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Innovation And Deregulation: The Case Of Texas Electricity Companies

Millicent D. Delaney

INNOVATION AND DEREGULATION: THE CASE OF TEXAS ELECTRICITY COMPANIES

A Dissertation

by

MILLICENT D. DELANEY

Submitted to the Office of Graduate Studies
of Prairie View A&M University
in partial fulfillment of the requirements for the degree

DOCTOR OF BUSINESS ADMINISTRATION

August 2024

Major Subject: Business Administration

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Approved as to style and content by:

Thiagarajan Ramakrishnan Chair	Hesam Shahriari Member
Yi Zhang Member	Moosa Khan Head of Department
Munir Quddus Dean of College	Dr. Tyrone Tanner Dean of Graduate Studies

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ABSTRACT

Innovation & Deregulation: The Case of the Texas Electricity Companies

(August 2024)

Millicent D. Delaney

B.S, The University of Tulsa

M.B.A., Keller Graduate School Management

Chair of Dissertation Committee: Dr. Thiagarajan Ramakrishnan

Deregulation has played an essential role in the restructuring and development of various industries. In the energy industry, deregulation has empowered consumers by offering them more provider choices, economic security, and affordability. It has reconstructed the energy transmission, distribution, and generation processes, thereby making energy more cost-effective for customers. Most studies in this area examined the impact of deregulation from consumers' perspectives and mainly focused on European and other non-U.S. markets. There are not many studies that examined the impact of deregulation in the energy sector of the United States.

Therefore, this study is an examination of the impact of deregulation on provider innovation in the Texas market, the largest deregulated electricity market in the United States. Using deregulation events in the Texas electricity market as natural experiments and multiple measures of innovation, this study will enhance the understanding of the relationship between deregulation and innovation in the energy sector. The researcher drew on Schumpeter's theory of creative destruction, contestability theory, and Christensen's disruptive innovation theory

This study has theoretical and practical implications. From a theoretical perspective, it contributes to the literature in innovation and deregulation from the viewpoint of energy utility companies. From a practitioner's perspective, the findings of this study may assist utility companies in determining the optimal timing and allocation of resources for innovation. Furthermore, the discoveries can help policymakers in different states establish a structure for deregulation in their energy utility markets.

Keywords: deregulation, innovation, patents, Schumpeter's theory of creative destruction, contestability theory, Christensen's disruptive innovation theory

DEDICATION

This study is dedicated to my late friend, YharNahKeeShah "Ya-Ya" Smith, whose spirit, kindness, and support enriched my life. Your confidence, inspiration, and strength helped in my journey through life, especially in pursuit of this doctorate. I will continue to reflect on the shared memories and laughs we had. Thank you for the continuous golden nuggets of wisdom and compassion you shared with me and others throughout your lifetime. May your soul rest in peace, and may your memory be a blessing to all who knew you. With all my love and gratitude, this is for you, my dear friend.

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I want to thank my chair, Dr. Thiagarajan Ramakrishnan, and my committee members, Dr. Hesam Shahriari and Dr. Yi Zhang. Thank you for your unwavering support and patience. Thank you for listening to my rambling and helping me craft it into the presented written piece. Your transfer of knowledge through your countless examples, experiences, encouragement, and teaching helped me through this process.

To my fellow members of the inaugural Doctor of Business Administration class of 2024, who made this journey meaningful and valuable: at first, we all looked at each other like we were getting into something. It has been a pleasure to see each one of our journeys being fulfilled. Thank you for your constant encouragement, late-night Zoom calls, and help throughout the journey.

To my coworkers, church members, and friends, asking how my dissertation was going: thanks for praying for me, for your words of encouragement, and for helping me through the times when I wanted to quit every other day. Now I have time to hang out and have fun again.

Finally, I would like to thank God for carrying me through this study time. I know this is not the end. I cannot wait to see what is in store for my life.

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CHAPTER I

INTRODUCTION

Background of the Problem

Deregulation is the technique of reducing or removing authority from the government in a specific industry and is implemented by government entities to foster increased competition within that industry (Kenton, 2024). Over the past 40 years, industries such as energy, airlines, telecommunications, and railroads have fallen into the category of natural monopolies, which have the characteristics of acquiring and selling goods with little competition within the industry (Marino et al., 2019). Because of the lack of competition, government entities created regulation policies to help create more competition that would increase consumer affordability and encourage competition (Borenstein & Bushnell, 2000) and innovation (Gencer et al., 2020) within the industry.

