraints will be analyzed in greater detail through examination of their specific issues as well as the contributing factors of these specific issues.

Driver 1: Shortage of Truck Drivers

The capacity of a process is determined by the limits of its resources (Swink et al. 2011, pg. 57). In keeping with transportation as the process activity, one of the associated resources that limit capacity related to transportation is labor, or human capital. For the trucking industry, this is the labor market for qualified, professional drivers. In a 2012 study, ninety percent of for-hire truckload (TL) carriers said they could not find enough drivers who were capable of meeting Department of Transportation (DOT) requirements (Costello 2012). This introduces our first main driver of significance, the national truck driver shortage.

There are multiple factors contributing to this shortage of drivers, including the level of job difficulty, the economic recession, and federal regulations. Several of these will be explored in the following sections.

Level of Job Difficulty

The majority of people believe that truck driving is an easy to job, and therefore, that it is relatively easy to get hired as a truck driver. In truth, truck driving is a tough profession that is both physically and mentally taxing. Further, motor carriers are actually very selective in their hiring process. It is more time consuming to qualify a safe driver than it is to disqualify an unsafe driver. In addition, the industry can only process

150,000 people per quarter (Markham 2012). To further complicate the issue, the age of the typical driver is rising, and carriers are having difficulty finding the next generation of drivers to replace them (Markham 2012, pg. 25). According to the American Trucking Associations, the combination of industry growth, driver retirements, and people leaving the industry for other reasons means that the trucking industry will need to bring on nearly 100,000 new drivers each year, on average, over the next ten years (Costello 2012). From a statistical perspective, industry growth represents 36%, while retirements, non-voluntary departures, and voluntary non-retirement departures represent 37%, 16%, and 11% of people leaving the industry, respectively (Costello 2012). The Bureau of Labor Statistics predicts that employment for heavy and tractor-trailer truck drivers is projected to grow 21% from 2010 to 2020; this is faster than the average for all occupations (U.S. DOL, 2012).

Economic Recession

The U.S. trucking community was devastated by the recession as carrier after carrier closed their doors or sidelined a portion of their fleets as business dried up along with the economy (Markham 2012, pg. 24). The recession resulted in several downside effects for motor carriers, such as, deteriorated service quality, declined employee engagement, increased hiring and training costs, and decreased profits (Hoss 2012). In this environment, it became increasingly difficult for organization, particularly their human resource leaders and departments, to respond to the challenge of building an effective, skilled workforce. Companies that survived have been in no rush to reinvest in capacity, made cautious by the economy's slow recovery (Markham 2012, pg. 24).

However, the organizations that emerged upright have a lot of leverage today in terms of being able to charge higher prices for space on their trucks (Markham 2012).

Federal Regulations

In addition to the fallout from the recession, there are two main government regulations exacerbating the driver shortage: the proposed changes to the Hours of Service (HOS) regulations and the new Compliance Safety Accountability (CSA) program.

Under the current rules, a driver can restart his Hours of Service after taking 34 consecutive hours off. The new rules call for two consecutive nights of rest, which would push the restart up to 45-48 hours (Markham 2012). Although the maximum driving time and minimum time off remain the same in terms of hours per day in the new proposal, the changes to some of the restart provisions will effectively reduce seat time. Other changes include limiting restarts to once per week and a mandatory half-hour rest break during each shift, further reducing drive time. Although safety is paramount in the trucking industry, the American Trucking Association does not see a need for these changes, especially since the industry has been safer than ever under the existing rules (Markham 2012). In order to halt the changes, the ATA has sued the Federal Motor Carrier Safety Administration, and a decision on the matter is expected shortly before the proposal date of implementation in July 2013 (Markham 2012). The overall perception around the proposed changes is that they will take us backward, not forward into the future.

Calls for improved highway safety have also led to increased scrutiny of truck and driver violations (Markham 2012, pg. 25). The U.S. Department of Transportation's

Federal Motor Carrier Safety Administration, or better known as FMCSA, has recently launched a regulation called the Compliance Safety Accountability, or CSA (U.S. DOT, 2013). The new safety measurement system includes seven categories for measuring on-road performance as well as potential crash risk: fatigued driving or Hours-of-Service, unsafe driving, controlled substances and alcohol use, driver fitness, vehicle maintenance, cargo-related violations, and crash indicators (U.S. DOT, 2013). By expanding the previous four broad categories to seven more specific categories, the FMSCA believes it will be better equipped to identify carriers with patterns of high-risk behaviors (U.S. DOT, 2013). The American Trucking Association has submitted a list of proposed changes, including modifications to make a more accurate reflection of crash risk, to ensure industry divisions are compared against their peers, and to test the system before implementing it to ensure that it accurately identifies carriers that are unsafe (U.S. DOT, 2013).

