FORECASTING THE FUTURE OF LOGISTICS:

THE FORMULATION OF AN INTERNET OF THINGS CAPABILITY INDEX

GRADUATE RESEARCH PAPER

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Abstract

As the third wave of information technology (IT) disruption within the logistics enterprise, the Internet of Things (IoT) holds the capability to greatly impact the United States Air Force's (USAF) understanding and preparation for future conflicts. As the pivotal decade of 2020-2030 approaches, the interconnection between information and communications technology (ICT), energy and transportation will drive logistics evolution throughout global infrastructure as IoT is further integrated. This paper considers the statistical relationship between IoT and the logistics environment and then models alternate futures within an established IoT framework through forecasts of China, Russia, North Korea, Iran and +1 Nation States using the International Futures model from Pardee University. In fulfillment of National Defense Strategy objectives, a conceptualized framework is introduced to visualize where this innovative technology will enable new efficiencies and an Index Score is formulated towards measuring competitive advantage. Ultimately, nation states and regions with higher IoT Capability Index Scores equate to strategic advantage in future operating environments marked by adaptation. Results reveal while the United States maintains competitive advantage currently, peer competitors are rapidly advancing as 2030 approaches. The strategic implications call for reemphasis on infrastructure within internal borders and strategic alliances. The conclusion introduces a "Futurists look towards 2030", an introduction of four future research considerations within the USAF logistics enterprise, and a call for logisticians to embrace IoT and consider the leadership methodology associated.

To Faith, Family and Future

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I would like to express my sincere appreciation to my classmates, peers and friends for assisting the exploration of enhanced integration between logistics and IoT in the future. Your feedback and insight proved invaluable. Special thanks to Major Kiel Gilliland for consistently raising the bar and serving as Class Leader.

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Daniel P. McGuire

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FORECASTING THE FUTURE OF LOGISTICS:

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I. Introduction

"This marriage between where industry is going and the innovation that we see coming out, and where there are military applications to allow us to do the kind of conflict in the future, is as exciting as anything else I'm looking at."

General David Goldfein, July 27, 2017

Background and Motivation

The Department of Defense (DoD) and United States Air Force (USAF) should think big, start small, and learn fast about the Internet of Things (IoT) and the associated logistical capability towards future state contested environments. Credited with the origin of IoT as terminology in 1999, Kevin Ashton predicted the future of computing will be conducted by computer-enabled objects or things, rather than by organically produced data (Ashton, 2011). Complementary, Nicholas Negroponte (then head of the Media Lab at MIT) stated IoT would embed intelligence via advanced, interconnected software making things smarter and more productive (Zhou, 2013). Currently, Industrial Internet of Things (IIoT) and Industry 4.0 (I4.0) are evolving the commercial enterprise with high rates of return on investment and best practice case studies throughout the globe (Montreuil, 2011). Enhancing prior waves of information technology (IT)-driven competition, IoT within IIoT/I4.0 enables disruptive innovation by leveraging the three core elements of physical components, “smart” components, and connectivity (Porter and Hepplemann, 2015). As the pivotal decade of 2020-2030 approaches, the most moderate of strategic forecasts calculate double-digit annual growth rates culminating in over 30 billion connected things within a multi-trillion market (Ashton, 2011).

Faced with the most complex, adaptive environments the military has ever seen in a 2+2+1 world (NDS, 2018), the USAF logistics enterprise must adjust. By better forecasting the logistical interaction with the physical environment, opportunity arises to visualize where the evolved integration of smart technology will create new efficiencies (Pardee Center, 2018; Porter and Hepplemann, 2014; Rifkin, 2014; Montreuil, 2011). Therefore, the key for the USAF logistician becomes understanding the future environment and associated interconnections. After a comprehensive literature review, this paper will consider IoT’s statistical significance with the logistics environment and then model strategically selected variables within crafted alternative futures towards the formulation of an IoT Capability Index Score.

Foundationally, this research firmly believes IoT is already present, is currently evolving and adapting, and will flood the logistics enterprise despite labeling from academia. Therefore, this research is centered upon future-state integration with global implications by asking ‘what if?’ (George, 2017). What if USAF logistics could identify the next disruptive innovation within future state logistics and the critical time period of integration? What if USAF logistics could forecast alternative futures of a nation or region's capability to exploit the innovation and gain competitive advantage? Correspondingly, this is in connection with NDS's foresight of an analogously wicked, interconnected, complex and adaptive environment (NDS, 2018).

Further passions and concerns related towards the next generation impact motivation as well. The research believes any step forward to better understanding military applications of new and emerging technology which allow us to enhance future conflict (Goldfein, 2017) is a worthwhile effort. The motivation as a logistician is to help shape the future of the enterprise by empowering the next generation to educate and prepare for the next wave of disruptions within future state operations. In fact, the 2018 NDS implores the application of Professional Military Education towards embracing the exploration of new technology and techniques to understand and counter competitors (NDS, 2018). Motivation as a student and scholar is to apply a Master of Strategic Foresight and Doctorate of Strategic Leadership towards shaping and embracing this future. As a scholar of logistics, the desire to step out of a pragmatic comfort zone and investigate the evolution and integration IT offers through IoT is exciting. The research further seeks to incorporate knowledge gained from the excellent instruction and academic rigor of the Advanced Study of Air Mobility (ASAM) Intermediate Development Education program. In the end, the research sought to obtain an appropriate balance of offering quantitative analysis gained through ASAM with the qualitative reasoning and advanced prudence degrees in the private sector supply.

Problem and Purpose Statement

The current logistics enterprise is comprised of several overarching functional disciplines to include maintenance, repair and overhaul, end-to-end supply chain management, and predictive analysis and forecasting which determines the size and capabilities of the fleet (Logistics Information Technology, 2016). As technology has advanced, the majority contributor informing decision makers has become data. Data encircling machinery, parts, vehicles and airframes and the multitude of computational entities regarding their reliability, location, and movement. However, technologies operate within an increasingly aging interconnection of internet communication, fossil fuel energy, and an inter-state highway transportation network which has nearly exhausted its means of efficiency and productivity. Correspondingly, the enterprise is unable to rapidly adopt evolving technologies with potential to enhance the system. As a result, departments are over-optimized towards exceptional performance (NDS, 2018) at the cost of effective decision making, policies and capabilities.

As the world of IoT advances within the logistical landscape, the USAF must visualize and model future environments to one day realize new efficiencies. If the USAF does not adapt, the pattern of maintaining an abundance of software, systems, and programs causing fragmented communication will replicate itself as the USAF seeks to posture for future operational environments; only this abundance may be in the form of data. Data in speed and quantity beyond capacity thereby prohibiting the ability to make impactful decisions. When initially outlining the way forward, two options remain viable. The USAF can either accept the current interconnected system and gradually max out efficiency while relinquishing capability or seek to enhance and adjust the system. If the USAF adapts the system, a manner which exceeds adversarial capability must be realized. Therefore, the purpose of this research is to determine an appropriate framework to view IoT capability within future state logistics and introduce a theoretical IoT Capability Index Score to evaluate competitive advantage across nations and regions.

Research Objectives/Questions/Hypothesis

The research objectives center upon how best to conceptualize strategic advantage within the future logistics enterprise as the international landscape evolves. To this end, this research will identify the best models, simulations, theories, and equations in which to forecast and implement. Complementary, a conceptual framework is introduced to understand the key drivers of future state logistics within an IoT system. To accomplish this, a systems model known as International Futures (IF) is utilized to forecast and understand the competitive IoT capability adversaries may hold in the future. Finally, this research introduces a theoretical Index Score to guide the future of the integration of IoT within logistics. Ultimately, this paper will answer a specific research question (RQ) and three complementary investigative questions (IQ):

RQ1. What is the right time period, system model and corresponding framework to investigate IoT capability within future state logistics?

IQ1. What statistical significance does IoT hold within a logistical, interconnected systems measurement as compared with additional next generation adaptations?

IQ2. What are the best variables and alternative futures to forecast and what do their comparative results reveal regarding competitive advantage?

IQ3. What is a baseline formula to measure IoT capability and what do forecasted projections reveal regarding competitive advantage?

Integrating the results from these research and investigative questions, future state logistics maintains potential to transform the understanding of the physical environment and thus exponentially advance the ability to fly, fight and win in the adaptive, constrained environments of the future.

Research Focus/Scope

The focus of this research is to educate and empower the next generation of USAF Logisticians towards future state operations regarding the introduction and integration of IoT. To do this well, the scope of this paper is in conceptualizing, forecasting and formulating critical logistics drivers within infrastructure towards better understanding future state competitive advantage. The logistical parameters within infrastructure are drawn from three categories: information and communications technology (ICT), energy and transportation. This research introduces the statistical relationship between IoT and the logistics environment and then displays IF forecasts towards a better understanding of the interconnections between logistics and the adaptive environment. This understanding is accomplished through modeling and simulations using algorithmic equations influence by the prioritization of technical innovation per the NDS and Pardee Center's *Pattern of Human Progress* respectively. Ultimately the research does not want to infringe upon the manner, location, and processes in which the USAF should begin IoT implementation.

Nor is this research attempting to solve any operational obstacles within future, adaptive and interconnected environments the 2+2+1 global landscape holds. What this research will provide is an innovative way to view the future within the interconnected system IoT is postured to enhance. Therefore, any statements made towards the interconnected environment of 2+2+1 are intended to help shape perspective and anticipate the adaptive battlespace of the future.

Assumptions/Limitations

1. Logistical innovations become more significant as the scope and measurement of human interaction with the physical environment increase. The research assumes an investigation into future state logistics will require application of human systems modeling.
2. Just as infrastructure was paramount to enable capability of previous IT disruptions within logistics, infrastructure will be critical to examining IoT capability.
3. Any modeled forecasts will not be exact and will contain standardized error. What the research assumes then is finding value within the trends and tendencies to include increases, decreases, averages and additional extrapolative calculations.
4. The range of parameters tested within the interconnection between ICT, energy, and transportation are not considered all-inclusive by this research. Instead, they have assumed an appropriate baseline (per literature review) as a representative sample in which to draw inferences and a theoretical framework to forecast IoT integration and capability.
5. If new methods are not established to understand and conceptualize IoT integration,

USAF logistics will become outdated and ineffective in meeting the adaptive, operational environments of the future.

6. This antiquated and imbalanced interconnection will negatively impact the capability of the USAF to fight and win the next war.

A few minimal limitations were identified. First, while many resources offer insightful viewpoints on individual aspects of IoT or infrastructure, this paper is one of the few, or only, organic efforts at integrating all within a systematic construction offering simulation modeling of the international landscape; therefore, there were virtually no baselines of comparison. Second, the ideals of this interconnection imply difficulty in modeling. Though not an expectation, testing all scenarios within complex, adaptive communication networks is near impossible. Third and last, the topic presented is an adaptive concept and thus the academic research associated is evolving; therefore, data were limited to information and terminology gathered by 31 Dec 2017.

Theory

To realize this research, exploratory sequential mixed methods was applied. Meaning the research first entered a qualitative research phase to best understand the current trends and tendencies driving IoT evolution within logistics before engaging a quantitative analysis. Through this progression, this research derived a generalized, abstract theory of an evolutionary process, grounded in the measured parameters of an interconnected system. To investigate the quantitative portion of exploratory sequential mixed methods, a simulated model focused upon human systems was utilized within IF where the domain of human action and choice "assumes broadening…given the dynamics of human systems proliferates" (Pardee Center Scenario, 2018:1). This effort within IF included elaborate structural equations which identified the collective strength of multiple variables within logistics infrastructure.

Methodology

Data to determine applicability is primarily qualitative paired with simulation modeling within IF. Applicability involved a cohesive partnership between the USAF Institute of Technology (AFIT) and Headquarters Air Force (HAF) A4/7P, interviews and presentations through commercial leaders, and correspondence with a leading academic institution in forecasting international futures. Introductory conversations regarding the future of technology and computers systems in mobility where held with Air Mobility Command (AMC) A4 in the Fall of 2017. Refining the answer to the central research question occurs through an extensive literature review from books, text books, academic, peer-reviewed journals, USAF strategic guidance, and industry best practices. The answer to the central research question determined what conceptual framework best visualizes IoT capability, the critical decade in which to forecast and the systems model to utilize. The qualitative research shaped the development of strategic themes within the complementary investigative questions. The investigative questions examine the statistical relationship IoT and additional next generation adaptations hold towards logistical, interconnected systems data, and deliberately select key variables and alterative futures to forecast and compare. Ultimately, an "IoT Capability Index Score" is formulated and applied. This research concludes with a summary of strategic implications, "A Futurist's Look Towards 2030", future research recommendations and a call for logisticians to embrace IoT capability within the Enterprise and consider how leadership methodology might adapt congruently.

Implications

By better understanding the interconnections within IoT integration, the USAF experiences increased ability to adapt the logistics enterprise and exceed the competitive advantage of adversaries. USAF logistics will require an enhanced ability through IoT within this interconnection to monitor data, enact remote control, and optimize algorithms to allow for product self-sufficiency (Gubbi, 2013). This ability enables autonomous operation, self-coordination, and self-diagnosis and furthers the requirement for modern infrastructure (SOTU, 2018).

What the logistician will find is the application of this interconnection will occur first towards ground-based assets, then aerospace vehicles and ultimately space assets. As an accredited futurist, the belief is this relationship will serve as the necessary application towards advancing artificial intelligence and future space capability. In turn, this evolution will secure the United States of America's (USA) future towards the end of this century and solidify stability for the next generations.

II. Literature Review

"Innovation occurs at the point a leader's heart breaks" (Ryberg, 2016).

