

A Student Journal of Public Policy Research • Volume 6, Fall 2015



Rice University's Baker Institute for Public Policy

STUDENT FORUM

The Rice Cultivator, Volume 6
A Student Journal of Public Policy Research

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Rice University's Baker Institute Student Forum

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Editor's Note

The Baker Institute Student Forum is pleased to present the sixth edition of *The Rice Cultivator: A Student Journal of Public Policy Research*. The *Rice Cultivator* maintains its status as one of the few public policy journals that is entirely written, edited, and published by undergraduate students. As an arm of Rice University's Baker Institute for Public Policy, the Baker Institute Student Forum publishes *The Rice Cultivator* in hopes of engaging undergraduate students in public policy research, showcasing the innovative projects conducted by Rice University undergraduates, and promoting thoughtful, reasoned dialogue about public policy within the Rice community.

The first section of this volume includes the first, second, and third place winners of the Baker Institute Student Forum's second annual Undergraduate Public Policy Conference. The topic of this year's competition was energy, and dozens of papers from students at Rice and from universities across the country were submitted. Out of 12 finalists, the top three papers are published here and represent some of the most innovative ideas in addressing the energy issues the United States faces today. The second portion of this publication consists of six policy papers that cover a wide variety of topics, ranging from economics and cybersecurity to early childhood education and recycling. All of the papers in this section were submitted by Rice University students. We would like to thank all of the talented authors who submitted papers to be considered for *The Rice Cultivator*.

Furthermore, *The Rice Cultivator* is proud to announce its expansion this year to include a team of two copy editors. This year's copy editors, Natalie Danckers and David Ratnoff, were chosen from a large applicant pool, and we are lucky to have such qualified and talented individuals on the team. Natalie and David greatly accelerated and improved the publication process, and without their hours of dedication the publication would not be possible.

Additionally, we would like to thank the Baker Institute staff that assisted with this publication. First, we would like to extend our gratitude to the Baker Institute Student Forum's faculty advisor, Joe Barnes, who has shown tremendous support for this publication. We would also like to thank Lianne Hart, Julia Retta, Rebekah Skelton, Sonja Fulbright and Shawn O'Neill of the editorial and graphics departments.

As always, we hope that *The Rice Cultivator* will spread the message that public policy exists in many forms and is accessible to all audiences.

Aruni Ranaweera

Editor, *The Rice Cultivator*

Addressing Crude-by-Rail Safety Concerns

by Jacob Mansfield '16, Delaine Tubbs '18

First Place Winner — BISF Undergraduate Public Policy Competition, 2014

Abstract

In the Bakken region of North Dakota, shale production has quickly surpassed 1 million barrels per day. However, without suitable pipeline infrastructure and with future projects taking years to develop, surging crude production has forced domestic suppliers to resort to transporting crude via existing rail lines. Despite costing as much as \$5 to \$10 more per barrel than pipeline, rail has helped producers avert supply overhangs and price discounts and provided northeastern domestic refiners a competitive advantage. Crude shipments by rail have also increased nearly 150 percent from 2012 to 2013 and ushered a higher demand for manufacturing tank cars. Manufacturers currently possess a backlog of orders for new tank cars that will take approximately two years to fulfill. Rail transportation poses multiple advantages including a more flexible network, quicker transit times, and a higher safety record. Although rail appears to be a boon for the crude industry, a series of tank car derailments and explosions that endangered local communities and ecologically vulnerable areas have presented new safety concerns. The Association of American Railroads (AAR) previously imposed voluntary industry measures ranging from speed limits in urban areas to modifying the standard tank car design. The Department of Transportation and its subsidiary, the Pipeline and Hazardous Materials Safety Administration, have also suggested more stringent safety standards for tank car design and rail operating procedures. However, a myriad of suggestions and voluntary measures leave the risk of derailment unresolved. This paper examines the development of crude-by-rail and the preexisting safety measures in place and proposes solutions aimed at preventing derailment and mitigating its potential consequences.

Introduction

The Shale Boom

In recent history, the United States has been classified as a net importer of energy resources, becoming the center of domestic political and security concerns. However, with the advent of horizontal drilling and hydraulic fracturing, or “fracking,” new energy reserves have become economically feasible to extract. Regions such as the Eagle Ford region and Permian Basin in Texas have experienced a surge in production within the past few years to over 1.4 million barrels per day (b/d) and 1.6 million b/d, respectively, and an increase of production by over 20,000 barrels month-over-month. The largest growths in production are seen in the Bakken region of North Dakota where production is approaching 1.1 million b/d.¹

Bakken shale crude is revitalizing American energy production because of its potential reserves as well as its crude quality. Providing industry background information on crude oil, there are two specific properties that are used by producers and refiners for identification: 1) viscosity or American Petroleum Institute (API) gravity and 2) sulfur content. First, API gravity characterizes crude oil as either “light” or “heavy.” Lighter crude oil tends to offer lighter hydrocarbons and requires less processing, whereas denser, heavy crude requires more refining and additional catalytic cracking equipment. Consequently, light crude fetches a premium and is generally preferred among refiners. Second, sulfur content is characterized as either “sweet” or “sour.”² Traditionally, refiners have perceived sulfur as a waste by-product from refining and an additional cost to operations. There are newly emerging markets for sulfur, such as with fertilizer manufacturing³; however, because of the increased cost of extraction, sweet crude is generally preferred due to its low sulfur content.⁴ Bakken crude is both light and sweet and should earn a premium on the open market and rival the current crude pricing benchmark West Texas Intermediate (WTI).

Increased domestic production of light, sweet crude is crowding out the need for foreign crude supplies from the Middle East and Nigeria.⁵ Near the end of 2013, domestic crude oil production exceeded crude oil imports for the first time since 1993.^{6,7} Examining annual data from the Energy Information Administration (Figure 1 in appendix), it is evident that within the past three years, US domestic oil production has significantly increased, while crude imports have declined, displaying an inverse relationship. As witnessed in 2013, US domestic production is exceeding the level of imports, creating a crowding-out effect. Additionally, domestic production is on track to continue this trend. According to the EIA, “US crude oil production is projected to increase from an average of 8.7 million bbl/d in 2014 to 9.2 million bbl/d in 2015 and to 9.3 million bbl/d in 2016.”⁸ The lower 48 states have historically produced the majority of domestic crude oil output; however, the recent increase in crude oil production is exclusively attributed to greater output in shale fields such as the Eagle Ford and Permian Basin in Texas and the Bakken region in North Dakota (Figure 2 in appendix). From a political standpoint, increased domestic production means higher energy security and protection from volatile foreign countries. Recently, the invasion of Iraq by the radical Islamic group ISIS caused surges in Brent oil futures prices, as traders speculated about the likelihood of a disruption in Iraqi crude production.^{9,10} As the US market becomes less reliant on foreign resources, the domestic energy market can obtain further stability.

The Importance of Logistics

Having a suitable distribution network and proper logistics is paramount for transporting energy resources from suppliers to refiners and end users. Logistics help achieve allocative efficiency in the national market by reducing supply overhangs that can devalue a product. For instance, Cushing, Oklahoma, a major crude oil market terminal, experienced a supply bottleneck in 2012 due to infrastructural constraints that severely limited crude transportation. This contributed to a price inversion in which Bakken prices were discounted by as much as \$28 under the benchmark.¹¹ Price differentials between Bakken crude oil and WTI have closed with infrastructure improvements. Transportation

infrastructure improvements also increase the liquidity and frequency of trading that allows pricing to accurately represent the natural market.

As domestic energy production surges, transportation infrastructure will require expansion and substantial capital investments. Evaluating data published by IHS, investment in oil and gas infrastructure during 2014 was estimated between \$85–90 billion and should remain high for the foreseeable future.¹²

However, since the summer of 2014 in which WTI and Brent benchmarks experienced crude prices above \$105/bbl, prices have since deflated to approximately \$60/bbl. This sharp decline is attributed to reduced expected global demand for crude oil as well as oversupply. As a consequence, exploration and production (E&P) firms that are involved in extracting crude oil have significantly decreased production and delayed capital investments in future expansions. While the necessity for additional capital investments in order to expand US energy infrastructure will still exist, price-drops have sufficiently delayed such advances in the short term and more current data is unavailable.

Figure 3 in the appendix displays the estimates for average annual investment by mode of transportation produced by IHS. IHS also presents two scenarios in forecasting direct capital investments in oil and gas infrastructure. In the base case (Figure 4 in appendix), investment peaks in 2014 below \$90 billion and tapers off to approximately \$58 billion in 2025. In the high case (Figure 5 in appendix), capital investment is approximately \$94 billion in 2014, peaks in 2019 at over \$100 billion, and tapers off to approximately \$80 billion in 2025. As displayed in Figures 3 through 5 in the appendix, pipelines represent the largest capital investments used to improve transportation infrastructure by a large margin. This expansion of infrastructure also represents a sizable economic contribution in the form of jobs, gross domestic product (GDP), and government revenue. Infrastructure improvements in the base case forecast an estimated 900,000 jobs, \$94 billion in US GDP, and \$21 billion of government revenues. The high case forecasts creation of approximately 1,147,000 jobs, \$120 billion in US GDP, and \$27 billion in government revenues.

Logistics is important for achieving an allocative efficiency of resources and contributing to economic growth predominantly through more jobs, GDP, and government revenues. As previously depicted in the Cushing, Oklahoma, case, inadequate infrastructure can inhibit operations and stymie future growth in energy production.

Crude-by-Rail

As domestic crude production expanded in areas such as rural North Dakota, producers found themselves without sufficient infrastructure to transport crude to market. As previously mentioned, pipeline infrastructure is receiving greater capital investments than any other infrastructure and is the preferred method among crude producers for transportation. Even now, Bakken crude producers laud pipelines as the best option for transporting crude.¹³ However, US refineries are located in traditional crude oil production areas such as the Gulf of Mexico and the West and East Coasts, and it is nearly impossible for new refineries to come

online near new production sites, which creates a logistical dilemma.¹⁴ Initially faced with a sudden expansion in production and nonexistent pipeline infrastructure, rail was the only available option to move landlocked crude out of the Bakken.¹⁵

Most of the rail infrastructure existed prior to the “shale boom” and was readily activated or expanded to suit crude transportation. Compared to pipeline, rail is relatively more geographically flexible with an extensive network of terminals and routes. Rail also transports crude significantly more quickly. Rail can transport Bakken crude to Gulf refineries in five to seven days versus 40 days with pipeline.¹⁶ Whereas pipeline projects may take as much as five to seven years from start-to-finish and represent a long-term investment, rail is more responsive to market conditions, with additions completed within 18 months.¹⁷ Additionally, because shippers can segregate different crude grades by tank car, rail also ensures product purity compared to pipelines that can contaminate transported crude with residual material from previous shipments.¹⁸ Rail also faces fewer regulatory barriers because track line expansions require no new permits, as opposed to proposed pipeline plans—such as TransCanada’s Keystone Pipeline—that face more public scrutiny and have a longer political green-lighting process. While rail poses multiple logistical advantages, the largest is costs and the elimination of supply-gluts. Previously, comparable Bakken crude sold for \$4 to \$28 per barrel cheaper than WTI due to a lack of adequate infrastructure. Despite costing \$5 to \$10 higher per barrel than pipelines, rail removes supply overhangs as well as price discounts and makes crude producers more profitable.¹⁹ Improving access to a cheaper domestic crude alternative also helped lower operating costs and saved refiners in Philadelphia from closure.²⁰

Rail’s flexibility and immediate availability contributed to its quick adoption in the Bakken region and also nationwide. Consequently, “crude-by-rail” has increased dramatically since 2010.²¹ The Association of American Railroads (AAR) reports that the number of terminated carloads of crude oil transported by US railroads increased from 236,656 in 2012 to 435,560 in 2013 (displayed in Figure 6 in the appendix).²² The Energy Information Administration (EIA) estimates the growth of rail use even higher in volume, with US crude oil refinery receipts for rail increasing 150 percent from 2012 to 2013 (Figure 8 in appendix).²³ Rail has sustained an upward momentum over the past four years and now carries over 1 million b/d.

Although rail represents a linchpin in the logistics of crude production, it has recently presented new risks and safety concerns. A derailment in the small Canadian town of Lac-Mégantic on July 6, 2013, (Figure 9 in appendix) that killed 47 people and destroyed 30 buildings in the town center initially launched rail safety into public dialogue. In response to the incident, the Canadian Transportation Safety Board released an aggressive timeline in which older model DOT-111 tank cars must be phased out by May 2017. Other regulations were also imposed, including speed restrictions, more stringent inspection standards, and emergency response plans for shippers and railroads.²⁴ More recently, 17 tank cars derailed in Lynchburg, Virginia, on April 30, 2014, spilling approximately 30,000 gallons of crude into the James River and forcing more than 350 people to evacuate their homes. Oil spills from tank car derailments pose a threat to both nearby communities as well as ecologically vulnerable areas. Since the Lac-Mégantic incident, seven other major derailments have occurred in North

America. Figure 10 in the appendix displays a one-year timeline of crude-by-rail incidents provided by the National Resource Defense Council. Accidents such as these have caused crude tank cars to be compared to soda cans carrying volatile materials and pipelines-on-rail.²⁵

According to the Federal Railroad Administration (FRA), rail as a mode of crude transportation has a better safety record than even pipeline and barge.²⁶ Prior to these accidents, the railroad industry voluntarily adopted preventative safety standards such as new tank car designs, self-regulated speed limits, and new routing technology. In March 2011, the AAR petitioned the Pipeline and Hazardous Materials Safety Administration (PHMSA), a Department of Transportation (DOT) subsidiary, to establish new standards for tank car design.²⁷ Without any conclusive decisions from PHMSA, the AAR devised a new tank-car design called the CPC-1232 model with more stringent safety standards and required that all new tank car manufacturers use this design after October 1, 2011. The CPC-1232 features thicker puncture-resistant shells, protective head shields, thermal protection, and top-fitting protection. However, the National Transportation Safety Board (NTSB) is unconvinced that these modifications offer significant safety improvements over the previous DOT-111 model.²⁸ The AAR estimates that there are currently 228,000 DOT-111 model tank cars in use, of which, 92,000 are used for transporting flammable liquids and 18,000 are built to the latest industrial safety standards (Figure 11 in appendix).

As a result of heightened public concern, the DOT and PHMSA have been pressured to take regulatory action to increase crude-by-rail safety. The DOT initially released an emergency order (DOT-OST-2014-0067) on May 7, 2014, requiring all railroads operating tank cars shipping more than 1 million gallons of Bakken crude to notify the State Emergency Response Commissions (SERC) about operations through their states.²⁹ An accompanying safety advisory encouraging shippers to use tank cars “with the highest level of integrity available” was also released without any mandate.³⁰ The DOT-111 model tank has especially been criticized for its outdated design and lack of safety features. Otherwise known as the “legacy car,” the DOT-111 design has received active use for decades with minimal revisions. Previous evaluations of the design deemed the DOT-111 tank cars susceptible to puncturing and at risk for transporting hazardous materials.³¹ However, the DOT-111 represents the largest portion of the crude oil tank car fleet. The newer CPC-1232 poses challenges of its own, considering it was the model that derailed in the Lynchburg, Virginia, accident. The DOT and PHMSA, which are responsible for regulating rail transportation of flammable liquids, are in the process of determining suitable safety standards.

Proposal

In order to prevent future incidents and mitigate the risks associated with crude rail transportation, we offer the following proposal addressing tank car design, rail infrastructure, speed, routing, braking systems, and crude oil labeling. Late into developing this proposal, the DOT released a highly anticipated Notice of Proposed Rulemaking (NPRM) on July 23, 2014, outlining potential regulations.³² The NPRM is available for a 60-day comment period, and proposals set forth by the DOT are subject to final revisions and changes. The proposal set

forth in this paper aims to provide a definitive set of regulations. Throughout the development of the proposal, we aimed to create a final and unique set of standards. However, in light of the recent NPRM, our standards have taken on an additional function of answering the questions put forth by the DOT just days ago.

States, municipalities, and private organizations have all tried to make sense out of the rapidly expanding crude-by-rail industry, but the regulatory landscape has become cluttered and confusing.³³ Given the rapid expansion of crude-by-rail, as well as the increasing clamor from the rail industry and local communities alike, a comprehensive and uniform overhaul is in order. This proposal aims to implement both preventative and mitigative barriers to limit the risk of an accident and the magnitude of an accident's consequences, should it occur.³⁴ Additionally, our proposal aims to increase safety through two primary metrics: decreasing the likelihood of derailment and decreasing the conditional probability of hazardous material release.

The proposal would require implementation by the DOT and PHMSA and financing by rail companies, shippers, and tank-car owners. The proposal does not include subsidization of any form, because the previously mentioned capital investments display that there is sufficient private investment to cover necessary developments and rail improvements.

Tank Car Design

The DOT-111 tank, created in the 1960s, has been declared unsafe since a 1991 FRA review,³⁵ yet over 200,000 tanks still operate today, with approximately 78,000 carrying crude.³⁶ There is a minority of DOT-111 tank cars (previously estimated at approximately 18,000) built after October 2011—referred to as “good-faith cars”—that are equipped with head shields, top-fitting rollover protection, half-inch-thick normalized tank steel (onunjacketed cars), double-shelf couplers, and bottom skid protection³⁷ and that meet the industry imposed CPC-1232 standard.³⁸ Going forward, these voluntary standards should be codified by the DOT (PHMSA) with key additions and specifications to bring uniformity to the crude-by-rail industry, including:

- A. Top-fitting protection: All cars carrying crude should be fitted with protective top fittings that include both rollover protection and high-flow-capacity pressure relief valves.
- B. Bottom outlet protection: The bottom outlet should be reconfigured for maximized skid protection and to prevent the handle from opening in an accident or derailment. This should include skid protection as well as either: recessed valves, protective shields, and breakaway design or removal of the handle altogether.
- C. Head shield protection: All tanks should be fitted with full height half-inch thick steel head protection shields regardless of whether or not the tank is jacketed or unjacketed.
- D. Tank shell thickness: Unjacketed tank cars must have a minimum tank thickness of 1/2 inch, while jacketed cars may retain their minimum of 7/16-inch tank thickness, with a 1/8-inch thermal protection layer.
- E. Tank material: All tank cars should be constructed with normalized TC-128B steel in lieu of the commonly used A-516 grade steel.

All new tankers should immediately be built within the aforementioned standards. DOT-111s built before October 2011 not fitting these standards will begin to be phased out immediately and must either be retrofitted or retired within six years. Any tank cars meeting CPC-1232 standards must be phased out or retrofitted within eight years.

Braking Systems

Unit trains should add locomotives equipped with either electronically controlled pneumatic (ECP) brakes or distributive power (DP) braking with radio capabilities. Trains selecting DP braking systems should place two locomotives at the head of the train with a third locomotive placed two-thirds down the length of the train. All crude-carrying unit trains should meet these braking standards within one calendar year.

Increased Rail Inspections

The DOT should mandate that all rail companies inspect their own tracks a minimum of twice every calendar year, regardless of the speed classification of rail. Should private companies choose to selectively increase inspections, the new metric for increased inspection should be the presence of crude-carrying tankers. Following inspections, companies should follow up on potential track issues within 14 days. To ensure that tracks are maintained, the DOT should randomly check 5 to 10 percent of rail infrastructure every calendar year.

Speed Reductions

Every unit train carrying 20 or more cars of crude oil should reduce speed from the current 50 miles per hour (mph) to 40 mph in the 46 High Threat Urban Areas (HTUA) designated by the Department of Homeland Security (DHS). The 40 mph speed limit should also be implemented in any future regions or metropolitan areas designated by the DHS as HTUAs.

Communities not originally designated as HTUAs may apply for special consideration within 90 days of the implementation of the law. Interest groups may also apply on behalf of ecologically sensitive regions or significant water sources affected by rail. To mitigate arbitrary applications, the burden of proof should remain with the applicants. The metrics for qualification are: significant population density near tracks transporting crude, the passage of more than 130,000 barrels of crude daily, or proven environmental sensitivity.

Rail Corridor Risk Management System

All crude tank cars should immediately implement the Rail Corridor Risk Management System (RCRMS) which analyzes over 10,000 routes daily based on 27 risk factors, including hazmat volume, trip length, population density along route, availability of alternate routes, and emergency response capability to determine the safest route.³⁹ Already voluntarily adopted within the industry by the AAR, this statistical model should be mandated as a required system for route selection among all market participants.

Labeling Crude

In addition to existing labeling standards, shippers must ensure their tank cars are equipped with emergency response information and proper labeling of crude properties, including boiling point, flashpoint, and origin of contents.

Reasoning

A multitude of voluntary standards leave manufacturers and shippers confused and often hesitant to expand.⁴⁰ Federal overhaul offers the advantages of clarity and authority that other actors and interest groups lack while bringing a timetable and enforceable consequences to crude-by-rail.⁴¹ Lack of safety regulation contributes to continued loss of revenue, as demonstrated by the \$10 million lost in the first five months of 2014 alone in crude-by-rail incidents.⁴² Economic advantages also result from enticing investors and crude producers alike to the rail market that was previously seemingly unnavigable.

Tank Car Design

Despite CPC-1232 standards and PHMSA's safety advisory issued on May 27, 2014, urging the retirement of all DOT-111s from crude service, 82 percent of crude is shipped in the pre-October 2011 DOT-111 model.⁴³ A statistical comparison of DOT-111 and CPC-1232 tank cars showed that DOT-111s are significantly more prone to derailment or to releasing their contents. The probability of a spill declined from 0.41 to 0.24 (a 41 percent reduction), and the average number of tanks releasing contents shrank from 1.83 to 1.03 (44 percent reduction) when a fleet of CPC-1232s was compared to a DOT-111 fleet.⁴⁴ However, the CPC-1232 still needs modification as demonstrated by the rupture of a CPC-1232 in the Lynchburg crash (Figure 13 in appendix), according to the National Transportation Safety Board.⁴⁵

First, the addition of bottom fittings addresses one of the most common spill points. Cars with bottom fittings protections are 55 percent less likely to release content and release 42 percent less quantity, should an accident occur.⁴⁶ Further, a comprehensive analysis reveals that following the proposed standards for amended tank thickness, top fittings, protection, and full-height head shields reduces the risk of content release in the case of an accident from 34.07 percent to 22.54 percent.⁴⁷ Finally, regulating the use of normalized TC-128B ensures a more uniform and higher tensile strength,⁴⁸ making it less inclined to both brittle and ductile failures in a derailment.⁴⁹

The timeline takes into account costs and rate of production. The industry currently produces approximately 30,000 tankers a year, but production is backlogged about two years. The replacement or retrofitting of 78,000 would take roughly two and a half years. An extra year and a half is factored in for future car orders and allows more time for cars that are relatively safer, adding flexibility and a prolonged timeline to invest the estimated \$1 billion in costs.⁵⁰ The prolonged timeline is more reasonable and likely to be accepted by the industry than DOT proposals, which advocate for full phase out in two years.³⁴ The DOT timeline is too expedited and does not provide sufficient time given manufacturing capacity and the preexisting backlog. An accelerated phase-out risks removing a necessary means of transportation and hampering Bakken crude production.⁵¹

The industry has already integrated some new safety standards into tank car design in the past two years. Despite concerns raised by shippers, new modifications also do not significantly reduce volume capacity or add excessive weight, both of which directly correlate with shipper's costs.⁵² The modified tanker does not trade efficiency for safety: compared to the DOT-111 model, capacity is only reduced by 2.5 percent for insulated car designs and a 1.1 percent reduction for uninsulated car designs and TC-128B steel does not add more weight than A-516 steel.

The recent DOT proposal leaves DOT-111 reform up for debate by presenting various options, particularly the choice between 7/16- or 9/16-inch tank thickness. The former has been proven insufficient, while the later is not feasible. First, a 9/16-inch standard would render all existing cars, even those built months ago, obsolete. Second, it would add roughly 4,000 pounds to the tank weight and only yield a 4 percent decrease (0.2157 to 0.2127) in conditional probability of release in an accident.⁵³ Both of these considerations make it probable that in the 60-day commenting period, shippers will likely eliminate the 9/16-inch option. Finally, while safety additions add weight that contributes to quicker track degradation, the DOT-proposed reform does not include infrastructure maintenance measures. Our comprehensive proposal addresses both and doesn't neglect the risks of track performance.

Braking Systems

Advanced DP and ECP braking systems reduce lateral forces and friction that lowers the impact of heavy trains on tracks during braking and further reduces track deterioration. Brake application and release commands are also transmitted by radio communications that significantly shorten all brake command propagation times. Stopping distances are reduced through faster brake application, and more rapid acceleration and deceleration is also made possible.⁵⁴ General Electric (GE), the leading producer of DP brake technology claims that its proprietary LOCONTROL® technology offers 30 percent faster and smoother starting and stopping distances, 22 percent faster starting and stopping times, improved fuel efficiency, and operating cost reductions averaging 10 percent.⁵⁵

The DOT's proposals only include ECP brakes as an option for tank car specifications, which is not practical for the entire industry. ECP is only feasible if the cars travel within the same unit train for extended periods of time, which reduces the flexibility of removing tank cars that makes rail an attractive alternative to pipeline.⁵⁶ Furthermore, every car in a unit train must be equipped for ECP to work, which makes conversion expensive and lengthy. Due to the common practice of "mixing and matching" crude tankers with other freight train cars, the DOT mandate would require more of the rail industry apart from just crude tanks to make the switch.⁵⁷ ECP brake technology is still in its infancy and providing options between braking systems allows competition among manufacturers and reserves shippers the autonomy of choosing their own technologies. ECP braking also requires further testing on proven problems such as compression system contamination, accelerated wheel and brake pad wear, overheating, and electrical interference.⁵⁸

Track Inspection

Broken rails or welds are the leading equipment-related causes for train derailments. The FRA REA database implicates broken rails in 106 out of 438 hazardous material derailments between 2002 and 2011, or approximately 24 percent.⁵⁹ However, only 1 percent of rail track is examined by the FRA annually.⁶⁰ Multiple state transportation departments and even the NTSB concede that rail inspection and maintenance has not sufficiently grown correspondingly to increased crude-rail traffic.⁶¹ There is even speculation that the Lynchburg derailment was caused by a track defect.⁶² Track inspection aims to prevent derailment by targeting track defects and is the most cost effective means of increasing safety.⁶³

Any previous attempts to address rail defects have fallen short. Legislation that calls for increased inspections focuses on classes 4 and 5, which precludes class 6 and leaves trains traveling at speeds up to 110 mph. Additionally, this excludes classes 1, 2, and 3, which are oftentimes the highest risk because of their proximity to high-density population areas. Passenger train tracks, as opposed to tracks carrying hazardous materials, are also given precedence in inspection and maintenance. All of these preexisting issues have reduced the priority of crude-carrying rail lines, which need the most inspection, as crude derailments have massive destructive potential.⁶⁴

Speed Reductions

Severity of rail accidents as measured by the average number of cars derailed is proven to have a direct correlation with speeds. Trains traveling at higher speeds subject hazardous materials to greater forces that also increase the probability of a release of hazardous material.⁶⁵ The 46 federally determined HTUAs require more stringent speed limitations, since accidents in areas with dense populations risk consequences of a higher magnitude.