Another area of concern is the data used in the safety system. In addition to convictions, all citations and warning will be included in the database. The carrier portion of the database will keep 24 months of inspections and crash reports, while the driver profiles will contain 36 months of data (U.S. DOT, 2013). Background checks are extensive, and drivers with lower safety scores cannot get hired. Overall, these new standards have forced some existing drivers out of the market, while preventing others from coming in to the market (Markham 2012).

Driver 2: Aged and Inadequate Infrastructure

To reiterate, the capacity of a process is determined by the limits of its resources. In keeping with transportation as the process activity, another one of the associated

resources that limit capacity related to transportation is rated or design capacity. For the U.S. trucking industry, this is the rated or design capacity of our bridges and roads. This introduces our second main driver of significance, the national transportation infrastructure. Existing transportation infrastructure is aging rapidly, and both existing and new infrastructure are largely underfunded.

There are multiple factors contributing to the aging trucking infrastructure, including the inadequacies of bridges and roads. Insufficient levels of funding for both bridges and roads are making it more difficult to improve quality and reduce congestion. Several of these will be explored in the following sections.

Bridges

Bridges serve as an indispensable link for both commuters and freight on a daily basis; therefore, their "health" is directly linked to the nation's ability to compete in the global marketplace. The "2013 Report Card for America's Infrastructure" suggests that the average age of the nation's bridges has slightly declined from 43 years in 2009 to 42 years currently (ASCE, 2013). Over two hundred million trips are taken daily across deficient bridges in the 102 largest metropolitan regions (ASCE, 2013). According to the "2010 Status of the Nation's Highways, Bridges, and Transit" Conditions, published by the Federal Highway Administration (FHWA), there are approximately 600,000 bridges that exist within our transportation infrastructure (U.S. DOT, 2010). Of these, more than 30 percent have exceeded their 50-year design life (ASCE, 2013).

Despite billions of dollars in federal, state and local funds directed toward the maintenance of existing bridges, 68,842 bridges, or 11.5 percent of total highway bridges in the U.S., are classified as "structurally deficient," (ASCE, 2013). Structurally deficient

bridges require significant maintenance, rehabilitation, or replacement. These bridges must be inspected at least once every year to examine if critical load-carrying elements are in poor condition due to deterioration or damage. One-third of the total bridge decking area, or bridge surface, in the country is comprised of structurally deficient bridges (ASCE, 2013). This indicates that these bridges are significant in terms of size and length. Bridges can also be defined as "functionally obsolete," meaning that either the width of the lanes or the levels of load-carrying capacity are not sufficient to sustain travel. Despite the fact that large-scale urban bridges carry a high percentage of the nation's traffic, the majority of bridges under repair are smaller in scale. Overall, the total number of structurally deficient and functionally obsolete bridges account for nearly 25 percent of our nation's bridges (ASCE, 2013). The goal is to decrease this total below 15 percent over the next decade (ASCE, 2013).

In addition to structurally deficient and functionally obsolete bridges, "posted bridges" add to the complexity of the infrastructure. A bridge may be posted to limit the weight of vehicles, restrict the number of vehicles, or reduce vehicle speeds on the bridge if engineers find the safe load-carrying capacity to be less than standard load limits. From 2007 to 2012, the number of bridges closed to traffic has climbed from 2,816 to 3,585, while the number of bridges posted for load restrictions has decreased from 67,969 to 60,971 (ASCE, 2013). Although "posted bridges" are not necessarily a public safety risk, they can create congestion and force emergency vehicles to take lengthy detours. For goods going to market, this increases both the lead time and cost associated with the transportation process.

In the "2013 Report Card for America's Infrastructure," bridges received a grade of a C+, with "C" equating to "mediocre (ASCE, 2013)." A mediocre scale indicates that the infrastructure in the system or network is in fair to good condition, but shows general signs of deterioration and therefore requires attention. It can also include some elements that exhibit significant deficiencies in conditions and functionality, with increasing vulnerability to risk.