Chapter Overview

The USAF is facing a future where logisticians combat amplified challenges within increasingly complex, adaptive environments. If the logistics enterprise does not adapt towards rapid adoption of evolving technologies, the logistician's ability, reach and success becomes bound. This is a future the research considers both heart breaking and near frightening. In turn, this chapter will focus upon literature addressing IoT as progression towards innovative, operational concepts. Concepts this research finds passion in addressing when next generation challenges hold centrality. This chapter reviews literature offered by experts regarding IoT evolution and the interconnection of ICT, energy, and transportation within the logistics enterprise. Specifically, this chapter will address the historical perspective of industry and technology as well as the complementary association of demographics, culture and economics which predicts and calls for a new methodology. Ultimately, these relationships offer rationale towards utilizing the systems model of IF as the logistics enterprise requires identification, forecasting and comparison of competitive advantage going forward.

Why a New Methodology and Why Now: Introducing a Cyclical Perspective

To introduce the requirement for a new methodology, a brief background is provided towards industrial evolution, a third wave of IT disruption and the influence of infrastructure. This literature serves as a foundation to introduce complementary associations driving the necessity of logistics innovation. Most importantly, a cyclical perspective is visualized.

Industrial Evolution.

Within an industrial lens, consider the vast leaps forged within logistical infrastructure through the integrated network within ICT, energy, and transportation. Between 1900 and 1929, the United States constructed comprehensive infrastructure interconnections of electrical grids, telecommunications, roads, pipelines, water, and sewage (Rifkin, 2011). As a result, advanced production arose across every industry from manufacturing to real-estate propelling economic advantage and increased industrial competition. In time, these industrial advances framed 30-year waves of IT evolution. Namely, electronic information via computers in the 1960s followed by an integrated network of information via the internet in the 1990s (Porter and Heppelmann, 2014). The third wave of IT evolution is postured for 2020 in the form of IoT.

The Third Wave.

The third wave evolves towards smart, connected products leveraging embedded IT from the prior two waves (Porter and Heppelmann, 2014). Smart, connected products have three core elements: physical components, "smart" components, and connectivity components (Porter and Heppelmann, 2014). Within this system, unlimited value is generated; while the smart components enhance the value of the physical components, the connectivity to one another offers [existence outside the product itself] (Ashton, 2011:101). Through embedded IT the products themselves enable evolution by changing how logisticians understand value and view efficiency. Correspondingly, a virtuous cycle of incremental improvement arises and continually adapts. Across many fields, products will be far more efficient, effective, safe, reliable, and more fully utilized, while conserving scarce natural resources such as energy, water, and raw materials (Laitner, 2012).

The Influence of Infrastructure.

Each wave has relied upon an interconnection of infrastructure to reach full capability and gain new efficiencies (Ashton, 2011). With the first wave of innovation, computers offered stovepiped information about ICT, energy and transportation. The second wave, internet connection, introduced interconnection through shared information (Fleisch, 2010; Gubbi, 2013). As internet technology reaches maturation towards 2020, the interaction of ICT, energy and transportation within this current system has nearly exhausted its means of productivity from sharing information (Rifkin, 2014). USAF logistics must posture for a third wave and another disruption from the incorporation of IoT within this interconnected system. One in which ICT, energy and transportation not only share information with one another, but cognitively learn from one another with increased means of adaptation. This evolution is displayed below within Figure 1.

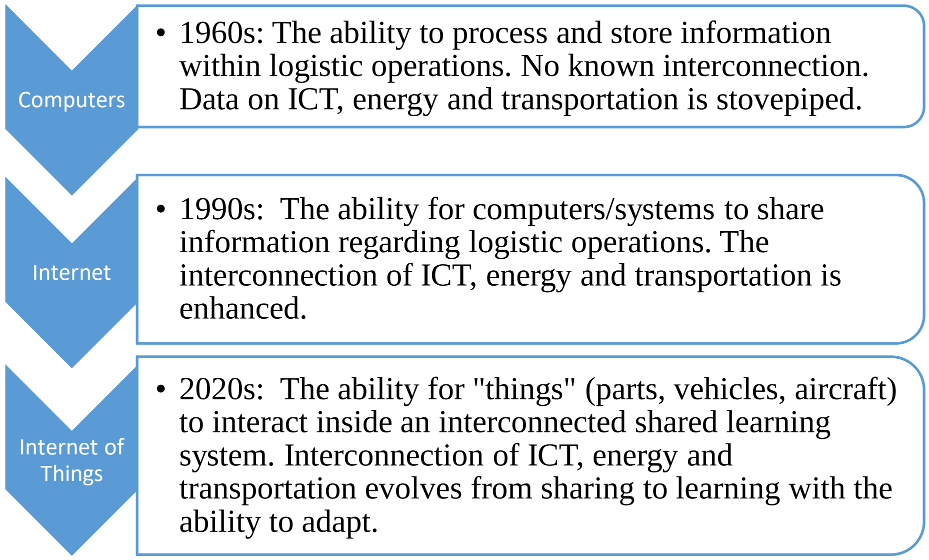


Figure 1. IoT Evolution in Logistics (Source: Author)

Understanding and communicating infrastructure requirements will be paramount as IoT is integrated. Consider first a future where "smart aircraft" are equipped with integrated sensor technology to enhance lethality across multi-domain operations. This evolution can never materialize unless the USAF first maintains a structurally sound aircraft and the means to modernize and sustain it. In this same viewpoint, to one day have IoT enabled logistics, nations must first have an efficient interconnection of ICT, energy and transportation within the first two waves. Complementary, nations must also hold future means of modernization and sustainment to create "smart infrastructure" (Rifkin, 2014:88) to reach the full capability of the third wave. To assess IoT capability then, the research holds the interconnection to be measured is between infrastructure parameters of ICT, energy and transportation. It is from this interconnection a framework of IoT Capability is conceptualized.

The Critical Decade: 2020-2030

In addition to, and linked with the sequence of technology, is the influence of demographics, culture and economic crises with criticality upon infrastructure (Fleisch, 2010). Understanding these associations provides insight into which modeling system to later utilize towards forecasting future state logistics. Ultimately, their relationship introduces a critical decade of 2020-2030 where IoT integration will become even more prevalent.

Demographics.

When engaging the future of IoT integration the world's population is of great consideration. In totality, the world's population experienced exponential growth since the nineteenth century as the need for an economic supplement from children within agriculturally focused, underdeveloped nations persisted (Rifkin, 2011). However, this model is rescinding, and the population explosion is ending (Freidman, 2009). In fact, the reductionist processes (Rifkin, 2014) which occurred decades ago within advancing, technologically focused countries are now progressing within the least developed countries (Rothman, 2014). Reductionist processes will radically alter the workforce, military end strength and arising political conflicts (Popescu, 2015). As population growth declines, combined with increased life expectancy, there will arise an older population with fewer workers to support the demand placed on the economy. It is possible in the decade of 2020-2030, the United States, and albeit the military, will gradually become short of workers and require them at the same time the rest of the industrial world feels a similar demand.

The Influence of Culture.

At the heart of America today is the blended culture of traditional values and disruptive innovations; consider the military as a reflection of this culture. Within the military, the core functionality of computer technology remains analysis and manipulation of quantitative data. In truth, the culture of the USAF came before the ability to compute and has thereby imparted significant consequences towards the utilization of technology. Arguably then, the binary logic held within USAF computations is merely an extension of military pragmatism and the desire to evaluate ideas within easy to understand practical consequences. However, this same technology maintains the capacity to transcend the ability to interact with the physical world. In fact, the ability for USAF culture to continually shape the practice of manipulating data and quantitative information is changing. The change is because the antiquated fragmentation is evolving through operational necessity (McChrystal, 2015). As the ability for computations and programming evolves, the culture of the USAF will by necessity follow; the conclusion of this paper addresses the requirement to rethink culture related to data and decision making.

50 Year Economic Crises and further influence of Infrastructure:

Every fifty years the United States has been confronted with a defining economic crisis reemphasizing the importance of infrastructure (Friedman, 2009). A historical, cyclical perspective reveals the transition from founders to pioneers (1776-1828), pioneers to small-town America (1828-1876), small-town America to industrial cities (1876-1932), and industrial cities to service suburbs (1932-1980). In interest of length, the research will consider the current fifty-year cycle beginning with President Reagan taking over the "failed" presidency of Carter (Friedman, 2009).

This presidency saw the transformation of the *New Deal* within the previous 50-year cycle, whereby the nation built numerous factories and hired urban workers as key to maintaining wartime economic gains. Infrastructure development through the interstate highway system provided means to develop suburbs, incite residential construction and create the middle class. Regan's *supply-side economics* intended to maintain demand and increase modernization through investment via a reduction in taxes. Supply-side economics not only set the foundation for the economic gains in the late 20th century but analogous with technology cycles will be repeated until it no longer creates an advantage (Rifkin, 2011). In fact, today's economic policy serves as an extension of 1980s policies advancing the end of this current fifty-year cycle.

Fast-forwarding to the next Presidency and beyond towards 2030, this model is forecasted to no longer suffice and the USA will need to modernize infrastructure. Because in this time, the USA and DoD will require increased production of goods and materials, but with less available labor. Given the current interconnections within the logistics enterprise have maxed efficiencies, the system must find a new way to adapt. Human systems and economics now become a significant factor inside the evolution of IT within logistics. The research now proclaims any conceptualization or understanding of IoT integration within an interconnected system must contain a human systems approach with demographics and economics as priorities.

2018 National Defense Strategy and the Importance of Technology in A2AD

The current environment sees US military forces emerging from a period of strategic atrophy (NDS, 2018) in which competitive advantage has eroded. The primary threat has become inter-state strategic competition (not just terrorism). Compounding this increasingly complex security environment is “rapid, technological change" (NDS, 2018:3) in which the Joint Force must in turn, rapidly adapt towards. As the strategic environment is further defined, the central challenge becomes the "reemergence of long-term, strategic competition" (NDS, 2018:3) via revisionist power. As the authoritarian model employed by China and Russia collides with rogue regimes of Iran and North Korea, the post-WWII international order is eroding via [expanding coercion and violations of sovereignty] (NDS, 2018:4). Through these tactics, the 2+2+1 environment seeks to optimize targeting of battle networks and challenge the ability to deter aggression.

A key theme becomes "new commercial technology will change society and, ultimately, the character of war" (NDS, 2018:5). Regarding Anti-Access, Anti-Denial (A2AD), the technological capability a nation holds within their borders will have greater and greater influence towards deciding the outcomes of future conflicts. Because both state and non-state competitors will have access to these technologies, the risk presents itself towards degrading conventional advantage. In fact, as digital connectivity increases across all aspects of life, attacks against critical defense, government and economic infrastructure must be anticipated. As the DoD seek to maintain technological dexterity, there must be "changes to industry culture, investment sources, and protection across the

National Security Innovation Base" (NDS, 2018:5). In future environments where time is a decisive parameter (Baker, 2017) the logistics enterprise must be able to make decisions and process data faster than the enemy. As decision makers are forced to adjust more rapidly than ever, the ability to exploit the advantages of new technology such as IoT becomes more prevalent. This becomes more impactful given a bill generating at least $1.5 trillion towards new investments to fix the infrastructure deficit (SOTU, 2018). Ultimately, the themes presented within the NDS shape the selection of alternative futures to forecast. To further define the international perspective, the selection of a model in which to forecast infrastructure variables and alternative futures is paramount.

Why the International Futures Model?

Various facets of business and industry seek to realize the complexity of human economic and social systems described above. With the foundational principles now obtained through literature review, the capacity to realize interconnections among interacting systems now becomes critical to this academic pursuit. Under the parameter category of technology, IF contains a subset titled *artificial intelligence subject to tasks* (IF Modeling System, 2017) which includes measures of IoT, robotics, machine learning and similar evolutions. Under the parameter category of infrastructure, IF reflects measurements within ICT, energy and transportation. Furthermore, the economic impacts introduced above require a model with incorporation of demographics and economics within the equations. This is the single systems model the research located containing such parameters and equations. As an integrated computer simulation with the ability to trace trajectories within human systems (Pardee Center Background, 2018), IF is just the model to utilize. Integrated computer simulation offers a comparison of alternative levers (Pardee Center Structure Based, 2018) inside a consistent framework, and the ability to investigate interventions through secondary and tertiary effect analysis. In connection to the adaptive themes within this research, IF has evolved over the past 25 years as a global database drawing heavily upon econometric and systems dynamics traditions (Pardee Center Background, 2018). See Figure 2 for an overview of the IF modeling approach depicting an inherently structure-based and agent-class driven approach (Pardee Center Structure Based, 2018).

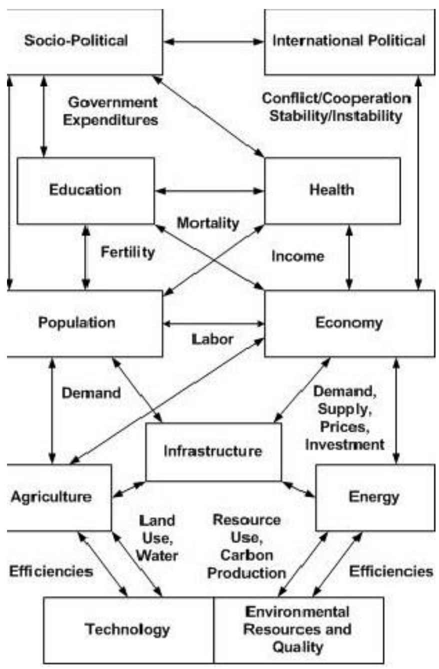


Figure 2. IF System Framework
(Pardee Center Visual Representation, 2018)

ICT, Energy and Transportation: Commercial and Government Application

IIot and I4.0 are already revolutionizing the commercial enterprise and establishing best practice case studies towards the interconnections of ICT, energy, and transportation within logistics. As nations capitalize upon this interconnection, the capability by which they can exploit efficiencies within the logistics infrastructure expands. As an application of ICT, Rio Tinto has introduced autonomous drilling information systems, including tunneling and boring machines, equipped with nearly 400 sensors to improve maintenance and better performance on fuel and tires. The integration of IoT into their operations has increased effective utilization of their haulage system by 10-15 percent, saving more than $80 million per year (Rio Tinto, 2014). As an example of energy, Alitalia also partnered with GE in implementing IoT towards fuel efficiency through changes in flight procedures, wing flap positions and adjustments in airspeed via sensor data. Alitalia's 1.5 percent savings is anticipated to save up to $2 billion per year going forward (Meunier, 2014). One example of transportation is at the port of Los Angelos where a partnership with General Electric (GE) Transportation is establishing a benchmark information portal to digitize maritime shipping data for owners and supply chain operators within secure, channeled access. The portal established between eight and 12 percent efficiency gains (Meunier, 2014). Overall, a survey by the American Society for Quality indicates of those organizations claiming smart manufacturing, 82 percent state increased efficiency, 49 percent experience fewer product defects and 45 percent experience increased customer satisfaction (Lopez Research, 2014). Although this is just a snapshot, this demonstrates the already progressed global application IoT is having within an interconnection of ICT, energy, and transportation.