To date, even the most stringent of the DOT's proposed policies—such as protecting towns with populations exceeding 100,000—have not protected endangered environments and smaller towns that fall below the existing thresholds. For instance, Lac-Mégantic and Lynchburg would not have qualified for lower speed limits under the proposed rules by the DOT, despite the relatively large volume of crude carried through the towns daily.⁶⁶ Missing from the DOT NPRM is mention of an oil spill that could contaminate vital water resources that local communities heavily rely on. Should a spill carry oil downstream to vulnerable water supplies, hundreds of communities could be endangered. The proposed application process is designed to maximize accessibility to protection and avoid excluding at-risk communities based on rigid metrics. Our proposal gives non-qualifying communities an opportunity to receive increased protection not previously provided.

Speed reductions can increase congestion on rail lines, lengthen shipment time, and increase unit costs per shipment. The industry has already begun to voluntarily lower speed limits to 40 mph,⁶⁷ but has also openly stated unwillingness to limit speeds to below 40 mph.⁶⁸ Therefore, 40 mph is the most likely compromise to make a required standard.

Rail Corridor Risk Management System

The rail industry developed the RCRMS jointly with several federal agencies to statistically analyze and identify the safest and most secure routes for transporting hazardous material. The model uses at least 27 risk variables, such as hazmat volume, trip length, population density along the potential route, availability of alternate routes, and emergency response capability.⁶⁹ The DHS also devised the system with a factor measuring proximity to iconic locations because of speculation that shipments could become targets of terrorism.⁷⁰ The AAR voluntarily requested that shippers carrying at least 20 carloads of crude implement the RCRMS system starting July 1, 2014. Mandating its use incorporates all shippers and standardizes rail operations. Widespread implementation will also increase feedback from train operators that will enhance the algorithms used. This comprehensive calculus avoids shallow routing standards that create the ethical dilemma that often inspires community backlash of transferring “risk from one population to another.”⁷¹ Also factoring track quality and trip length, the RCRMS system recognizes that diverting trains around cities increases risk of derailment.⁷²

Labeling

Currently, the FRA requires that shippers test shipped material accurately, identify all hazards of transported materials, and properly classify the material in the correct package group. Based on ignitability and its involvement in recent accidents, PHMSA concluded that Bakken crude is more volatile than other crude oils.⁷³ However, Bakken producers and the American Petroleum Institute (API) vehemently deny these allegations, citing other scientific research that claims no significant differences.^{74,75} Labeling transported crude better informs first responders and alerts communities of the properties of hazardous materials. This proposal suggests requiring indiscriminate labeling of all crude oils until more conclusive research definitively proves a significant difference. The net benefit gained through this provision is enhanced information that will assist emergency first-responders in the case of an accident.

Implications

Any additional safety requirements are bound to increase the costs of operations for shippers and railroads. Increasing tank thickness reduces the potential volume shipped and requires more tank cars. Reducing speeds slows down shipment orders and turnover rates for trains. ECP and DP braking systems translate into a new capital cost. Each new safety standard represents an additional unit cost measured by each tank car. For shippers and producers that are concerned with netbacks, or the net profit, additional costs raise the bottom line and come at the expense of potential profits. In the short term, this may result in lower profit margins.⁷⁶ However, increased safety standards do have the potential to improve profitability by reducing the probability of costly derailments and expensive crude oil spills.

Many have raised concerns that the crude-by-rail market is myopic or short-lived.⁷⁷ Rail has become largely successful in the absence of an adequate pipeline infrastructure. However, as the costs of utilizing rail increase, costly pipeline projects may become more feasible. These costs come in the form of both the variable unit costs outlined above as well as fixed costs associated with retrofitting tank cars and replacing obsolete ones. With rail and pipeline in

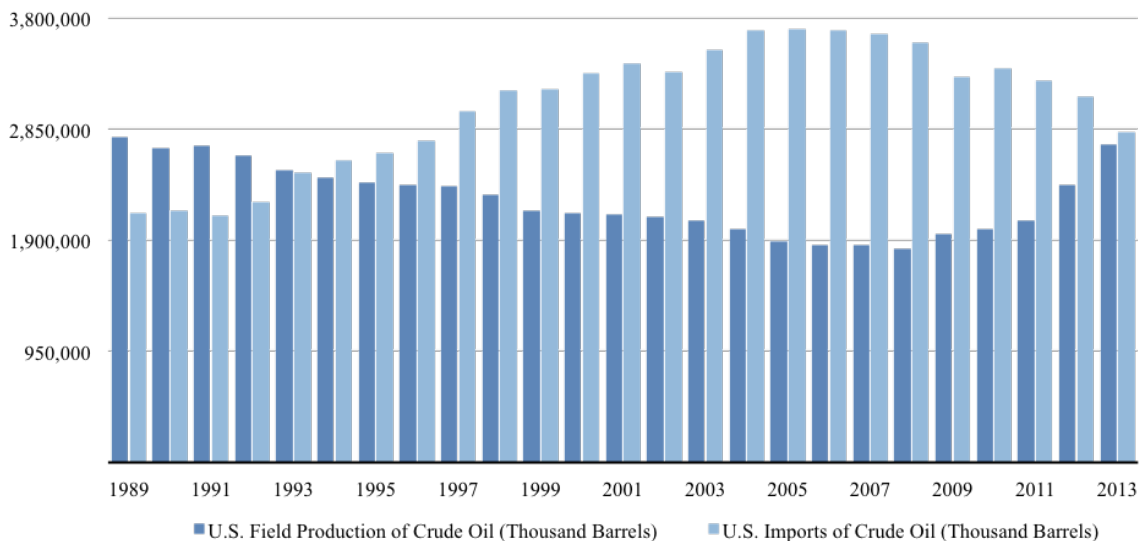
direct competition as logistical services, substantially increasing rail costs may close the gap and bring pipeline to the forefront. As previously mentioned, pipeline projects require large capital investments and are long-term initiatives. Pipelines would increase efficiency and lower costs, but at the expense of jobs tethered to railroad growth.

Although the backlog for tank cars is already estimated at over 60,000, there are allegations that this number could be larger; however, shippers and crude oil producers are holding off purchasing tank cars that may immediately become obsolete or require expensive retrofitting. An ambiguous regulatory environment can impede economic growth insofar as market participants wait on the sidelines. Providing clear and definitive measures allows participants to clearly define costs of operations and make necessary decisions.⁷⁸ Despite being counterintuitive, imposing regulations could encourage market involvement by removing political uncertainty.

Developing a policy proposal requires accounting for all stakeholders, including local communities, tank car manufacturers, oil producers, rail shippers, and even the environment. Therefore, proposing a set of regulations is a balancing act between appeasing different parties with conflicting interests. Additionally, a policy proposal must sufficiently account for the timeframe in which it will be implemented. If hawkish regulations prove too stringent, shippers may not be able to operate, crude production may falloff, and all the national economic benefits may never come to fruition. In the crude-by-rail case, regulations must adequately balance economic interests as well as safety concerns.

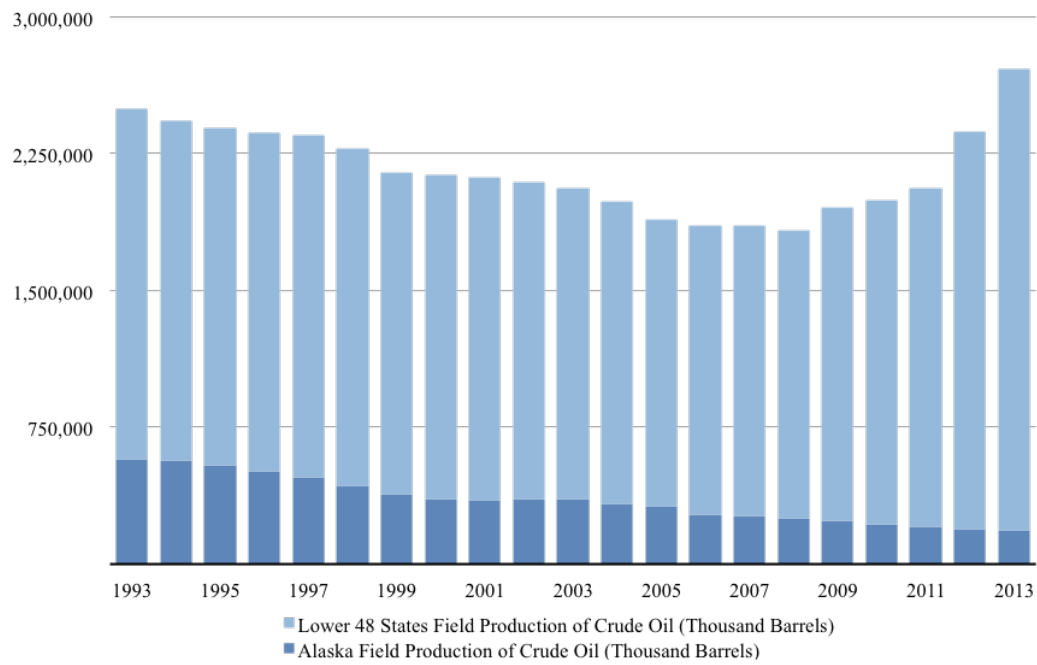
Appendix

Figure 1 – U.S. Crude Oil Supply and Disposition (thousands of barrels)



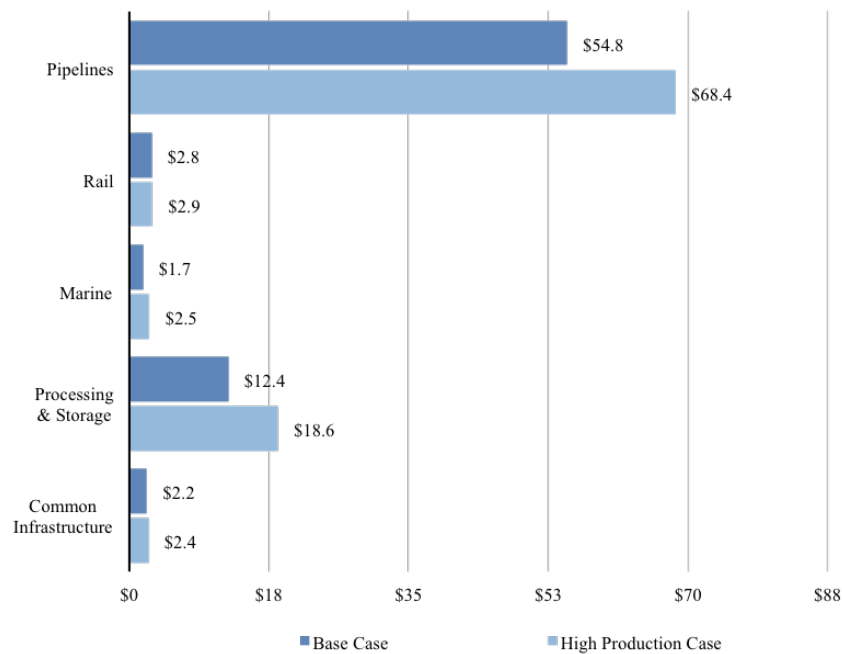
Source: The Energy Information Administration

Figure 2 – Composition of U.S. Domestic Crude Oil Production



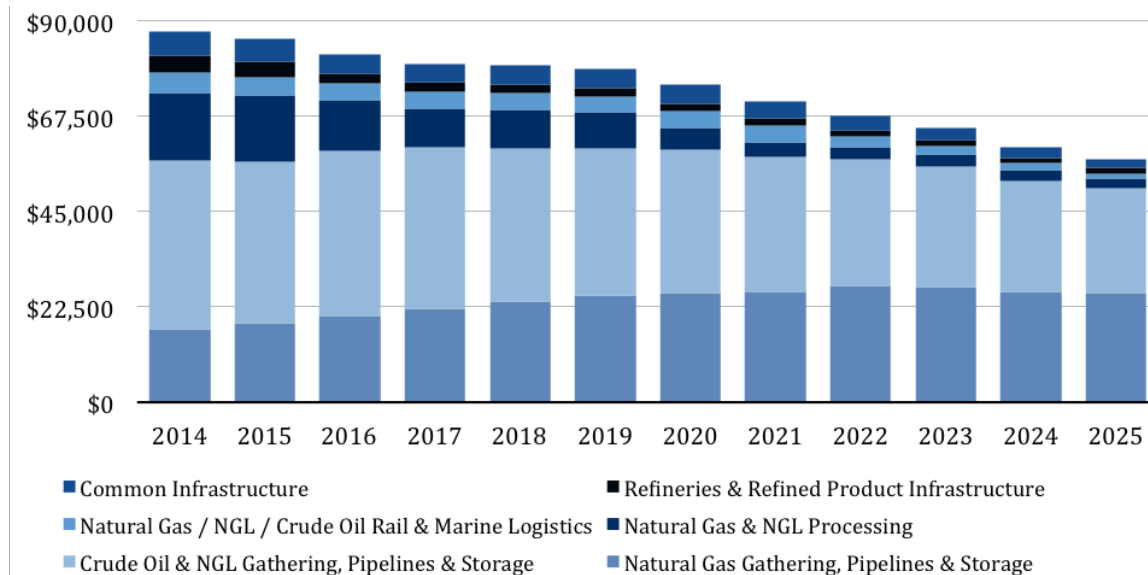
Source: The Energy Information Administration

Figure 3 – Average Annual Investment by Transport Mode (\$ billions)



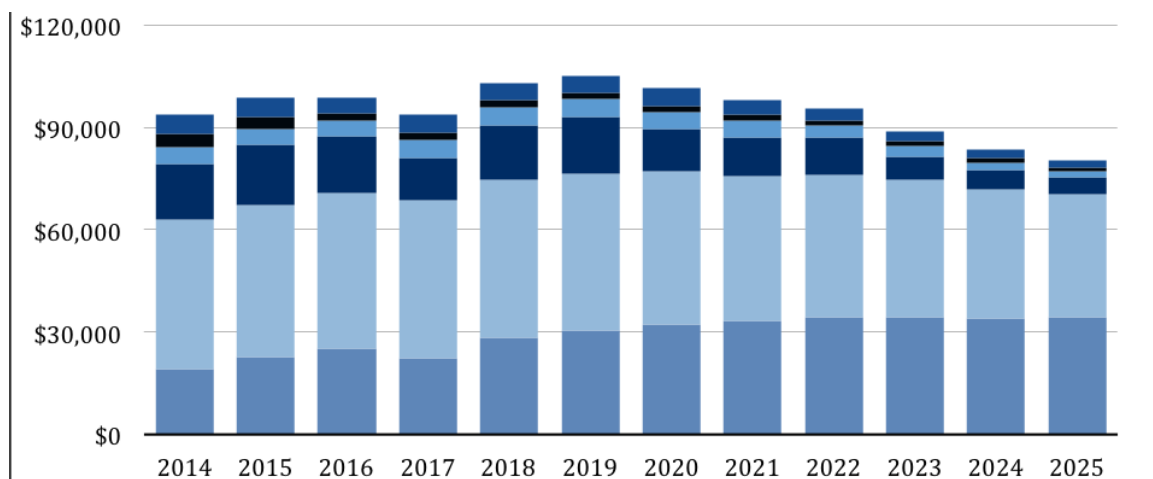
Source: IHS Global, Oil and Natural Gas Transportation Infrastructure Report, 2013

Figure 4 – Base Case: U.S. Direct Capital Investment Forecast 2014–2025 (Millions of 2012 Dollars)



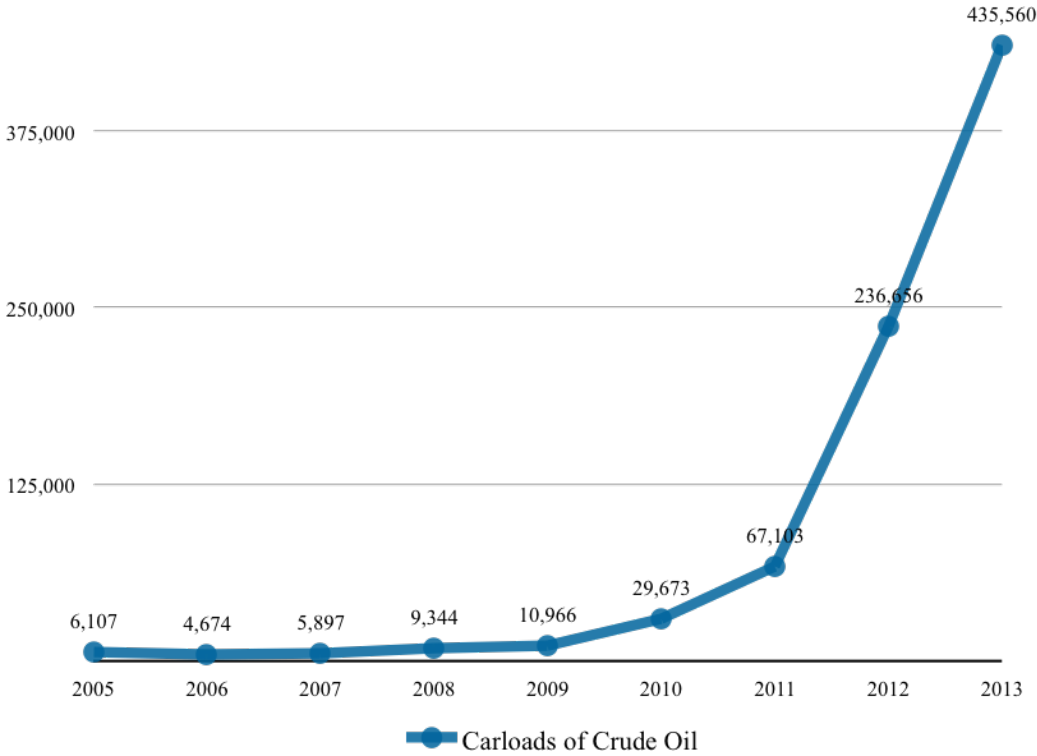
Source: IHS Global, Oil and Natural Gas Transportation Infrastructure Report, 2013

Figure 5 – High Case: U.S. Oil & Gas Direct Capital Investments Forecast 2014–2025 (Millions of 2012 Dollars)



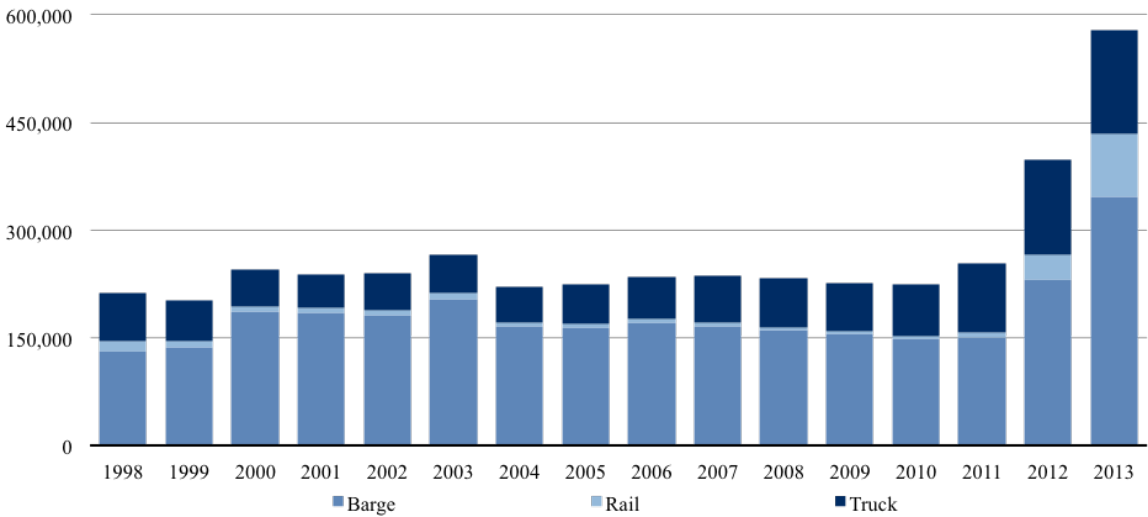
Source: IHS Global, Oil and Natural Gas Transportation Infrastructure Report, 2013

Figure 6 – Terminated Railroad Carloads of Crude Oil



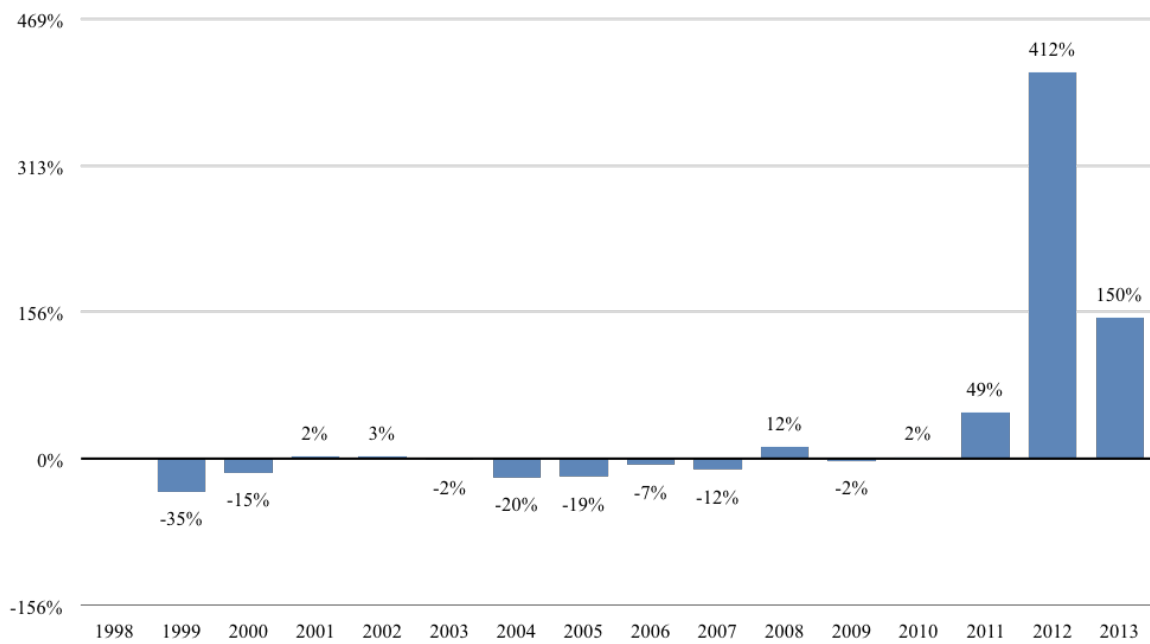
Source: The Association of American Railroads

Figure 7 – U.S. Crude Oil Refinery Receipts by Method of Transportation (Thousands of Barrels)



Source: Energy Information Administration

Figure 8 – Percentage Change in U.S. Crude Oil Refinery Receipts by Rail



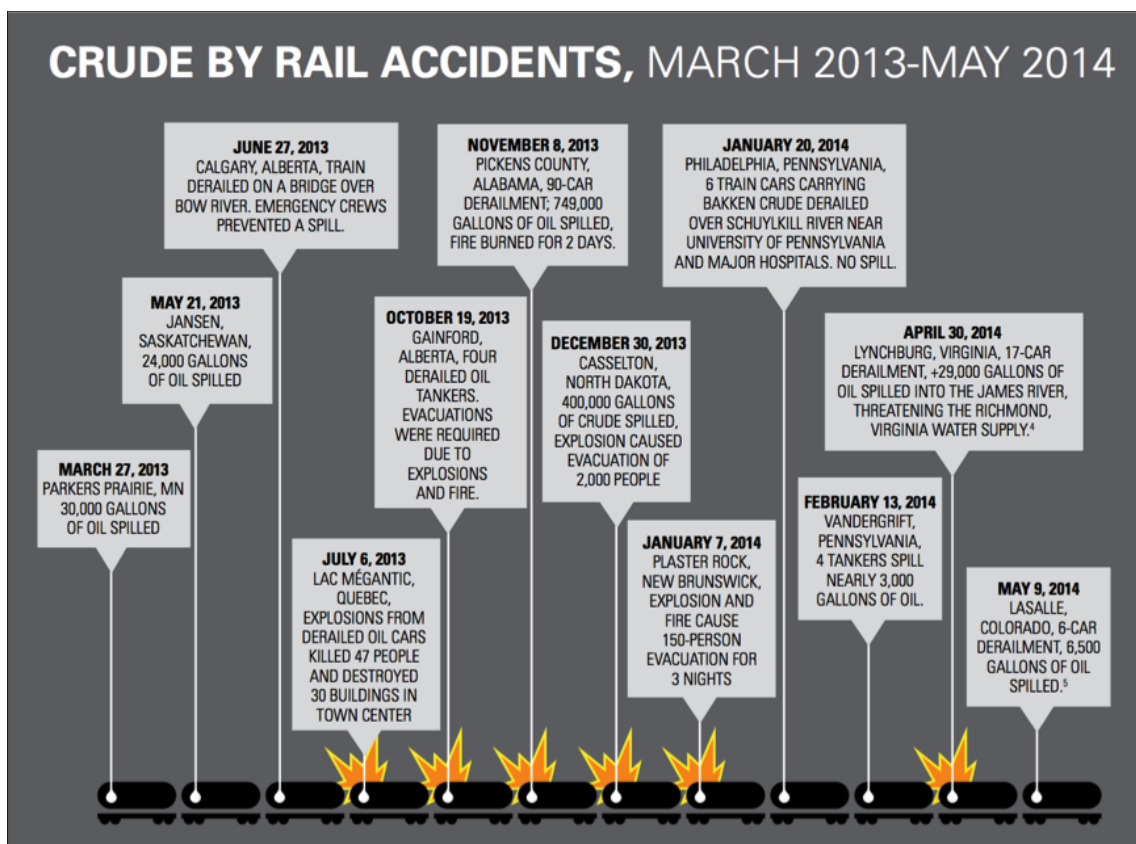
Source: Energy Information Administration