Although Congress has repeatedly declared bridge safety a national priority, existing federal programs offer no real incentives or assurances that aging bridges actually get fixed. The nation's bridges are divided between two programs, the National Highway Performance Program (NHPP) and the Surface Transportation Program, creating competition among the various transportation programs for funding. Of the federal money that is dedicated to bridge repair, states have the ability to "flex" or transfer up to fifty percent of that money to other projects at their own free will without any consequences (U.S. DOT, 2010). In addition, the current level of investment has not kept place with the rapidly growing backlog of aging bridges.

Bridge ownership is almost split evenly between locally owned and state owned. In order to address and overcome the current backlog of deficient bridges, the Federal Highway Administration (FHWA) estimates the current cost to repair or replace both structurally deficient and functionally obsolete bridges is almost $76 billion (U.S. DOT, 2010). If bridge maintenance continues to be deferred and bridge funding transferred to other projects, these backlog costs will continue to rise. The investment backlog for all of the nation's bridges is estimated to be $121 billion, including all cost-beneficial bridge needs, not just the replacement or rehabilitation of eligible deficient bridges (U.S. DOT,

2010). This estimate includes $102 billion in investment needs for federal-aid highway bridges, of which $60 billion is for the National Highway System bridges, which in turn includes $38 billion for Interstate System bridges (U.S. DOT, 2010). In order to eliminate the bridge backlog by 2028, the FHWA proposes average annual capital investments of $20.5 billion (U.S. DOT, 2010). Currently, only $12.8 billion is being spent annually on the nation's bridges, and this is not enough to sustain growth over time (U.S. DOT, 2010).

Roads

Roadways also serve as an indispensable link for both commuters and freight on a daily basis. Our nation's road network of more than 4 million miles allows direct access to ports and rail terminals for goods going to market. Steady growth is expected in the road haulage sector (USA Freight Transport Report, 2013). In 2013, growth of about 3.6 percent is expected, reaching 3.09 trillion tons per kilometer (USA Freight Transport Report, 2013). Between 2013 and 2017, Business Monitor International (BMI) forecasts annual average growth for the sector of 3.3 percent (USA Freight Transport Report, 2013).

Approximately 32 percent of America's major roads are in poor or mediocre condition, costing U.S. motorists who are traveling on deficient pavement $67 billion a year, or $324 per motorist, in additional repairs and operating costs (ASCE, 2013). Safety is a major concern since roadway conditions play a significant factor in approximately one-third of all U.S. traffic fatalities (U.S. DOT, 2010). Obstructions, median barriers, and narrow lanes and shoulders all present obstacles for motorists on the road. Deficient pavements are more common in urban versus rural areas, with 47% of

urban interstate vehicle miles traveled (VMT) over deficient pavements compared to 15% of rural interstates (ASCE, 2013). The ultimate cost of poor road conditions is significantly more than the cost to maintain those same roads in good condition. For example, preservation treatments are more efficient and effective in terms of both time and cost over total reconstruction of roadways (ASCE, 2013).

Although driver safety is of utmost importance, the problem of congestion within our nation's infrastructure poses the biggest challenge for commuters, freight shippers, and lawmakers alike. Congestion, including amounts of time, fuel, and money, has been on the rise over the past 30 years (Schrank, Eisele, and Lomax 2012). The congestion "invoice" for the value of delay time and wasted fuel is up to $121 billion in 2011 from just $24 billion in 1982 (Schrank, Eisele, and Lomax 2012). In 2011 alone, this has caused urban Americans to travel 5.5 billion hours more and purchase an extra 2.9 billion gallons of fuel (Schrank, Eisele, and Lomax 2012). Rural areas and smaller cities are not exempt from this problem; congestion is worse in all areas, not just urban areas and larger cities. A major part of the problem is that the number of miles travelled nationally by vehicles, or vehicle miles traveled (VMT), has increased by 39% between 1990 and 2009 (Schrank, Eisele, and Lomax 2012). Despite people driving longer distances on average, newly constructed road mileage has only increased by 4 percent (ASCE, 2013).