Regarding government application, a recent report from Air Force CyberWorx (2017) sought to overcome the complexity of acquisition and integration regarding IoT. The initiative sought to make Air Force Bases (AFB) better places to work, more energy efficient, and more secure within a culture of continuous learning. To meet these objectives, Air Force CyberWorx assimilated a diverse range of participants from military and industry who generated hundreds of ideas under the strategic themes of pushing valuable info to base users, minimizing waiting times and providing ubiquitous mobile coverage (Air Force CyberWorx, 2017). The report later envisioned an [ecosystem of IoT capabilities] (Air Force CyberWorx, 2017:11) to include fitness, scheduling, security, food services, and maintenance which offer an improved experience for Airmen, better command and control for base leaders and more efficient mission execution (Air Force CyberWorx, 2017). Building from this foundation, this research envisions a future marked by a global embracement of these capabilities. An embrace towards consequential integration of IoT capability within offensive and defensive means of aggression. As a result, methodology to measure peer adversary capability to employ IoT towards strategic advantage further establishes the necessity of integration.

Assessing Risk and Identifying Complexity

The risk and complexity of IoT integration creates mass challenges within safety, privacy and security. IoT devices create the need for robust security management (Pescatore and Shpantzer, 2014) to protect the data flowing to, from, and between products, protect products against unauthorized use, and secure access between the product technology and other corporate systems (Porter and Heppelmann, 2014). The access will require new authentication processes, secure storage of product data, protections against hackers for product and customer data, definition and control of access privileges, and protections for production (Abomhara, 2015). In general, data protection and information security are essential requirements within infrastructure

(Gubbi, 2013). As IoT creates an accelerated shift within controlled technology, there is a broader spectrum from which to select and attack targets. Moreover, as technology increases in diversity so are the technologic tools in which to attack it. Exponential channels of information create concerns related to heterogeneity and interoperability (Koubâa and Andersson, 2009). To better understand the scope this threat presents, the analysis and findings section will outline some trends and tendencies towards the IF cybersecurity index (Pardee Center Infrastructure, 2018).

Summary

This chapter details IoT evolution and associated application and documentation. The chapter then discussed the overarching historical context regarding IoT necessity and implementation to include demographics, culture and economics. The NDS introduced the necessity to measure a nation or regions means to capitalize on an infrastructure evolved to support logistical adaptations in operations marked by A2AD. The NDS also offers the basis for selection of alternative futures within IF. Finally, this chapter also provided a section on commercial and government application and cyber security concerns. As a result, the research question is now answered regarding the appropriate framework to conceptualize IoT integration into future state logistics, the critical time period in which to forecast and the appropriate systems model to utilize. Displayed below in Figure 3, a conceptualized framework of IoT Capability frames the selection of variables to forecast and the formulation of an IoT Capability Index Score.

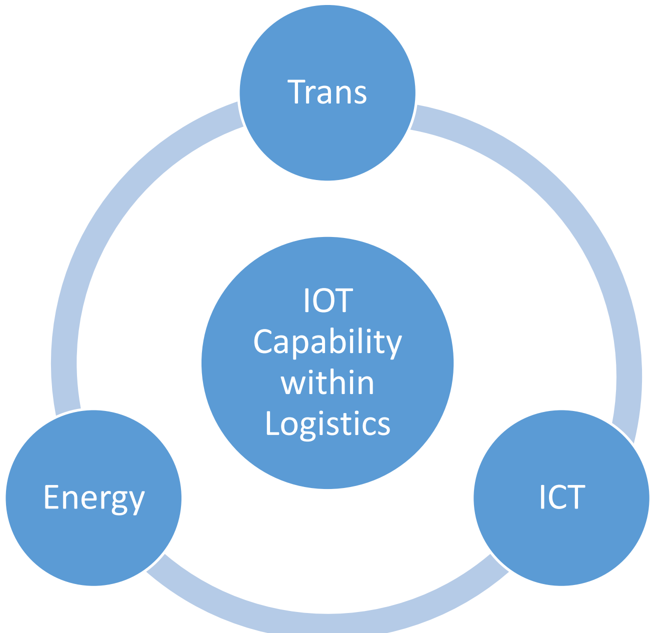


Figure 3. Conceptualized Framework for IoT Capability within Logistics
(Source: Author)

III. Methodology

Chapter Overview

This chapter outlines the methodology used to investigate the statistical relationship of IoT compared with other next generation adaptations and the forecasting of IoT capability through IF. With the qualitative phase completed through literature review, the research now addresses complementary IQs. After describing sources of data used for research, this chapter presents human-systems measurements from United States Logistics Cost Share of Gross Domestic Product (GDP) and IF *artificial intelligence with specifics to task* to perform analysis of variance (ANOVA) and assess statistical significance. This chapter then identifies the ability of IF to forecast parameters and associated variables towards an Index Score. The chapter concludes by detailing methodology applied towards IF parameter selection and introducing the associated structural equations.

Data Sources

In answering RQs and IQs, this research used a comprehensive review of articles regarding IoT, IT evolution, simulation, modeling and the key dependent variables introduced. In addition to five textbooks, 91 articles were identified then narrowed to 23 to focus upon central themes. Data sources which fulfill IF computations related to ICT, energy and transportation include national and international associations, agencies, unions and federations and global sources such as world bank indicators (Pardee Center Infrastructure, 2018).

The NDS asks us to "evolve innovative operational concepts" (NDS, 2018:9) by anticipating how competitors and adversaries will employ innovative technologies in attempts to deter and defeat us. With this agenda introduced, this paper seeks to make an academic attempt through one specific context: IoT capability within future state logistics. To this end, this research obtains a baseline consumption of data from competitive adversaries within 2+2+1. If this research can compile a baseline means of evaluating IoT capability, then a discussion can begin regarding how to best adapt and monitor the data and metrics IoT offers going forward. The IF model and associated forecasts are an academic attempt towards providing one methodology for anticipating the implications of [new technologies and the strategic advantage associated] (NDS, 2018:5). Through the algorithmic formulas, which contain a centrality upon infrastructure and its relationship with demographics, economics, socio-political, and international-political parameters, this research offers a relevant forecast towards the redefinition, defense and importance of infrastructure the NDS asks us to study.

To help understand the statistical linkage between IoT and the logistics enterprise, the research first compares historical data from the 2015 *Council of Supply Chain Management Professionals*' (CSCMP) "Annual State of Logistics Report" with IF's *artificial intelligence with specifics to tasks*. Given the implied difficulty in modeling, this research will consider statistical significance to be at the .1 p-value. To best implement the theoretical framework for IOT integration, the research will consider two alternative futures within IF.

Data Description in CSCMP

To consider a relationship between logistics and IoT, data from United States Logistics Cost as share of nominal GDP was utilized towards statistical analysis. This data is helpful given the influence of economics and demographics is offered. A display of this data from the time frame of 2006-2014 is shown in Figure 4.

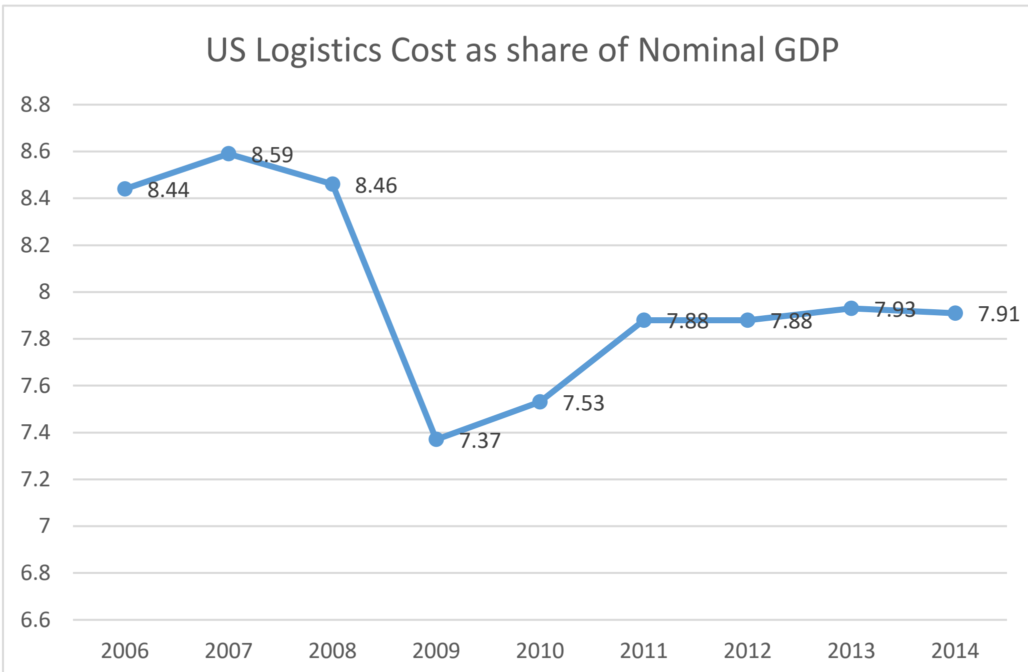


Figure 4. US Logistics Cost as a share of Nominal GDP

This data will be statistically compared with IF *artificial intelligence specific to tasks* scores which include parameters of machine learning, computer visualization, language processing, IoT, robotics, and reasoning. Statistical comparison will reveal a fundamental baseline of how IoT compares to alternative IT advancements as related to the logistics enterprise. A breakout of associated values from the *artificial intelligence specific to tasks* within the established baseline of 2006-2014 is found below in Table 1.

Table 1. IF Artificial Intelligence Specific to Tasks Forecast

	Log % of GDP	Machine Learning	Computer Visual	Language Processing	IoT	Robotics	Reason
2006	8.44	9.307	9.447	8.927	9.545	9.352	8.315
2007	8.59	9.323	9.46	8.956	9.556	9.371	8.376
2008	8.46	9.339	9.472	8.983	9.567	9.389	8.434
2009	7.37	9.353	9.484	9.009	9.577	9.406	8.488
2010	7.53	9.368	9.495	9.034	9.587	9.422	8.538
2011	7.88	9.381	9.505	9.057	9.596	9.437	8.585
2012	7.88	9.394	9.516	9.08	9.604	9.451	8.63
2013	7.93	9.406	9.526	9.102	9.613	9.465	8.672
2014	7.91	9.418	9.535	9.122	9.621	9.478	8.712

Data Description in IF

IF Methodology of Standardized Sequencing towards Forecasting.

Regarding infrastructure, IF employs a methodology of standardized sequencing for each forecasted year. This process includes estimating the expected levels of infrastructure, translating levels into requirements, forecasting the actual levels and estimating the social, economic and environmental impacts of the infrastructure. The standardized sequence is depicted below in Figure 5.

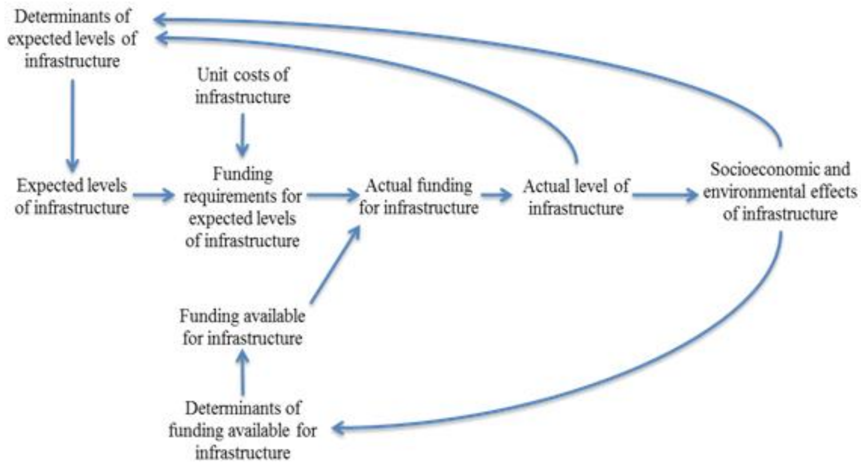


Figure 5. Standardized Sequence: Infrastructure Forecasts (Pardee Center Flow Charts, 2018)

IF Methodology to Forecast Alternative Futures.

The Figures within section IV will compare two alternative futures for multiple variables. One alternative future contains the label [0] to indicate "baseline" and the other alternative future is labeled [1] to indicate "working." As concerns the methodology within IF, the base case is a future remaining consistent with current social and economic trends resulting from policy frameworks; IF produces the base case organically without any manipulation by the user. In comparison, the working model added additional parameters of technological and military focus per the strategic themes presented in the literature review; through this process, there was manipulation by the researcher.