Figure 9 – Image of Lac Mégantic Aftermath



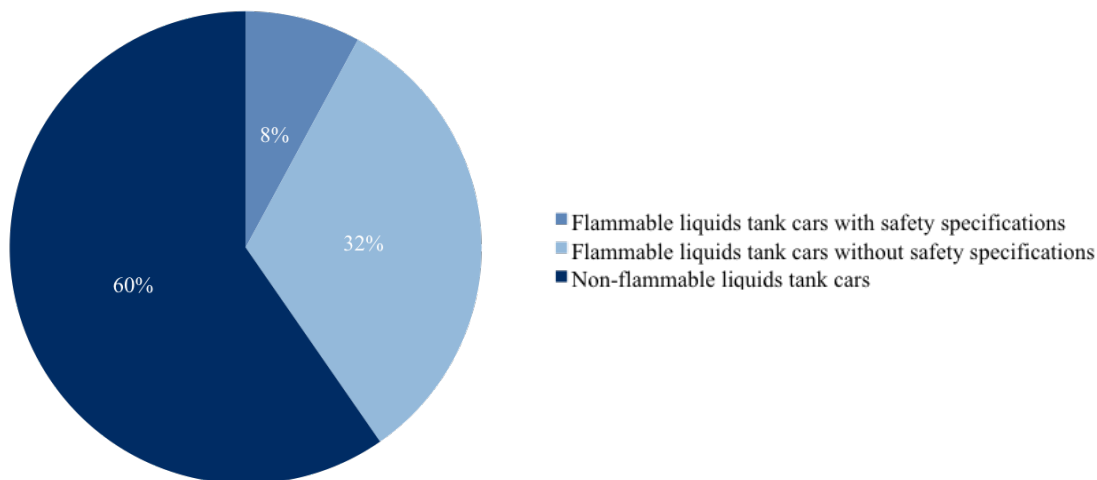
Source: Canadian Press

Figure 10 – Timeline of North American Crude-by-Rail Accidents



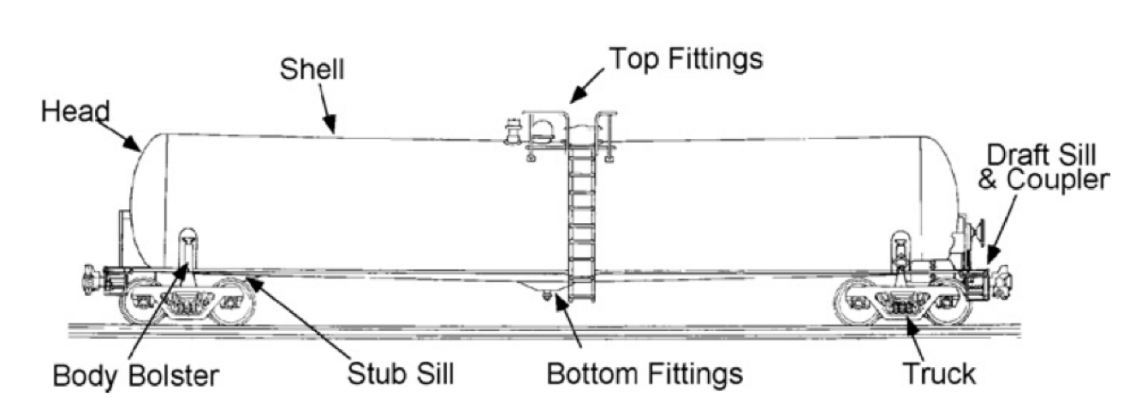
Source: The National Resource Defense Council

Figure 11 – Composition of DOT-111 Tank Car Model Fleet



Source: The Association of American Railroads

Figure 12 – Diagram of Tank Car Design



Source: Journal of Hazardous Materials

Figure 13 – Image of Tank Car Derailment in Lynchburg, Virginia



Source: The Associated Press

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Nothing is Certain Except Climate Change and Taxes: Environmental, Economic, and Bipartisan Benefits of a Revenue-Neutral Carbon Tax

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Abstract

In June 2014, the US Environmental Protection Agency released the Clean Power Plan, a proposal for regulating carbon dioxide emissions from coal-firing power plants on a state-by-state basis. Unfortunately, the Clean Power Plan is economically inefficient, environmentally ineffective, and difficult to implement. Instead of adopting the Clean Power Plan, the United States should levy a revenue-neutral carbon tax on all domestic power plants that utilize coal, petroleum, or natural gas to produce electricity. According to projection models, between 2016 and 2030, a revenue-neutral carbon tax can lower carbon dioxide emissions by at least 25 percent more than the Clean Power Plan. A revenue-neutral carbon tax is also projected to create 2.1 million jobs by 2025, raise US GDP, and incentivize a broad shift toward renewable energy.¹ Furthermore, the carbon tax's fee-and-dividend will redistribute 100 percent of tax revenues to US households. The rebate will counteract potential increases in energy prices and consumer goods. As an upstream tax, the carbon tax would apply to less than 2,500 power plants and would be easy to administer. If the carbon tax is accompanied by a border tax adjustment, US manufacturers will be able to compete with nations that do not regulate their emissions. Although the current lack of bipartisan cooperation in Congress presents a profound challenge to passing a carbon tax, recent polls suggest that bipartisan support for a carbon tax is rising. By adopting a revenue-neutral carbon tax, the United States will set a precedent for adopting energy policies that maximize both environmental and economic benefits.

Introduction

In the United States, negotiating effective energy policy is more complex than simply balancing reductions in greenhouse gas (GHG) emissions with economic interests. The United States is currently more politically divided than at any other point in the past 20 years, and partisan antipathy between Democrats and Republicans continues to deepen.² In such an acrimonious political climate, an effective energy policy cannot merely mitigate GHGs. It must establish points of consensus by limiting uncertainties and aiming for positive environmental and economic progress. The emissions reductions featured in the US Environmental Protection Agency's most recent policy proposal, the Clean Power Plan, fail to justify the economic uncertainties that the policy will create. Furthermore, it is highly uncertain that the Clean Power Plan will push the most pollutant states toward updating their energy production infrastructure. In contrast, a revenue-neutral carbon tax on carbon dioxide (CO₂) emissions from power plants is a more reliable policy. A revenue-neutral carbon tax uses

market mechanisms to incentivize emissions reductions and produce more positive economic outcomes. With more benefits to offer both sides of the political aisle, a revenue-neutral carbon tax internalizes many of the externalities associated with climate change without needlessly burdening taxpayers.

Relevant Policy: The Clean Power Plan

On June 2, 2014, the US Environmental Protection Agency (EPA) released the Clean Power Plan, a proposal for regulating coal-fired power plants and reducing domestic greenhouse gas emissions. The Clean Power Plan is the newest linchpin of President Obama's broader Climate Action Plan. Drawing its regulatory power from Section 111 of the Clean Air Act, the Clean Power Plan consists of two main elements. The first element calls for state-specific targets for lowering CO₂ emissions from power plants by 2030. State targets are determined by a formula in which emissions from fossil fuel-fired power plants are divided by total state electricity generation (from fossil fuel-fired power plants and other power sources).³ Assigning emissions targets on a state-by-state basis takes into account each state's unique profile of emissions and power sources. The second element of the Clean Power Plan includes guidelines to assist states in developing plans for reaching their targets.⁴

According to the EPA, emissions reductions under the Clean Power Plan will enable the United States to cut carbon pollution by 30 percent between 2005 and 2030—the equivalent of cutting annual emissions from two-thirds of US passenger vehicles.⁵ The EPA estimates the monetary value of a 30 percent emissions reduction at \$55 billion to \$93 billion. This figure accounts for the prevention of 2,700 to 6,600 premature deaths and 140,000 to 150,000 childhood asthma attacks.⁶

Uncertainties of the Clean Power Plan

Although the Clean Power Plan may improve public health and reduce emissions, its structure allows for a troubling number of uncertainties. A 2014 report from the US Chamber of Commerce (CC) suggests that the benefits of the Clean Power Plan are overshadowed by its adverse effects on the US economy. Between 2014 and 2030, the Clean Power Plan will lower US Gross Domestic Product (GDP) by an average of \$51 billion every year, lead to an average annual loss of 224,000 US jobs for 15 consecutive years, force US consumers to pay \$289 billion more for electricity, and lower total disposable income for US households by \$586 billion.⁷ The EPA has pointed out that climate-related disasters cost the American economy more than \$100 billion in 2012. The agency alludes that the emissions reductions under the Clean Power Plan will reduce future damage from hurricanes, tornadoes, and other events exacerbated by climate change.⁸ However, the Clean Power Plan will not reduce emissions by enough to reduce disaster recovery costs.

The Clean Power Plan's economic uncertainties are paralleled by its environmental shortcomings. It is clear that the Clean Power Plan's reduction of domestic CO₂ emissions is insufficient to impact global emissions. Although global carbon emissions are anticipated

to rise by 42 percent between 2005 and 2030, the Clean Power Plan seeks to lower domestic emissions by only 30 percent.⁹ Therefore, the Clean Power Plan will reduce global emissions by only 1.8 percent.¹⁰ Given that the United States emitted 16 percent of global CO₂ emissions in 2013, a 1.8 percent reduction is not sufficient to mitigate the United States' contributions to climate change.¹¹ A 2009 report from the Union of Concerned Scientists states that the United States must aim for "at least" a 56 percent reduction by 2030 to make any difference in mitigating the consequences of climate change, which contributes to extreme heat, droughts, storms, acidifying oceans, and rising sea levels.¹² By targeting coal-fired power plants, the Clean Power Plan only addresses emissions from about 18 percent of annual energy consumption in the United States.¹³ A more effective policy will monitor CO₂ emissions from other energy sources such as petroleum and natural gas. Finally, by setting its baseline at 2005 and its emissions reductions goal at 30 percent, the Clean Power Plan is grasping at low-hanging fruit. Since 2005, the United States already has lowered domestic emissions by 15 percent. A policy that proposes to lower emissions by another 15 percent "puts a neat political bow on progress already taking place."¹⁴

The Clean Power Plan also features inequitable emissions reductions standards. A deeper look at the states' reductions goals reveals that the Clean Power Plan generally places the lowest burden on the most pollutive, carbon-intensive states, such as West Virginia, Kentucky, and North Dakota. The Clean Power Plan encourages the formation of interstate carbon trading systems, in which the most CO₂-intensive states can purchase carbon credits from less CO₂-intensive states. This enables heavy polluters to avoid investing in energy-efficient infrastructure and renewable fuel sources, such as biofuels, solar, and wind.¹⁵ Meanwhile, the formula for calculating emissions reductions goals often penalizes less pollutive states. For example, Washington already has a relatively low carbon-intensity baseline, but still must meet ambitious emissions reductions goals.¹⁶

A final uncertain element of the Clean Power Plan is its timeline for implementation. Once the Clean Power Plan is finalized, states will be left to form their own emissions reductions strategies. Although states are supposed to submit initial strategies by mid-2016, they can request extensions and delay submission of plans until 2018.¹⁷ The International Energy Agency recently concluded that delaying a transition to low-carbon energy production by two years has increased the global cost of transitioning by \$4 trillion.¹⁸ The long wait for tangible emissions reductions under the Clean Power Plan may complicate future renewable-energy efforts. For all of the reasons stated above, the Clean Power Plan is an economically and environmentally inefficient pathway for emissions reductions. It heightens uncertainties surrounding the future of the US economy, places an inequitable burden on different states, and fails to ensure adequate emissions reductions.

In a 2008 report on policy options for mitigating CO₂ emissions, the US Congressional Budget Office noted that the best energy policy should maintain "a balance between the uncertain benefits and costs of reducing CO₂ emissions."¹⁹ The Clean Power Plan's economic uncertainties are not balanced out by its benefits. Rather than accept the Clean Power Plan as currently proposed, the United States must move toward an energy policy that pursues

more concrete certainties, such as more reliable economic tradeoffs and equitable emissions reductions standards across states. A well-known aphorism, often attributed to Benjamin Franklin, states that “the only things certain in life are death and taxes.”²⁰ Following this line of thought, the energy policy with the most certain benefits is a revenue-neutral carbon tax on CO₂ emissions from power plants that utilize coal, petroleum, or natural gas. To mitigate concerns about international trade and errant emissions, the carbon tax should be accompanied by a border tax adjustment.

Proposal for the Revenue-Neutral Carbon Tax

According to a report from the Citizens' Climate Lobby (CCL), a well-designed carbon tax “can capture about 80 percent of US emissions by taxing only a few thousand entities.”²¹ This statement highlights the sheer efficiency of carbon taxation. Even if the carbon tax were levied on every electricity-producing power plant that uses coal, petroleum, or natural gas, less than 2,500 entities would be involved.²² As a Pigovian tax, the carbon tax brings the hidden costs of CO₂ to the attention of producers and consumers and assists markets in internalizing the negative externalities associated with climate change and air pollution.²³ By incorporating a fee-and-dividend system, a revenue-neutral carbon tax counteracts the negative economic effects of taxation. Adding a border tax adjustment would further protect the US economy from competition with countries that do not limit CO₂ emissions.

The revenue-neutral carbon tax has three crucial components: initial and future tax rates, the tax base, and revenue distribution. Most of the following tax features are derived from carbon tax models proposed by the CCL, Gilbert Metcalf, and David Weisbach.

Tax Rate

The tax would begin in 2016 at a rate of \$10 per metric ton of CO₂ and would escalate at a rate of \$10 per year until 2025.²⁴ Power plants using coal and petroleum, which emit the most CO₂ per unit of energy, will be most burdened by the tax. Theoretically, by 2025 there will be a significant amount of renewable energy infrastructure in place; therefore, power plants using coal and petroleum will begin to become obsolete. A model of the carbon tax indicates that by 2035, the economic benefits of carbon taxation will begin to decline. At this point, the tax rate on power plants using coal, petroleum, and natural gas can be gradually lowered. A definite goal would be to keep the tax in place until every power plant reliant on coal or petroleum for energy has been phased out. Power plants using natural gas will stay on-line until there is more information on the potential hazards of hydraulic fracturing.

Tax Base

The carbon tax will be levied on electricity plants that use coal, petroleum, or natural gas to produce electricity. By applying to all three energy resources, the carbon tax achieves much fuller coverage than the Clean Power Plan, which only covers about 39 percent of electricity generation in the United States.²⁵ Administratively, a carbon tax is relatively simple and low-cost to implement because the EPA already collects data on CO₂ emissions from larger power generators.²⁶ Given that there are only about 2,339 major power plants in the United States

that produce electricity, collecting tax revenue and monitoring the power plants' progress in reducing CO₂ emissions is completely feasible.²⁷ In comparison, the Clean Power Plan poses enormous administrative challenges. Time and money must be invested in approving state plans, granting extensions, and monitoring state progress.

Revenue Distribution

Every dollar from the carbon tax would enter a fee-and-dividend system and will be refunded to American citizens through checks or direct deposit on a monthly basis. Revenue will be distributed to households, with children below 18 years of age counting for half the revenue value of adults. By 2025, the tax would return nearly \$400 billion to households—equivalent to \$300 per month for a family of four.²⁸ If a carbon tax is adopted, industries tied to households—such as health care, retail, and home construction—would benefit from the tax because increased disposable income from a fee-and-dividend tax tends to increase consumer spending. In contrast, the Clean Power Plan is expected to lower annual disposable income per family by an average of \$200 between 2014 and 2030, with a peak annual loss of \$367.²⁹ Although annual losses from the Clean Power Plan may seem small, they add up to a total shortfall of \$586 billion in disposable income for American households between 2014 and 2030.³⁰

If there is sufficient political will, a portion of the carbon tax revenue can be redirected to help shift the United States toward a low-carbon economy.³¹ Politicians can sponsor a bill to divert some revenue toward the development of a renewable energy grid. Alternatively, individual states could enact similar policies, with more environmentally progressive states setting an example for others to follow.

Border Tax Adjustment

When paired with a carbon tax, a border tax adjustment is designed to prevent “carbon leakage”—the shifting of production to countries without a carbon pricing mechanism.³² If a carbon tax is implemented without a border tax, US producers could avoid the tax by outsourcing production to countries with negligible CO₂ emissions standards. Finished products can be imported back into the United States and resold by US producers. A border tax negates the economic benefits of exporting production outside the United States.

The border tax adjustment will be aimed at the CO₂ emissions involved in the production of any goods brought into the United States for sale. The border tax will levy the same rate on imported manufactured goods, agricultural products, and fuel imports as the carbon tax will levy on domestic producers.³³ It follows then that the border tax rate would start at \$10 per metric ton CO₂ and escalate by \$10 every following year until 2025. The border tax will also follow the same gradual lessening of the tax after 2025 until all power plants reliant on coal and petroleum are phased out.

The objectives of the border tax are twofold. As mentioned above, the border tax is crucial for preventing further CO₂ emissions. Furthermore, the border tax places “upward pressure” on global prices of coal, petroleum, and natural gas, and incentivizes nations that trade with the United States to lower their emissions.³⁴ If foreign countries can produce items with less fuel, they can avoid the tax and reap the economic benefits.

The border tax is designed to be revenue-neutral, much like the carbon tax itself. Revenue from the border tax will be collected separately and redistributed to states on a monthly basis. The states will be allowed to distribute the revenue amongst manufacturers that are making efforts to reduce CO₂ emissions and improve efficiency. The revenue will support American manufacturers' ability to compete internationally.

Benefits of the Revenue-Neutral Carbon Tax

In comparison to the Clean Power Plan, the revenue-neutral carbon tax has clear and quantifiable environmental, economic, and administrative benefits. The carbon tax proposed above is projected to reduce CO₂ emissions by 33 percent between 2016 and 2025 and by 52 percent between 2016 and 2035.³⁵ According to these numbers, the carbon tax will put the United States on track to achieve at least a 56 percent reduction in emissions by 2030. As mentioned previously, the Union of Concerned Scientists believes that reducing emissions by 56 percent before 2030 is necessary to mitigate the most severe consequences to the climate.³⁶ In this area, the carbon tax is dramatically more effective than the Clean Power Plan, which is designed to reduce emissions by only 15 percent between 2016 and 2030. The environmental benefits of the carbon tax can also be seen in public health indicators. The EPA expects the Clean Power Plan to only prevent 2,700 to 6,600 premature deaths by 2030.³⁷ In contrast, the carbon tax is expected to prevent over 13,000 premature deaths by 2025.³⁸

While the environmental benefits of a revenue-neutral carbon tax are impressive, the economic benefits present an even stronger case for implementation. The carbon tax is expected to increase US GDP by \$80–90 billion between 2016 and 2025.³⁹ In comparison, the Clean Power Plan will lower GDP by an average of \$51 billion every year between 2014 and 2030. The carbon tax is projected to create 2.1 million jobs by 2025 and 2.8 million jobs by 2035, a complete reversal of the annual anticipated loss of 224,000 US jobs under the Clean Power Plan.^{40,41} Although the carbon tax targets power plants that use coal, petroleum, or natural gas, every coal-producing state will gain hundreds of thousands of new jobs by 2025. For example, top coal-producing states such as West Virginia, Kentucky, and Pennsylvania would each gain an average of nearly 600,000 jobs between 2016 and 2025.⁴² Job growth can be attributed to the positive effects of a fee-and-dividend tax on labor-intensive industries, such as health care and retail. The carbon tax is also anticipated to raise the number of jobs in the renewable technology sector.

In general, the revenue-neutral carbon tax is preferable to the Clean Energy Plan because it relies on incentives. In a 2014 report on policy options for reducing CO₂ emissions, the US Congressional Budget Office (CBO) made it clear that incentive-based policies, which give businesses and individuals a motive to curb activities that produce CO₂ emissions, are vastly more efficient than command and control policies.⁴³ The revenue-neutral carbon tax provides economic incentivizes for weaning off CO₂-intensive energy sources such as coal, petroleum, and natural gas. In contrast, the Clean Power Plan represents a command and control approach, in which the government “mandates how much individual entities [can] emit.”⁴⁴ Given that the Clean Power Plan mandates emissions reductions on the state level, it should be characterized as a soft version of command and control policy.

While a cap-and-trade system is also an incentives-based policy, a carbon tax is superior for a number of reasons. In a cap-and-trade system, states or countries trade GHG emissions credits. More energy-intensive entities buy credits from less energy-intensive entities. Unfortunately, in a cap-and-trade system, the price volatility of emissions credits can reduce or delay long-term investment. Furthermore, the European Union Emissions Trading System (EU ETS)—the largest cap-and-trade network in the world—has proven difficult to regulate and ineffective at making a major impact on European GHG emissions.⁴⁵

While the economic, environmental, and political benefits of carbon taxation may seem hyperbolic, real-world carbon taxes have demonstrated success in all areas. In 2008, British Columbia implemented a carbon tax at a rate of US\$9.31 per metric ton. British Columbia's economy has done well under the tax, and fuel consumption has dropped 4.5 percent per person.⁴⁶ Some political analysts speculate that supporting the carbon tax actually helped certain politicians get elected in 2009.⁴⁷ Within the United States, smaller-scale models of carbon taxation have also been successful. In 2007, the city of Boulder, Colorado, implemented the United States' first tax on carbon emissions from electricity. The Boulder City Council voted to raise the tax level in 2009 and renewed the tax in 2012.⁴⁸ Both of these examples speak to the feasibility of a carbon tax.

Potential Disadvantages and Remedies for the Revenue-Neutral Carbon Tax

If a carbon tax is implemented, a valid concern would be that shifts in the tax rate will fail to reflect the true marginal costs of CO₂ emissions.⁴⁹ A carbon tax is justified because it internalizes the externalities of CO₂ emissions; if the tax rate fails to reflect the externalities of CO₂ emissions, then, in theory, the tax has failed. However, by incorporating a fee-and-dividend component, a carbon tax can buffer inaccurate calculations of externalities. Furthermore, future research could produce more information about the marginal cost of a metric ton of CO₂. Future tax rates can be adjusted according to new information.

Another concern is that carbon taxes tend to be regressive, meaning that the increased prices of utilities and goods are largely borne by lower-income groups.⁵⁰ Under the carbon tax, it is likely that the costs of electricity and consumer goods will initially increase. However, over time energy and consumer goods will become less energy-intensive, and therefore less subject to the carbon tax. Due to the combination of tax-free renewable energy and monthly rebate checks from the tax revenue, one study suggested that a revenue-neutral carbon tax would eventually become progressive.⁵¹

Perhaps the most obvious disadvantage of a carbon tax is increased energy and electricity prices for consumers. However, the fee-and-dividend component of the proposed carbon tax should help consumers cope with increased costs. Moreover, increases in energy prices can incentivize consumers to become more energy-efficient and mindful of energy usage.

Implementation of the Revenue-Neutral Carbon Tax

The chief barrier to establishing a carbon tax is raising the political will in Congress to establish the tax. Under Article I, Section 8 of the US Constitution, Congress holds the power to impose taxes and collect revenue. While the Clean Power Plan can be established through an executive mandate from President Obama, a carbon tax must be voted into law. Carbon tax proposals must contend with significant political opposition, especially from politicians who balk at the idea of adding a tax or intentionally raising energy prices.

Fortunately, there are indications that support for a carbon tax is increasing. On June 22, 2014, researchers from the University of Michigan's Center for Local, State, and Urban Policy released poll data indicating that over 55 percent of Americans support a fee-and-dividend carbon tax.⁵² Although Democrats are overwhelmingly in favor of such a tax, 43 percent of Republicans also support it. Additionally, over 51 percent of Republicans would support a carbon tax if the revenue went to fund renewable power programs. Overall, the poll indicates that Republicans are becoming much more receptive to carbon taxation as a viable energy policy. Various forms of carbon tax have been endorsed by conservatives such as George P. Shultz, secretary of state under President Ronald Reagan, and Greg Mankiw, economic advisor to George W. Bush and Mitt Romney.⁵³

Another consideration is that most Republicans do not want the US EPA to expand its regulatory powers. To prevent this from happening, the GOP's best option is to offer a market-based alternative to the Clean Power Plan. Although Republicans tend to oppose energy policies aimed at reducing GHG emissions, they should find economic benefits of a revenue-neutral carbon tax more appealing than the economic uncertainties of the Clean Power Plan. If information about the economic, administrative, and environmental benefits of a revenue-neutral carbon tax is promulgated among Republicans, they could become more interested in encouraging their political representatives to vote for carbon tax proposals.

Although establishing a carbon tax may require emphasizing the benefits for Republicans, a revenue-neutral carbon tax is truly a bipartisan policy. Carbon taxes can avoid becoming entangled in ongoing debates about tax reform, individual income tax rates, corporate taxes, and tax expenditures.⁵⁴ By being revenue-neutral and incorporating a fee-and-dividend approach, a carbon tax works as a self-contained system that is distinctly separated from general fiscal policy and regular tax codes. Furthermore, models of the revenue-neutral carbon tax's economic effects suggest that if the tax rate starts at \$10 per metric ton and adds \$10 per year, the tax will be "a robust revenue item for the federal government...through at least 2035."⁵⁵ Both Democratic and Republican politicians should be receptive to increased revenue.

Some opponents may be wary of a federal carbon tax, and may express a preference to implement carbon taxes state-by-state or even region-by-region. In theory, each state could adopt a carbon tax and set their own rate to achieve its emissions reductions targets under the Clean Power Plan. In reality, allowing states to charge different tax rates for electricity could create "serious economic distortions."⁵⁶ States with lower targets, and therefore lower

tax rates, could export power and carbon-intensive goods to states with higher tax rates. This scenario would produce “carbon leakage,” and could jeopardize overall emissions reductions and the progress of low-emitting states.⁵⁷ The process of setting up state taxes and negotiating tax revenue distribution could greatly complicate tax codes.

A final consideration is that a revenue-neutral carbon tax has never been proposed to Congress. A partial-rebate carbon tax, the Climate Protection Act of 2013, was introduced to Congress in 2013 with 60 percent of the revenue rebated to US citizens and 40 percent directed toward a Pollution Reduction Act. While still pending, the response to the bill has been negative. Perhaps a revenue-neutral carbon tax could be more successful, especially when viewed as an alternative to the Clean Power Plan.