In the "2013 Report Card for America's Infrastructure," roads received a grade of a D+, with "D" equating to "poor (ASCE, 2013)." A rating of poor indicates that the infrastructure in the system or network is in poor to fair condition and mostly below standard. Many elements are approaching the end of their service life; therefore, a large

portion of the system or network exhibits significant deterioration. As a result, condition and capacity are of significant concern with strong risk of failure.

Currently, annual capital investment spending by federal, state, and local governments is at $91 billion (ASCE, 2013). In order to maintain all of the nation's highways at their current condition, the FHWA estimates this would cost $101 billion in annual capital investment between 2008 and 2028 (U.S. DOT, 2010). Furthermore, investment would need to rise to $170 billion annually, or an additional $79 billion annually from current investments, during that same time period in order to improve the nation's highways (ASCE, 2013). Of that $170 billion, $85 billion would need to be directed toward improving the physical condition of existing assets in order to achieve the Department of Transportation's State of Good Repair benchmark (ASCE, 2013). This benchmark measures existing physical assets to determine if they are functioning as designed within their useful service life and being sustained through regular maintenance and replacement programs.

In 2009, Congress passed the American Recovery and Reinvestment Act, commonly referred to as the "stimulus package." Total funds allocated between tax benefits, entitlements, and contracts, grants and loans have been increased from $787 billion to $840 billion since the enactment of the Recovery Act (U.S. Federal Government, 2012). In order to provide long-term economic benefits, the Act specifically targets infrastructure development and enhancement. The Department of Transportation received a total of $48.1 billion, of which $38.6 billion was distributed through existing funding programs (U.S. Federal Government, 2012). In particular, approximately $25.7 billion was paid out in contracts, grants, and loans to the Federal

Highway Administration for the Highway Infrastructure Investment (U.S. Federal Government, 2012).

Driver 3: Sustainability Initiatives

In keeping with transportation as the process activity, another one of the associated resources that limit capacity related to transportation is legislation. For the U.S. trucking industry, this becomes a constraint because the industry will be forced to adapt existing practices in order to comply with new, more restrictive regulations. This introduces our third main driver of significance, environmental sustainability, which presents significant challenges for the future of the industry. There are numerous and unprecedented costs being imposed upon the industry to reduce emissions from trucks.

A common concept that has recently emerged is the "triple bottom line," referring to the economy, the environment, and society. In transportation, the "triple bottom line" relates to sustainable solutions for the natural environmental systems surrounding the transportation system, the economic efficiency of the system, and societal needs (e.g., mobility, accessibility, and safety). According to the Environmental Protection Agency (EPA), transportation is the second largest emitting sector of carbon dioxide (CO_2) greenhouse gases behind electricity generation (U.S. EPA, 2013). In fact, the transportation sector consumes 29 percent of the total energy used in the United States; this represents 5 percent of global greenhouse gas emissions (U.S. EPA, 2013). For the first time, the 2012 Urban Mobility Report includes measures of additional CO_2 emissions as a result of congestion. In 2011 alone, approximately 56 billion pounds of additional carbon dioxide (CO_2) were released into the atmosphere of urban congested areas (Schrank, Eisele, and Lomax 2012). This total equates to about 380 pounds of

additional carbon dioxide (CO_2) per auto commuter during congestion (Schrank, Eisele, and Lomax 2012).

In 2009, the U.S. House of Representatives passed The American Clean Energy and Security as a comprehensive national climate and energy legislative act that would establish an economy-wide, greenhouse gas (GHG) cap-and-trade system. It also included critical complementary measures to help address climate change and build a clean energy economy. The American Trucking Association (ATA) was adamantly opposed to this legislation because it threatened to increase fuel costs and jeopardize the economic viability of trucking companies (Bulk Transporter, 2009). Given thin operating margins, trucking companies know that their fleets are extremely sensitive to rapidly shifting operating costs. In addition, the cap-and-trade program grants oil refiners 2 percent of the carbon allowances between 2014 and 2016 (Bulk Transporter, 2009). Although this will help mitigate refinery greenhouse gas emissions, it completely ignores carbon emissions from the combustion of petroleum products. As a result, the ATA believes this grant is inadequate and leaves downstream users, such as trucking companies, with the full exposure to dramatic and sudden fuel price spikes (Bulk Transporter, 2009). In terms of choosing a new truck, this has had such an impact that operators now rank fuel consumption over purchase price (Bulk Transporter, 2009).