Many studies of the energy industry show how deregulation has affected consumer pricing, innovation, renewables, and policies (Necoechea-Porras et al., 2021). The methods used in these studies include literature reviews, empirical techniques, monopolist systems, deregulation from political, economic, and competitive perspectives, and system reconfiguration (Bolinger & Wiser, 2009; Borenstein & Bushnell, 2015; Borenstein & Bushnell, 2000; Littlechild & Kiesling, 2021; Prentis, 2014; Stokes, 2015).

This dissertation follows the *Publication Manual of the American Psychological Association, 7th Edition.*

This study examined the electricity industry in the United States, specifically focusing on the state of Texas. Texas is known for having a high level of deregulation, with 85% of its electricity market deregulated (Baldrick & Hui Niu, 2005). This study aimed to identify deregulation's impact on innovation by examining the patents.

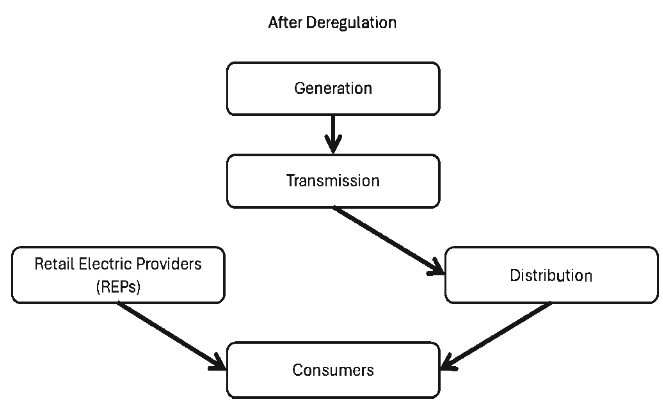
Statement of the Problem

The deregulation of the Texas electricity market has been characterized by major legislative and regulatory actions that have involved many people, bringing some changes to the structure in the electricity market (see Figure 1 below). In 1975, the Texas Public Utility Regulatory Act (PURA) was passed, creating the Public Utility Commission of Texas (PUCT) to manage energy firms. After the federal Public Utility Regulatory Policies Act (PURPA) was passed in the 1980s, Texas saw more competition for market energy (Jang, 2020). However, Senate Bill 7, which called for the deregulation of the energy market and was approved into law in 1999, was the most important change. This change encouraged competition and lowered prices, allowing consumers to choose their energy source (Brehm & Zhang , 2021).

The electricity market officially opened to competition on January 1, 2002. The Electric Reliability Council of Texas (ERCOT), a key partner, managed the change and kept the grid reliable. Deregulation separated the generation, transmission, and distribution processes, making the market for retail electricity providers (REPs) more competitive, as shown in Figure 1. Major stakeholders within the electricity industry include incumbent utilities like TXU Energy and Reliant Energy, new market entrants, regulatory bodies like the Public Utility Commission (PUC), and consumer interest groups (Brown et al., 2022).

Figure 1

Texas Electricity Market Before and After Deregulation



Note: This chart was created with the information provided by the Public Utility Commission of Texas (PUCT) (Public Utility Commission of Texas, 2024) *and Electric Reliability Council of Texas (ERCOT)* (ERCOT, 2023) *websites.*

The Texas energy market has experienced numerous problems and complaints over the years, mostly due to its unstable environment and price fluctuations during harsh weather events like the winter storm in February 2021. This event demonstrated that the systems are not sustainable, leading to much attention from regulators and calls for changes (Lo Prete & Blumsack, 2023). In response to this event, the Texas Legislature passed Senate Bill 3 in 2021 to make the grid more resilient and secure. It included regulations for handling power plants and other important infrastructure (Public Utility Commission of Texas, 2024).

The changes that have occurred with the deregulation of the Texas electricity market have created an environment that has produced several types of innovation. Technological developments are the initial domain where this phenomenon is observed, with a surge in new technology patents aimed at improving business processes and product development (Jemala, 2021). This environment has allowed process enhancements that improve the delivery of services and increase operational efficiency (Cho & Linderman, 2020).

Business model innovations have also emerged as a critical component of this transformation. For example, reorganizing utility business models in reaction to deregulation has enabled increased adaptability and robustness in energy markets (Popp, 2020). These models often integrate inventive finance techniques and income streams that closely align with the evolving dynamics of market restrictions and efforts to address climate change (Agyeman & Lin, 2023).

Furthermore, the widespread increase in patents in the Texas electrical industry highlights the significance of intellectual property in stimulating technical advancement. Patents are a protective structure and attribute for further innovation, allowing firms to utilize their inventions and improvement (Ørstavik, 2021). This has been noticeable in the renewable energy industry, where patents have played a crucial role in promoting the development of clean energy technology (Shubbak, 2019).