Conclusion

If the Clean Power Plan is implemented in its current form, it will set a poor precedent for future US energy policy. Aside from being environmentally weak, economically uncertain, and difficult to administer, the emissions standards outlining the Clean Power Plan were passed in 2013 by presidential memorandum. Although the proposed Clean Power Plan has incorporated a comment period, the period ended on December 1, 2014. As requested by President Obama in his memorandum, the plan’s final standards and guidelines will be set by no later than June 1, 2015. If an executive instrument, such as a presidential memorandum, is required in order to pass an energy policy, it seems clear that either the policy is lacking or bipartisan cooperation is extremely low. In the United States, it seems that both assumptions currently hold true. A revenue-neutral carbon can bring economic, environmental, and political solutions. Politicians and advocacy groups on both sides of the political aisle must publicize the benefits of a revenue-neutral carbon tax. With sufficient bipartisan support, a revenue-neutral carbon tax can lead the United States toward cleaner energy and a brighter future.

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Drip Irrigation and Agricultural Energy

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“The challenge for 21st century governance is to embrace the multiple aspects, roles, and benefits of water, and to place water at the heart of decision-making in all water-dependent sectors, including energy.”¹

Introduction

Agriculture has laid the groundwork for other industries, new technologies, and paradigmatic policies, becoming the framework for U.S. economic growth. However, for all that agriculture has sustained and created, there are severe inefficiencies in the modern food chain. In an age of increasing global competition and new global threats, the inefficient use of resources is no longer an excusable offense. Global climate change, for example, poses a rapidly increasing existential threat that must be constantly mitigated and combated. Enormous increases in the demand for natural resources, as a result of a growing population, are imminent. It is the time for action and, surprisingly, the answer returns to our roots: agriculture and water. “Water and energy are intertwined,” explains the Union of Concerned Scientists, and “smart choices now will mean lower risks, greater energy security, and strong environmental and economic benefits.”² By investigating new approaches to farm irrigation, which accounts for approximately 80 percent of the United States’ consumptive water use,³ we believe policymakers can address some of the most pressing problems facing the country. This paper will primarily explore the use of drip irrigation, or microirrigation.

Drip irrigation works through “the slow, frequent, even application of low-pressure water to the soil surface near the base of plants or directly into the root zone of the plants (subsurface) through a network of tubing and outlets (emitters).”⁴ Bainbridge observed that this kind of technology is not new—there is documented use of an ancient “buried clay pot irrigation” in China where “water seeps out through the clay wall of the buried clay pot at a rate that is influenced by the plant’s water use.”⁵ Despite a long history of international use, microirrigation is not widely utilized in the United States and constitutes less than 7 percent of the nation’s irrigation withdrawals in 2005, compared to 43.5 percent for flood irrigation and 49.9 percent for sprinkler systems.⁶ The combination of dramatic technological advances, the increasing price of water, and dwindling water supplies provide the perfect opportunity for systematic change.

Through the correct use of pro-rata tax pricing of electricity used to pump water for irrigation, change is not only possible, but also likely. This excise tax on electricity would

serve as an incentive for farmers to switch to a more efficient irrigation method and would solve the problems that the current system, established by the Environmental Quality Incentives Program, faces.

Effective adoption of new technologies and policies is a critical step in improving the efficiency of agriculture irrigation and general water/energy consumption. Implementing drip irrigation is, for some, an easy decision. Advocates are quick to note drip irrigation's "potential to at least double crop yield per unit water," citing research data from India that show impressive results—water use reductions of 30–60 percent and typical yield increases of 20–50 percent.⁷ Case studies in India illustrate the shift "from conventional surface irrigation to drip irrigation ... has increased overall water productivity by 45–255 percent for crops."⁸ However, the policy choice is not clear-cut. Ward and Pulido-Velazquez note that "where return flows are an important source of downstream water supply, reduced [water] deliveries from the adoption of more efficient irrigation measures will redistribute the basin's water supply, which could impair existing water right holders who depend on that return flow."⁹ Further, Van der Kooij et al. observe that most of the research conducted in this area of study lacks coherent definitions and a common understanding of efficiency or effectiveness. For example, "actual water savings depend on where the 'saved' water is going: is it productively used elsewhere or does it flow to the sea?"¹⁰ While Van der Kooij et al. determine that "the evidence about the water-saving potential of drip irrigation is far from conclusive,"¹¹ a claim we will investigate later in this proposal, it is critical that readers and policymakers make a concerted effort to be excessively critical when it comes to questions and research about the use of drip irrigation. This is necessary not only because it is a fairly untested technology, but also because it has the potential to solve problems that could be disastrous if mishandled.

After investigating the potential benefits and costs of drip irrigation, we will defend the policy implementation of a pro-rata tax on electricity in order to encourage its use in agriculture.

Background

Current Irrigation Systems

The majority of today's agricultural irrigation heavily favors the use of surface-level approaches. Currently, out of the estimated 55 million acres of irrigated farmland, only 3.7 million acres are irrigated with drip, trickle, or low-flow micro sprinklers.¹² Another 31 million acres are irrigated using a more traditional sprinkler system. The Food and Agriculture Organization (FAO) of the United States describes the traditional method as:

[A] method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.¹³

The remaining acres utilize gravity methods, which can be even less efficient than the sprinkler systems. These apparatuses work by using “a free-surface gravity flow” to introduce water “at a high point or along a high edge of the field and allowed to cover the field by overland flow.”¹⁴ While “75 percent of the irrigated area in the world is surface irrigated,”¹⁵ American farmers have largely shifted to the more efficient sprinkler system, perhaps demonstrating the potential viability of moving toward an even more efficient irrigation method in the future.

This constantly evolving landscape of agricultural irrigation shows the profit motive at work; the shift from furrow to sprinkler systems demonstrates little more than the fact that it is “economically profitable to convert from furrow surface irrigation to center pivot sprinkler irrigation systems.”¹⁶ However, both sprinkler and gravity systems are much less technologically and managerially intensive than drip systems. Their initial setup cost is also substantially lower, allowing farmers to save money through the continued usage of an already existing infrastructure rather than having to establish an entirely new irrigation method. The upfront costs to changing systems are high, especially for drip irrigation, making a transition seem impossible. Peters explains, for example, “due to high filtration requirements and additional tubing to get the water placed directly at each plant, drip has the highest initial costs per unit land area of any irrigation system.”¹⁷ These costs must be overcome in order to allow a more widespread adoption of the drip irrigation method.

Current Problems

The first problem with current irrigation systems is inefficiency. According to Wilson and Bauer, “drip irrigation exceeds 90 percent efficiency whereas sprinkler systems are 50 to 70 percent efficient,” and surface gravity methods are, on average, even less efficient than sprinklers.¹⁸ While these numbers are subject to variability based on different applications of the general methods, the overall trend clearly shows that both sprinkler and gravity methods are substantially less water-efficient than drip methods. The second problem that arises in the use of the two more prevalent methods is that some surface and sprinkler irrigation systems could require more labor per acre, increasing total costs, and may “require additional labor and energy costs that may not be recovered by savings in water deliveries.”¹⁹ These costs could be reduced by drip irrigation systems where “labor and operating costs are generally less, and extensive automation is possible” due to the decrease in the need for unskilled labor.²⁰ Overall, it is apparent that America’s irrigation efficiency has the potential increase substantially if more farmers converted to drip irrigation.

Current Policies

In order to gauge an effective policy solution to the problems in agricultural irrigation, it is important to first examine the current stance of the federal government on improved irrigation methods. The driving force behind policy in this field today is the Environmental Qualities Incentives Program (EQIP). Established by the 1996 Farm Bill, the EQIP is a conservation program “in which farmers and ranchers implement conservation practices on agricultural working land in return for financial cost-share assistance and technical assistance.”²¹ A fairly substantial portion of the funding for the program goes toward providing subsidies for farmers looking to establish more efficient irrigation methods for

their fields. Therefore, it is important to note there is already a significant government policy targeted at increasing irrigation efficiency.

However, our policy proposal approaches the problem of irrigation efficiency from another avenue, electricity pricing. Instead of focusing on subsidies, we suggest water pricing in the United States is variable based on geographical region, and is predominantly decided by what are called irrigation districts. These districts “collect fees from their members, in return for providing water delivery services. The districts use those revenues to pay for their costs of capital, operations, and maintenance, and for paying the state or federal agency for the district’s water supply.”²² The federal agency that provides much of the water supply is the United States Bureau of Reclamation. Despite the importance of the federal government in supplying water to the irrigation districts, there is no comprehensive federal tax or pricing regulation on the water actually pumped by farmers for irrigation producers, something that our proposal suggests should be changed.

Therefore, some current practices, such as subsidies provided by EQIP, are headed in the right direction to support better irrigation practices, but there remain potential changes in policy that could greatly improve the situation.

Policy Problems

In this case, the question remains: Why has there not been a significant increase in the usage of drip irrigation, the most efficient form of crop irrigation? Much of this has to do with the aforementioned high upfront costs of installing and maintaining a drip irrigation system. Despite the noted benefits, many farmers continue their traditional forms of irrigation because the costs of transition are perceived to be too high. Furthermore, while there is an incentive to switch to drip irrigation as per subsidies provided by the EQIP, there is not an incentive to move away from other forms of irrigation, especially sprinkler systems. Because the energy, primarily electric and gas, used to pump water for agriculture is often tax-exempt or priced much lower for agricultural buyers, there is no substantial incentive for farmers to switch to a more efficient irrigation method. Subsidies level the playing field for drip irrigation, but give no unique reason to undergo the risks—the potential for incorrect implementation of irrigators, the potential for loss of crops and revenue, etc.—associated with switching from sprinkler systems. A punitive tax on electricity, however, handily pushes the economic incentives substantially in the direction of drip irrigation.

Proposal

Kumar and Palanisami have found “that the most ideal policy environment for promotion of microirrigation technologies in the well-irrigated areas would be pro-rata pricing of electricity, which would create direct incentive for water use.”²³ These types of excise rates (normalized for the size of the farm) create a tax “in proportion” to electricity use and “refer to the share or portion of the proceeds to be received based on the fractional amount of debts due, the ownership share, or the amount of responsibility,” changing the incentive structure for agricultural irrigation.²⁴ A pro-rata tax increase on electricity would almost act as a farm

subsidy for this emerging technology, since the “low electricity pricing policies and shifting of electricity tariff from pro-rata to flat rate have reduced the marginal costs of water to zero,” resulting in farmers using both groundwater and electricity inefficiently.²⁵ The negative consequences, as M.D. Kumar points out, are obvious: “over pumping, changes in crop pattern towards more water intensive crops, well deepening, drilling new bore wells, increase in well investments, pumping costs, well failure and abandonment, and out migration, which are increasing at a much faster rate.” However, introducing a marginal cost for electricity could motivate farmers to use water more efficiently at the field level and farm level “through careful use of irrigation water in crops; better agronomic inputs; optimizing costly inputs for crops; careful selection of crops and cropping patterns; and livestock composition that give higher return from every unit of water and low water consuming crops.”²⁶

This kind of indirect tax is the critical step in creating a more efficient and effective system. Lee, in a proposal recommending the water excise tax, explains that “indirect regulation is best suited to avoid the very real possibility that we may run out of drinking water within our lifetimes ... the federal government should indirectly regulate commercial water use through market forces.”²⁷ Specifically, it should impose an excise tax on all commercial water withdrawals, forcing corporations and businesses to pay for the water they use in their operations. While Lee’s policy proposal goes further than our suggestion, the underlying principles are the same. Ultimately, the proposal described here would cause a change “in commercial water use [that] would be unavoidable and organic, and would lead to a necessary decrease in corporate consumption of water.”²⁸ In an article explaining the commonalities between the Indian and U.S. irrigation systems and why studies conducted abroad provide useful information at home, Nagaraj et al. explain:

Free or flat rate electricity reflecting zero marginal cost for lifting groundwater is bound to have profound impact on groundwater overdevelopment and exploitation besides wastage of water. If energy for extraction is priced it will improve equity and efficiency of water transactions since the seller and the buyer will both have to be cautious in its utilization.²⁹

Pro-rata and excise taxing systems create a pricing mechanism that organically leads to drip irrigation and an improvement in our food chain, since “pricing of electricity induces an element of caution and prudence on the part of farmers to go for efficient irrigation technologies, thereby promoting use efficiency.”³⁰

Expected Benefits

Increase Crop Yield and Water Efficiency

As stated above, water efficiency in drip irrigation is around 90 percent, substantially higher than the average water efficiency for the other two types of irrigation. It has become clear that “agricultural irrigation cries out for efficiency improvements,” Soloman explains, because:

The amount of water devoted to irrigation impacts on supply in two ways. It restricts the water available to urban consumers, forcing system owners to find more distant, and thus more expensive, supplies. It also lowers groundwater (aquifer) levels by withdrawing more water than sparse rainfalls can recharge, thereby reducing the water available to meet future needs and increasing the cost of obtaining water.”³¹

This demonstrates that the inefficient use of water is a negative externality because it will affect populations outside the immediate vicinity of the area where the water is being used for irrigation. Drip irrigation fixes this problem through a variety of improvements in the process of irrigation—specifically, “water is distributed more slowly and precisely, avoiding unnecessary wetting of plant leaves, reducing water loss from wind or evaporation, and minimizing moisture wasted on weeds, unplanted areas, and runoff.”³² While improvements to sprinkler systems and even surface irrigation methods are possible, such improvements do not offer the comprehensive increase in water efficiency that drip irrigation allows for because inevitable natural variables like wind and evaporation will, in almost every case, affect drip less than the other two methods.

As a result of this increase, as Block states, “drip irrigation’s significant boost for crop yields cannot be ignored.”³³ Using case studies, Block gives the example of the growth of almond farms in California and drip irrigation’s significant role in making California the world’s number one producer. Furthermore, drip irrigation is able to perform better in drought conditions than the other forms of irrigation. Pfeiffer and Lin show that “corn yields under dropped nozzles can be up to 13 percent higher than yields under conventional center pivots, and that the yield benefit is greatest under irrigation deficit situations.”³⁴ These “irrigation deficit situations” are most commonly present in a period of drought. This benefit of the drip irrigation system is not only useful during the occasional drought, but it is also an essential tool to prevent the negative impacts associated with global trends caused by climate change and the increasing strain of an ever-increasing population. Researchers at the National Center for Atmospheric Research estimate that climatic trends will have a negative effect of 10 percent on yields of corn and wheat in the next 20 years.³⁵ They also conclude that while the overall yield of food will continue to increase, demand for food will also sharply increase in the near future and outstrip production. This sobering finding makes it all the more important to begin discussing ways to increase the crop yields without wasting increasing amounts of water, an equally essential resource for human survival.

Decreased Energy Consumption

Using more efficient watering systems will allow farmers to cut back on antiquated irrigation infrastructure that create growing drains on the economy. For example, in the United States, “diesel-powered pumps are used on about 10 million irrigated acres. A 10 percent improvement in water-use efficiency could reduce annual diesel consumption by 8 gallons per acre, saving about \$18,000 on 1,000 acres. Nationwide, farmers could save up to 27 million gallons of fuel and \$55 million per year.”³⁶ We must realize that “all agricultural operations require energy in the form of electricity, the magnitude of which varies as per different agro-climatic zones and even from farmer to farmer.”³⁷ As Jains explains, “the largest share of energy is utilized for pumping irrigation water. Various research studies have shown that

water saving, electricity saving, irrigation efficiencies, and yield of crops using drip irrigation are substantially higher than crops irrigated by the conventional flood irrigation method.”³⁸

This energy consumed to irrigate crops inhibits economic sustainability and creates unacceptable inefficiencies. The FAO declares that “the global food system needs to reduce its dependence on fossil fuels to succeed in feeding a growing world population” and that “the challenge is to decouple food prices from fluctuating and rising fossil fuel prices.”³⁹ While advocating for an “energy-smart” model, the FAO report explains the imperative for efficiency; “High and fluctuating prices of fossil fuels and doubts regarding their future availability” make for a potentially bleak future if policy does not “take better advantage of [the] dual relationship between energy and food.”⁴⁰ The case studies in India clearly highlight this significance: “In India about 52 percent of its total electricity is generated using fossil fuel (coal). Indian agriculture consumes about 30 percent of its total electricity.”⁴¹ Accordingly, India is among the top 10 fastest growing economies in the world.⁴² India’s fossil fuel share is expected to rise to 74 percent of total energy by 2010, with a corresponding increase in CO₂ emissions. Thus, energy efficiency and increased water productivity in agriculture has a huge impact on water and energy policy in India.⁴³ It is just a matter of time and implementation to realize similar effects in the United States.

V. Possible Costs

Increased Water Usage

One of the most serious problems facing the implementation of this policy is that increased water usage could create downstream water cycle problems that would harm the soil. As productivity increases, so does a farmer’s incentive to use more water to maximize total crop yield. Various studies have actually shown that when farmers are able to utilize more efficient forms of irrigation, including drip, there is a high likelihood that more water will be used, either because the farmers decide to irrigate more land or because they switch to potentially more profitable and more water-intensive crops.⁴⁴ This presents a difficult situation where both options—drip irrigation and non-drip irrigation—may be detrimental to water conservation, regardless of choice. In that case, one of the key benefits of drip irrigation would become moot.

Any solution addressing these problems must respond to the specific causes creating this paradox of efficiency. First, the EQIP already provides protection against farmers increasing the amount of land they irrigate after they garner subsidies. In 2008, a provision to the program’s water conservation section was added that required those who were given assistance not to increase the amount of land they irrigated.⁴⁵ Next, the increase of water-intensive crops can be primarily resolved by the pro-rata tax pricing on electricity that this proposal calls for. The tax would incentivize farmers not to pump as much water, so there would be less incentive to plant more water-intensive crops even if irrigation was more efficient. In other words, simply giving out subsidies makes pumping water relatively cheaper, making it more attractive for farmers to pump an excessive amount of water to grow “thirstier” crops, but the pro-rata tax draws this motive back down while still giving farmers a reason to switch to drip irrigation.

Cost

Another obstacle commonly cited as prohibiting farmers from switching to drip irrigation is the cost of transition. Currently, the cost of drip irrigation systems is around \$500 to \$1,200 or more per acre.⁴⁶ This increase in cost is often seen as a substantial barrier for farmers to overcome. Installing the new system and learning about its use also takes time and resources to implement. However, these costs are negligible if one takes into account the present day solutions.

The current subsidy being offered under the EQIP is based on the discretion of the organization. As an example, subsidies in Delaware consist of a payment rate of \$1,170 per acre.⁴⁷ Therefore, a substantial amount of the cost is being paid, making the cost of transition equal to, if not cheaper than, maintaining current irrigation methods. The cost of drip irrigation technology will also decrease as it becomes more advanced and easier to implement, further reducing the transition barrier. Drip irrigation's efficiency also transfers these costs, meaning the system will pay for itself in time. In fact, according to Stalcup, "while initial costs are 40-50 percent higher than center pivot systems [a common form of sprinkler system], growers can expect to see those costs paid back within two to five years."⁴⁸ This analysis assumes cost without consideration of subsidies, so, in reality, this becomes an even better deal for farmers.

Politics

Currently, there is no political capital to spend on another agriculture fight in Congress. Issues such as the repeal of the Affordable Care Act and the Keystone pipeline have taken precedence, and Miller and Dinan note that "last year's elections did little to break gridlock on Capitol Hill."⁴⁹ The legislative stalemate is further exasperated by Obama's pledge of vetoes for almost all major Republican policies, which only furthers a back-and-forth that will leave little room for other important legislation to even be considered.⁵⁰ It seems that any new policies may have to wait another two years to make headway as Congress rolls over many of the same battles it fought in the last election cycle.

But there are reasons to remain optimistic about the future of drip irrigation. The small scope of this policy would not require too much capital from politicians, and some of the most ardent opponents of leveraging farm taxes would likely see the merits of this minor increase. For California, undergoing one of its worst droughts in history, a change in water usage systems seems both feasible and mandatory, since "at [the current] usage rate, California has less than two years of water remaining," and "restrictions on agricultural water use have forced many California farmers to leave fields fallow."⁵¹ Other states, like Texas, Arizona, and New Mexico, face similar problems, and even the gridlocked Congress may be motivated to move more quickly considering the severity and proximity of the problem. For example, current House majority leader Kevin McCarthy, a Republican from California, is moving to use congressional power to manage his state's drought problem, which he called the "crisis of the century in California."⁵² At the very least, the politics of the proposal in this paper are not cemented in the ineffectuality of the current Congress.

VI. Conclusion

Drip irrigation provides a unique opportunity to combat water scarcity, food insecurity, and the negative effects of climate change. As demonstrated by extensive research, drip irrigation is more efficient in water and energy use than current methods and aids the necessary shift for U.S. energy and agricultural policy to address a rapidly changing world. As seen most prominently with successes in India, the pro-rata tax pricing on the electricity used to pump water for irrigation is a proven and tested method for creating the incentive necessary for farmers to shift toward drip irrigation. By changing the pricing system, farmers will organically move to more effective irrigation methods, resolving some of the most repeated criticisms of drip programs like transition and labor costs. Ultimately, drip irrigation provides a cost-effective method for farmers to increase their crop yields while diminishing their wasteful consumption of natural resources. These inefficiencies at the base of American society and agriculture diminish the nation's economic prospects and sustainability. To provide for the future and to capitalize on American potential, we recommend the implementation of a pro-rata tax on electricity used for irrigation with the intention of increasing use of drip irrigation.

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Texas Roadways: Congested and in Need of a Solution

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Abstract

The purpose of this paper is to examine the problem of congestion on Texas roadways. A vast amount of research on this topic has been conducted with data collection and mathematical models that would be too complex for the purpose of this essay. This essay simply tries to provide insight into the background behind the traffic, its main causes, and solutions to the issue. I have attempted to base this work off hard numbers and statistics, without being overwhelmingly dense. Congestion is not a distant issue; it is a problem that affects everyone. While it may seem trivial in nature compared to other hot-button topics, congestion results in \$12 billion in wasted fuel for Texan motorists and a total of 472 million hours waiting in traffic. Reducing such inefficiencies could reap sizable benefits on the state economy. For freeways, this paper will analyze solutions that provide constant traffic flow with a minimum disparity in speeds. With non-freeway roads, this paper will explore converting traditional intersections into roundabouts and synchronizing traffic lights to reduce vehicle stops. While this paper focuses on Texas roads, the research conducted can be applied to other areas of the United States, as well.

Introduction

Traffic congestion is a problem that has many negative impacts throughout society. It is an issue that is expected to worsen and have more harmful effects on Texas' population in the future. It is estimated that congestion cost Texas drivers approximately \$12 billion last year due to idling. Additionally, drivers in Houston wasted about 52 hours in traffic, drivers in Dallas-Fort Worth-Arlington wasted about 45 hours, in Austin 44 hours, and in San Antonio 38 hours.¹ In total, the Texas A&M Transportation Institute calculates that Texans wasted an aggregated 472 million hours in traffic in 2012.²

Traffic also has a major impact on commerce in the state. About 1.6 billion tons of freight were transported through Texas in 2010, 62 percent of which was transported by trucks.³ Businesses faced \$2.1 billion in truck freight-moving costs, excluding the value of delayed shipments.⁴ By 2040, it is expected that trucks will haul 66 percent of total freight; therefore, companies looking to transport goods will place high importance on road quality. After taking traffic into consideration, some companies, such as Dell in 1999, have diverted their operations from Texas to other states. As it is estimated that Texas will have 20 million more people by 2050, the harrowing reality of congestion seems to be inevitable if the status quo holds.⁵

Causes

Traffic seems to be one of the pervasive facets of life nowadays, but what exactly causes congestion in the first place? Without delving too far into the theoretical mathematics behind this question, traffic flow is impaired mainly because of the disparity in vehicle speeds on roads.⁶ There are other factors that can also influence congestion, such as merging traffic and intersections, which result in a buildup of cars. However, the compression of rows of cars during rush hour is generally due to stop-and-go conditions, where cars accelerate and then brake as they approach slower cars. Drivers who excessively change lanes because they want to overtake other vehicles can cause small amounts of braking in traffic. According to Dr. Eddie Wilson from the University of Bristol, “the stop-and-go waves are generated by very small events at the level of individual vehicles. In certain situations a tipping point is reached that magnifies small effects to create large changes that can involve hundreds of vehicles and which may be a couple of miles long.”⁷ Essentially, there is a constant struggle between three groups of motorists on roads: those who drive below the speed limit, those who drive near or at the speed limit, and those who drive above the speed limit. It is the disparity in speeds between these drivers that, when coupled with a high number of vehicles on a road, causes congestion to occur.

Freeway Solutions

It may seem like speed limits are set arbitrarily. In reality, many of them are set according to research. Many traffic engineers and departments of transportation have arrived at a consensus that the 85th percentile of recorded speeds (the speed at or below which 85 percent of the traffic moves) should be the speed limit. This percentile is chosen because it is believed that motorists exceeding this speed are not driving reasonably and are statistically likely to be involved in an accident.⁸ Also, research has shown that changing the speed limit does not have significant effects on changing the 85th percentile, as drivers will continue driving at whatever they consider reasonable speeds.

It should be noted, however, that most speed limits are not posted within the recommended 5 mph range of the 85th percentile of recorded speeds. In fact, in many areas the speed limit is below the 50th percentile or even an average of recorded speeds. Figures 1 through 5 in the appendix show different average speeds for Houston-area freeways where the speed limit is 60 mph. According to a study conducted by the Institute of Traffic Engineers (ITE) that examined 35 sites in Texas with speed limits between 35 and 60 mph, only 31 percent of the speed limits followed the 85th percentile rule. Had speed limits been 10 mph higher, 91 percent of drivers would have been driving below the legally required maximum. For rural areas surveyed with speed limits of 65 mph, had the speed limit been 5 mph higher, 89 percent of drivers would have conformed to the legally required maximum, compared to the current 59 percent. Essentially, this study found that in many areas there were significant disparities between speed limits and the 85th percentile.⁹

As mentioned above, people drive at varying speeds, regardless of the set speed limits. Drivers who do not want to break the law do not drive above the speed limit. However, the speed limit in many cases is set artificially low or has not been updated, causing some law-abiding citizens to drive slower than they would with a higher speed limit. Updating the speed limit to reflect actual flow of traffic may reduce the disparity in speeds that eventually causes congestion. To counter excessively prudent drivers, speed minimums could potentially be put in place as well. There are also laws that can be adopted, such as Georgia's "Slow Poke" law, that penalize motorists who cruise in the left hand lane and cause faster drivers to suddenly accelerate and brake. As long as traffic flows as close as it can to a uniform current, there should be fewer delays. In conditions where weather may be severe, construction is taking place, or heavy congestion is likely, variable speed limits should be enforced. This system has shown a reduction in travel times by between 5 and 15 percent where implemented in Germany.¹⁰

To deal with issues regarding merging, Texas should introduce a system called "zipper merging." Motorists would merge one by one at the point of obstruction rather than as soon as possible. While this may seem like "cutting in line" in front of other commuters, zipper merging does, in fact, reduce the length of a backup by about 40 percent.¹¹ Traditional merging causes traffic to flow smoothly in one lane and then stop when allowing motorists from the next lane to merge over. Meanwhile, drivers in the second lane are driving very slowly and are nearly stopped until they can merge into the first lane. With zipper merging, there would be a more constant speed between both lanes and less variability in speeds, thus leading to less braking and a more constant flow of traffic.