Researchers consider the base case a good starting point for scenario analysis for two reasons. First, it is built from initial conditions of all variables and on parameters that have been given "reasonable values from data or other analysis" (Pardee Center Scenario, 2018:1). These initial conditions and parameters make up the package of interventions that constitute the base case scenario. Second, the base case is periodically analyzed relative to forecasts across the range of issue areas covered by IF. The analysis then provides internal coherence and consistency with insights of respected forecasters (Pardee Center Background, 2018). In contrast, an alternative future labeled working is an intervention intentionally designed to increase levels of security. While the strategy for achieving a secure future is still evolving, there remains one constant: the competing strategies of global actors will and must interact (Pardee Center Scenario, 2018). While no computer simulation is ever completely accurate, IF offers detailed analysis towards the value of intervention as relates to a secure future. As shown in Table 2 below, the working alternative future incorporates strategic interventions such as increased investment in research and development, protectionism in trade, and increased electronic networking, technological advancement, and expenditures on the nuclear enterprise. This manipulation was framed by the literature review's strategic themes and implemented through self-learning by the researcher on the means to forecast variables within IF.

Table 2. Working Case Manipulations

Strategic Intervention	Description	Working Case Adjustment
Research/Development	expenditure multiplier	10% increase
Trade Barriers	Protectionism; import taxes	10% increase
Electronic Networking	networked persons	10% increase
Tech Advancement	expenditure multiplier	10% increase
Nuclear Enterprise	expenditure multiplier	10% increase

IF Ability to Generate Index Scores.

When determining the parameters to choose within IF, the ability to view a r-squared, and standard error (SE) is maintained to best indicate the strength of the relationship within the cross-sectional analysis of the database. An additional reason IF furthers development of an IoT Capability Index is the equations closely follow computer code where there is a single computed variable on the left and one or more input variables and parameters on the right. To accommodate the lack of "non-mnemonic single letter variable names towards more intelligible computer-based variable names" (Pardee Center Equations, 2018:2), documentation within IF may use asterisks to distinguish different values of the same variable name on the left and right-hand sides of equations.

As Figure 2 visualized, categories of parameters and associated data within IF is highly interconnected and lend towards the ability to formulate index scores. Figure 6 demonstrates the ability of IF to generate index scores as relates towards infrastructure measurements and thus IoT capability. The formulation of the IoT Capability Index Score will unfold within Chapter V.

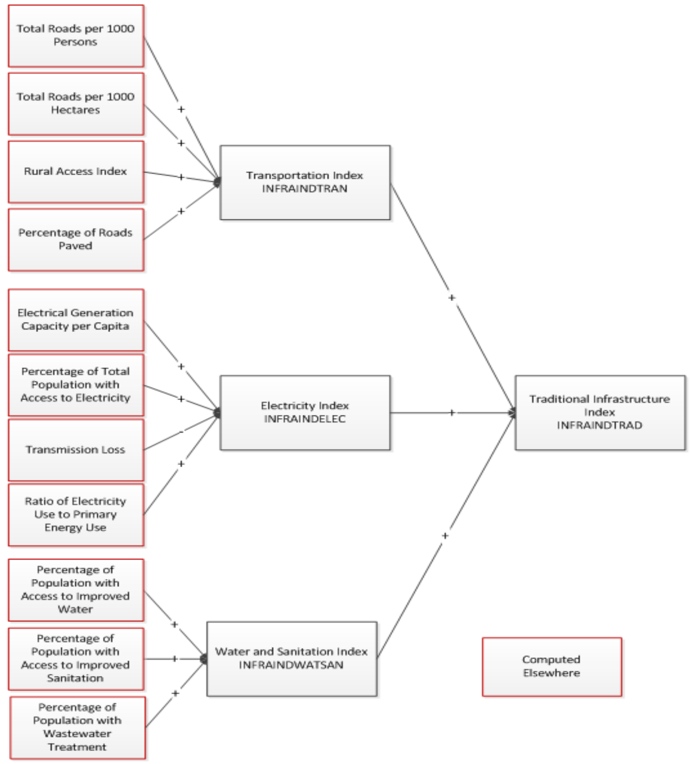


Figure 6. IF Ability to Generate Index Scores (Pardee Center Infrastructure, 2018)

Selection Methodology of IF Parameters for Forecasting.

Not every parameter available within IF contains an associated equation. Therefore, the research considered the 13 equations available within the IF categories of ICT, energy, and transportation and narrowed down to six based on trends and information revealed throughout the literature review. For instance, equations which included economic representation, GDP for instance, and demographic influence such as *total population per a million persons* (Pardee Center Equations, 2018) were prioritized. Using exploration of ICT equations as an example, the research considered society no longer says "Internet-connected smartphone" or "interactive website" because connectedness and interactivity are now a given; as 2030 approaches many predict “all the things” (Gubbi, 2013:1647) will be connected and the term IoT will be redundant. What this means is connectivity becomes a driver. Therefore, this research selected ICT parameters containing equations able to represent the ability of people (and thus a workforce) to connect. For this reason, the research did not consider fixed telephone lines or fixed broadband subscriptions. The research instead considered only mobile and selected *mobile telephone subscriptions and mobile broadband subscriptions*. Similar methodology was applied when selecting two each parameters within energy and transportation. The more broad, connected and inclusive the parameter, the higher the research considered integration. Therefore, the research selected *electricity share, infrastructure electricity, total road density and total roads paved*. To restate, this range of parameters is not considered all-inclusive but an appropriate baseline (per literature review) to draw inferences and logical conclusions towards IoT integration and capability. As a baseline, the prototypical equation within IF is displayed in Equation 1 below.

The prototypical equation within IF is:

$$Y = a + b1*X + b2*X^2 + b3* X^3 + b4*\ln(X) + b5*X^{b6} + b7*e^{(b8 * X)}$$

Equation 1. Prototypical IF Equation

It is from this equation all others selected by the research are modeled. This includes two each within the infrastructure categories of ICT, energy and transportation.

(1) Mobile telephone subscriptions per 100 persons

$$ICTMOBIL_{r,t} = 43.938 + 23.919 * ln(GDPPCP_{r,t}) + 1.405 * GOVREGQUAL_{r,t}$$

Equation 2. ICT_1: Mobile Telephone Subscriptions per 100 persons

In this equation, *ICTMOBIL* represents *mobile phone subscriptions per 100 persons, GDPPCP* represents *gross domestic product per capita at purchasing power parity in thousands constant 2005 dollars* and *GOVEREGQUAL* represents *government regulatory quality using the World Bank Worldwide Governance Indicators (WGI) scale (shifted 2.5 points so that it runs from 0-5 instead of from -2.5 to 2.5)* (Pardee Center Equations, 2018). There are also additive shift factors, multipliers, targeting parameters, technology shift parameters and saturation levels adjusted within IF. These adjustments were created in a combination of the baseline forecast and via the researcher within the working forecast. Per IF, the value is not allowed to decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .53 (Pardee Center Equations, 2018).

(2) Mobile broadband subscriptions per 100 persons

$$ICTBROADMOBIL_{r,t} = -21.827 + 9.139 * ln(GDPPCP_{r,t}) + 9.357 * GOVREGQUAL_{r,t}$$

Equation 3. ICT_2: Mobile broadband subscriptions per 100 persons

In this equation, *ICTBROADMOBIL* represents *mobile broadband subscriptions per 100 persons, GDPPCP* represents *gross domestic product per capita at purchasing* *power parity in thousand constant 2005 dollars*, and *GOVEREGQUAL* represents *government regulatory quality using the World Bank WGI scale* (shifted 2.5 points so that it runs from 0-5 instead of from -2.5 to 2.5) (Pardee Center Equations, 2018). There are also additive shift factors, multipliers, targeting parameters, technology shift parameters and saturation levels adjusted within IF. These adjustments were created in a combination of the baseline forecast and via the researcher within the working forecast. Per IF, the value is not allowed to exceed ICTMOBIL in the absence of a target or multiplier and will not decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .70 (Pardee Center Equations, 2018).

(3) Electricity Share

$$ENELECSHRENDEM_{r,t} = 0.979 * GDPPCP_{r,t}{}^{0.275} * INFRAELECACC(national)_{r,t}{}^{0.492} * FossilShare_{r,t=1}{}^{-0.077} * NonFossilShare_{r,t=1}{}^{0.123}$$

where,

$$FossilShare_{r,t=1} = \frac{ENP(oil)_{r,t=1} + ENP(gas)_{r,t=1} + ENP(coal)_{r,t=1}}{ENDEMSH_{r,t=1}}$$

$$NonFossilShare_{r,t=1} = \frac{ENP(hydro)_{r,t=1} + ENP(renew)_{r,t=1}}{ENDEMSH_{r,t=1}}$$

Equation 4. Energy$_1$: Electricity Share

In this equation, *ENELECSHRENDEM* represents the *ratio of electricity use to total primary energy demand*, in percentage, *GDPPCP* represents *gross domestic product per capita at purchasing power parity in thousand constant 2005 dollars*, *INFRAELECACC(national)* represents the *percent of total population with access to electricity in percentage*, *FossilShare* represents the *ratio of fossil fuel production to total primary energy demand in base year*, as a fraction, *NonFossilShare* represents the *ratio of hydroelectric and renewable energy production to total primary energy demand in base year*, as a fraction, *ENP* represents the *energy production for oil, gas, coal, hydro, and other renewables in billion barrels of oil equivalent* and *ENDEM* represents the *total primary energy use in billion barrels of oil equivalent (*Pardee Center Equations, 2018). Further, this equation utilizes an extrapolative formulation of three parameters and a multiplier but does not contain a shift factor. Per IF, the value is not allowed to decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .65 (Pardee Center Equations, 2018).

As described above the value of ENELECSHRENDEM is used to calculate the value of desired electricity use, given by INFRAELEC * POP, where *INFRAELEC* is *electricity consumption per capita in kilowatt-hours* and *POP* is the *total population in a million persons*. The calculation for INFRAELEC:

(4) Infrastructure Electricity

$$INFRAELEC_{r,t} = ENELECSHRENDEM_{r,t} * \frac{ENDEM_{r,t} * \mathrm{EnDemDFRIVal}_{r,t} * 17{,}000}{POP_{r,t}}$$

Equation 5. Energy₂: Infrastructure Electricity

In this equation, *INFRAELEC* represents the *electricity consumption per capita in kilowatt-hours*, *ENDEM* represents *total primary energy use in billion barrels of oil equivalent*, *EnDemDFRIval* represents a *multiplicative shift factor based on the ratio of the actual energy consumption in physical units in the historical data to the apparent energy consumption calculated in the pre-processor* (Pardee Center Equations, 2018). Regarding the value, there is an adjustment to the physical data to match the financial data on energy imports and exports; this converges to a value of 1 over a number of years given by the parameter. *17,000* represents the *conversion factor from barrels of oil equivalent to kilowatt-hours* and *POP* represents the *total population within a million persons* (Pardee Center, 2018). An additional multiplicative shift factor is used to adjust the estimate of INFRAELEC further. Per IF, the value is not allowed to decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .65 (Pardee Center Equations, 2018).

(5) Total Road Density

$$\ln(INFRAROAD_{r,t}) = -2.539 + 0.483 * \ln(\frac{GDPP_{r,t}}{LANDAREA_{r,t}}) + 0.183 * \ln\left(\frac{POP_{r,t}}{LANDAREA_{r,t}}\right) - 0.102 * \ln(LANDAREA_{r,t})$$

Equation 6. Transporation$_1$: Road Network Density

In this equation, *INFRAROAD* represents the *road network density in kilometers per 1,000 hectares*, *GDPP* represents the *gross domestic product at purchasing power parity in billion constant 2005 dollars, LANDAREA* represents the *land area in 10,000 square kilometers (million hectares)* and *POP* represents the *total population in a million persons* (Pardee Center Equations, 2018). This equation utilizes extrapolative formulations, additive shift factors, and a multiplier. Per IF, the value is not allowed to decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .79 (Pardee Center Equations, 2018).

(6) Total Roads Paved:

$$INFRAROADPAVEDPCNT_{r,t} = \frac{100}{1 + e^{-(-1.022 + 0.833 * GDPPCP_{r,t} + 0.756 * POP_{r,t} - 0.726 * LANDAREA_{r,t} - 0.267 * INFRAROAD_{r,t})}}$$

Equation 7. Transportation$_2$: Total Roads Paved

In this equation, *INFRAROADPAVEDPCNT* represents the *road network (paved percent in percentage)*, *GDPPCP* represents *gross domestic product per capita at purchasing power parity in thousand constant 2005 dollars*, *LANDAREA* represents *land area in 10,000 square kilometers (million square hectares), POP* represents *total population in a million persons*, and *INFRAROAD* represents *road network density in kilometers per 1,000 hectares* (Pardee Center Equations, 2018). This equation utilizes extrapolative formulations, an additive shift factor, and a multiplier. Per IF, the value is not allowed to decline in the absence of a target or multiplier or lack of finance for maintenance. This equation was organically created by IF within cross-sectional data through use of ordinary least squares (OLS) regression; the R-squared value is .45 (Pardee Center Equations, 2018).

IF CyberSecurity Index Methodology.

Utilizing the International Telecommunication Union (ITU) database, IF offers cybersecurity measurements as an index encompassing five categories. These five categories are legal measures regarding institutions and frameworks towards cybersecurity and cybercrime, technical measures endorsed by the nation, organizational measures towards the development of cybersecurity, capacity building towards awareness and access to resource, and the degree of intrastate and international cooperation (Hughes, 2015). Cybersecurity within IF will be measured and analyzed in later chapters towards the assessment of competitive advantage and implementation into an IoT Capability Index Score.

Data Analysis and Synthesis

This research presents an organic, original methodology towards a statistical comparison of IoT and the logistics environment as represented by historical, economic data of the percentage of GDP. This is computed to demonstrate the statistical relationship of IoT as compared to other *artificial intelligence specific to tasks*. This research then introduces the methodology for identifying IF parameters selected for simulation modeling and forecasting within an interconnected system. The analyzed data set includes two each parameters within the categories of ICT, energy, and transportation. The analysis and characterization of this data provide a baseline comparison for future state applications within IoT enabled logistics. The parameters for adapting these models were calculated within IF using the base case and the ability to manipulate the working case towards strategic themes represented in the literature review.