The purpose of this study was to examine the impact of deregulation on innovation. By examining patents from the United States Patent and Trademark Office

(USPTO) and significant events, the aim of this study was to uncover the effects of deregulation on innovation among utility companies in the state of Texas. This study addressed the following research question: What is the impact of deregulation on innovation among utility companies in the state of Texas?

Numerous studies have analyzed various perspectives of deregulation from the consumer's viewpoint; a global viewpoint of analyzing various countries; a comparison of areas within a country; or a comparison between two or more states. Other studies discuss innovation but rarely address the effects of deregulation. Furthermore, not many studies have examined deregulation's effects on innovations with the parameter of a single state with various entities over a 20-year range using patents as a measure for deregulation.

The rest of the dissertation is organized as follows: Chapter II includes background information on the Texas electricity market and a review of the previous studies that address the impact of deregulation on innovation, methodologies, and theories on deregulation. Chapter III contains a discussion of the methodology used for conducting this study. Chapter IV presents the findings of this study. Chapter V provides the discussions and implications of this study. Chapter VI offers a conclusion to the study by providing the limitations and directions for future research.

CHAPTER II

LITERATURE REVIEW

This section presents the theoretical support for the current study. First, the extant literature associated with deregulation and innovation is reviewed. The impact of deregulation on innovation in Organization for Economic Cooperation and Development (OECD) countries and in the United States is also examined. Different methodologies are also explored to investigate the relationship between deregulation and innovation. Gaps in the literature are discussed, followed by a discussion of the theories used for this study. Finally, this section states the hypotheses based on the theories.

Prior Literature on Deregulation and Innovation

Organization for Economic Cooperation and Development (OECD)

Several studies in innovation and deregulation have concentrated on the Organization for Economic Cooperation and Development (OECD) nations and countries outside the United States. Agyeman and Lin (2023) investigated the influence of deregulation on the power business, emphasizing its role in mitigating climate change in OECD countries. The authors used Schumpeter's creative destruction theory to conduct their study. Their results indicated that competition and deregulation promoted innovation. Further, their results also showed that monopolies that experienced deregulation in OECD nations promoted technical innovation, with feed-in tariffs and technology research, by encouraging renewable energy and electrical sector innovation.

Al-Sunaidy and Green (2006) investigated energy deregulation in OECD nations, concentrating on the monopolistic power business. Results showed that policies that fostered deregulation in OECD countries led to the breakdown of the monopoly, which encouraged more competition and investment. Cambini et al. (2016) investigated the regulatory consequences on research and development (R&D) budgets and Europe Patent Office (EPO) applications. The results indicated that vertical separation and European Union (EU) deregulation increased R&D and patenting, but market restrictions may lead to outsourcing innovation.

Jamasb and Pollitt (2005) investigated EU energy sector liberalization, market innovations, and barriers to a united European market, concentrating on competition, efficiency, and economic advantages. The results indicated that due to concentration and capacity issues, European market liberalization caused uncertainty, reduced investments, and reduced innovation. Further, the investigation into UK energy sector patents found that innovation was expanding, but regulation was dampening progress (Jamasb & Pollitt, 2011). Jamasb and Pollitt (2011) suggested that diminished R&D investment inhibited patenting. Prior research also investigated how deregulation affected power sector innovation in 31 OECD nations. The results demonstrated that market forces could not offer long-term incentives for innovation (Jamasb & Pollitt, 2005).

Marino et al. (2019) researched how deregulation affected innovation in the electrical industry. The authors investigated the OECD nations, where they discovered a correlation between the reform's reduction in regulatory obstacles and a decline in patenting, resulting in a U-shaped association between innovation and the non-manufacturing sector (NMR index). Odubiyi and Davidson (2005) investigated the effectiveness of the energy market in England and Wales, focusing on inexpensive contracts and enhanced customer service. Their findings showed that deregulation positively or negatively affected innovation in the countries globally.

Wang and Mogi (2017) examined the country of Japan and the impact of deregulation and market competition on the electricity grid. Their study was conducted from 1978 to 2014 and looked at both the input and output of R&D. Findings indicated that deregulation and increased market competition led to a decrease in R&D expenditure but an increase in patent applications and quality. This suggested that deregulation may have shifted the focus of utilities toward more short-term, business-oriented R&D projects rather than long-term, public-oriented research.