Local Road Solutions

"Local roads" in this context refers to non-freeway streets that have lower speed limits and streetlights, yield signs, or stop signs. As mentioned before, speed limits should be updated to reflect the true flow of traffic. However, inefficient coordination of traffic lights or constant requirements for cars to stop can also affect fuel costs and traffic flow.

Traditional four-way intersections are favored over roundabouts in Texas and the United States. However, roundabouts have been found to be more effective methods of conducting traffic flow and are thus touted by many departments of transportation. According to a Kansas State University study that compared traditional intersections to roundabouts, implementation of the latter led to a 33.3 percent decrease in cars that had to stop in approaching the intersection, a 14.1 percent decrease in queue length at the juncture, and a 34.1 percent reduction in delay time for the intersections with the highest average delays in Kansas. Researchers at the Insurance Institute for Highway Safety (IIHS) found there was a 20 percent decrease in delays for commuters after adoption of roundabouts at sites in Kansas, Nevada, and Maryland.¹² Also, according to the Federal Highway Administration (FHWA), roundabouts decrease crashes by about 35 percent, which would cause less accident-related delays and assist in easing congestion.¹³ Roundabouts are also cost efficient and, in the long run, provide more cost-benefit than traditional stoplights.

According to the Maryland Department of Transportation (MDOT), the average roundabout costs an estimated \$250,000 to construct.¹⁴ However, the lifetime of this type of intersection is 25 years, compared to the 10 to 20 year expectancy of traffic lights,¹⁵ and is estimated to save up to \$5,000 in traffic light maintenance costs annually,¹⁶ bringing total savings to \$125,000. In a study in Virginia, roundabouts contributed to a savings of 200,000 gallons of gas annually at 10 intersections.¹⁷ Assuming a price of \$3 a gallon, commuters save an additional \$60,000 per year in fuel savings. These numbers do not even account for the reduction in accident costs at each roundabout. Aggregated together, roundabouts should be an attractive construction project at intersections undergoing renovation or being newly constructed in Texas.

For streets that cannot be converted to a roundabout, the synchronization of traffic lights should be adopted. As part of the Texas Traffic Light Synchronization (TLS) Grant Program II, which took place in the early 1990s, lights at 1,348 intersections in the state were coordinated to optimize the number of green lights a driver would encounter. During this particular project, stops were decreased by 11.5 percent, fuel consumption by 13.5 percent, and delays by 29.6 percent. Despite a total expenditure of \$7.7 million, Texas commuters were estimated to benefit \$32.30 for every dollar spent.¹⁸ Coupled with restrictions on left hand turns and a countdown to notify drivers of when a light is about to turn green, an expansion of such programs can have great benefits for motorists.

Cons of Implementation

Although reducing congestion seems like a goal most people would agree on, there might be some opposition to the solutions suggested in this paper. For example, people may still drive excessively cautiously or not maintain a uniform flow of traffic. The proposed solutions most likely would not help during natural disasters and other calamities that cause hyper congestion. Government officials or certain advocacy groups may still advocate against raising speed limits, and even reducing them in certain roads, in order to maintain an image. Lastly, with the prospect of higher speeds and less congestion, police departments and oil companies might oppose the suggested changes, since they would potentially lose out on revenue earned from issuing citations and selling fuel.

Other Solutions to Explore

In addition to efficiently managing traffic, congestion can be reduced through the expansion of public transit such as rail or encouraging other methods of transportation such as walking and cycling. Alternatively, there are some proponents of instituting a “congestion fee” for commuters who use roads that face a high amount of traffic during rush hours. Such a system has been put in place in central London with some positive results.

Conclusion

Congestion is an issue that could have harmful ramifications for the economy. Previous research and projects have shown that there are solutions to improve the flow of traffic. A 30 to 40 percent decrease in delays and idling of cars can prevent the unnecessary waste of billions of dollars in the Texas economy. A famous proverb says that time is money, and if congestion is left unsolved, commuters will keep wasting both.

Appendix

These figures are speed charts from Houston TranStar. They represent selected segments of major freeways in the city. For all segments, see <http://traffic.houstontranstar.org/speedcharts/>.

Figure 1 – US-59 Southwest Southbound from Hillcroft to Bissonnet

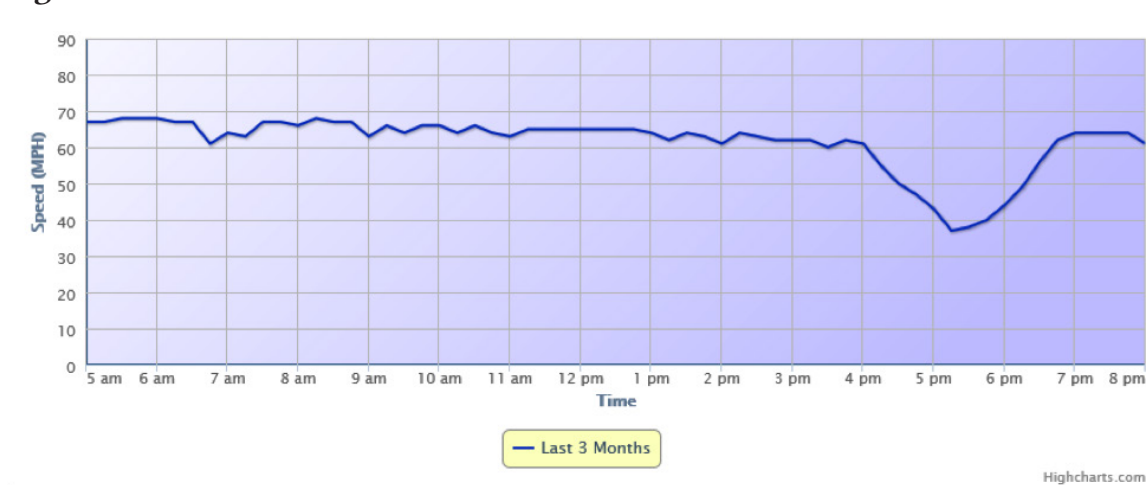


Figure 2 – IH-10 Katy Westbound from IH-610 West Loop to Antoine

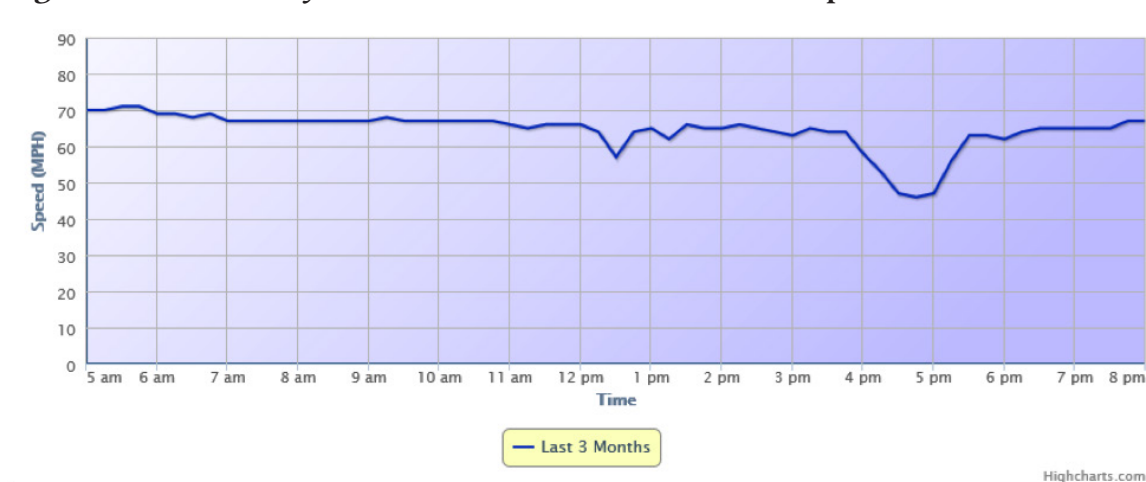


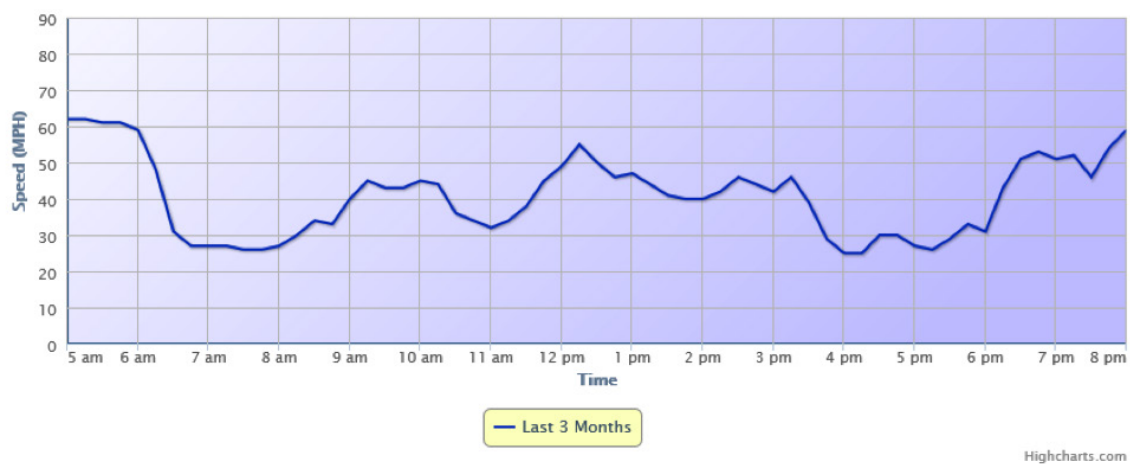
Figure 3 – IH-610 West Loop Northbound from Westheimer to IH-10 Katy



Figure 4 – IH-45 Gulf Southbound from Telephone to IH-610 South Loop



Figure 5 – US290 Northwest Eastbound from West 34th to IH-610 West Loop



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A Pragmatic Approach to Texas Prekindergarten Reform

by Kaylen Strench '16

Introduction

Early childhood education has become a hot topic in education and political circles, and with good reason. Research has shown that prekindergarten not only prepares children to succeed in kindergarten,¹ but also may contribute to their well-being down the road.² Prekindergarten programs are especially beneficial for children from low-income households, who tend to start kindergarten developmentally behind their peers.³ A study of the New Jersey Abbott preschool program, which serves three- and four-year-olds in the poorest districts in the state, demonstrated that the program showed positive effects on child development and kindergarten readiness assessments. In addition, the study showed that these gains persisted until the last time the children were measured, when they were in second grade.⁴ Further, a study monitoring the long-term effects of preschool on children enrolled in the high-quality “Child-Parent Center” preschool programs in Chicago found that participating children were more likely than their peers to have completed high school (71.4 percent to 63.7 percent), more likely to attend a four year college (14.7 percent to 10.1 percent), less likely to be incarcerated (20.6 percent to 25 percent), and less likely to suffer from depressive symptoms (12.8 percent to 17.4 percent).⁵ Based on these studies, it is clear that prekindergarten has important and measurable benefits for children that can last a lifetime.

However, not all prekindergarten programs are made equal. There are two important elements that determine the efficacy of early education programs for children across the state. First, the quality of prekindergarten programs directly determines the amount of progress that children can make in the classroom. Top organizations specializing in early education research, such as the National Institute of Early Education Research (NIEER), have studied various high- and low-achieving prekindergarten programs and identified the factors that tend to contribute to high-level results. A few of the critical factors identified are class sizes of 20 students or fewer, student-teacher ratios of 10:1, highly educated teachers (at least a bachelor’s degree and certificate in early education) who have ongoing opportunities for professional development, and effective implementation of evidence-based curricula.⁶ Based on NIEER’s report of state spending per pupil, high-quality programs exhibiting these characteristics tend to spend at least \$5,000 per child per year for a half-day program and \$8,000 for a full-day program.⁷

Another important factor determining the efficacy of prekindergarten programs is how accessible they are to children, and particularly children from low-income families. Studies repeatedly show that low-income children have the most to benefit from prekindergarten

because by age four they are often already behind on certain developmental skills.⁸ Furthermore, many of the model prekindergarten programs that have shown the most dramatic results directly served low-income children, such as the Perry Preschool Project⁹ and the Chicago Child-Parent Centers.¹⁰ However, it can be harder for low-income families to enroll their children in high-quality prekindergarten due to the expense of most private prekindergarten programs and the difficulty of matching work schedules so that parents are able to drop off and pick up their children.

Thus, instituting high-quality programs that are accessible to the low-income children that need them will ensure that every dollar going toward prekindergarten achieves its maximum rate of return.

Current Policy

Currently, Texas funds half-day prekindergarten for districts that have at least 15 children who meet current Texas Education Agency (TEA) eligibility criteria. Eligible children must have an educational or economic disadvantage (their family's household income must be no more than 185 percent above the poverty level), be in the custody of the Department of Family Protective Services, have a parent in active duty in the military or who died while serving in combat, be homeless, or be non-English language proficient. NIEER reports that as of 2013, Texas spends an average of \$3,331 per child per year on prekindergarten education. While Texas does require public school teachers to have at minimum a bachelor's degree and a certificate in early childhood education, it falls short in several other "benchmarks" necessary for quality prekindergarten education. Furthermore, while Texas does provide comprehensive guidelines for prekindergarten education, these guidelines are strictly voluntary, and there is neither a monitoring system nor an incentive to ensure such guidelines are being utilized in the classroom. As of now, Texas only meets two of the 10 benchmarks put forward by NIEER.

Figure 1. Quality Prekindergarten Program Benchmarks—Texas, 2013

QUALITY STANDARDS CHECKLIST			
POLICY	STATE PRE-K REQUIREMENT	BENCHMARK	DOES REQUIREMENT MEET BENCHMARK?
Early learning standards	Comprehensive	Comprehensive	<input checked="" type="checkbox"/>
Teacher degree	BA (public); None (nonpublic) ²	BA	<input type="checkbox"/>
Teacher specialized training	Generalist (EC–6th); Bilingual (EC–6th); ESL (EC–6th); SpEd (EC–6th) (public); ² None (nonpublic)	Specializing in pre-K	<input type="checkbox"/>
Assistant teacher degree	HSD (public); None (nonpublic)	CDA or equivalent	<input type="checkbox"/>
Teacher in-service	150 clock hours/5 years	At least 15 hours/year	<input checked="" type="checkbox"/>
Maximum class size		20 or lower	<input type="checkbox"/>
3-year-olds	No limit ³		
4-year-olds	No limit ³		
Staff-child ratio		1:10 or better	<input type="checkbox"/>
3-year-olds	No limit		
4-year-olds	No limit		
Screening/referral	Immunizations ⁴	Vision, hearing, health; and at least 1 support service	<input type="checkbox"/>
Meals	Depend on length of program day ⁵	At least 1/day	<input type="checkbox"/>
Monitoring	None	Site visits	<input type="checkbox"/>

TOTAL
BENCHMARKS
MET

2

Source: National Institute for Early Education Research

Rationale for Change

Texas' current prekindergarten program limits the effectiveness of early education for Texas four-year-olds. First, while Texas' half-day program is less expensive for the state than a full-day program, it prevents many children who would benefit the most from prekindergarten from being able to enroll. Parents who work full-time need a place where their child can be cared for during the entire day. Since half-day programs do not accommodate this schedule, particularly for single parents and two-income families, many parents with eligible children may choose to instead put their child in a non-educational facility, leading their child to fall further behind wealthier peers who are enrolled in educational programs. Thus, half-day programs mean prekindergarten cannot reach many of the children who are eligible for enrollment and who would benefit the most.

Second, by failing to require prekindergarten programs to meet certain critical benchmarks, Texas is funding programs that could be ineffective. Studies by NIEER show that class size and teacher-student ratios affect classroom environments and students' resulting performance. Specifically, NIEER cites a study from the National Institute for Child Health and Human Development that analyzed different teacher-student ratios and class sizes and found that children in class sizes that met the standards (20 per class, staff-student ratio of 1:10) displayed greater school readiness and language comprehension and fewer behavioral problems in later evaluations.¹¹ This study's results were also confirmed in studies such as The National Daycare Study and the evaluation of the Tennessee STAR requirements, which also experimented with different class sizes and ratios. Collectively, these studies have shown that the smaller the class size, the greater the effectiveness of prekindergarten programs and that class sizes above 20 and teacher-student ratios greater than 1:10 risk being relatively ineffective.¹²

It is also disconcerting that Texas teachers are not monitored to ensure that they are implementing material effectively and, even worse, not required or incentivized by the state to follow an evidence-based curriculum. NIEER reports that when teachers are not utilizing an evidence-based curriculum, they are more likely to introduce their own opinions and beliefs into their teaching.¹³ In order for children to build the skills necessary for kindergarten readiness, they must be learning those skills through an empirically proven method.

Finally, Texas does not spend enough money per child to achieve any of these quality standards. According to NIEER, achieving quality benchmarks correlates with spending per student.¹⁴ As previously stated, currently Texas spends only \$3,331 per child per year for half-day prekindergarten. High-achieving states spend far more than this, and for good reason: smaller class sizes and top-notch curricula are more expensive. According to NIEER's 2013 *The state of preschool* report, no state meeting all 10 quality benchmarks spends less than \$4,850 per pupil per year for half-day programs.

Thus, it is clear that there are gaps in Texas' current prekindergarten program that need to be filled in order for the program to be as effective as possible.

Policy Options

Policy experts have suggested several options to improve Texas' prekindergarten program. Some have argued that Texas should mimic Oklahoma and institute universal prekindergarten. Such a program would remove eligibility requirements and allow all children in Texas to attend half-day prekindergarten free of charge. Studies of Oklahoma's universal prekindergarten program have demonstrated that it has been moderately successful. Researchers at Georgetown University found that the program improved results in kindergarten pre-math assessments by 21 percent and improved assessment results in early literacy skills by 52 percent.¹⁵ Furthermore, a significant proportion of the state's eligible children have utilized Oklahoma's program. Researchers state that 60 percent of four-year-olds participate in the publicly funded prekindergarten program and 90 percent of all children enrolled in prekindergarten are enrolled in the public program instead of private programs.¹⁶ This indicates that parents utilizing prekindergarten are most likely to be utilizing the high-quality, state-funded option.

Universal prekindergarten seems to be the ideal model; however, it is not clear that free prekindergarten for all children in Texas is the logical next step. The universal element of Oklahoma's program is not the only factor that explains the state's success. Oklahoma also exhibits far higher quality standards than Texas, meeting nine out of 10 NIEER benchmarks, compared to Texas' two out of 10. Unlike Texas, Oklahoma has regular monitoring and site visits to ensure curricula are top-notch and effectively implemented, and the state requires that programs adhere to the recommended class sizes and teacher-student ratios. Oklahoma also provides funding for full-day programs in districts where there is a demand. This means parents who work full-time are often able to utilize prekindergarten programs that wouldn't be available in Texas. Though the Georgetown study did report that all children benefited from Oklahoma's prekindergarten program, it specifically stated that children from low-income families stood to benefit the most.¹⁷

Universal prekindergarten is also problematic in that it is extremely expensive. The Legislative Budget Board estimates that expanding Texas' half-day prekindergarten to a universal model would cost \$583 million annually.¹⁸ If Texas is going to spend a significant amount of money, it seems more rational to increase the effectiveness of the program by first increasing quality and expanding access to children who would benefit the most. State funding for more affluent children who are not at high risk of falling developmentally behind and whose parents may be able to afford other options should be a secondary concern.

Thus, the better option is to spend state funding on providing eligible children with more access to these programs and increasing quality standards to mimic some of the successful aspects of Oklahoma's program. There are multiple ways to achieve these goals. Focusing on quality, states could provide competitive grants to programs that meet high quality standards. Thus, the state would supply minimal quality-level funding to all districts (\$5,000 per pupil per year) and then offer extra funding to those districts that cap class sizes at 20, maintain teacher-student ratios of 1:10, and effectively implement an evidence-based curriculum. The

challenge with competitive grants is that they are not politically viable in an arena such as the Texas Legislature, which prioritizes conserving funds and minimizing social spending. As a recent example, in 2011, Texas agreed to cut \$5 billion from public schools. Furthermore, former Governor Rick Perry demonstrated his skepticism of funding competitive education grants that are not absolutely necessary by vetoing House Bill 130, which proposed grants to high-achieving prekindergarten programs, in the 81st Legislature. In short, any policy favoring non-essential spending, even as an incentive for quality, will likely not be approved. Thus, it is important to cut funding requirements as much as possible while still maximizing the efficacy of Texas prekindergarten.

Another option is to maintain the status quo. This is not a completely unreasonable choice. Large class sizes and high student-teacher ratios mean more access and less spending on facilities. Though the Legislative Budget Board has not reported definitive cost savings from maintaining the current program, there is good reason to believe that limiting expenses resulting from smaller class sizes and low student-teacher ratios would save the state money in the short term. Furthermore, if the state maintains current student-teacher ratios, prekindergarten programs can serve more students for the same cost.

Yet, while the current program is lower cost in the immediate future, it is neither maximally effective nor cost-effective in the long run. Studies of various programs have estimated that long-term investment in prekindergarten can lead to a rate of return to the state of between \$3 and \$10 for every \$1 invested.¹⁹ This money comes from prekindergarten's tendency to increase employment, lower crime and delinquency rates, lower expensive special education enrollment, and decrease grade retention. However, such rates of return are correlated with quality. A \$7 return rate is based on one of the highest quality programs, the Perry Preschool Program, which includes very small class size, highly educated teachers, and very high spending per pupil. However, lower quality programs serving disadvantaged pupils do not achieve the same results, and thus returns are lower.

If Texas wants a program that makes the most economic sense down the road, it needs to maximize quality and access, specifically for children from low-income households who are already eligible for the program. The status quo may be cheaper in the short run, but it is actually far more costly in the long run.

Recommendations

I propose that Texas implement increased quality standards and incentivize full-day prekindergarten for eligible children by manipulating the current funding formula. For quality, Texas would follow the recommendations instituted by NIEER and numerous other research organizations and cap class sizes at 20 students and teacher-student ratios at 1:10. Furthermore, it would increase spending per pupil per year from \$3,331 to \$5,000 (for half-day programs) to support monitoring of curricula and smaller class sizes. Finally, it would give school districts incentive to offer full-day prekindergarten for TEA eligible children by offering to fund 70 percent of the school day on the condition that the district funds the other 30 percent of the day.

On average, the cost of a quality full-day program is around \$8,000 per child per year, based on estimates from other states in the NIEER yearbook. Since TEA would only be paying for 70 percent of each full day, I estimate the increased spending per child per year would amount to around \$3,000, assuming all districts take advantage of full-day spending.

There are numerous reasons why this is the best course of action. First of all, this program increases quality, but the changes are manageable. While it does require the addition of new teachers and perhaps the construction of additional facilities, these measures ensure that students receive maximal benefits and classrooms have the required amount of supervision. Monitoring, while also a significant cost, is far less expensive than an overhaul of curricula and allows districts to maintain some control over what is taught to students. Increased spending by the state means districts will not bear the full burden of these changes, but they will also be motivated to spend efficiently since they are receiving a fixed amount of funding. Finally, incentivizing full-day prekindergarten by manipulating the school funding formula means districts that do not have demand for full-day prekindergarten can opt out of the program, but districts that have children and parents who desperately need it can participate without bearing the full brunt of the cost and perhaps without sacrificing quality in the process.

While these measures are a far cry from what would be required for prekindergarten to migrate to a universal model, this plan allows Texas to meet additional benchmarks for prekindergarten—expanding quality and access—without overwhelming districts or the state and by utilizing funds as effectively as possible. It ultimately provides essential quality measures and increased access to children who stand to benefit the most from early education.

Conclusion

Texas should be wary of both preserving the status quo and making sweeping, unfounded change when it comes to prekindergarten. Though prekindergarten is an unrivaled strategy in increasing kindergarten readiness, expanding the program too quickly or in the wrong way may minimize its overall impact on children. Yet, it is perhaps equally wrong to maintain the status quo, in which the children who would benefit most from the program may not be able to gain the access they need and quality standards are not being met. For these reasons, a full-day, high-quality program for children under the current eligibility criteria is the best prekindergarten model for Texas.

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Instability and Its Impact on Development Assistance: The Arab Spring and World Bank Aid Allocation to the MENA Region

by Makenzie Drukker '18

On December 18, 2010, the eyes of the world turned to Tunisia, where the self-immolation of a merchant sparked an uprising throughout the country. Soon after, anti-government protests erupted throughout the Middle East and North Africa (MENA) region in a movement known as the Arab Spring. While Tunisia was able to institute a new government in the aftermath of the turmoil, other countries—like Libya and Syria—continue to endure prolonged and devastating conflicts. Over the course of these uprisings, there have been almost 250,000 deaths, and several million people have become refugees.¹ Throughout the MENA region, it appears that the majority of the most intense violence has subsided, but there remains a lingering sense of unrest. Many states in the MENA region remain hotbeds of terrorist activity, and economic instability persists.² It may take years for these states to recover and maintain stable regimes.