Summary

This chapter outlined the methodology used to conceptualize the future relationship between IoT and the logistics environment. Methodology regarding data sources, data description and parameter selection within IF was defined and the associated equations presented. Specifically, this design develops procedure within IF to produce alternative futures. The results of IF modeling offers direct comparison of specially selected dependent variables as compared with time in highly contested regions. The focus of the methodology remains to visualize the future where the logistics enterprise and IoT are intimately interconnected.

IV. Analysis and Results

Chapter Overview

This chapter first details the findings and results of the investigative questions. This research then introduces the theoretical formula in which to forecast IoT Capability and compare competitive advantage. The operational risk towards reframing the ability to conceptualize logistics in new and adaptive ways is insignificant at this time; this is a theoretical framework in which to visualize the logistical interconnections where IoT capability is best realized. Additionally, the analysis reveals logisticians can increase their understanding of these interconnections through simulation modeling and forecasting methodology.

Statistical Comparison of CSCMP with Artificial Intelligence Specific to Tasks

When seeking to establish a baseline conceptualization of IoT and the logistics environment, the results of statistical comparison are found in Table 3.

Table 3. Results of Statistical Comparison

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95.0%*	*Upper 95.0%*
Intercept	6288.984	8656.9	0.7265	0.5201	21261.	33839.3
Machine Learning	189.422	511.52	0.3703	0.7358	1438.4	1817.33
Computer Visual	-1018.13	868.89	1.1718	0.3259	3783.3	1747.07
Language Processing	756.4323	809.48	0.9345	0.4190	1819.7	3332.57
IoT	-808.275	675.15	1.1972	0.3172	2956.9	1340.36
Robotics	435.0033	1138.8	0.3820	0.7279	3189.1	4059.14
Reason	-184.11	193.79	0.9500	0.4122	800.84	432.627

This Analysis of Variance (ANOVA) reveals no statistical significance between any of the *artificial intelligence specific to tasks* parameters and US logistics business costs as a share of nominal GDP. However, what the ANOVA does reveal is IoT has the best statistical measurement of any parameters presented within IF. Interestingly, this value is much better (over 100% better) than that of robotics and machine learning and just slightly better than computer visualization. This indicates IoT, of all parameters presented, demonstrated the greatest ability to influence logistics posture as presented in the literature review and may enable other next generation adaptations. There are further key takeaways when reviewing the line fit plot and residual plot from the ANOVA in Figure 7.

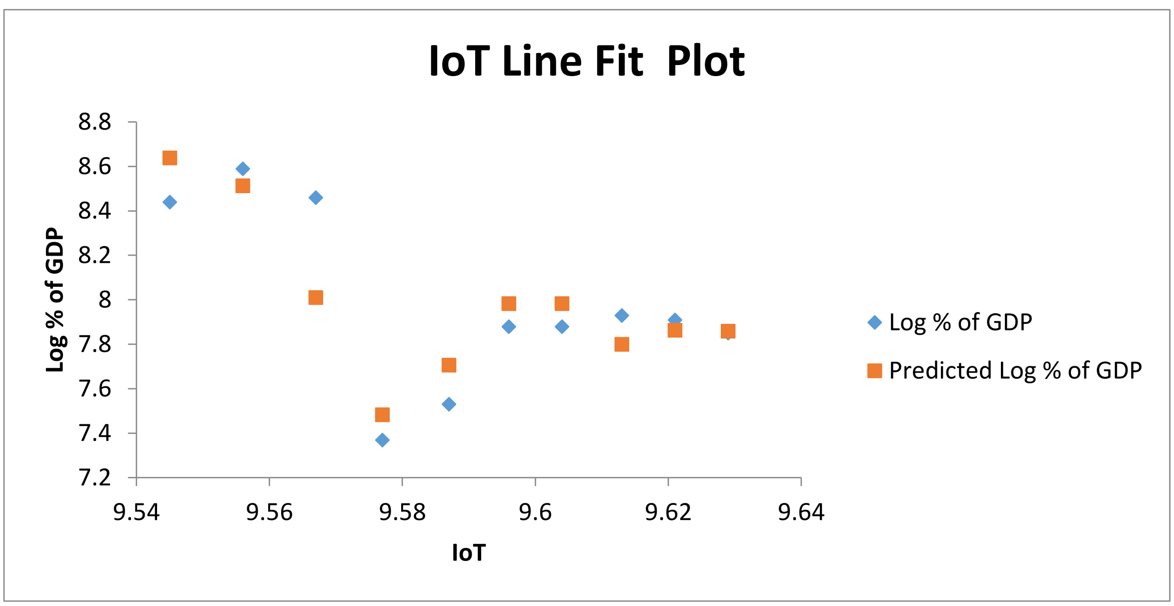


Figure 7. IoT Line Fit Plot

When reviewing the line fit plot, there are inferior fits in 2006-2008, a much better fit in years 2009-2012 and very close fits in 2013-2014. Quantitatively, the ability of IoT to further influence economic variables going forward is indicated. An analysis of the residual plot in Figure 8 reveals a similar theme:

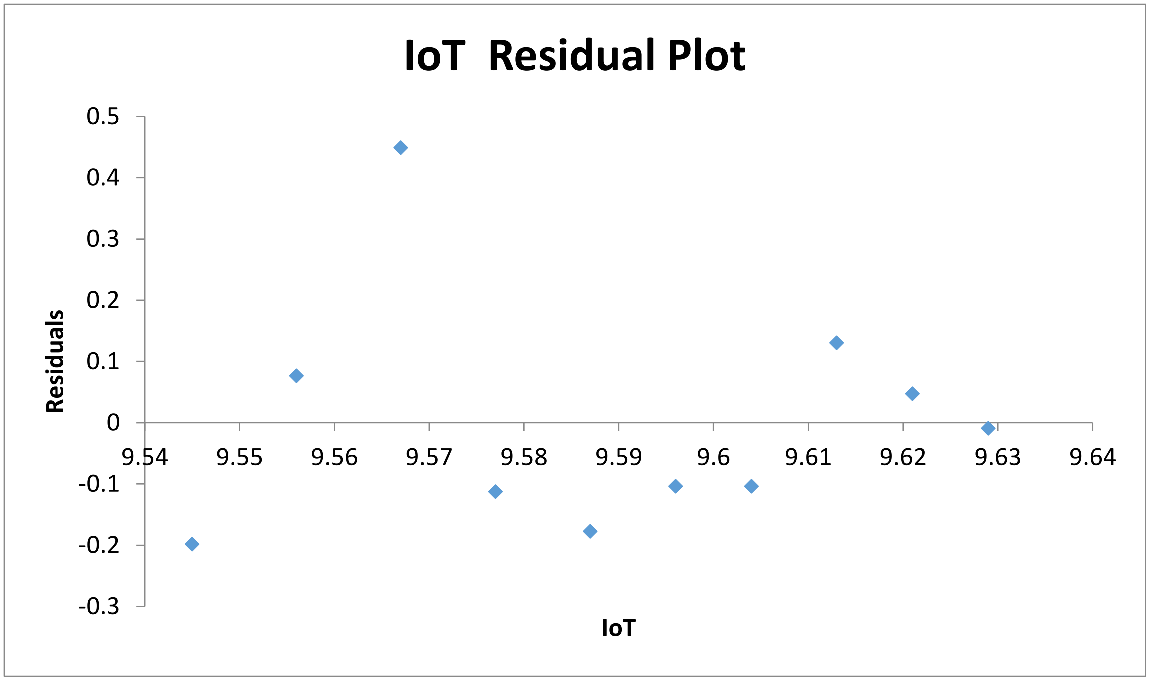


Figure 8. IoT Residual Plot

While the residuals differed greatly from 2006-2008, the remaining years offer a much closer prediction towards 2013-2014. Given this trend, this research concludes the application of IoT within artificial intelligence will continue to become a more accurate predictor going forward and increase relevance as a statistical comparison within the logistics environment. The comparison also means the selection of parameters and associated formulas within IF (given GDP is referenced within each formula) is further justified.

Results of the IF Simulations

ICT Forecasts.

When analyzing mobile phones per hundred people within competitive nation states and regions, there are many interesting takeaways as shown in Figure 9.

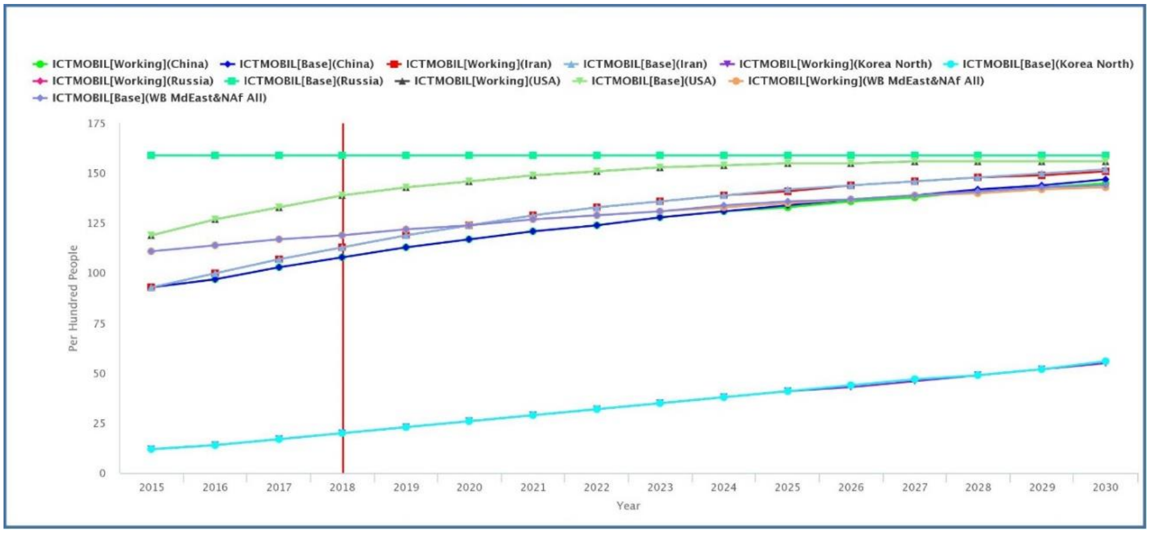


Figure 9. ICT$_1$ Forecast

To begin, Russia maintains the highest percentage throughout the forecast (average of 159.23) but varies the least (an average of .55). The forecast implies Russia's already heavy use of mobile phones connected with a steady or declining population growth rate towards 2030 (Friedman, 2009). Iran increases the most at an average of 57.9 and is nearly identical with the US by 2030. The Middle East and North Africa show average increases of 32.75 with the highest surges from Djibouti and Syria (in addition to Iran). Regarding nations the US has established bases within, the nations of Jordan, Kuwait, and Saudi Arabia all display decreases within this parameter. This analysis of ICT becomes even more interesting when paired with a mobile phone with broadband/internet connectivity.

Regarding the percent of population using a mobile device with broadband and connectivity capability, there are some noteworthy trends within Figure 10 as the technological and economic turning points through 2030 are considered.

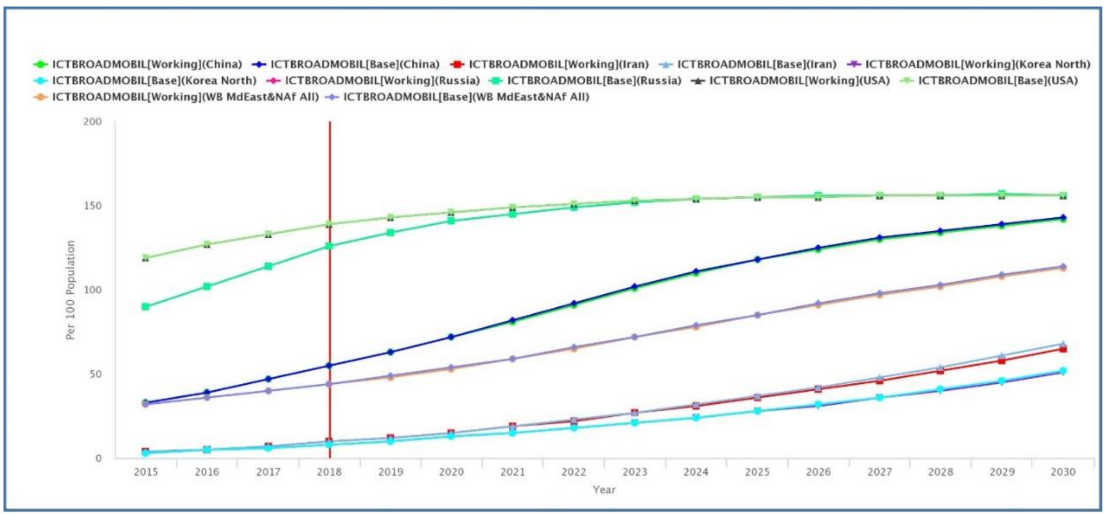


Figure 10. ICT_2 Forecast

While each country and region reveal an increase, it is China which grows over 100 percent in both future simulations and Russia grows 66%. Within the Middle East and North Africa, many nation states grow over 100 percent as well to include Jordan, Libya, Algeria, and Yemen. Interestingly, Bahrain is the only nation-state to show a decline. In all cases, the working scenario shows a slight decrease (1.22% on average) as compared to the baseline scenario. The comparison reveals by 2030, Russia will match the United States regarding population using a mobile device with broadband and connectivity and China will not be far behind.

After reviewing these two forecasts it is important to offer a synopsis of the trends located within ICT. As 2030 approaches the US will see the environments of its adversaries advance their infrastructure through mobile phones and mobile phones with connectivity. In the cases of China, Iran, and Russia, the capability to connect devices and enhance data and information exchange will be nearly identical to the US. This capability means while the US holds advantage for now, it may eventually lose advantage within these parameters of IoT. While both North Korea and the region of North Africa and the Middle East will see increases, they will not be able to match this capability.

Energy Forecasts.