Similarly, many studies examined the effects of deregulation on innovation in countries outside the United States. Table 1 provides a sample of countries about which studies discuss deregulation and its effects on innovation. Table 2 provides an overview of studies of their findings and the implications for the current study. The next section examines studies conducted within the United States.

Table 1

Overview of Countries Studied and Deregulation Effect on Innovation

Author & Year of Publications	Countries Studied	Deregulation effect on innovation

Agyeman and Lin (2023)	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, South Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom	Positive
Al-Sunaidy and Green (2006)	Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States	Positive
Cambini, Caviggioli, and Scellato (2016)	Austria, Belgium, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Norway, Portugal, Sweden, and Slovak Republic.	Positive
Goto and Sueyoshi (2009)	Japan	Negative
Jamasb and Pollitt (2005)	Austria, Belgium, Bulgaria, Bosnia–Herzegovina, Croatia, Czech Republic, Denmark, France, Serbia, Montenegro, FYROM, Germany, Greece, Hungary, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovak Republic, Spain, Switzerland	Negative
Jamasb and Pollitt (2011)	United Kingdom	Negative
Marino, Parrotta and Valletta (2019)	Australia, Austria, Belgium, Brazil, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, South, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Spain, South Africa, Sweden, Turkey, United Kingdom	Positive
Odubiyi and Davidson (2005)	England and Wales	It does not address the effect on innovation
Wang and Mogi (2017)	Japan	Complex: Negative (R &D Input); Positive (R&D Output)

Woo, King, Tishler and Chow (2006)	North America (U.S. and Canada), Europe, Australia, New Zealand, and Asia (Hong Kong and Singapore)	Complex: Negative (R &D Input); Positive (R&D Output)

Prior Research in the United States

Several studies examined the impact of deregulation on the energy industry in the United States. For example, Gould (2018) investigated the components that made up Texas' Competitive Renewable Energy Zones (CREZ) applicable across the country. Reviewing components from these four factors is the social, technological, economic, and political (STEP) analysis that looks at various kinds of technology and market shifts. The results of this study suggested that to strengthen Texas' energy system, legislation should support the CREZ project, which was an investment in transmission infrastructure upgrades and may need national grid regulation required by FERC.

Jang (2020) compared Florida's electricity costs to those of Massachusetts and Texas. This study examined how deregulation affected renewable energy sources and power costs in the three most influential US states. Results from this study indicated that Florida's power rates increased due to natural gas pricing and capacity levels, while the impact of federal deregulation was minimal. In deregulated states like Massachusetts and Texas, retail competition drove down costs, while state competition drove up prices.

Ka and Teske (2022) examined how state PUC-regulated monopoly energy rates and services affected electricity prices and renewable energy sources. The study focused on deregulation from 1973 till the late 1990s regarding policy changes and rates, conducting a cross-sectional analysis. Findings indicated that non-incremental modifications and legislative actions may impact monopoly energy tariffs and services overseen by state PUCs.

Littlechild and Kiesling (2021) examined the Texas blackout from a creative destruction theory perspective. The authors investigated whether a market or regulatory failure caused the Texas blackout. The theories of Hayek on complex phenomena, creative destruction, and examining the Texas blackout. Results indicated improvements were needed to enhance blackout and brownout forecasts and analysis.

Stokes (2015) investigated how Ontario, California, and Texas policies compared to green energy in the power market. The author took an in-depth look at political case studies necessary to comprehend policy choices that impacted the change of the energy system, policies for green energy, and the utilities' business models. Findings indicated that to fight climate change, institutions needed to change so that technology could move forward in the electricity industry.

Woo et al. (2006) explored the impact of electricity deregulation on innovation through a comparative analysis of various countries. Their findings underscored the nuanced nature of this relationship, highlighting that the effects are not straightforward. Instead, the influence of deregulation on innovation is contingent upon a complex interplay of factors. These factors encompass the specific design of the electricity market, the prevailing regulatory framework, and the unique context of the electricity sector within each country or region.

Methodology Used in Prior Studies

Previous research has explored the connection between innovation and deregulation using various approaches. A standard method involves conducting literature reviews, which comprehensively examine different facets of the electricity industry. These reviews delve into policy changes, patent data, and the overall impact of deregulation. By synthesizing information from diverse sources, researchers understand the complex relationship between these two key factors.

Al-Sunaidy and Green (2006) examined how energy reform spread in OCED countries. Their study discussed issues related to the energy industry's monopolist system, that is, generation, supply, transmission, and delivery systems. The authors concluded that deregulation spread through the OCED countries. Each country has its own rules and procedures. Unbiased factors must help encourage competition, investment, and supply in the energy business to break up the monolithic characters that work in it.