Equipment upgrades are becoming more and more necessary as regulation gets passed. The next mandate is slated for 2014 – the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) Greenhouse Gas 2014 (GHG14) initiative (Fleet Equipment, 2012). According to original equipment manufacturers (OEMs) and engine makers for trucks, changes to the engines and

aerodynamics of the vehicles will be necessary for compliance with the upcoming GHG14 mandate (Fleet Equipment, 2012). This also includes the addition of lower rolling resistance tires, which can be combined with on-board tire monitoring and inflation systems. At least half of fleets' tire problems, including compromised fuel efficiency, are caused by improper inflation (Fleet Equipment, 2012). This problem is more widespread than many fleets realize. Automatic tire inflation systems can connect all tires on the trailer to a controlled air supply to fill and maintain tires at the desired pressure setting, even while the vehicle is moving. As air pressure drops below the tiremaker's recommended level or the fleet's desired pressure, air is automatically routed to refill any underflated tires (Fleet Equipment, 2012).

Although these upgrades run at a high cost, they will help to combat new regulations surrounding the reduced hours of service for truck drivers. On-board recorders are also being widely adopted as a means of improving fuel economy and safety. For example, GPS devices have the capabilities to track a driver's speed, miles per gallon, hard braking and other factors (Markham 2012). Given this information, companies can better determine optimal routes, times, and driving modifications. The American Trucking Association (ATA) supports mandatory use of the devices in all vehicles. Other advancements, in various stages of adoption, include a trend toward automatic transmission, anti-idling technologies, and skirts on trailers to assist with fuel economy (Markham 2012, pg. 28).

To complicate matters, The Federal Highway Trust Fund (HTF), which contributes the bulk of federal funding for transportation, is on a path to bankruptcy as it relies on dwindling gas tax revenues. The federal gas tax has remained at 18.4 cents per

gallon since the early 1990s, and revenues are decreasing further due to more efficient vehicles (U.S. DOT, 2010). New fuel efficiency standards under the Obama administration will increase fuel economy to 54.5 miles per gallon (mpg) for cars and light-duty trucks by 2025 (U.S. EPA, 2013). The Congressional Budget Office sees the crisis worsening as these newly proposed fuel economy standards are expected to lower fuel tax revenues by an additional 21% by 2040 (ASCE, 2013). Such a decrease would result in a $57 billion drop in the Highway Trust Fund between 2012 and 2022 (ASCE, 2013). Clearly, the nation can no longer rely solely on the fuel tax to generate the necessary future revenues for the Highway Trust Fund.

The American Recovery and Investment Act includes a new transit grant program that will allow projects to compete for grant funds (U.S. Federal Government, 2012). These grant funds are to be based on how much the project is expected to reduce energy consumption or greenhouse gases, or both (U.S. Federal Government, 2012). According to Secretary LaHood, "this grant program establishes the transit industry as a leader in reducing America's dependence on foreign oil, addressing global climate change and creating green jobs," (U.S. Federal Government, 2012). Despite the opportunity presented by this grant program, it still means that the trucking industry will have to compete with other modes of transportation in order to receive project grant funds.

DISCUSSION

Discussion of Driver Shortage

Trucking companies and shippers need to act decisively if they want to counter current and long-term capacity trends that threaten to lower the supply of truckers and raise supply chain costs. As previously mentioned, such a shortage could create a domino effect on the economy resulting in supply chain disruptions, delayed deliveries and drastic price increases for consumer products. The good news is the driver shortage is not an intractable, unsolvable problem; however, the longer carriers wait to address the problem, the harder it will be to solve the problem. You can build all the trucks you want, but you aren't going to increase capacity without more truck drivers.

Before the economic slowdown, trucking companies began taking a top-to-bottom look at how everyone in the organization focuses on drivers as the central force in the company. This approach needs to be developed and maintained through good times and bad to keep drivers in the industry, otherwise the industry will continue to lose capacity in terms of resources. Many industry experts believe that finding trucking capacity will get even more challenging before it gets easier (Markham 2012). Faced with this national truck driver shortage, the industry must take responsibility and focus on long-term solutions. In the words of Neil Voorhees, Director of Safety and Security for Trimac Transportation, "we have to stop talking about it and do something about it (Weber 2012, pg. 20)." Not only does this new focus involve letting go of archaic ideas, it involves making fundamental changes to the way we approach workforce planning in terms of both recruiting and retention of truck drivers (Weber 2012). As the Theory of

Constraints suggests, our processes must be managed and continue to improve over time; this requires constant creativity and innovation.