There are many interesting takeaways when analyzing the ratio of electricity use to total primary energy demand (in percentage) in Figure 11 through competitive adversaries and an at-risk region.

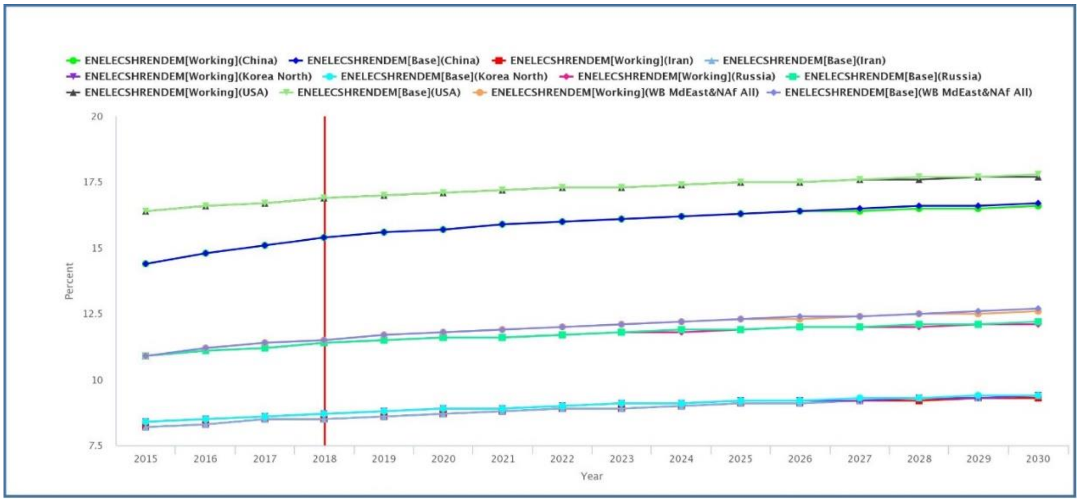


Figure 11. Energy1 Forecast

While each nation state and region increase in this ratio, it is China which increases the most (nearly double of competitors) at an average of 2.21% by 2030. China is the US's closest competitor in this area with averages only 1.12% less through the forecasted timeline. Libya, Jordan, and Syria have the most considerable increases within North Africa and the Middle East at an average of 3.34% which is nearly triple that of the US and adversary competitors. In each computation, the working forecast is less than the baseline forecast at an average of .07% with the associated trends described above remain consistent.

When analyzing the electricity consumption per capita in kilowatt-hours towards 2030 in Figure 12, there are many interesting observations.

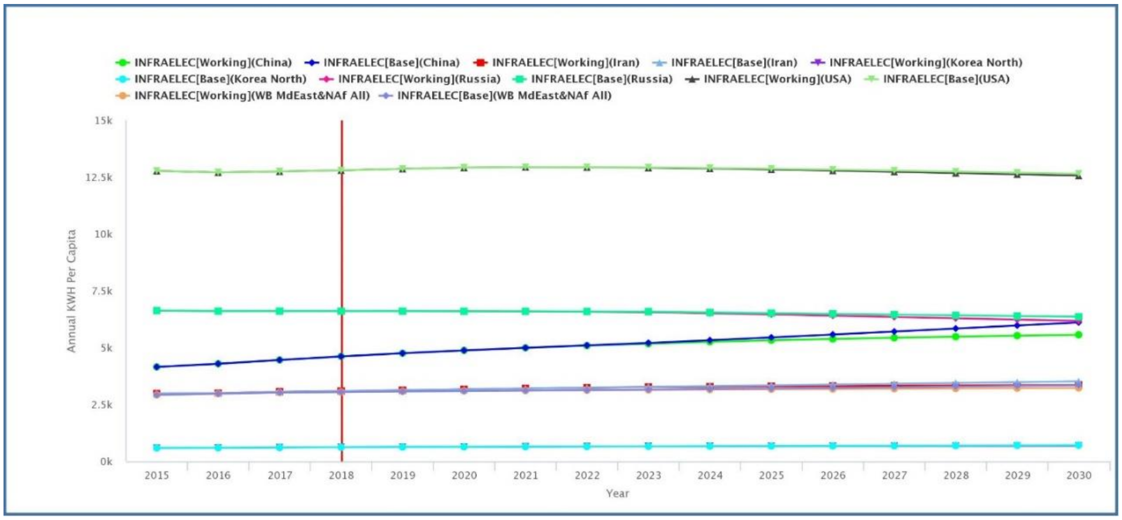


Figure 12. Energy2 Forecast

To begin, the United States maintains a consumption average of 3.1 times that as its competitors and at-risk region. No one else comes close. While China and Russia show similar consumption per capita as the forecast reaches 2030, Iran maintains a consumption nearly half as less and North Korea nearly nine times as less. The Middle East and North Africa closely resemble the consumption rates of Iran at only a 1.04% difference. The nation states with the most noticeable gains in consumption include Libya at an average 2.54K and those postured to have less consumption include Bahrain, Kuwait, Oman and Saudi Arabia at an average of 1.78K. In most calculations, the working-based forecast measured less than the baseline forecast at an average of 226.9.

There are important trends to consider as a synopsis of the energy forecasts are reviewed. Primarily, not only does the US hold competitive advantage, they increase advantage as infrastructure progresses and means of consumption are widely available. As the forecast reveals, the US maintains not just the highest consumption rates but also the best electricity share. This forecast postures the US well for integration and utilizing of IoT capability as the formulas included an account for GDPPC, fossil share, and non-fossil share. The closest competitor in this arena is China, with North Korea falling behind exponentially.

Transportation Forecasts.

The road density network (in kilometers) analysis between the US and competitive adversaries reveal many exciting perspectives in Figure 13.

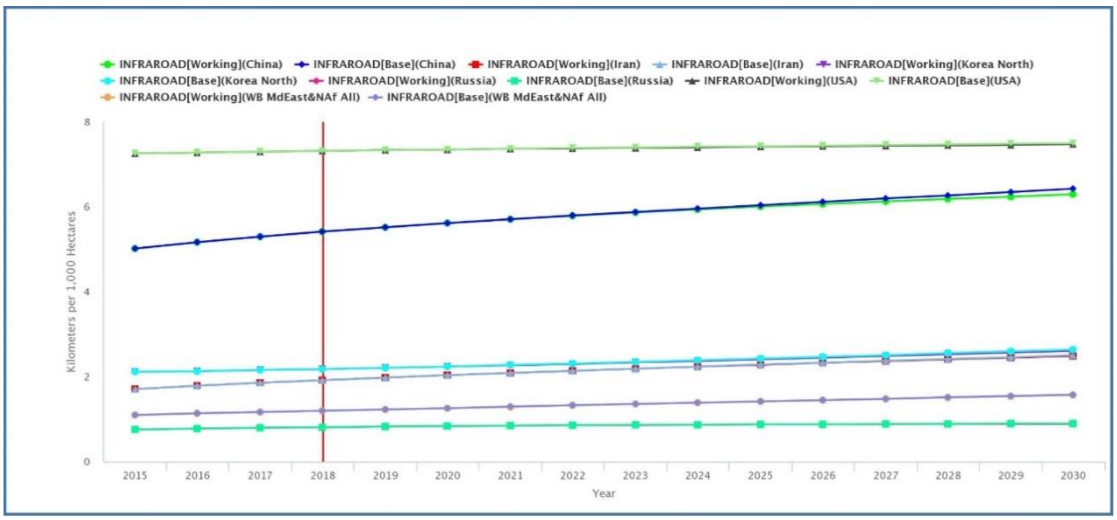


Figure 13. Transportation$_1$ Forecast

While the United States maintains a higher percentage against its competitors at an average of 4.4%, China is only an average of 1.18% less as it grew the most percentage towards 2030 (1.28% compared to a .22% growth for the US). Russia maintains the least percentage at .90 with Korea and Iran nearly identical (only a .13% difference). In the region of the Middle East and North Africa, there is a .47% increase and an average of

1.58% placing the region higher than Russia, but less than Iran and North Korea. Lebanon, Jordan, Israel, and Kuwait display the most significant increases at an average of 3.39%. In most cases, the baseline forecast showed higher percentages than the working forecast at an average of .05%.

The analysis of road networks (paved percent in percentage) in Figure 14 represents increased ability within an interconnected logistics framework where transportation can enable IoT integration.

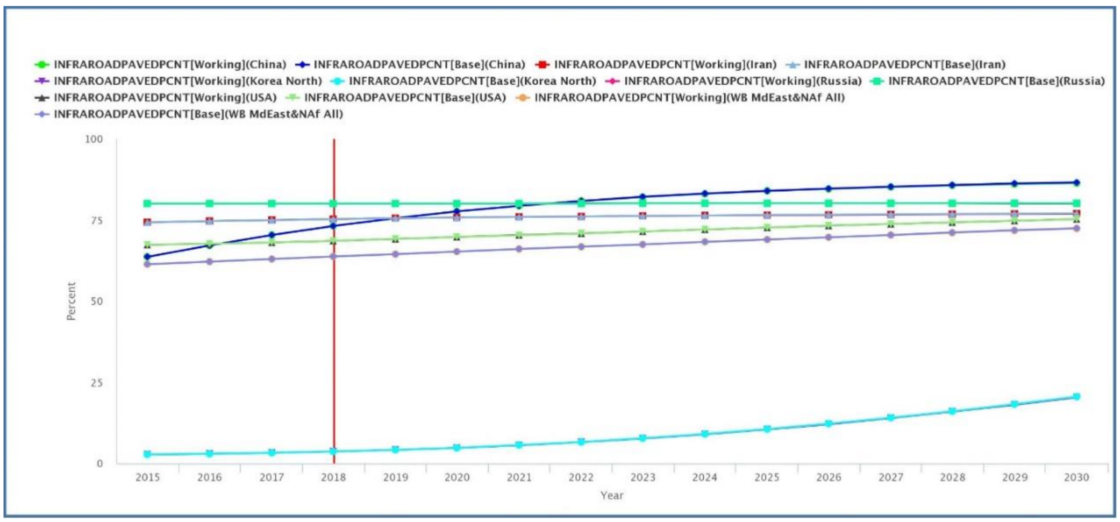


Figure 14. Transportation2 Forecast

To begin, this is the first and only parameter in which the US lags behind its competitive adversaries. China, Russia, and Iran each hold higher percentages than the US at average percentages of 11.22, 4.87 and 1.77 respectively. Correspondingly, the most growth was seen in China at an average percentage of 1.43 per year, followed by North Korea at 1.1 a year and the US at .49; while North Korea did grow an average percent of 17.65 cumulative towards 2030, they are projected to have just 20.48 percent by 2030, which is

72.8% less than the United States. The at-risk region of the Middle East and North Africa revealed an average percent increase of 11.11 towards 2030 with the highest gains being the nation states of Saudi Arabia, Yemen, and Oman. Comparatively, the working-based forecast shows a slightly less increase than the baseline forecast at an average percentage of .18. All other trends remain consistent.

A synopsis of the transportation forecasts offers a helpful perspective. The forecasted state of roads helps reveals the degree in which transportation infrastructure can enable IoT within the interconnected system of logistics. While the US holds an advantage in road density, it does not have nor maintain advantage within roads paved. Overall, this is a set of infrastructure variables in which the US begins to lose competitive advantage. In this sense, China emerges as a prominent competitor regarding the ability to integrate IoT within transportation infrastructure.

Cybersecurity Index Forecast.

The literature review introduced the need to assess risk and identify complexity. The cybersecurity index from IF is one tool to help measure this area and the forecast is provided in Figure 15.

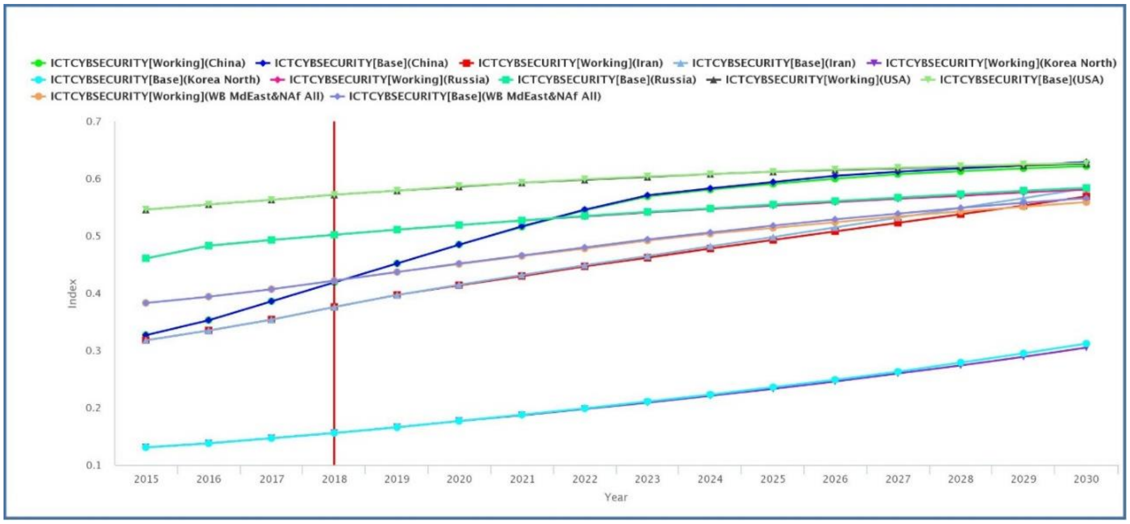


Figure 15. Cyber Security Index

The cybersecurity index reveals interesting results later incorporated within the theoretical formula derived for IoT Capability Index. As the decade of 2020-2030 advances, the chart reveals some key trends including North Korea lagging behind, China's strong growth and the US's lack of growth. Legalities, technical measurements, access and resources are influencing the US measurement towards 2030. In fact, while the US grew an average of .08, China grew an average of .298 and surpasses the US in the baseline forecast in the year 2030. Alongside transportation, this is a critical measurement in which the US is postured to lose competitive advantage. Iran grows an average of .258 and is nearly identical with Russia in baseline forecast by the year 2030. Within the North Africa and Middle Eastern nations, a few nation states match the US and China or even surpass them to include Israel, United Arab Emerits, and Saudi Arabia. With these seven parameters calculated, charted and analyzed, the research can now introduce a theoretical framework in which to view their interconnection as pertains IoT capability. A summary of their results related to competitive advantage is found below in Table 4.