As these states attempt to recover political and economic stability, support and assistance from the global community is critical. History has shown the negative consequences of leaving post-conflict states to rebuild on their own without assistance.³ Afghanistan is a particularly poignant example. Much like the coups and civil unrest in the MENA region today, Afghanistan endured a series of coups during the 1970s, followed by a series of civil wars. The United States and the Soviet Union subsequently withdrew their presence in Afghanistan. The Taliban later took hold of the government and controlled it until the United States invaded in October 2001. Afghanistan's economy never truly recovered, and unemployment today hangs at approximately 43 percent.⁴ Post-conflict states face the challenge of rebuilding their governments and economies while also attempting to maintain peace and quell residual violence. This task can be daunting and, in some cases, impossible without outside assistance.⁵ Afghanistan received little to no outside assistance, which allowed fundamentalists to take control of the government and did nothing to help its war-ravaged economy. Thus, as the MENA region attempts to stabilize after the Arab Spring, it needs to receive developmental assistance.

The World Bank is uniquely positioned to provide this assistance to the MENA region. It has widespread global influence: its two main bodies, the International Development Association (IDA) and the International Bank for Reconstruction and Development (IBRD), have 173 and 188 member states, respectively.⁶ Because it has so many member states, the World Bank's aid is more often perceived as multilateral and less likely to be accused of having a direct political agenda, compared to unilateral or bilateral aid. Depoliticized aid is preferable, because aid associated with commercial or political agendas is often less effective and more volatile.⁷ The World Bank can also help compensate for the lack of foreign direct investment (FDI) in conflict-prone and politically unstable states in the MENA region. While individual countries

and private companies may be wary of investing in unpredictable political and economic climates, the World Bank, as an international organization, can assume greater risk because potential losses are distributed across its member states. The World Bank's large base of both monetary and political support, and the security it derives from this support, make it the organization best suited to aid the MENA region.

Despite the fact that development is vital to post-conflict recovery, World Bank assistance to the MENA region decreased following the Arab Spring. The following chart shows the number of World Bank operations (projects and programs) in six of the countries that experienced some degree of unrest during the Arab Spring. Three of these countries saw their governments overthrown at least once; one faces an ongoing civil war; and two experienced unrest and protests, but limited violence. These countries were selected because they represent both the Middle East (Yemen and Syria) and North Africa (Egypt, Tunisia, Algeria, and Morocco), as well as a cross-section of the severity of conflicts during the Arab Spring. (It would have been interesting to include Libya as well, but project and operations data for Libya was unavailable.) As Figure 1 illustrates, in countries with projects or programs active in 2010 prior to the outbreak of the Arab Spring, the number of projects and programs decreased following the onset of conflict. In most cases, the number of projects was reduced by at least half, though in Yemen the number of projects decreased by almost 80 percent. No projects took place in Syria in 2012. That year, the World Bank's budget was approximately \$52 billion, divided between its two bodies. None of that money went to addressing the growing humanitarian and economic crises in Syria.⁸ If the World Bank continues to decrease operations in these countries, their rebuilding and development efforts will suffer, instability will resume, and conflicts may reemerge.

Figure 1: World Bank Operations in Six MENA Countries in 2010 and 2012⁹

Country	Number of operations (2010)	Number of operations (2012)	Extent of conflict
Tunisia	7	3	Government overthrown
Yemen	14	3	Government overthrown
Egypt	11	5	Government overthrown multiple times
Syria	2	0	Ongoing civil war
Algeria	0	0	Major protests
Morocco	9	5	Protests and governmental changes

The World Bank's failure to concentrate more of its resources in the MENA region, even as violence recedes, is indicative of larger problems in their aid allocation strategy. Firstly, the World Bank has a tendency to avoid providing aid to conflict-prone states. Projects and programs in these areas are riskier and less likely to be implemented successfully, so the World Bank prefers to give aid to more stable countries.¹⁰ While this strategy is better for the success rates of their projects, it hurts the conflict-prone states, like those in the MENA region, that are desperately in need of aid. Secondly, the World Bank has a preference for giving aid to countries that have shown "good governance" (i.e., governmental and economic stability).¹¹ This preference particularly disadvantages the MENA region, as several regimes before the Arab Spring were corrupt and despotic. These two preferences derive from the World Bank's Country Policy and Institutional Assessment Index, which measures "institutional quality."¹² While useful for analyzing stable states, the index unfairly biases aid allocation against states in turmoil, as their institutions may be in flux and thus less likely to meet the World Bank's quality guidelines. Still, as a practice, allocating aid to countries with "good governance" reduces the chances of misuse of World Bank funding. Of course, the World Bank does not completely abandon conflict-prone or politically unstable countries. But if these patterns persist and continue to negatively affect the allocation of development aid to the MENA region, the region's recovery is likely to be long and protracted.

Despite the World Bank's wariness of dispensing aid to unstable states and countries in conflict, it does not need to decrease aid to these countries. Instead, it can change the type of aid given. The World Bank has two main options for allocating aid: One is programmatic aid, which includes budgetary support and structural adjustment lending. The other is project aid, usually in the form of specific investment loans.¹³ With programmatic aid, recipient countries have much more discretion in how they use the funds. Thus, it is easier for a corrupt or unstable state to misuse or waste programmatic aid. By contrast, project aid is more targeted, leaving countries with less leeway to allocate the aid however they choose. In less stable states, project aid is more likely to be effective because the World Bank clearly defines and monitors projects' goals and progress.¹⁴

Constrained project aid is the World Bank's best option for providing aid to the MENA region. The Arab Spring has brought varying degrees of unrest, both civil and violent, to every state in the region. This unrest has left governments nervous, weakened, crippled, or overthrown, and economies have suffered, if not collapsed. By focusing its efforts in the MENA region on project aid instead of programmatic aid, the World Bank can do more to ensure that the aid is used as intended. Although project aid is more intensive and requires greater involvement from the World Bank compared to programmatic aid, the additional international support ensures aid efficacy in volatile MENA countries.¹⁵

While the World Bank should be encouraged to give as much development aid as possible to the MENA region to boost economic and political stability after the Arab Spring, it should be wary of bilateral aid. A prominent disadvantage of bilateral aid is that it is often tied to the political or commercial agenda of the donor state. Bilateral aid is often less effective at promoting development and alleviating poverty because it sometimes prioritizes the donor's

interests over the recipient's needs.¹⁶ For example, much of the bilateral aid given to Iraq and Afghanistan throughout the 2000s aimed to support the US military and its strategic interests, and did not fully consider the needs of the recipient countries. For this reason, that development aid was largely ineffective.¹⁷ Especially considering the vulnerability of the MENA region today, it is imperative for aid to be as stable and recipient-focused as possible. Thus, the World Bank should encourage potential bilateral aid donors to funnel funds into less politicized, multilateral World Bank projects to help ensure aid stability and a focus on regional needs.

World Bank aid is exactly what the MENA region needs to foster development and growth in the wake of uprisings that have destabilized most of the region's governments and economies to various degrees. For a region that already suffers from poverty, lack of economic diversity, reliance on few key industries, and a history of oppressive governments and terrorist activity, this destabilization could prove disastrous. Case studies like Afghanistan in the 1980s have shown that withdrawing from a country post-conflict and providing it with little to no aid for development or reconstruction can have devastating consequences. Somalia has a similar history: as a colony, it survived largely on subsidies, and its collapse was largely due to the fact that foreign aid was cut off in 1991.¹⁸

Therefore, it is imperative that the World Bank—an influential and multilateral lending organization—do as much as possible to encourage development in the MENA region. However, between 2010 and 2012, there was a marked decrease in the number of World Bank aid projects in at least six countries with Arab Spring uprisings. Despite the World Bank's aversion to giving aid to unstable or conflict-prone countries, it is precisely those countries that need development aid to bolster their economies and political stability. In order to alleviate this problem, the World Bank should use more constrained forms of development aid—i.e., project aid instead of programmatic aid—in unstable countries, since it reduces the likelihood that the aid will be wasted or misused by the recipient government. Project aid to the MENA region would most likely require more oversight and funding than comparable projects elsewhere, but it would be an investment in the region's future. The World Bank should also caution against bilateral aid, which is often politicized and unpredictable, instead encouraging potential donors to contribute through its multilateral projects. Because the World Bank aggregates funds from countries worldwide, its aid is not necessarily tied to a single country's political or commercial agenda. If the World Bank follows these policy prescriptions, it will be better equipped to allocate aid to the conflict-prone MENA region and help build peace, stability, and economic prosperity.

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Military Service and Human Capital Development

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Abstract

The necessity of conscription is a contentious topic of debate. This paper intends to delve into the controversial aspects of conscription policy and determine its effects on draftees. It will examine the differences between mandatory and voluntary military service, and the potential impact of military training on human capital. Previous studies have examined the effects of military service on soldiers' human capital; this paper looks to examine these results and establish a connection between participation in the armed forces and human capital development. It will also make an effort to determine whether a policy of conscription or incentivized military service is the better vehicle to achieve human development and explore the long-term and short-term developmental effects of conscription and volunteer service. In the first two sections of the paper, economic research and data from the past century will provide evidence in favor or against each method in terms of providing the greatest economic gains while minimizing economic losses. Also discussed is the issue of universally applying and adopting largely Western-tested systems of voluntary army enlistment policies in developing nations faced with radically different recruitment challenges and incentive structures. After reviewing criticism of these two recruitment systems, the last sections will attempt to explain possible benefits of military training with regard to human capital development, as well as attempt to construct an optimal military selection policy with additional incentives that provide economic benefit to nation-states that retain a standing army.

Introduction

History

Conscription has been a tool that many societies have implemented over the course of history. Qin Shi Huangdi, the first emperor of China, implemented such a system 2,000 years ago in order to build the Great Wall of China. More recently, the United States famously instituted a controversial draft to recruit soldiers for the Vietnam War during the 1960s. Many opposed being forced to participate in a war they did not support. Despite opposition, conscription still exists in many countries today, notably in Israel, South Korea, and Singapore. Mandatory military training exists in countries such as Switzerland and Taiwan. In countries that do not face direct sovereign threats, there has been a trend of transitioning the military to an all-volunteer force.

Importance

With regard to economic value, bold statements are sometimes made about the “benefits” of military training and service on mental and physical development. For example, within popular American culture, it is often said that joining the military “builds character,” “develops strong work ethic,” and “promotes teamwork.” It is implied that these qualities, acquired as a direct result of service in the military, should translate to productivity and earnings gains in the civilian world. These claims frame the value of military service in a way that highlights its national security capabilities and also its potential to enhance or destroy the human capital of military personnel. Does military service have a noticeable effect on human capital? If so, what military policies, incentives, and regulations can help maximize contributions to the national economy? The answers to these questions are worth considering, especially in making important policy decisions.

The Effects of Conscription on Human Capital

Conscription and Economics

Conscription has historically been the predominant method of creating manpower for the military and continues to be extensively used today. As of 2004, Mulligan and Schlieffer noted that 95 out of 164 examined countries continued to use conscription to fill their military ranks.¹ It is understandable that conscription remains a popular choice among national governments. First, it ensures that the minimum level of military manpower needed will be met, even if most of the able-bodied male population does not desire to serve. Second, it means that governments do not need to raise military wages and benefits in order to attract volunteers, both of which significantly increase up-front per-soldier expenditures.

However, conscription does not hold a similar popularity among modern economists. The academic opposition surrounding conscription took off in the 1960s, when the first wave of influential papers from the likes of Friedman, Hansen and Weisbrod, and Oi provided compelling arguments and evidence against the existing American draft system. In “The Case for Abolishing the Draft—and Substituting for It an All-Volunteer Army,” Milton Friedman lays down the fundamental logical framework for the argument against the draft.² As a prominent free market economist, Friedman asserts that conscription generates inefficiencies by taking high-productivity civilian earners and forcing them into military roles for which they do not have optimized skills.³ In contrast, a volunteer force allows people who have optimized skills or a desire to acquire skills for a military role to participate as they wish, thus arguably creating a better-functioning military body.⁴ Conscription also has the following issue: the loss of efficiency gains from specialization, combined with low conscript pay, could lead to reduced earnings and production potential of individual draftees, which Friedman believes amounts to a 50 percent tax rate on pre-conscription income.⁵ In addition to these implicit taxes on individual earnings, there are societal costs that may be difficult to measure, such as loss of individual and economic freedom, as well as a loss of extra energy and resources spent dodging the draft that could be turned toward more productive measures. Oi’s research supported these claims by presenting evidence for an implicit tax levied on conscripted individuals. Hansen and Weisbrod’s study also reported an invisible social tax on conscripts in addition to decreases in real gross national product that could be attributed to the draft.⁶

Are the claims made by Friedman and his colleagues justified by further economic research? Does compulsory conscription significantly affect the human development of societies that implement it? Is there a legitimate case to be made for conscription as a more desirable source of military manpower as opposed to an all-volunteer force? Since Friedman's report, there has been a wealth of research into the economic consequences of compulsory conscription, and with new census data available every few years, more conclusions can be reached about the effect of conscription on entire generations of draftees across their lifetimes. As these results are further explored, clearer explanations can be formed to answer these important questions. The rest of this section will be dedicated to examining the potential effects of compulsory conscription on the accumulation and development of human capital.

Conscription and Health

There are no known negative or positive health effects on conscripts that could result uniquely from the implementation of conscription itself. Instead, because conscription "casts a wide net" and forces young males of all socioeconomic backgrounds into service, any existing effects on health due to active military service may be amplified and imposed on groups of conscripts who otherwise would not be in the military. One well-documented health effect experienced by World War II and Korean War veterans was an increased likelihood to take up smoking in the military.⁷ Cigarette manufacturers freely distributed their products both abroad and domestically at subsidized prices to American soldiers during these eras, creating a situation where even soldiers who weren't on active duty had cheap and easy access to tobacco. Anywhere from 36 percent to 79 percent of premature veteran fatalities from heart disease and lung cancer could be attributed to smoking habits developed during military service from this time. In the case of conscription, draftees with high earning and production potential in the civilian economy who would not otherwise enlist in a volunteer army would be exposed to greater risk of acquiring a smoking addiction across all combatant positions. Premature death and non-lethal physical ailments would therefore reduce productivity and cut short lifetime earnings.

In addition to smoking problems, a significant number of Vietnam War veterans also suffered from post-traumatic stress disorder (PTSD) and substance abuse. PTSD often hampers an individual's ability to handle day-to-day functions while increasing risk for mental disorders such as anxiety and depression.⁸ PTSD is also linked to substance abuse, including addictions to drugs and alcohol during service and after. Opiates like heroin were natively grown and readily available throughout the Southeast Asian region, and injured soldiers also became addicted to painkillers, or barbiturates. The combination of drug addiction and mental illness instigated by PTSD resulted in barely-functional war veterans who were at risk of death due to overdose or suicide.

All in all, studies on the relationship between military service and soldier health show a significant relationship between military participation and adverse health risks compared to non-veterans. Although direct combat especially exposes conscripts to injury, death, and mental disorders, even peacetime non-combat soldiers could develop unhealthy addictions to tobacco or alcohol under the US draft system. An argument could be made that the risks associated with large-scale conscription could cause unnecessary damage to groups of high-

potential males, thereby potentially permanently inhibiting or ending their ability to be productive and contribute to the national economy.

Conscription and Crime

It is difficult to directly relate conscription to any meaningful patterns in criminal tendencies and behaviors in veterans. However, the existing literature suggests that criminal tendencies of veterans depend more on circumstantial socioeconomic conditions after military service ends than the method of military enrollment. For example, research on American World War II conscripts showed a decrease in criminal tendencies and delinquency among veterans compared to non-veterans of similar background from the same cohort.⁹ It is theorized that the breakdown of socioeconomic barriers in the military and the generous education and training opportunities (such as the G.I. Bill) give crime-prone disadvantaged and delinquent draftees access to social mobility, allowing them to move away from criminal careers. However, a different study on Argentine World War II conscripts painted the opposite picture, where criminal tendencies for the average veteran increased relative to non-veterans.¹⁰ The authors of this study believe that military service, by increasing expertise in the usage of violent weapons and methods, actually decreased the entry costs into violent crime. Additionally, this effect may have also been related to lower job prospects and earning potentials for veterans of military service compared to nonveterans in Argentina. In other words, veterans of military programs that did not offer them social mobility and earnings growth found crime to be a more attractive and lucrative option after military service. Therefore, it seems to suggest that for conscripted armies, it is important for the military to provide disadvantaged and delinquency-prone conscripts with means of socioeconomic improvement and social mobility so that criminal tendencies are suppressed, not encouraged.

Conscription and Socioeconomic Gain

At the heart of Friedman's and Oi's studies is the assertion that forced military service interrupts the accumulation of human capital and permanently places most draftees at a developmental disadvantage compared to their undrafted peers. This amounts to an implicit tax on conscripts that undrafted individuals do not have to pay.¹¹ Economists have tested to see if this disadvantage exists by comparing long-term earnings between veterans and non-veterans from the same draft cohorts in countries that utilize conscription.

A plethora of research data shows that conscription does not have as widespread of a negative impact on earnings as Friedman or Oi might have their readers believe. Take, for example, the case of the United States draft. Earlier research conducted by Fredland and Little in 1980 suggests that earnings for WWII veterans actually increased relative to non-veterans.¹² However, this study did not take into account selection bias, where minimum selection requirements such as high school education and criminal record led to biased selection of draftees with inherently higher human capital stock. Accounting for selection bias, Teachman and Tedrow in 2004 found that there were no significant differences in long-term earnings.¹³ Likewise, earlier research by Angrist in 1990 found that Vietnam veterans earned less than non-veterans, but a later follow-up by Angrist and Chen in 2008 also found no significant difference in earnings as veterans approached the age of 50.¹⁴ Outside of the US draft, long-

term earnings differences have been found to be insignificant in the case of British, West German, and Portuguese conscripts.¹⁵ Meanwhile, Swedish draftees earned a premium, while Dutch and Argentine draftees made less than their counterparts who avoided the draft.¹⁶ At least from an earnings standpoint, the evidence points toward conscription as neither helping nor hindering the earnings potential of conscripts.

A closer examination of subgroups within draft cohorts reveals a pattern of significant progress that specifically benefits the disadvantaged socioeconomic groups, including the undereducated, minorities, and individuals without many labor market prospects to begin with. Sampson and Laub identify the WWII draft as a “turning point” for many economically disadvantaged and delinquent young men.¹⁷ They theorize that the military served as a transformative experience for these youths by reducing the importance of socioeconomic classes and providing transferrable skills and education opportunities that they otherwise would not have had access to on their own in civilian life.¹⁸ This, in turn, boosted their human capital accumulation and eventually their earnings over similar non-veterans. Similar results have been found in Portugal since the 1960s, where undereducated draftees benefited significantly in earnings from the service, while other adequately educated draftees saw no improvement.¹⁹ Portugal’s military service included robust training programs for undereducated servicemen, and Portuguese law also dictated that employers must rehire draftees after they return from service, guaranteeing conscripts a spot in the labor market and a smooth transition back into civilian life.²⁰

Economists have also extensively explored the relationship between conscription and education attainment. Studies on the post-war education attainment of WWII, Korean War, and Vietnam War veterans show that the G.I. Bill was hugely responsible for the acceleration of education attainment in America, which would in turn boost social mobility and productivity for the underprivileged socioeconomic classes.²¹ However, returns on education were found to be lower for veterans on the G.I. Bill than non-veterans. Additionally, the returns on education from the G.I. Bill diminished over time, with the WWII veterans experiencing the greatest returns and the Vietnam veterans experiencing the lowest. As greater proportions of the working population earn degrees and become more educated, the value of higher education diminishes.²² These findings have important implications for incentive policy: servicemen residing in a country with higher proportions of uneducated or undereducated males would experience greater financial benefits from a subsidized education plan for servicemen than those serving in a country that has already achieved high education saturation among its populace.

The Effects of Voluntary Military Enlistment Policies on Human Capital

The Growing Popularity of the All-Voluntary Military

A nation may derive greater economic flexibility and efficiency by transitioning from a policy of conscription to a policy of voluntary enlistment. In most cases, a draft incentivizes the military to conscript an excessive amount of recruits.²³ Proponents of an all-voluntary service have argued that the military will be forced to efficiently pay the socially optimal price for new recruits as the market takes over for a central government’s mandated conscription wage.²⁴ This

changes the dynamics of the supply market for the military, usually increasing the percentage of applicants who are marginalized by or impoverished in society. For example, in the 1970s and 1980s, the application rate of African Americans in the US skyrocketed, while application rates of European Americans remained stagnant. In this case, the new incentive structures opened many doors for African Americans, leading to higher wages within the military as well as “modest long-run increase[s] in [their] civilian earning” once re-adjusting into society.²⁵

The United States also exhibits cases where market forces lead poorer regions, such as the Appalachia, to shoulder greater burdens of supply for the military. A disproportionate amount of the Iraq War's casualties originally hailed from Appalachia, where the average per capita income is 18 percent lower than the national average and unemployment rates are 75.9 percent greater than the national average.²⁶ These market forces combine with the conservative political attitude prevalent in the region to make the armed forces, especially serving in the Iraq War, a very attractive option among locals, even though their opportunities both in the military and once they return home remain sparse due to personal and situational or structural limitations.²⁷ In this case, the voluntary military model provides an illusion of choice, yet can be argued to be just as coercive for those in dire poverty as conscription is, with few extra benefits if any at all.²⁸ Some of this can be attributed to the fact that most Appalachian recruits go into combat roles, which do not produce civilian-friendly skills, as combatants realize once they return home.²⁹ A simple way to better incentivize noncombatant roles in order for recruits to develop skills usable in civilian markets would be to simply increase bonuses for noncombatant positions.³⁰

Although the transition to a voluntary force solves many issues on the supply side for military recruitment, there still remains a glaring issue on the demand side. The monopsonistic nature of a nation's military causes some of the problems present in a conscription-based system of recruitment to carry over to volunteer-based systems. These are not only limited to issues of “excessive training costs associated with high personnel turnovers,” but also issues of optimal pricing of new recruits.³¹ First, determining individual prices of each recruit will remain a difficult and costly endeavor. Second, given political constraints in which wage discrimination is largely impossible among similarly ranked recruits, the military faces perverse incentives to follow its marginal supply instead of its supply schedule.³² Without the proper knowledge of the demand schedule (which remains a military secret), it is a challenge to determine which of these inefficiencies is the lesser of two evils. In either case, given that the military in many nations, including the United States, is usually that nation's largest employer of young individuals just entering the workforce, the effect of the military's selection policies on the labor market is rather significant.³³

Nations making this conscription-to-voluntary service transition change their military's focus onto a market made more of willing volunteers looking for an attractive wage (rather than the a market of reluctant conscripts demotivated by substandard wages). Advertising campaigns reflect this new direction, emphasizing individual growth and opportunity through “money for college, marketable skills, achievement, adventure, personal transformation.”³⁴ The realities of conscription, with its emphasis on duty to the nation, patriotism, and collective action, gives way to more capitalistic structures of personal incentives for economic betterment and self-

improvement. For the United States and other developed nations following suit, the government engaged in its first experiments of mass-market advertising with “expensive military advertising campaigns” to entice new recruits with promises of what can be summarized as developing the human capital base.³⁵ The advertisement campaigns and gradual rebranding of the army drew inspiration from a Chicago school’s advice to government officials on how to restructure and communicate incentives to new recruits.³⁶

The Case of Israel

Even Israel, while still maintaining a universal conscription policy, has altered internal structure of the Israeli Defense Forces (IDF) in order to emulate other nations’ market-based practices. The IDF largely operated without regard to a budget until 1985, when the financial infrastructure of Israel’s army changed so that the military handled its own expenses. As a result, reserve soldier duty (the enlisted soldiers considered active) fell sharply. For the first time in its existence, the IDF adopted a “semi-selective recruitment model...one that deviated from universalist principles” in how it utilized its stockpile of soldiers.³⁷ This slight change from a purely patriotic and nation-centric sense of duty to a more mixed set of incentives incorporating opportunity-based activities did not consistently produce beneficial outcomes for Israeli recruits’ human capital development. For instance, a program designed to more quickly assimilate undereducated immigrants into the nation by enlisting them in a “special track that combined military training with basic education” was scrapped in favor of a model that involved funding education after finishing the mandatory draft, which considerably limited these immigrants’ human capital development in the civilian world.³⁸

Yet not all of these changes have adversely impacted IDF soldiers’ futures. Israel’s government is looking to Britain (which has a longstanding tradition of a voluntary army) and its recent establishment of privately managed philanthropic funds to aid wounded soldiers returning from Afghanistan. Taking this as inspiration, the IDF is attempting to partner with philanthropic groups to set up a “new form of business sponsorship” for “the marketization of the education system.”³⁹ The current model attempts to ease Israeli soldiers into technocratic professions that grant not just development of human capital, but also generate economic returns to the IDF through the development of new weaponry and robotics, such as drones. The success of these programs is touted by the IDF as an example of the high transferability of “skills learned in the army [that] are usable in the civilian labor market” in order to assure Israeli taxpayers “that public budgets are therefore not being wasted.”⁴⁰ In these ways, market-based incentive structures popular in all-volunteer militaries in developed countries have been successfully integrated into and partially adopted by conscript militaries in other developed countries, primarily for the incentive structure’s achievements in furthering human capital development.

Unforeseen Consequences: Ghana’s Infrastructure Problem

In contrast to developed nations, there have been some issues when developing nations adopt the voluntary army structure in an attempt to reform military structure or create incentives for new recruits. In each of the cases where the voluntary model has failed, it was the result of policymakers in the developing nations and their advisors from developed nations overlooking crucial disparities. Some nations, such as Ghana, suffered from a lack of sound political

infrastructure. Rampant corruption and lack of opportunity to provide the correct incentives created lackluster conditions to maintain a quality standing army using the volunteer military model. Other nations are so diverse and susceptible to ethnic tensions that volunteer armies regularly experience waves of factionist tendencies, rendering the armies inefficient and creating perverse incentive structures reminiscent of cronyism in the militaries' ranks.

Before the 1990s, the incentive structure of Ghana's military ran top-down. "Authoritarian military code protected the corruption of senior officers [from] being questioned and exposed by their juniors," essentially maintaining an inherently oppressive system that benefited "only a handful of people" at the top of the hierarchy.⁴¹ This power structure increased the likelihood of the volunteer army choosing to protect the interests of ethnic groups across the nation, further dividing Ghana's military power into distinct factions.