A perfect example of a company who has risen to the human resource challenge is Con-Way Freight, a Fortune 500, less-than-truckload (LTL) transportation company based out of Ann Arbor, Michigan. Although the shortage is primarily in the truckload (TL) industry, other organizations can still benefit from the successful strides made by Con-Way Freight and its more than 19,000 employees nationwide. Con-Way realized they could no longer rely on traditional methods of "post and pray" to provide employees. As a result, they figured out how to build a workforce, one person at a time, by growing talent from within the organization. Their philosophy is to build truck drivers from the ground up, with the skills and experience that the organization wants and needs to meet demand (Moss 2012, pg. 68).

According to HR Magazine, Con-Way started their own driving schools in 2010. The schools are located at 84 of their facilities, and use their own equipment and 180 veteran drivers as instructors (Moss 2012). The driving schools actually pull students from the ranks of dockworkers because these employees already have a sense of the business, the pace of work, and the culture at Con-Way. Managers have already had a chance to evaluate these employees, and thereby avoid having to deal with incompatible work practices that drivers with previous experience sometimes bring to the job. The formal curriculum includes 80 hours of classroom study coupled with 160 hours behind the wheel with supervision from an instructor (Moss 2012). Dockworkers also have the option to work part-time while attending class so that they can earn a living while learning. Despite Con-Way's net investment of $6 million per year for these schools,

students commit time and energy to the program without having to pay (Moss 2012). Commercial for-profit truck driver training schools typically charge $4,000 to $6,000 for tuition, so these students are grateful for the opportunity afforded them to learn a profession and improve their earning power (Moss 2012). These schools have already graduated nearly 600 professional truck drivers, who have continued to outperform seasoned drivers while enabling Con-Way to maintain a retention rate of 90% (Moss 2012).

Con-Way believes that their truck drivers are truly the company's "front line" in today's competitive freight trucking market (Moss 2012). Because these truck drivers are performing multiple functions for Con-Way customers, their official title is "driver sales representative," rather than just your generic truck driver (Moss 2012). It is important for these drivers to understand that truck driving is more than just a job; it can be a great career as well. In fact, some senior drivers make more than $90,000 a year, plus benefits and bonuses (Moss 2012, pg. 66). Upon graduating and passing their state license exams, students of the Con-Way driving schools can expect to earn on average $45,000 to $55,000 in their first year (Moss 2012). Building a workforce requires continual innovation and assessment, and once you have the right people on board, the challenge shits to keeping these people safe, engaged, motivated, and productive. Bob Petrancosta, Vice President of Safety at Con-Way, concludes by saying "the opportunity to cultivate and shape the right driving behaviors from the outset is clearly delivering a higher level of safe performance (Moss 2012, pg. 68)."

Truck Jobs Today, a national placement firm specializing in truck driver recruitment, says military veterans could also help alleviate an alarming shortage of

truckers and avoid costly impacts (Bulk Transporter, 2012). The recently passed Military Commercial Drivers' License Act of 2012 makes it easier for veterans and active service personnel to obtain a CDL required for a trucking career (Bulk Transporter, 2012). These military veterans represent underutilized resources that could be increased to subdue capacity constraints as they relate to the national truck driver shortage.

Discussion of Infrastructure

In addition to optimizing the use of existing capacity, we need to develop performance-based investment strategies that will ensure that resources are directed to those projects with the highest performance return on investment. Interest in modern public-private partnerships (PPPs) has been renewed as one way to help meet the infrastructure funding need in the United States (Papajohn, Cui, and Bayrakta 2011). Transportation projects, such as the interstate highway system, have been built based on a public-public partnership between the federal and state governments. Adding a private partner to this mix can be challenging; therefore, a need exists to identify what factors will allow the U.S. to implement PPPs in transportation more effectively (Papajohn, Cui, and Bayrakta 2011, pg. 126). The current debate over PPPs lacks the theory and research needed to support the various views of PPPs (Papajohn, Cui, and Bayrakta 2011, pg. 126). Promoters say they bring needed financing, technology, management, and risk sharing to infrastructure development, while detractors say government agencies are better positioned to finance and own infrastructure and protect the public interest (Papajohn, Cui, and Bayrakta 2011, pg. 126).