Table 4. Summary of Forecasted Trends towards IoT Capability

Infrastructure Category	Competitive Advantage	Critical Influences
ICT	⇔	regulation, connectivity
Energy	⇧	availability, consumption
Transportation	⇩	land area, road networks
Cybersecurity	⇩	tech measurements, resources

Base Case verses Working Case: Individual Parameter Measurements.

In virtually all measurements, the base case forecast displayed higher values than the working case. Intuitively, this is a logical result. Under the working case, the forecasted parameters would find a degree of added constraint when strategic inventions are increased. Interestingly, the difference between the values appear minimal. Meaning a nation can enhance key infrastructure parameters through strategic interventions with nominal degradation in capability. After generating and analyzing a theoretical IoT Capability Index Score, this paper will analyze if this trend between base and working case holds.

Formulation of an IoT Capability Index Score

Similar to additional indexes represented within IF, this research is introducing an index concerning one manner to view the interconnections within IoT. This research is titling the formulation as the "IoT Capability Index Score" and desires to demonstrate the relationship of these parameters in a simplistic, organic, and comparable value. This research does not claim this Index to be a solution to the complex issues surrounding 2+2+1. However, this research does claim this Index to be one method to view the interconnections within IoT and seek to understand the 2+2+1 environment through comparison. Within the applied equation below, the research no longer considers the +1 region and associated states as their measurements offered little consistency outside of nations the United States already has a forward presence. Located below is the theoretical visualization of the IoT Capability Index in Figure 16 followed by the associated formula in Equation 8 as applied to the 2+2 nation states.

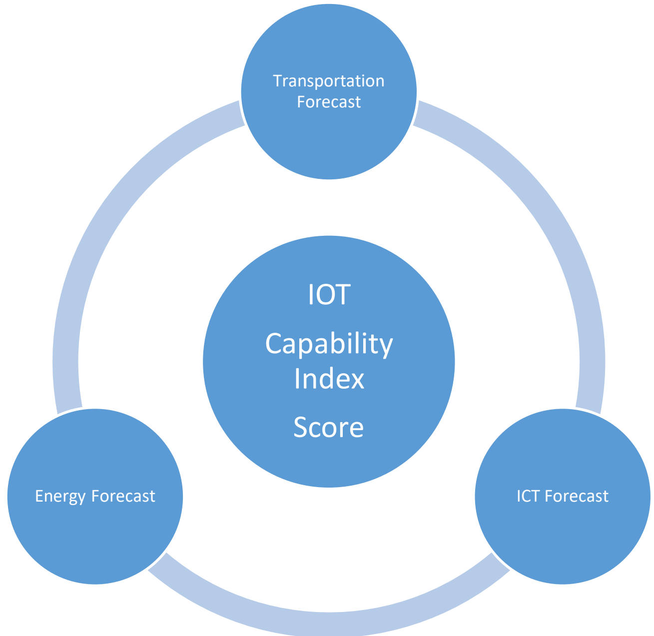


Figure 16. IoT Capability Index Score (Source: Author)

Theoretical Equation:

$$[(ICT_{n,r,t} * (n/N)) + (Energy_{n,r,t} * (n/N)) + (Transportation_{n,r,t} * (n/N))] * (ICTCYBSECURITY_{r,t})$$

Equation 8. Theoretical IoT Capability Index Score Equation (Source: Author)

In this weighted equation, a measurement of a *nation-state or region (r)* at a *given year (t)* occurs through the combination of the weighted score of their *"n" ICT parameters, Energy parameters and Transportation parameters* multiplied by their *Cybersecurity Index Score*. *N* represents the *total number of ICT, energy and transportation parameters considered in the equation* and *n* represents the *individual parameter*. The utilization of N and n within a theoretical formula is intentional as this research hopes the formula will be adapted, modified, and enhanced in the future.

Additional economic and demographic variables are not included within this theoretical formula as they are previously measured and incorporated within IF infrastructure equations. When comparing nation states or regions to one another, this research found it best to baseline the metric measurements to a consistent scale of 0-100. When seeking to calculate this theoretical equation towards research presented, an applied research equation is displayed in Equation 9.

$$[\ [ICTBROAD_{r,t} * (n/N) + ICTBROADMOBIL_{r,t} * (n/N)] + [ENELECSHRENDEM_{r,t} * (n/N) + INFRAELEC_{r,t} * (n/N)] + [INFRAROAD_{r,t} * (n/N) + INFRAROADPAVEDPCNT_{r,t} * (n/N)]\ ] * (ICTCYBSECURITY_{r,t})$$

Equation 9. Applied Research Equation (Source: Author)

In the weighted equation representing the research, *ICTMOBIL* represents *mobile phone subscriptions per 100 persons*, *ICTBROADMOBIL* represents *mobile broadband subscriptions per 100 people*, *ENELECSHRENDEM* represents *the ratio of electricity use to total primary energy demand (in percentage)*, *INFRAELEC* represents *the electricity consumption per capita in kilowatt-hours*, *INFRAROAD* represents *the road network density in kilometers per 1,000 hectares* and *INFRAROADPAVEDPCNT* represents *the road network (paved percent in percentage)* and *ICTCYBSECURITY* represents the *cybersecurity index*. The weighted values of each of the six variables are added together and then multiplied by the cybersecurity index. Including the cybersecurity index is a further effort at better understanding the capability IoT presents for a particular nation-state or region in a particular year. *N (6)* represents the *total number of parameters considered in the equation*, and *n (1)* represents the *individual parameter*.

Charting the IoT Capability Index through 2030

Figure 17 represents the graph of the IoT Capability Index score towards 2030. This chart is simply calculated and simply analyzed.

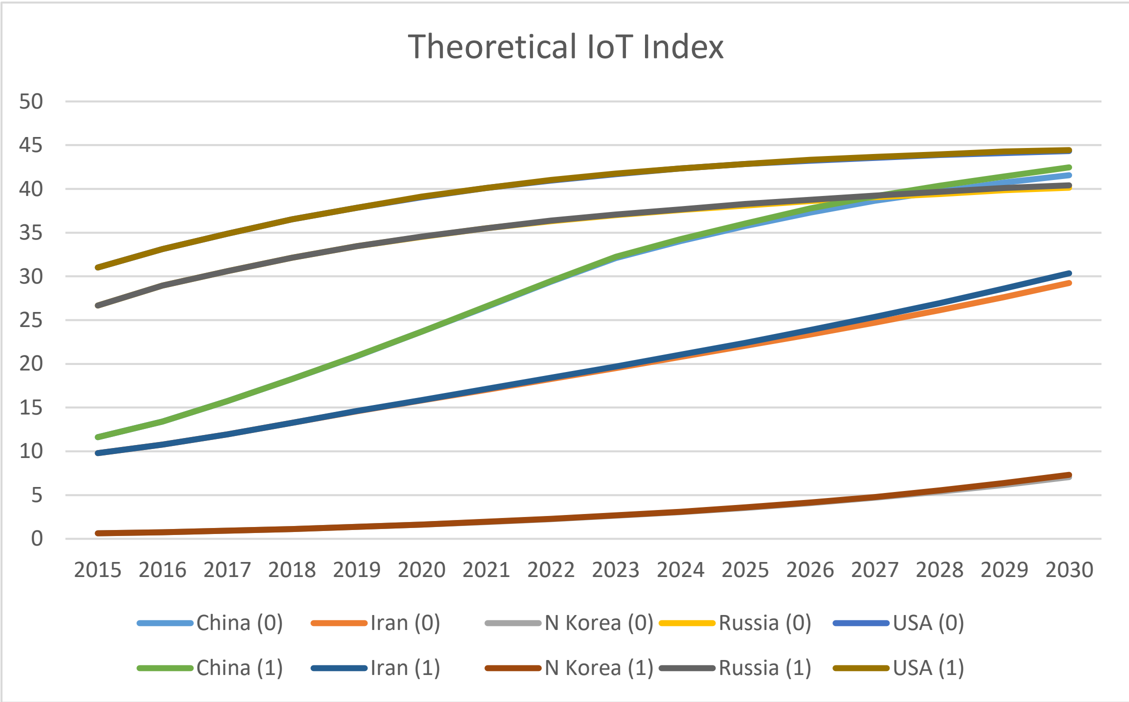


Figure 17. IoT Index Score charted through 2030

As the theoretical index is computed, the US is forecasted to maintain a competitive advantage within the measure of the interconnection between ICT, energy, and transportation through the year 2030. However, the growth rates are not as rapid peer competition and begin to plateau. North Korea lags behind but experiences steady growth towards 2030. While Iran lags as well, they begin to experience an accelerated growth towards 2025-2030; by 2030, they almost reach the state the US currently holds.

While Russia closely models the growth of the US, China advances the most during this theoretical forecast and surpass Russia by 2030. The figure indicates both China and Iran (if they continue to experience these rates of growth) would ultimately surpass the US in the future.

Base Case verses Working Case: IoT Capability Index Score.

Analysis of the base case verses the working case reveal a reversal of the previous trend. In the formulation and application of the IoT Capability Index Score, implementation of strategic interventions reveals higher values than the base case. Meaning nation states who apply strategic interventions as they consider infrastructure parameters, will find the integration and capability of IoT to be of greater value. The strategic implications of these measurements hold significance as nations and regions seek to maintain competitive advantage in future, adaptive environments where new technologies hold exponential influence.

To restate the intent of the research, the results of this theoretical IoT Index is not intended to drive decision making towards the 2+2+1 international environment. However, this theoretical index is intended to demonstrate one method IoT can be viewed while illustrating the power of the interconnections between ICT, energy, and transportation.

Summary

IoT integration maintains the potential to revolutionize the logistics enterprise within an interconnected system of ICT, energy, and transportation. The statistical comparison presented early in the chapter established IoT has the best statistical relationship with logistical, interconnected systems data when compared with other prominent and *artificial intelligence parameters specific to tasks*. The parameters selected and forecasted within the IF model contain equations including economic and demographic variables and represent a foundational construct in which to view the interconnection of ICT, energy, and transportation in which IoT holds capability to enhance. Once compiled, the research offered initial analysis of the base case forecast verse the working case forecast. The chapter then introduced an organic, theoretical IoT Capability Index Score with the intent of adaptation going forward as logisticians seek to better understand interconnections throughout a global, operational focus.

V. Conclusions and Recommendations

Chapter Overview

This chapter summarizes the research's major conclusions, outlines their strategic implications, offers a "Futurists view towards 2030," recommendations for future study and a recommendation for action. As introduced, an IoT Capability Index Score is a meaningful measure to compare the strategic advantage of nations and regions. Strategic implications are found within global adoption of increased technological communication and the necessity to view infrastructure modernization as a means of defense. Projections towards aerospace, space and hypersonic capability are offered within a "Futurist's view towards 2030". Recommendations for future study include partnerships with Air Force Cyberworx, AMC, and Air Force Sustainment Center (AFSC). Recommendations for actions call for logisticians to embrace IoT and consider how culture may need to adapt.

Conclusions of Research

This research introduces the value of IoT integration through IF forecasts offering the quantitative analysis of competitive advantage and the framework to best integrate and exploit IoT capability. Regarding competitive advantage, while the US gains in energy and holds in ICT, advantage is lost within transportation and cybersecurity. When assessing 2+2+1 the competitive adversary China is not far behind overall US projections. While Iran and Russia maintain a stable position within this construct, North Korea is forecasted to lag. As an average, the at-risk regions of North Africa and the Middle East also lag, but many nation states (especially those with a United States presence) are postured to make significant gains within areas of ICT, energy, and transportation. While the base case outperforms the working case inside individual measurements, the working case shows increased value within an IoT Capability Index Score. Ultimately, the IoT Capability Index Score captures a means to measure IoT advancement towards 2030 and the strategic advantage associated.

Applying this research, the USAF can further formulate meaningful tools to analyze and incorporate data towards improved decision making. As IoT follows the patterns described in the literature review, it will be nations with higher IoT Capability Index scores who are best postured to enable the full capability of IoT and increase competitive advantage. IoT, if adopted across all levels of the USAF, will enable cost-effective modernization of infrastructure (Montreuil, 2011) towards the ability to fly, fight and win in future contingencies. Further application of IoT assists data alignment of resources from planning and budgeting to execution and procurement within expeditionary logistics (Porter and Heppelmann, 2015). Through embracing IoT, the USAF can obtain new standards to posture for war in a budget-constrained environment and fulfill Combatant Commander requirements.

Summary of Strategic Implications

Strategic implications from this research are found within the fulfillment of the NDS, the modernization of infrastructure and an adapted logistics culture. The DoD is experiencing a period where successful attacks on the U.S. homeland have thoroughly impacted societal trends (NDS, 2018). Globalization of information, trade, finance, and travel further influence these patterns (Rothman, 2014) whereby the U.S. no longer finds protection via conventional military power. A key opportunity going forward will be information sharing towards the purposes of defense support. IoT in logistics represents the advancement of technological communication means, devices and sensors shared with interested parties (Montreuil, 2011). The logistics enterprise must not allow this to be a disadvantage but an advantage.

The logistics enterprise must remain cognizant of the many challenges and implications regarding the future of global infrastructure. Continued exploration of future infrastructure development and its correlation with socioeconomic principles should remain an international priority. The logistics enterprise should seek to aggressively pursue opportunities to enhance and sustain the infrastructure in states and regions suffering from poverty, low education and poor health. This research concludes investing in global infrastructure means investing in the potential for decreased conflict.