However, later governments, which were mostly short-lived due to the common occurrence of coups, attempted to reform the structure of military, promising new recruits that they would become part of various focus groups and committees within the military structure.⁴² By 1984, these reformist committees were prominent in many European and North African nations, and Ghana hoped to emulate their successes by creating a more efficient, united military body. This was pursued in an attempt to balance the top-down seniority structure with bottom-up bodies of authority spearheading gradual reform. Yet, the reform backfired. What worked exceptionally well in more homogenous European and North African nations did not transfer well to Ghana's partisan and highly fractious military. The creation of bottom-up committees facilitated the "manipulation of ethnic divisions," favoring Ewe soldiers most prominently when they were first adopted.⁴³ Rather than helping alleviate grievances in the military and stifle rampant corruption, the committees reinforced the well-established "informal and personalistic" channels of promotion and recruitment.⁴⁴

The military continued to function as an inefficient system of patronage, fueled by the voluntary system that self-selected certain ethnic groups and sustained by the internal factions. Furthermore, "excessive centralization of budgetary resources in the Armed Forces"—meant to curb corruption and embezzlement scandals—caused the "control and allocation of funds [to lie] with the General Headquarters" of the army (the most powerful of the military branches given Ghana's paltry air force and navy).⁴⁵ As a result, "commanders did not control what their troops needed in order to function properly," and the military operated at a wasteful loss.⁴⁶

Another reason for the deterioration in the human capital development in the Ghanaian army was a severe drop in the military's budget over several decades. Military expenditures in Ghana dropped from 8 to 9 percent of the budget in the 1970s to 4 to 7 percent by 1993.⁴⁷ As the Minister of Finance said in 1993, "Ghana spends a small percentage of the total national income on its military compared to other countries. Soldiers live in dilapidated quarters and their hardware is obsolete."⁴⁸ Indeed, soldiers were leaving the army and, unable to find employment since they had been replaced after leaving to serve in the military, ended up more destitute than before they were recruited, making the military a machine of human capital extraction rather than human capital progression.

Civilian institutional oversight of the army did not gain serious ground until the early 1990s. When the new 1992 Constitution was adopted, the Ministry of Defense transferred from military officials to civilian personnel, and the national political systems transitioned from the rule of shadow dictators to a legitimate democracy.⁴⁹ The corruption within the ranks slowly eroded as a result, and Ghana's military began more inclusive enlistment projects.

Despite these reforms, Ghana continues to struggle with its legacy—one created by constant upheavals within its military leadership and the experimental policies that permitted the preservation of “internal tensions that allowed the military to be manipulated” by special interest groups.⁵⁰ Ghana's internal infrastructure and political and military institutions must be reformed in an organic way that solves its unique problems; no developed nation's military policy will be able to aid it. Such a feat would require a dismantling of the power structures that have become entrenched and politicized over time. Only then can the small nation's military policies benefit new recruits and become a tool for human capital development.

Effects of Military Training and Service on Soldiers

Despite the previously mentioned drawbacks of conscription, there are still facets of military training that are desirable and should be considered by a government looking to adopt a wide program of enlistment. Military training at its core is believed to cultivate a respect for discipline, obedience, and work ethic. However, there has also been research on more tangible effects of military training on soldiers. These studies have been widespread in terms of scope and time. There are some limitations in terms of the varying datasets utilized and different methodologies applied to determine correlations. Also, military training in different countries could potentially have different effects. Nonetheless, a study conducted in 2004 suggests that 14 percent of Caucasians and 17 percent of African Americans born in the United States between 1965 and 1969 have served in the military.⁵¹ Therefore, any impact from military training can have a significant effect on society due to the large number of people that have enlisted in the all-volunteer force.

Health

Although many soldiers who enter combat tend to have negative health outcomes such as PTSD, drug addiction, or physical injuries, military training itself can have positive effects on a recruit's well-being. The physical fitness tests (PFT) for army enlistment in the United States are designed to test two levels of fitness: muscular and cardiovascular. Recruits between the age of 17 and 21 must perform 44 pushups and 46 sit-ups in two minutes each. They must also run two miles in 13 minutes and 36 seconds.⁵² However, the nature of military training requires constant fitness, thus there are semi-annual PFT's as well. The minimum requirements are 42 pushups, 53 sit-ups, and two miles in 15 minutes and 54 seconds.⁵³ Therefore, trainees must be in great physical health throughout the duration of military service in order to uphold the rigorous standards of the army.

However, improved health can have other benefits on a recruit, particularly those in their late teens. Obesity has been a rising epidemic among teenagers, particularly in countries like the

United States and Mexico. This can have long-term consequences, including health care costs for diseases such as diabetes. Studies also establish trends between teen fitness and intelligence, as well as university attendance. One study surveyed 1.2 million military recruits born over a span of 26 years in Sweden, where conscription is enforced. The report looked to establish trends between cardiovascular and muscular fitness and intelligence in 18-year-old recruits. The researchers then compared the results to academic performance and socioeconomic condition later in life. The study found strong significant results between cardiovascular fitness and scores on intelligence tests. It also found that fit 18-year-olds were more likely to attend university and have higher paying jobs in the future. The researchers theorized that cardiovascular fitness rather than muscular fitness led to better outcomes because of higher oxygen intake from the hearts and lungs to the brain.⁵⁴ This higher level of oxygen was perceived to have a positive impact on developmental outcomes for these trainees.

However, military training also provides better opportunities for nutrition as well. The meals of soldiers are carefully controlled to allow a certain amount of calories, fats, proteins, minerals, and other nutrients. In order to maintain their levels of fitness, soldiers have certain benchmarks for nutrition that should be achieved in order to sustain the physically strenuous life they lead. A study by the US Army Medical Research and Nutrition Laboratory found that soldiers meet the benchmarks set for nutrient consumption. They also discovered that mineral and vitamin intake exceeded minimum levels.⁵⁵ The fact that armies can control what is served in mess halls allows for the facilitation of nutritionally optimal meals for recruits. Therefore, military training also allows for generally healthy nourishment.

Diversity

A common argument for conscription or military service is that it enables the opportunity for people of various backgrounds to assimilate into one entity for a common patriotic purpose. President Harry Truman issued executive order 9981, which desegregated the army, in 1948. This order increased African American involvement in the army from 10.5 percent of personnel in 1945 to 12.2 percent in 1962.⁵⁶ Today, African Americans represent almost 16 percent of active duty and reserve members of the army.⁵⁷ It should be noted that African Americans make up only 14 percent of the total population in the United States, thus they are overrepresented in the military.⁵⁸

Exposure to different races and ethnic groups has led to a somewhat better understanding between the various recruits. Only 12 percent of Caucasian soldiers and 37 percent of African American soldiers that were surveyed in 1943 in a study conducted by Charles Moskos Jr. were favorable toward integration. Those numbers increased to 25 and 90 percent respectively in 1951, three years after the passage of Executive Order 9981. In data obtained in 1965, an overwhelming 84 percent of African American soldiers felt that there was more racial equality in military life compared to civilian life. Lastly, 51 percent of infantrymen in all Caucasian units in 1951 felt that segregated units were better. However, only 31 percent of integrated units felt the same. Therefore, the data illustrates that military service in that era allowed for better race relations between soldiers and perhaps a greater mutual respect for each community.⁵⁹

This report is useful because it shows that although African Americans faced great discrimination from Caucasians during that era, military service allowed for some reconciliation between the two groups for enlisted members. This insight can be particularly helpful for other countries with diverse populations where societal discrimination against minorities has been prevalent. It would seem that the tough nature of military training and combat service allows for people of different ethnicities to appreciate each other in a manner that would not be possible in normal civilian life.

Marriage

There has been some research to indicate that military service increases marriage rates among veterans. A study conducted by researchers at Syracuse University found that African American veterans were 54 percent more likely to marry within five years of having a child than non-veterans. They did not find significant results for Caucasians and Hispanics.⁶⁰ However, these groups already have much higher non-veteran marriage rates than African Americans. The study posits that African Americans receive more employment and higher income opportunities from military service due to less discrimination in the army than in civilian life. The higher chance of steady employment, in theory, leads to more stable marriages. Another explanation the researchers provide is that completion of military service can perhaps “enhance black men’s perceived marriageability in the eyes of female partners” and “the ability to meet the economic and relationship challenges of marriage.”⁶¹ Therefore, there are potential psychological as well as economic reasons that military service leads to higher marriage rates among African American soldiers.

However, the question arises as to why marriage is important. According to the Census Bureau, 34.6 percent of children living with two unmarried parents are in households receiving food stamps. Similarly, 44.7 percent of children living with only their mother are in households receiving food stamps, compared to 21.6 percent of kids living with only their fathers. Almost 15 percent of children living with only their mothers and 11 percent of children living with only their fathers do not have health insurance. Nearly 12 percent of children living with unmarried couples also do not have insurance. Comparatively, only 7.5 percent of children living with married parents are uninsured.⁶² Another study found that children growing up in single-parent households have a 52 percent chance of not attending college and a 28 percent chance of obtaining low grades.⁶³ Therefore, there is significance in the debate of the importance of marriage in society. It should be noted that this section has focused on marriage in the United States; however, marriage may be more highly regarded in more conservative nations. Therefore, military service may not have any effect on marriage rates in those countries.

Transferability of Skills

Much discussion has occurred about the transferability of skills for veterans who are no longer in the military. Many studies, however, have been inconclusive due to statistical and sampling problems. Nonetheless, there are advocates for veterans who suggest that these soldiers have intangible assets, such as personality traits, that help enable them to be successful in post-military life.

Veterans in particular are active entrepreneurs, with veteran-owned companies making up 9 percent of all companies in the United States, although this group accounts for less than 9 percent of the population.⁶⁴ Veterans own 13.2 percent of finance and insurance companies; 12.7 percent of transportation and warehousing firms; 12.4 percent of mining, quarrying, oil, and gas companies; and 10.9 percent of professional, scientific, and technical service firms in America.⁶⁵ The percentage of professional, scientific, and technical service firms veterans own is especially of note. It is likely that they acquired the knowledge of these trades through tasks learned and skills developed in the military. There is also discussion of intangible skills that veterans learn in the military, such as leadership, resilience, decision-making, commitment, and the ability to work in teams. These are fundamental skills to starting and owning a business. Therefore, it can be argued that the armed forces enables soldiers to hone their abilities for use in both military and civilian life, particularly in regard to entrepreneurship.

A Potential National Service Framework

This section will briefly discuss how the government could institute a program that would entail incentivized voluntary military training and service. As previously mentioned, conscription may have negative effects on income due to the fact that soldiers might be leaving salaried positions and unwillingly accepting lower compensation from the military. Also, many argue that the lack of choice in mandatory military service diminishes much of the patriotic aspect of service. Others argue that military service should be a national duty of every citizen. A potential compromise is a national service program (NSP) with a period of military training that offers incentives to entice people to join. It should be noted that the following framework is a combination of several existing smaller programs and ideas that have been discussed in the past.

Incentives

In the 1990s, the Clinton administration tried to enact a large scale NSP where youth would be rewarded with tuition aid for volunteering service. A similar program can be enacted with a requirement for military training. In exchange, recruits would be entitled to tuition aid from the federal government. Also, the government could add another requirement for national entitlement programs such as Medicare, food stamps, etc., by requiring participation in an NSP. Currently, US immigrants wishing to be naturalized can serve in the military to hasten the process. Such incentives can be applied to this program as well. Of course, the incentives would differ by country, since problems vary depending on location.

Government Benefit

The question arises as to how the government benefits by enacting an NSP. Firstly, there are physical and intellectual standards that must be achieved to enter the military and be acceptable for training. There would be citizens who need access to the various aid programs available through participation but who do not meet the standards of acceptance. Such strong incentives would perhaps inspire those citizens to train in terms of fitness and aptitude in order to be able to pass entrance exams. Thus, the government indirectly achieves objectives that it would otherwise want to advance. Also, if the duration of the training were long enough, the government would achieve some measure of human capital development for these participants based on the effects previously mentioned.

However, with such a voluntary program and the expected young age of participants, the government would be able to provide lower compensation than needed to attract older soldiers or other federal social workers. The government would then be able to utilize these participants for socially beneficial tasks such as construction, repairs, cleaning, teaching, or assisting the elderly at the fraction of the cost. The reduction in cost could be significant for the Pentagon or a similar department of defense in another country if these recruits perform low-skill tasks that are currently being outsourced to other workers. Therefore, while being trained in combat, participants in such an NSP would also perform tasks that would not only instill work ethic in youthful recruits, but also justify incentives such as tuition aid by reducing costs for menial government tasks that need to be performed.

Conclusion

Implications

The implications of these findings are far reaching. The burdens of conscription have been documented since social scientists and economists first began studying the effects of conscription seriously during World War I. Yet there are nations that still use conscription as the preferred strategy for supplying their militaries' ranks.⁶⁶ Totalitarian states will continue to conscript their populations for the foreseeable future. However, in most of the world, the past 30 years show that conscription has grown unpopular, not just among civilians, but also among world governments.⁶⁷ This trend reflects economists' findings that conscription armies continue to run inefficiently.

As volunteer armies replace conscription armies, the free market takes over for the government in recruiting for the military. In most cases, this makes the pricing of recruitment much more efficient than conscription, although unforeseen effects include a focus on the marginalized poor. This can be a boon to a nation's poverty-stricken population, as long as the right resources are in place, such as the provision of education to recruits leaving service. Another unforeseen consequence of volunteer armies replacing conscription involves the transfer of volunteer-recruitment military policies from developed to developing nations that lack the infrastructure and resources to support such policies. This has caused some developing nations to suffer setbacks that jeopardize the cohesiveness and strength of their armed forces. Many of the issues developing nations faced with their conscription policies live on despite the transition to volunteer military policies. Creating useful volunteer military enlistment policies is dependent on the unique context and situation of those nations, factoring in such things as ethnic tensions in non-homogeneous states, lack of sound financial infrastructure, political motivations, and administrative corruption and inefficiency. Developing nations will continue to face challenges in reconciling voluntary military enlistment policies with expanding their human capital base.

However, the positive effects of military training can go a long way to improve human capital stock in all nations that require a standing military for their defense policies. Physical fitness and marriage stability promote better overall health in society. Increased access to education for marginalized and impoverished populations improves livelihood and contributes significantly to a nation's standard of living and GDP growth. For societies grappling with homogenizing a nation-state, military enlistment, if carried out successfully, helps reduce

ethnic tensions and fosters diversity in the ranks, contributing to overall patriotism. Furthermore, it is thought that due to the discipline and connections recruits make during their time in the military, soldiers exhibit a more entrepreneurial spirit after leaving the force and retiring to a civilian life. However, this may also be due to other factors, such as attainment of education.

Omitted Discussions

Due to the limitations on the length and scope of this research paper, the authors could not address every issue pertinent to the topic of military service and human capital development. A number of factors were either not discussed directly, were assumed for the sake of simplicity, or were deemed too complex to accurately address. In order to do justice to these topics and discover how they may enrich this paper's arguments and findings, further analysis and research is required to better understand these points and possibly open up avenues to papers of similar but different inquiries.

A severe limitation of this paper lies in the dearth of military service research regarding the economics and human capital of developing nations. Most of the studies currently available are focused on developed nations' military policies, such as Israel and the United States,, or historical analyses in Europe. Yet the scholarly world has not paid much attention to the military situations of other nations from an economic perspective. Given the globalization of military endeavors, this remains crucial to a multitude of disciplines and deserves more attention. Studies and models of Western or industrialized nations are, after all, not universal and assuming that they are can hold grave consequences.

The paper did not discuss the effects of participating in the National Guard or reserve forces in any given nation since these groups blur the boundary between civilian and military life; therefore, research on their human capital development is limited. Also not discussed is the effect of actual warfare or constant standing armies, such as those in Israel and South Korea, on nations' military service policies and soldiers' human capital development. Additionally, this paper assumed that military forces only serve to fulfill roles of violence. It did not address some real-life alternative functions for the military, including delivering human aid and relief to disaster areas. Lastly, the effects of private military employment on human capital development in traditional standing armies and in national military policies remain unexplored. However, privatized warfare remains a very important topic in this field of inquiry since "the supply of supplementary military services by private companies, including the revival of mercenarism in several conflict areas around the world," has been steadily increasing over the past few years.⁶⁸

Future Outlook

Countries looking to advance a form of national defense or human capital development policy should look to incentivized military service to advance their objectives. While military training itself seems to have positive impacts on recruits, forced enrollment seems to dampen the positive aspects of service. Poor and diverse countries, such as India or Ethiopia, should consider the implementation of such a program to supplement existing goals of human capital

development in order to enhance the lives of their citizens. Naturally, such NSPs would have to be tailored to local cultures, needs, and domestic issues with further research, but nonetheless could have potentially beneficial impacts on economic development. The authors of this paper hope that the discussion of military service and its effects on enlisted personnel continues in the future with further investigation.

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A Game with No Rules: Taming the Lawless Battlefield

by Gregorio Flores '16

Abstract

The Law of Armed Conflict sets certain standards for modern warfare, including protection of hospitals and a clear definition of “use of force.” International law has no mention of how cyber attacks should be treated and whether they are considered a use of force. Cyber attacks, such as Stuxnet, have become increasingly damaging. Many countries have bolstered their cyber military efforts in order to protect themselves and to develop cyber offensive capabilities. Cyber law needs to be tightened within these countries, off-limits targets need to be marked so that they can be avoided during cyber attacks, and the United Nations needs to clearly define situations in which cyber attacks would be considered a use of force.

Introduction

One of the most frightening characteristics of nuclear weapons is their capability for widespread destruction. A single person can take the lives of thousands by performing one simple act far from the target. While a comparison between a nuclear missile and a cyber attack may seem dramatic, cyber attacks have grown increasingly damaging and have the potential to harm a country in ways similar to a nuclear missile. Astonishingly, there is no international law outlining the rules of engagement in terms of a cyber attack. Furthermore, situations in which cyber attacks could be considered a “use of force” are not clearly defined. This is extremely important in terms of retaliation and UN sanctions. These issues need to be addressed as nations continue to expand their cyber capabilities. In this paper, I will discuss the current rules of war, provide a history of cyber attacks, examine the rise of cyber armies, evaluate the potential of cyber attacks, and recommend how cyber attacks should be addressed in international law.

Developing the Rules of War

War is certainly not without death, destruction, and devastation, but rules help limit its reach into civilian lives. A prominent Latin maxim, “In times of war, the law falls silent,” highlights the barbarism of unregulated warfare.¹ Few rules, if any, regulated ancient combat. In modern times, such an absence of agreements governing conflicts between nations could lead to destruction on a much larger scale. As devices and methods of war continue to advance, so too must the laws that govern it. In 1864, the first Geneva Convention reached a consensus and set forth regulations for combat that obligated nations to provide relief to wounded

soldiers and civilians without consideration for nationality and to deem medical personnel as “neutral.”² Since then, multiple additions have been made to the articles of the original Geneva Convention as new weapons were used. The 1925 Geneva Protocol prohibited the use of chemical and biological weapons in war in response to the use of tear gas, mustard gas, phosgene, and chlorine in World War I.³ Although eventually unsuccessful, the Nuclear Non-Proliferation Treaty in 1968 sought to prevent the spread of nuclear weapons and set an important precedent for international cooperation between nuclear and non-nuclear states to prevent proliferation.⁴

The 1977 Geneva Convention discusses the need to carry out international reviews of new weapons and to determine the “lawfulness of new weapons before they are developed, acquired, or incorporated into a military’s arsenal.”⁵ Article 37 of the Geneva Convention Protocol states, “In the study, development, acquisition, or adoption of a new weapon, means, or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party.”⁶ The 1977 Geneva Convention had the foresight to see that, as our technologies increase, so should international law.

International Law

The Law of Armed Conflict (LOAC) is composed of “a set of rules, established by treaty of custom, that seeks to protect persons and property that are affected by armed conflict and limits the rights of parties to a conflict to use methods and means of warfare of their choice.”⁷ The LOAC is comprised of agreements from the Geneva and Hague Conventions, several other treaties, and case law.⁸ There are four core principles of LOAC: distinction, military necessity, unnecessary suffering, and proportionality. “Distinction” requires an army to distinguish at all times between civilian and military objectives. “Military necessity” obligates an army to only use measures deemed indispensable for securing the ends of the war. No greater force or violence should be used to carry out a military operation than is circumstantially appropriate. “Unnecessary suffering” prohibits nations from employing weapons, projectiles, and material and methods of warfare that can cause superfluous injury or unnecessary suffering. “Proportionality” prevents attacks that may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilians, damage to civilian objects, or any combination of these that would be excessive in relation to the concrete and direct military advantage provided.⁹

The Geneva treaties and protocols were most recently updated in 2005 with Protocol III, which does not address any new weapons or methods of warfare. Certainly a conflict on the scale of World War I or World War II, the wars that shaped the Law of Armed Conflict, has not occurred in recent memory. Codes that govern warfare, however, should be updated to reflect modern warfare.

There is no portion of the Law of Armed Conflict that specifically addresses cyber attacks. Three factors can explain this omission. Firstly, a cyber attack is not universally defined.

The Congressional Research Service provides no official definition for cyber attack or cyber warfare.¹⁰ The US Department of Defense prefers to use the term “cyber threat” when discussing threats to cyberspace. Its 2011 Strategy for Operating in Cyberspace makes no use of the term “cyber attack” or “cyber warfare.” While the Strategy acknowledges the potential for cyber threats to cause damage to private and public entities, no definitive statements exist to determine what constitutes an act of aggression or an attack, only that there is certainly a threat that the US government considers and anticipates.¹¹

Secondly, no consensus exists on whether a cyber attack constitutes a use of force under international law and whether a cyber attack would justify a military response from the attacked nation. Article 2(4) of the UN Charter states, “all members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the United Nations.”¹² If the United Nations determines that such force has been used against a nation, Article 51 states, “nothing in the present Charter shall impair the inherent right of individual or collective self-defense if an armed attack occurs against a Member of the United Nations.”¹³ What constitutes a use of force is ambiguous. Armed violence seems to be an obvious use of force, but what about other methods, such as economic aggression or interference, which can have similarly devastating effects? The United Nations hesitates to authorize the use of armed forces by the UN Security Council and does not consider economic and communication sanctions as holding nearly the same weight as an act of violence. Article 41 of the UN Charter gives the Security Council the obligation to take measures that do not involve the use of armed force (economic sanctions, interruption of communications, etc.). Only if those methods prove to be ineffective can Article 42, the use of force by the Security Council, be enacted.¹⁴ Because cyber attacks have damaging economic effects rather than violent ones, based on the UN Charter as it stands, a cyber attack would not be viewed as a use of force, precluding retaliation under Article 51. UN Resolution 64/211 calls for the creation of a global culture of cybersecurity, advocating that nations perform a “voluntary self-assessment” of efforts to protect critical information infrastructures.¹⁵ While this resolution acknowledges the potential of cyber attacks, the United Nations does not clearly define what constitutes a cyber attack, nor does it outline how a member nation can respond after a cyber attack.

History of Cyber Attacks

The lack of an international agreement concerning cyber attacks is not for a lack of such events. Although modern computers and the Internet have only been around for a few decades, the history of cyber attacks starts more than 30 years ago. In 1982, during the heart of the Cold War, one of the first computer-based attacks was carried out against the Soviet Union. A Soviet Committee for State Security (KGB) officer provided key Soviet technologies, including computers that controlled industrial technology processes, to the CIA. This intelligence led to the delivery of a faulty computer design to the Soviet Union and a massive pipeline explosion in 1982.¹⁶ While there is much debate as to the cause of the explosion, a targeted effort to disrupt computers that aided industrial processes provides an example of a coordinated cyber attack’s potential to cause destruction. Cyber attacks can create scenarios

in which computer-controlled equipment malfunctions, leading to devastating events like pipeline explosions.

In 2003, the Davis-Besse nuclear power plant in Ohio was infected with a worm that caused data to overload the site network, rendering computers in the plant unable to communicate with one another. The plant's Safety Parameter Display System was unavailable for almost five hours, and the process computer was unavailable for over six hours.¹⁷ The event was not deemed significant because the control and protection functions of the plant were not affected, but such an event demonstrates the vulnerability of computer systems that control power plants and other infrastructure. If computers that control systems within a nuclear facility can be compromised for hours at a time, a cyber attack could easily trigger a catastrophic nightmare.

A similar security breach occurred in the electricity sector in 2003, when the SQL Slammer worm was released by an unknown source and spread across the Internet. It overtook 90 percent of vulnerable systems and affected more than 75,000 hosts in the United States, including several electricity sector systems.¹⁸ The incident caused no known electric system outages or disruptions, but bulk electric system control was impaired in some cases.¹⁹

In January 2000, a cyber attack occurred on a Supervisory Control and Data Acquisition (SCADA) system in Queensland, Australia, when a disgruntled ex-employee seized control of the plant's operating systems responsible for opening and closing sewage valves and communication systems. The attack lasted for more than three months until an engineer concluded that the valve malfunctions the plant experienced were not due to error but rather to someone who hacked into the control system and transmitted other signals to the valves. The hack resulted in a nearby river flooding with 264,000 gallons of raw sewage.²⁰ This attack required inside knowledge of the plant and its operating systems, and it exposed a vulnerability of SCADA data-control systems.

Incidentally, most industrial control systems rely on SCADA networks. These networks are designed to monitor and control various critical infrastructures or facility-based processes and run critical infrastructure such as power generation plants, transmission networks, refinery plants, oil and gas pipelines, and transport and communication systems. Previously, these SCADA networks operated in isolated environments, but they have become interconnected and Internet-based. These systems monitor wide-ranging networks and can send commands to any location within the network.²¹ The Queensland attack serves as an example of the potential damage that can be caused by a compromised SCADA system.

Cyber infiltrations have also quietly occurred within the United States, compromising the future integrity of many of our systems. Though no specifics have been given, current and former US national security officials admit that cyber spies have penetrated the US electrical grid and left behind programs that could be used to disrupt the system. Believed to have come from China, Russia, and other nations, these cyber spies mapped out the US electrical system and were undetected by the companies in charge of the infrastructure. A senior US

intelligence official says that such infiltrations embed software tools in US systems that could be used to destroy infrastructure, and “if we go to war with them, they will turn them on.”²²

Estonia fell victim in 2007 to one of the first cyber attacks that seemed to have a specific political agenda. Estonian officials claim that their country experienced a cyber attack at the hands of Russians after moving a Soviet war memorial in Tallinn, against the Kremlin’s wishes. After moving the memorial, the Estonian government experienced a “spam avalanche” that overwhelmed their computer servers and disrupted banks, newspapers, defense ministries, and hundreds of state and commercial websites.²³ Russia denied involvement, but instructions for attacking Estonian websites were found on many Russian language forums and websites. These instructions were often very specific and usually included very simple acts such as ping floods that, when thousands of attackers were involved, wreaked havoc.²⁴ The “flood” tactic used in the attack on Estonia demonstrates an important misconception of cyber attacks: that they have to come from a few well-trained, extremely knowledgeable experts. Simple spam attacks can be carried out by almost anyone with a computer and a set of instructions, and they have proven to be very effective. Because these attacks are easy to implement, states often fall prey to attacks from non-state actors. These attacks would not fall under the jurisdiction of any international laws concerning warfare and would be difficult to police. Governance of non-state actors is beyond the scope of this paper.