In the short term, the implementation of a risk-based prioritization model is helping to prioritize bridge repairs based on bridges' risk factors; this ensures that the

most urgently needed repairs are made first (Howerton, Sivakumar, and Herman 2012). Long-term transportation research is needed to develop more resilient bridges that have longer service lives and can sustain future levels of congestion growth (ASCE, 2013).

Discussion of Sustainability Intiatives

The American Trucking Association has committed itself to a series of measures that together can reduce diesel and gasoline fuel consumption by 86 billion gallons and CO_2 emissions of all vehicles by 900 million tons in the next 10 years (Graves 2012). The ATA Sustainability Task Force has identified six areas where the industry can help to accomplish this task: 1) Enacting a national 65 mph speed limit and governing truck speeds to 65 mph for trucks manufactured after 1992. 2) Decreasing idling. 3) Increasing fuel efficiency. 4) Reducing congestion through highway improvements, if necessary by raising fuels tax. 5) Promoting the use of more productive truck combinations. 6) Supporting national fuel economy standards for medium- and heavy-duty trucks (Graves 2012). By implementing these recommendations with its 2,500 members and 37,000 members of affiliated organizations, ATA is confident that the trucking industry can make a significant contribution to sustainability, while continuing to meet its obligations to its customers, its employees, and to the nation's economy (Graves 2012).

One of the ATA's supported programs is the SmartWay Transport Partnership, which was launched in 2004 as a public/private collaboration between the United States Environmental Protection Agency (USEPA) and the freight transportation industry (U.S. EPA, 2013*)*. Kraft Foods is one example of a company that has successfully built sustainability into their business strategy through participation in the EPA SmartWay partnership. They have been named a member of the Dow Jones Sustainability Indexes

(DJSI) for numerous, consecutive years. As a result of their "Super Truck" initiative, they are able to optimize outbound replenishment truckloads, and ultimately put more products on fewer trucks (Material Handling & Logistics, 2011). This is accomplished through software provided by Transportation/Warehouse Optimization (Material Handling & Logistics, 2011). By implementing this initiative alone, the company has already taken the equivalent of about 1,500 trucks off the road, which takes over a million miles off of the U.S. highway system (Material Handling & Logistics, 2011). In addition, Kraft Foods' private fleet and its top 50 carriers use Oracle Transportation Management to measure truck movements and design new trip segments to minimize "empty miles (Material Handling & Logistics, 2011)." Further economies of scale are achieved by using ships to make bigger deliveries less frequently. It is clear that the company does not rely on the implementation of a single technological solution.

However, the industry has only experienced major breakthroughs in the past few years. This is because the majority of the industry is comprised of smaller companies who do not have the resources or capabilities to implement these types of changes throughout their organization. For these smaller companies, compliance with sustainability initiatives means increasing costs and decreasing performance levels, not vice versa.

Conclusion

Constraints are an inherent part of the supply chain. Once you eliminate one constraint, it is replaced with a varying form of the original constraint or an entirely new constraint altogether. Overall, the Theory of Constraints encourages chain members to identify what constraints are preventing them from moving towards their goals and find

solutions to overcome the associated limitations of those goals. A partnership of government, trucking companies and their customers needs to be established to jointly solve the problems associated with these three main drivers of the capacity crisis facing the industry. Outside of this paper, little attention has been given to the application of the Theory of Constraints (TOC) concepts to understand or make predictions about these particular drivers.

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ABSTRACT

Although we do not operate in a static world, the Theory of Constraints can help us reach our goals by focusing our attention to the important constraints or drivers that are limiting the performance of the U.S. trucking industry. In order to explain the capacity crisis affecting the United States trucking industry, this paper develops a theoretical framework based on the Theory of Constraints to suggest that there are three drivers of significance: the national truck driver shortage, the infrastructure, and sustainability initiatives. Not only do these three drivers of significance interact, they have the combined ability to produce multiplicative effects on individuals, companies, industries, and the economy alike. By focusing on these particular constraints or drivers, we can better manage them and gradually devise strategies to alleviate them using the constraint-based approach.