As the infrastructure adapts under IoT integration, the USAF will require logistic leaders with an ability to optimize the interconnection of ICT, energy and transportation. Correspondingly, the USAF will also transform more rapidly from an era of data privacy to one of data transparency. For young Airmen who have grown up in a globally connected world where they post and share every moment of their life, the embracement of this ideal is probable. As more Airmen connect through congruent data streams, they easily share ideas and innovations. Upon which, a requirement for a new persona of leadership arrives.

Significance of Research: A Futurist's Look Towards 2030

The formulation and application of the IoT Capability Index Score revealed nations who prioritize infrastructure development with strategic interventions will find increased competitive advantage regarding future state logistics. This pull and push relationship of things with secure connectivity has already provided proof of concept (Zhou, 2013). In a household, a Fitbit can automatically start a coffee maker as one awakes, and a phone can automatically send the TV one's calendar and reminder notes all the while an air conditioner tracks departure time and prepares to go idle. In USAF operations, IoT capabilities could tell logisticians at all levels how to optimize traffic in the warehouse, where to best store different commodities and which materiel handling equipment is best suited for daily and contingency operations (Montreuil, Meller, and Ballot, 2010; Zheng, 2015; Zhong, 2017). Regarding flying hour operations, finalization of a flying schedule could automatically inform which aircraft to select and how to optimize the pairing of pilot and aircraft based upon predictive maintenance analytics, the pilot's training records, the training maneuvers, current weather patterns and nominal fuel consumption. These capabilities and more can be leveraged and implemented within current cloud technology and drive operations to record low marginal costs towards 2030 and beyond (Yang, 2017).

As productivity from the last generation of innovations peaks, an intersection with reductionist demography is seen towards 2030. Where this ultimately leads is the necessity and requirement of IoT to supplement and enhance the logistics workforce. This enhanced capability will be proven first on land-based platforms such as base, fleet and inventory management (Baker, 2017) before transitioning to aerospace and then eventually space. As logistics IoT revolutionizes the ability of land-based depots to modernize and repair aircraft, successes and associate data will one day deploy towards autonomous repair stations in space for satellites and vehicles. In fact, global command

and control will not only occur due to technology placed within space but will come from military personnel stationed in space.

"Space bases" resulting from industrialization and construction within space, will create mobile command and control centers with the most powerful means of military application ever seen in history (Friedman, 2009). Sight and communication will be pivotal as the DoD seeks to flawlessly operate advanced capability within the interconnection of space base to satellite to land-based target. The successes learned from increasing the understanding of the growing interconnection of logistics and IoT during the initial exploration and incorporation will be the foundation for technology capability in space one day. This is a similar pattern to the first use and then modernization of precision-guided munitions, or even before that, the first use and then modernization of aircraft. When this occurs, the military conceptualization of societal mobilization within a global battlefield will begin to fade.

In fact, the United States, through an increased interconnection of ICT, energy, and transportation within logistics, will usher in the evolution of precision-guided weapons with hypersonic capabilities. As the use of technology increases, speed, accuracy and range increase; the size of the required military force decreases along with the requirement of massive stockpiles of land-based resources and the petroleum associated. In truth, a weapons culture of interacting, synchronized sensors will be congruent towards the projected demographic reduction of 2020-2030. The ability to manage extremely complex weapon systems will be more pivotal than the courageous leadership of a [great man] officer (McChrystal, 2015:225). Additionally, given the working case revealed increased value as compared to the base case, a deeper look into future recommendations of study is warranted.

Future Research Recommendations

Following the completion of this paper, there are four main future research recommendations. The first recommendation centers upon the previously described "smart base" initiative with Air Force CyberWorx. In their 2017 report, Air Force CyberWorx seeks to prioritize lessons learned from the USAF Academy and Maxwell AFB within the next two years. Future research can partner with Air Force CyberWorx and Air Force Installation Management Support Center to provide quantitative analysis towards prioritization and implementation of additional experimental bases. This research may also extend towards AMC's selection of installations to implement the "Aerial Port of the Future" (Jenne, 2017) where IoT is forecasted to enable smart operations.

A second future research recommendation is found within the AFSC and the implementation of IoT towards smart manufacturing within the Air Logistics Complexes. Operationally, as the logistics enterprise undergoes exploitation through IoT integration, the necessity to embed smart, connected products within modernization efforts increases. Going forward, as IoT capability spreads further through ground-based assets within commercial and industrial sectors, associated data and lessons learned will connect towards aerospace assets at a rapid pace. Partnered research with AFSC can assist the timeline of applying IoT towards next generation aircraft while enhancing additive manufacturing and the evolution of logistics towards “near zero marginal cost” (Rifkin, 2014:95).

The third research recommendation is found in furthering the ability to identify risk and assess complexity within cybersecurity. The top concern regarding IoT integration within military operations continues to be cybersecurity (Abomhara, 2015; Air Force CyberWorx, 2017). However, it is prudent to identify, research and analyze whether a smart, interconnected system may evolve from cyberattack as a weakness to cyberattack as a strength. As the strength of connection and shared learning increases, the ability of a system to adapt and impart resiliency holds potential (Pescatore and Shpantzer, 2014). Considerations from blockchain technology may be applied within a shift from proof-of-work to proof-of-handling where gateways can offer secure, widespread coverage at an affordable cost. A study in this arena would partner with Cyber Command to forecast the potential of IoT integration to one day increase cyber resiliency.

A fourth and final research recommendation resulting from this research concerns a deep integration of digital and physical logistics within futurist application. As IoT continues becomes the third wave of disruptive IT innovation within logistics, a fourth wave becomes postured. The most logical conclusion in the next thirty-year cycle of 2020-2050 becomes exponential growth of artificial intelligence. As USAF logistics evolves towards smart, connected systems the logistics enterprise will one day facilitate what this research currently titles as the Internet of Military Things (IoMT). Research predicated towards the IoMT will ultimately shape what future-state logistics may know as the Internet of Logistics (IoL) in which physical and digital logistics are fully integrated within smart operations.

Recommendation for Action: A Call for Logisticians to Embrace IoT

Under IoT integration, logistics leaders are postured for success within a national strategy advocating modernization and innovation towards current resources. Leaders with the ability to effectively communicate sustainment on behalf of the DoD will be fully complementary to military success in the future. The evolutionary initiatives found within IoT integration pave the way for sustainment leaders to innovate new strategic requirements for the way the USAF postures for war and enables the next generation to fly, fight and win. To be successful, the USAF must educate, train and develop the logistics leaders of tomorrow in the application of IoT integration.

The concept of *big data* reveals a further implication. After moving towards installing a Chief Data Officer to capture, aggregate, and analyze, the USAF will need to tighten IT and R&D collaboration while maintaining newly established cloud connectivity and leveraging new human resource requirements (Zhou, 2013). The most urgent of these is the need to recruit new skill sets, many of which are in high demand. Engineering departments, traditionally staffed with mechanical engineers, must add talent in software development, systems engineering, product clouds, and big data analytics.

***A New Culture is Required*.**

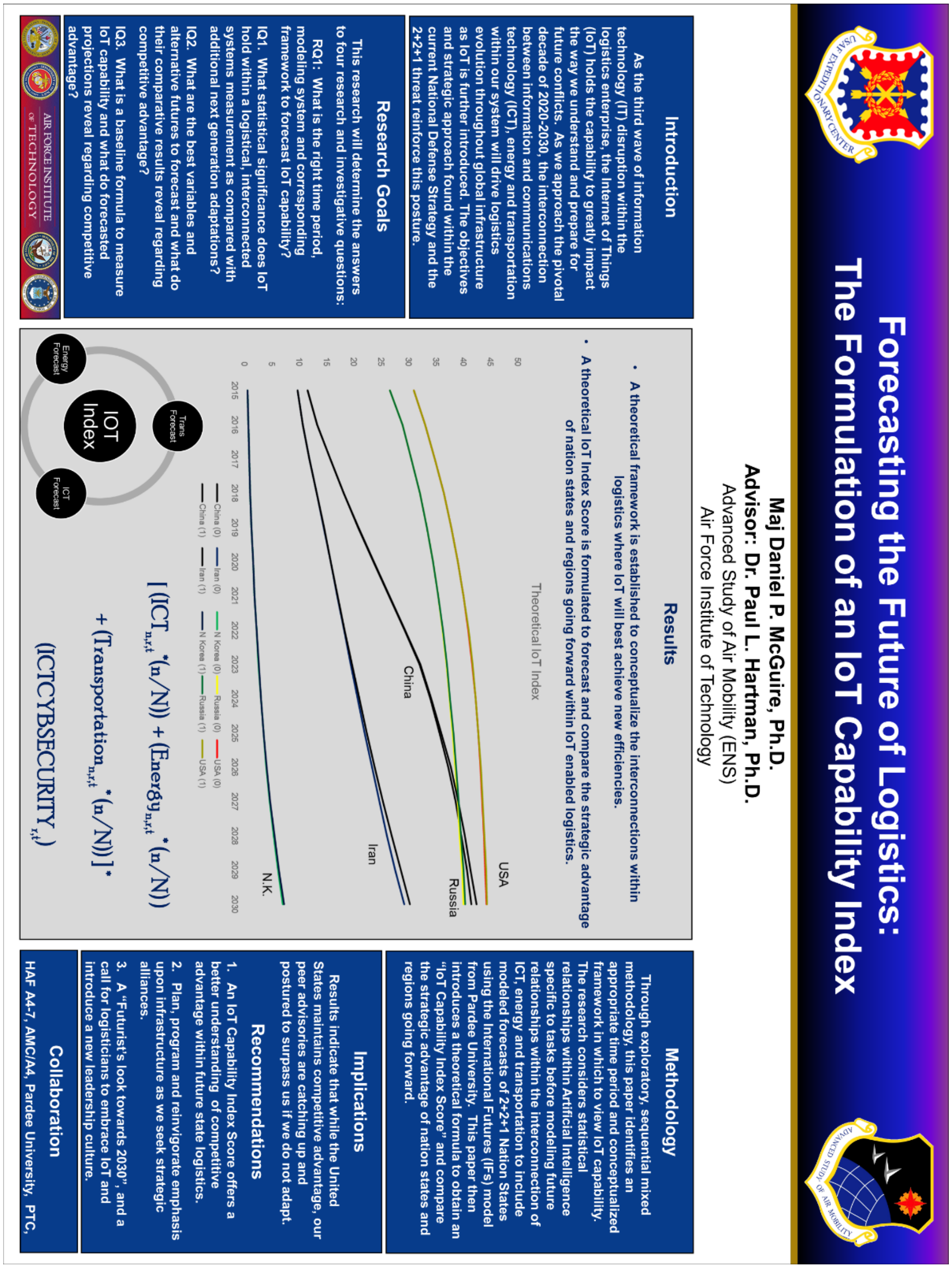
The move-by-move control which remains the current norm to most military operations is proving ineffective in a networked world of complexity and speed. In fact, as the DoD seeks to deliver performance at the speed of relevance (NDS, 2018), USAF logistics finds current processes are not responsive to need, and must shed outdated management practices and structures while integrating insights from business innovation. In a world where the leader can obtain more information than ever and thereby make more decisions, they must make less (McChrystal, 2015). If future leaders do not adapt, they will simply be overwhelmed by the accelerating speed and complexity and fade into obsolescence in nearly the same manner as outdated technology. As logistics and IT are further integrated, the days of a Senior Leader who acts as controller and surveyor of all will shift towards a crafter of information and culture; a key leadership trait will become promoting integration and collaboration within a similar pattern and infrastructure as the technologically advanced environment. Only those with the ability to lead in adaptation will find success.

Summary

In conclusion, this research provides senior leaders a theoretical assessment of how best to conceptualize future state logistics within the interconnection of ICT, energy and transportation where IoT is best postured to create new, systemic efficiencies. This research actively promoted the deepening relationship between the logistics enterprise and IT evolutions as IoT expands exponentially towards 2030. An implementation framework, systems model and time period in which to forecast are studied and presented. Ultimately, forecasts of 2+2+1 is offered to then create a theoretical IoT Capability Index Score.

The logistics environment will eventually evolve full circle (Rifkin, 2014). Just as the advent of the interstate highway system enabled an interconnected communication medium, today’s logistics industry can adapt the open-architecture metaphor of internet communication and remodel global logistics (Montreuil, 2011). As the USAF institutes a responsible infrastructure, smart, connected products can have a broad impact outside the DoD curtailing the impact of economics and demographics, giving rise to the next era of IT-driven productivity and advancing the influence of the logistics enterprise.

Appendix A: Quad Chart



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14. ABSTRACT
As the third wave of information technology (IT) disruption within the logistics enterprise, the Internet of Things (IoT) holds the capability to greatly impact the United States Air Force's (USAF) understanding and preparation for future conflicts. As the pivotal decade of 2020-2030 approaches, the interconnection between information and communications technology (ICT), energy and transportation will drive logistics evolution throughout global infrastructure as IoT is further integrated. This paper considers the statistical relationship between IoT and the logistics environment and then models alternate futures within an established IoT framework through forecasts of China, Russia, North Korea, Iran and +1 Nation States using the International Futures model from Pardee University. In fulfillment of National Defense Strategy objectives, a conceptualized framework is introduced to visualize where this innovative technology will enable new efficiencies and an Index Score is formulated towards measuring competitive advantage. Ultimately, nation states and regions with higher IoT Capability Index Scores equate to strategic advantage in future operating environments marked by adaptation. Results reveal while the United States maintains competitive advantage currently, peer competitors are rapidly advancing as 2030 approaches. The strategic implications call for reemphasis on infrastructure within internal borders and strategic alliances. The conclusion introduces a "Futurists look towards 2030", an introduction of four future research considerations within the USAF logistics enterprise, and a call for logisticians to embrace IoT and consider the leadership methodology associated.

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Internet of Things, logistics, innovative disruption, 2+2+1, competitive advantage, global futures, infrastructure

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