Perhaps the most discussed cyber attack to date is the Stuxnet virus, which crippled an Iranian nuclear facility in fall 2010 in the midst of rising global political tensions. The virus infected an estimated 50,000 to 100,000 computers, mainly in Iran, Indonesia, and Pakistan. Delivered through a thumb drive, the virus “hunted down” frequency converter drives at the Iranian nuclear facility at Natanz. The frequency converter drives control the speed of motors used to turn centrifuges that separate and concentrate uranium in reactors.²⁵ Reportedly, Stuxnet ruined almost one-fifth of Iran’s nuclear centrifuges.²⁶ Hailed as “an all-out cyber strike against the Iranian nuclear program” and “one of the most sophisticated and unusual pieces of software ever created,” Stuxnet’s speculated aim was to physically destroy a military target, which would make it the first cyber warfare weapon.²⁷

According to former US Defense Secretary Leon Panetta, the most devastating cyber attack to thwart the business sector occurred on August 15, 2012.²⁸ Saudi Aramco, Saudi Arabia’s national oil and gas firm, was struck by a self-replicating virus that infected 30,000 machines. This attack deleted important drilling and production data from computer hard drives, disrupted business processes, and necessitated a two-week recovery.²⁹ The attack did not trigger a rise in global oil prices because the damage was limited to the corporate information network, but if the attack had disrupted production infrastructure similar to the Stuxnet attack, then the global economy could have been drastically affected. The 1973 Saudi oil embargo demonstrated the fragility of our oil supply.³⁰ Even with increased domestic drilling and reserves, a prolonged modern halt on Saudi oil could create inflation similar to the kind that partially caused the 1974 stock market crash.³¹

Cyber Armies

Cyber attacks have not gone unnoticed by US government officials, who in 2014 passed an appropriations bill that raised the budget of the US Cyber Command from \$191 million in 2013 to \$447 million in 2014.³² Former US Secretary of Defense Chuck Hagel indicated that the Pentagon plans to more than triple its cyber security staff in the next few years, commenting, “The Department of Defense is on its way to building an elite, modern cyber force.”³³ This increase in spending and staff is dramatic, considering that it was not until 2011 that the US Department of Defense acknowledged cyberspace as a new domain of warfare.³⁴ US Cyber Command, founded in 2009, is comprised of multiple service components, including separate Army, Air Force, and Fleet Cyber Commands. The objective of the US Cyber Command is to “plan, coordinate, integrate, synchronize, direct, and conduct network operations and defense of all Army networks and when directed, conduct cyberspace operations in support of full spectrum operations to ensure US/Allied freedom in cyberspace.”³⁵

China has been more secretive about its cyber operations, and it denies any involvement in offensive cyber operations, claiming that its goal is simply to secure its own networks. In 2011, China’s Ministry of National Defense finally acknowledged the existence of the “Blue Army,” a cyber security squad charged with protecting the country from cyber attacks.³⁶ The Blue Army has a speculated budget of about 10 million yuan (US\$1.6 million) and is based in China’s southern Guangzhou military region. It is estimated that China has about 50,000 military hackers in place or in training. Furthermore, in an effort to reap economic benefits from the Internet while avoiding the diffusion of Western, anti-communist ideas, China spends a considerable amount of funds and manpower to maintain the Golden Shield Project and the Great Firewall of China.³⁷

Cyber military efforts are not restricted to the United States and China. Other world powers have invested in their own cyber forces in the cyber arms race. The United Kingdom has developed a cyber weapons program, intended to help counter cyber threats, at the Government Communications Headquarters. Armed Forces Minister Nick Harvey acknowledges the importance of investing in cyber forces, saying, “action in cyber space will form part of the future battlefield” and will be “an integral part of the country’s armory.”³⁸ India, which previously downplayed the importance of cyber forces, is in the process of establishing a tri-service cyber command in response to several instances of Chinese hackers breaking into sensitive government computer systems.³⁹ In an attempt to protect itself from both Chinese hackers and the North Korean nuclear threat, South Korea also established cyber operations in 2010.⁴⁰ South Korea’s National Cyber Security Center collaborates with the private and military sectors to improve warning systems, analyze and prevent cyber attacks, and coordinate cyber responses. South Korea hopes to develop weapons similar to Stuxnet with the intent of physically damaging North Korean nuclear plants and missile facilities.⁴¹

Potential of a Cyber Attack

Experiments have been carried out to attempt to reveal what would happen if a significant cyber attack was conducted in modern war. Professionals for Cyber Defense, a private cybersecurity group, modeled a realistic cyber attack, codenamed Dark Angel, on the United States. The attack simulation targeted rail transportation, pipelines, power infrastructure, financial services, and emergency service systems, as well as disabled general Internet service.⁴² Researchers at the Department of Energy's Idaho National Laboratory in March 2007 made a generator self-destruct using an experimental cyber attack.⁴³ Based on what we currently know about cyber attacks and simulations like these, we can paint a realistic picture of what a cyber campaign would look like.

A modern and unrestricted cyber campaign would be directed primarily at the target country's critical infrastructure, which includes energy, transportation, finance, water, communications, and emergency services. Broad immediate and long-term economic repercussions would be felt, and such a campaign would probably not distinguish between the public and private sector. An unrestricted cyber attack could result in significant loss of life if vital public services, particularly hospitals, were compromised. A successful cyber attack could lead to significant economic and social degradation.⁴⁴

A cyber attack against an Internet service provider would wreak havoc on the American economy and psyche. Management consulting firm McKinsey & Company found that among the G-8 nations, as well as Brazil, China, India, South Korea, and Sweden, the Internet was responsible for 3.4 percent of GDP, on average, and accounted for 21 percent of GDP growth over the last five years.⁴⁵ Loss of Internet could cripple the economy of the attacked country.

Creating a chronic loss of services such as power, emergency response, and television across the United States would cause citizens to lose their confidence in the US government. Individuals would question the status and security of their personal finances in savings and retirement accounts, and uncertainty could exacerbate a social and financial crisis.⁴⁶ The annual estimated economic loss from power blackouts is between \$104 and \$164 billion.⁴⁷ If a cyber attack caused significant power loss, the cost could be billions of dollars to the US economy and severe economic repercussions could be felt.

While this scenario is realistic, it is very difficult to diagnose the potential of future cyber attacks for several reasons. First, we cannot predict future technological developments. As it stands, SCADA systems, which require specific knowledge of each individual system to hack, are used by most public utility services and are generally isolated from the network, making them difficult to attack.⁴⁸ This would suggest that current technology minimizes the potential of a cyber attack on most public utilities. But, if weapons become computerized, cyber attacks could become even more dangerous and violent. As society introduces wireless and unmanned technology in different industries, the potential for damage increases.

Also, there is still very little historical evidence available to evaluate the potential damage of a cyber attack. Stuxnet was the first of its kind: a virus that was targeted, tailored, and able to disappear undetected, “Stuxnet is like a self-directed stealth drone: the first known virus that, released into the wild, can seek out a specific target, sabotage it, and hide both its existence and its effects until after the damage is done.”⁴⁹ Stuxnet could potentially just be scratching the surface, and we have yet to see a catastrophic event caused by a cyber attack. Major changes to the Law of Armed Conflict were caused by clear demonstrations of a weapon’s power, like mustard gas in World War I or the atomic bomb in World War II. Cyber attacks are relatively new and in the primitive stages of what they could become, offering a dearth of attacks that can be used to evaluate future threats.

Recommendations

As cyber attacks grow more powerful and countries grow more dependent on computers, cyber militants should no longer be able to damage infrastructure with free license. International law needs to be updated to include restrictions on a weapon that could cripple economies and infrastructure even more than a bomb could in certain scenarios. I have several recommendations that I think would hold nations accountable for their cyber actions and put limits on a weapon with such potential.

First, the United Nations should encourage its member nations to toughen cyber laws within their countries. No leading nation in the world allows private citizens to possess missiles or bombs or other military-grade, highly destructive equipment. The ubiquitous capability for cyber warfare mandates strong governance of cyber crime. While the concern of this paper is cyber attacks by nation states on other nation states, my recommendations are severely undermined if a country allows civilians to carry out cyber attacks without any consequences, or if a nation is able to avoid responsibility by claiming that they were unaware of a massive cyber attack conducted by civilians. The majority of cyber attacks come from individuals or criminal organizations within nations that do little to stop such activity, especially as “Cyber attacks have benefited from jurisdictional arbitrage. Organized cyber crimes are initiated from countries that have few or no laws directed against cyber crimes and little capacity to enforce existing laws.”⁵⁰ A nation should not be able to plead ignorance when a massive cyber attack is launched from within its borders. A UN member nation would certainly be held accountable if a missile was launched from its country, even without its knowledge. The United Nations needs to declare war on cyber crime and work to not only make all member nations create adequate laws against cyber attacks, but also to give each nation the tools to detect and address such activity.

Second, there needs to be a way for attackers to avoid affecting targets that they would not be allowed to hit during a physical attack. The very first Geneva Convention came together to mandate medical neutrality in war.⁵¹ When an army invades a country, the Law of Armed Conflict obligates it to avoid attacking hospitals. The same standard ought to apply to cyber attacks as well, although implementation of this standard will be challenging. It is one thing to tell an invading army to not bomb a hospital or shoot a medic, but it is another to tell a

hacker that a virus needs to be able to discern between a military target and medical files. The United Nations needs to devise a way to clearly digitally mark off-limits targets in the same way it marks medics with a red cross. Internet addresses of hospitals and health databases could be marked with a special code or perhaps placed on a separate network. Regardless of the solution, the United Nations needs to find a way to clearly delineate targets so that nations can adhere to the current Law of Arm Conflict during a cyber attack and avoid targeting vital medical infrastructure.

Third, “use of force” needs a clear definition with regards to cyber attacks. The term is vital in the UN Charter because it can mean the difference between war and peace. UN Article 2(4) prohibits the use of force between nations. In Article 51, if force has been used against a nation, then that nation has the right to retaliate in a proportional manner. This right of retaliation is key, and the United Nations needs to clearly define what constitutes a use of force with regards to cyber attacks to determine when Article 51 is relevant. Another summit on the scale of the Geneva Convention is needed to outline what should be considered use of force. My recommendation is that any cyber attack that leads to extensive physical damage to infrastructure, military, or civilians ought to be considered a use of force. Gathering intelligence should not be considered a use of force because it does not damage or harm. Causing a pipeline to explode through a cyber attack is similar to bombing a pipeline and ought to be considered an act of force in the eyes of the United Nations and Article 51.

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Houston's "One Bin for All" Initiative: Will It Improve Recycling or Harm the Environment?

by Nicolas Thorpe '15

Introduction

While Houston is the fourth largest and one of the most diverse cities in the United States, it is not considered to be the most environmentally friendly urban center. Known as the oil and gas capital of the world and the most automobile-dependent city in the United States, Houston also has one of the lowest waste diversion rates in the country. Currently, the City of Houston only diverts 19 percent of its waste from landfills: 6 percent is recycled and 13 percent is composted due to the city's mandatory yard waste compostable bag program.¹ Seeing as the national recycling rate is approximately 34 percent, the city has obvious room to improve. Under the leadership of Mayor Annise Parker and Sustainability Director Laura Spanjian, city officials have sought to innovate recycling as a means of making Houston a more environmentally sustainable and attractive urban area.

The City of Houston claims to have reached the next stage of recycling technology through its "One Bin for All" initiative (OBFA). As a winner of the Bloomberg Philanthropies' Mayors Challenge, OBFA seeks to revolutionize recycling by allowing Houston residents to place all trash, recyclables, and compostables in one bin. This waste would then be sorted and separated at a privately-run, \$100 million Materials Recovery Facility, thus replacing the current single-stream recycling program.² Whereas single-stream recycling programs place the burden on residents to understand what can and cannot be recycled, OBFA removes that burden and entrusts a processing facility to separate the waste. The city believes that this initiative will increase its waste diversion rate to 75 percent in two years, protect air quality, reduce garbage and recycling truck trips, create jobs, and serve as a 21st century model to communities around the world.³

While the city has repeatedly stated its commitment "to finding and using only those technologies that offer a positive impact on the environment, community, and city's financial future," a heated debate has emerged, with the Zero Waste Coalition, an environmental lobby, in stark opposition to OBFA.⁴ The Zero Waste Coalition bases many of its claims on the environmental consequences of OBFA; therefore, it is necessary to better understand the environmental implications of a program that seeks to transform recycling in Houston.

The objective of this paper is to clarify the environmental impact of OBFA and to understand the current debate surrounding the program. Furthermore, this investigation will answer the following question: What are the environmental implications of the City of Houston's "One

Bin for All” initiative? By outlining the history of the initiative, examining its environmental implications, and understanding the current policy challenges, it is evident that OBFA will, in fact, revolutionize recycling in Houston, given its innovative and technologically sophisticated approach and its emphasis on public-private partnership.

Methodology

For this investigation, I conducted interviews with the following individuals: Brian Yeoman, city of Houston advisor at the Clinton Climate Initiative; Chris Butler, program director for the “One Bin for All” initiative; Jim Blackburn, civil and environmental engineering professor at Rice University and member of the OBFA advisory board; Richard Johnson, director of energy and sustainability at Rice University; and Patrice Parsons, principal at Parsons and Associates and local environmental activist. These individuals provided a comprehensive context of the OBFA initiative and shared their perspectives on why Houston is the ideal location for this innovative program. Through this qualitative and ethnographic research, I sought to gain an understanding of the social, political, and technical dynamics of OBFA.

History of the “One Bin for All” Initiative

In 2008, Houston made national headlines for its low recycling rate; the City of San Francisco even offered to raise money and donate recycling bins to Houston.⁵ It was this embarrassment on the national stage that made Houston concentrate its attention on recycling. When Mayor Annise Parker took office in January 2010, city officials began to focus on creating a more environmentally sustainable city, including becoming more energy efficient and increasing the recycling rate. As environmental sustainability became an important tenet for the “creative class”—those who seek to live in transforming, creative, and diverse cities—the city of Houston sought to make itself a more attractive and competitive urban landscape.⁶

In fall 2011, based on recommendations by the Clinton Climate Initiative concerning the feasibility of single-stream recycling and advanced sorting technology, the City of Houston began conducting extensive research on recycling and toured multiple facilities in the United States and Europe. After completing this phase, the city and its sustainability office decided to pursue a recycling program that relied on advanced sorting technology.⁷

While examining the initial stages of the city’s plan, it is important to note residents’ sentiment toward recycling. Since Houston was one of the last major US cities to implement single-stream recycling and lacked a recycling culture, many saw traditional single-stream recycling in Houston as a failure. As local environmental activist Patrice Parsons puts it, “changing behavior is tough,” and the OBFA initiative was initially seen as an opportunity to increase the waste diversion rate while making recycling easier for the consumer.

In 2012, the City of Houston entered the Bloomberg Philanthropies’ Mayors Challenge with its OBFA initiative and was declared one of the challenges’ winners in March 2013. Upon accepting the \$1 million prize, Mayor Annise Parker described the need for OBFA in Houston:

Even with extensive education, easily available single-stream, and in cities where you actually have an economic incentive—which we do not since we don’t charge separately for garbage—you don’t achieve the recycling rates that would be available under this technology. And those of us who care about recycling have had the dilemma: You’re standing with something in your hand, and you’re looking, “Do I put it in the bin that says recycling, the bin that says compost, or the bin that says garbage?” This takes that decision away and automates it.⁸

Only a few months after receiving the award, the City of Houston issued a Request for Qualifications for private sector companies interested in building and managing the Materials Recovery Facility. The city is currently evaluating five proposals by private sector companies committed to building and operating the OBFA Materials Recovery Facility. As the city makes its final decision, it is utilizing the expertise and skills of the OBFA advisory board, which is composed of environmental and technical experts. In fact, the Materials Recovery Facility could be fully operational by late 2015 or early 2016. Figure 1 provides a more extensive timeline of the OBFA initiative.

As Houston continues to pursue the OBFA initiative as a long-term waste management strategy, the city is also expanding its single-stream recycling program. As of spring 2014, single-stream recycling was available in 70 percent of Houston households.⁹ Ever since Mayor Parker chaired the Solid Waste Task Force from 2006 to 2007, it has been her goal and campaign pledge to provide single-stream recycling at all city-serviced homes by the end of 2015.¹⁰

Figure 1. Timeline of the “One Bin for All” Initiative

2012	City of Houston submits proposal to the Bloomberg Philanthropies’ Mayors Challenge
March 2013	City awarded \$1 million from the Bloomberg Philanthropies’ Mayors Challenge
June 2013	City issues Request for Qualifications
August 2013	City receives Statements of Qualifications from 11 potential private sector partners
April 2014	City issues Request for Proposals
May 2014	Waste Characterization Study report released
June 2014	City receives five proposals and is currently evaluating these proposals
Late 2015/ Early 2016	The Materials Recovery Facility opens and is fully operational

Source: The City of Houston

Environmental Implications

As conversations surrounding the “One Bin for All” initiative continue, the main controversy of the program is related to its environmental implications. While the Zero Waste Coalition argues that OBFA is environmentally unfriendly and unjust, the city claims that the program will make Houston a more sustainable, inclusive, and attractive city.

One of the primary arguments in favor of the environmental sustainability of OBFA is the program’s significant carbon emissions savings. Through 5,000 fewer truck trips, 600,000 fewer vehicle miles per year, and by preventing waste from going to landfills, the City of Houston could dramatically lower its greenhouse gas emissions through OBFA.¹¹ Furthermore, the city has made clear its commitment to never burn trash or utilize waste-to-fuel incineration. While the city is interested in mixed-waste processing coupled with the technologies of anaerobic digestion, gasification, or catalytic conversion and composting, the details of these technologies have not been released because the city has not recommended the private sector partner yet.¹²

On the other hand, the Zero Waste Coalition has established a number of arguments against the “One Bin for All” initiative. In July 2014, the coalition released a report titled “It’s Smarter to Separate: How Houston’s Trash Proposal Would Waste Our Resources, Pollute Our Air, and Harm Our Community’s Health.” Throughout the report, the Zero Waste Coalition mentions that the “dirty” Materials Recovery Facility will rely on incineration, gasification, and combustion—which will lead to increased air pollution and greenhouse gas emissions.¹³ Furthermore, the Zero Waste Coalition says that OBFA will continue the City of Houston’s legacy of environmental oppression of minority residents. Texas Southern University professor Robert Bullard, a supporter of the Zero Waste Coalition, conducted the first research study in 1979 on the placement of waste incinerators and garbage transfer stations in Houston’s African-American neighborhoods. Since then, Bullard has conducted 20 studies about environmental injustice, which continues to be a point of contention in the Houston area.¹⁴

The possibly decline in environmental consciousness of Houston residents is another issue. By distancing consumers from the separation of their waste, OBFA could make residents unaware of the amount of waste they create and take away the personal ethics of recycling.¹⁵ However, if one looks at the Parker administration’s environmental track record, one notices the great strides that the city has made in energy efficiency, alternative mobility, and renewable energy. Mayor Parker has also stated the potential of the “One Bin for All” initiative to improve the health and quality of life in Houston.¹⁶

A major concern from the community at large is the technological feasibility of the OBFA initiative. Many, including the Zero Waste Coalition, stipulate that the technology does not exist to properly sort the waste and reach the city’s goals. In response to this, Sustainability Director Laura Spanjian and other proponents of OBFA point to a Materials Recovery Facility in Montgomery, Alabama, run by Infinitus Energy. By employing advanced sorting technology, food composting, and anaerobic digestion, the facility has achieved a 60 percent

waste diversion rate since opening in April 2014. Despite concerns that paper products will be contaminated by organic waste—which would effectively make them unrecyclable—this facility has not had difficulty selling its recycled products.¹⁷

Furthermore, this technology has existed in locations around the world, but has never been integrated or utilized at the scale that Houston seeks to do. According to Patrice Parsons, contamination is a minor concern for the City of Houston and proponents of the “One Bin for All” initiative because the technology has improved so dramatically over the past few years.

While there are valid environmental concerns related to the OBFA initiative, the city has made clear that it will only pursue a project that is environmentally friendly, technologically feasible, and financially sound. The city has also reiterated the fact that this facility will not incinerate its waste or be located in a low-income, minority community. Therefore, the main environmental implications of OBFA are a reduction in greenhouse gas emissions and an overall increase in the waste diversion rate of the city, both of which are positive for the city government and Houston residents.

Current Challenges

While recycling in itself remains a challenge for the city, there are significant obstacles associated with the “One Bin for All” initiative, in particular the Zero Waste Coalition and limitations of time. First, the Zero Waste Coalition is a well-funded and well-supported environmental lobby in the Houston area. Key organizations in this coalition include the Texas Campaign for the Environment, Sierra Club, Texas Environmental Justice Advocacy Services (TEJAS), and the Story of Stuff Project. Furthermore, this coalition has the backing of environmental justice expert Robert Bullard, who participated in the group’s “Waste and Environmental Justice Summit” in 2014.¹⁸

However, the influence and strength of the Zero Waste Coalition continues to remain in question. Some—including Clinton Climate Initiative advisor Brian Yeoman and OBFA program director Chris Butler—do not consider this environmental lobby to be a significant obstacle. On the other hand, Rice University energy and sustainability director Richard Johnson, Rice University professor and OBFA Advisory Board member Jim Blackburn, and Patrice Parsons see the Zero Waste Coalition as a threat because of their influence at the grassroots level, and therefore on city council members and other elected officials. Since the OBFA initiative has to be approved by city council, the Zero Waste Coalition might convince politicians to reject OBFA. However, since the details of OBFA have yet to be released, the environmental lobby has been engaging with the public in a debate without providing adequate information about the initiative.

Another major challenge is related to the amount of time it will take once the city makes a recommendation for a private company to construct and open the Materials Recovery Facility. After making the recommendation, the city will have to enter contract negotiations with the private company, which could take months. Furthermore, a public debate will most likely

occur, in which the community will voice their opinions on the OBFA initiative. Once the OBFA initiative is ready to be implemented, it will take time to issue a permit and construct the facility, as well as alter the garbage truck routes of the city.

The Future of “One Bin for All”

As the City of Houston moves forward with the “One Bin for All” initiative, the year 2015 represents a critical time. During 2015, the city will release information to the public related to the public-private partnership and the technology that will be utilized, thus encouraging a public debate about the controversial program.

The Zero Waste Coalition will continue to lobby against the OBFA initiative and will focus on influencing city council during the approval process. Currently, the coalition is attempting to persuade the City of Houston to adopt a Zero Waste Plan similar to plans in Austin, Dallas, and San Antonio.^{19,20} This plan would reduce waste through curbside single-stream recycling, composting, reusing materials, and other reduction techniques.^{21,22}

If the City of Houston implements the OBFA initiative, a key component will be an education and outreach campaign to educate residents on the program and the importance of reducing and reusing waste. According to Chris Butler, the city has already started creating an education plan, but this strategy has not yet been unveiled because the details of OBFA have not been revealed. This campaign seeks to temper concerns that Houston residents will become less aware of the amount of waste they produce if OBFA is implemented.

The success of the OBFA initiative could also influence the way commercial businesses and other private sector institutions recycle. The contract between the City of Houston and the private operating company is unlikely to be exclusive, thus providing an opportunity for other organizations to get on board with OBFA. In fact, Brian Yeoman explained how the environmental lobby should be focusing its attention on increasing recycling rates of the commercial sector, which is serviced by private waste management companies instead of the city. Many commercial entities and institutions—such as apartment complexes—do not currently offer single-stream recycling to consumers. Yeoman and other officials believe that implementation of recycling in these areas is crucial to making all of Houston more environmentally sustainable and that OBFA would have a wide impact in regards to recycling in the commercial sector.

The rest of the OBFA initiative remains in the public domain. As Houston gears up for a public debate and approval of OBFA by city council, there is still an element of uncertainty for the initiative. However, if successful, it has the potential to influence major urban areas around the United States that are struggling with waste allocation.

Concluding Remarks

As I ended my interview with Chris Butler, he said, “Trash was more political than we all thought.” Ever since the City of Houston began seriously evaluating its municipal solid waste program, the “One Bin for All” initiative has created controversy throughout the city and the United States. However, as Jim Blackburn put it, even in a city “entrenched in anti-environmentalism,” the worst-case scenario of the OBFA initiative is that the city’s waste management program will revert back to its current state.

Yet Houston represents the ideal location for this initiative. OBFA is philosophically consistent with Houston’s historic pro-growth politics, given the importance of a public-private partnership.²³ The financial burden of OBFA, namely building and operating the Materials Recovery Facility, is completely on the private company that is awarded the contract.²⁴ Like many of Houston’s past endeavors, this program minimizes the public’s risk. In fact, according to Jim Blackburn, the city has not spent a dime of taxpayer money on the creation of OBFA; all funding has been sourced from the \$1 million prize money.

Brian Yeoman compared the OBFA initiative to Columbus’s travels to the New World and President John F. Kennedy’s announcement of the space mission to the moon. There is risk when achieving greatness, and the city has the potential to revolutionize recycling with this innovative program. Houston is a city of entrepreneurship, innovation, and technological sophistication. For Jim Blackburn, OBFA represents one of the last remaining ways to make Houston eco-friendly: in a city where “you could pay people \$100 to recycle, and they would not do it out of spite,” the “One Bin for All” initiative allows Houston to take a “quantum leap in recycling.” If this program is successful, Houston could become a leader in environmental sustainability and recycling in urban areas.

After conducting interviews and independently researching the “One Bin for All” initiative, I have no doubt that this program will significantly increase the recycling rate of Houston. There are challenges ahead, but the City of Houston will overcome these obstacles and become an example of technological innovation and environmental sustainability.

Endnotes

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