Borenstein and Bushnell (2000) examined the successes and failures of electricity that has expanded globally. Their literature review discussed deregulation from political, economic, and competitive perspectives, as well as the restructuring of transmission systems, and concluded that the energy industry’s regulation and increased market processes had pros and cons. Deregulation without market power might hinder sector transformation and cause a regulatory reaction. Consumers may pay more in the short term for restructured markets, but better investment choices will pay off long-term.

Comparing restructuring investment efficiency to conventional regulation makes measuring these long-term gains difficult.

Gillen (2006) examined PUC function, stakeholder influence, and creative energy cost recovery strategies. This study reviewed the history of the Texas electricity industry. Texas' regulatory efforts benefit utilities through innovative financial solutions, but competition from investors and legal challenges impacts consumers, resulting in $5-7 billion in costs.

Jamasb and Pollitt's (2005, 2008) studies examined EU electricity sector liberation, possible market innovations, and obstacles to a unified European market. In a 2005 study, the authors discussed how macroeconomic theory benefitted consumers and the economy through competition and efficiency. Due to concentration and capacity issues, European market liberalization caused uncertainty, reduced investments, and reduced innovation. In the 2008 study, the authors examined the research, development, and innovation industry and the causes of the decline in the industry. The study discussed the R&D failure due to competition, unbundling, privatization, government financing, and increased leverage, suggesting the need for empirical research on liberalization.

Jamasb and Pollitt (2015) revisited the subject of electricity market liberalization, offering fresh insights into UK patenting trends. They emphasized the importance of aligning research and development efforts with the dynamic needs of the electricity market. Their work consistently underscores the intricate nature of electricity market liberalization and its diverse effects on innovation. This research serves as a valuable reminder of this field's ongoing challenges and opportunities.

Littlechild and Kiesling (2021) thoroughly investigated the Texas blackout, aiming to pinpoint its root cause - whether it stemmed from a market failure or a regulatory oversight. The authors shed light on the underlying issues by applying Hayek's theory of complex phenomena and the concept of creative destruction alongside a comprehensive review of previous blackout events in Texas. Based on their analysis, they proposed several improvements in forecasting and analytical techniques to understand better and mitigate the risks of blackouts and brownouts in the future.

Munson and Kaarsberg (1998) comprehensively analyzed the obstacles hindering progress in the electricity industry. Their research identified several key barriers that impede advancements, including limitations on suppliers, constraints within the existing grid infrastructure, and financial and environmental challenges. Based on their findings, they proposed the removal of these barriers as a crucial step towards fostering a more innovative and efficient electricity sector. This, they argued, would pave the way for significant improvements in the industry's ability to meet the evolving needs of society and the environment.

Necoechea-Porras et al. (2021) analyzed deregulation policies' impact on the energy sector, analyzing literature and macroeconomic effects. The authors reviewed various theories and models and found that government deregulation performed better than other reforms and the government must communicate effectively with stakeholders. In addition, tariffs also helped in improving efficiency and producing energy.

Stokes (2015) compared Ontario, California, and Texas policies and renewables in the electricity market. The author discussed in-depth political case studies crucial for understanding policy decisions affecting energy system transformation, renewable energy policies, and utilities' economic models. Findings indicated that combating climate change required institutional change for technological advancement in the electrical sector.

Syed et al. (2020) conducted a comprehensive exploration of the functionality of smart grids. Their study encompassed a thorough review and definition of smart grid technology, providing a foundational understanding of this innovative system. Building upon this knowledge, they offered valuable insights into effectively managing data within the innovative grid framework. Moreover, their research culminated in recommendations for specific technologies that can be leveraged to optimize data handling within the smart grid environment.

Woo et al. (2006) thoroughly examined deregulatory initiatives across various contexts, meticulously documenting challenges encountered, and lessons learned. Through a comprehensive literature review, they critically assessed the effectiveness of restrictive measures within the global deregulation landscape. Based on their findings, they cast doubt on the viability of such constraints and advocated for a more proactive approach. The authors posited that governments should actively pursue deregulation to address existing limitations and foster a more dynamic and competitive environment.

Numerous studies have employed empirical approaches to investigate the monopolist system from various angles, including its political, economic, and competitive implications. Additionally, researchers have used real-world data to examine the impact of deregulation on these aspects. Furthermore, the restructuring of transmission systems, a critical component of the electricity sector, has been addressed.

Cambini et al. (2016) examined regulatory impacts on the R&D budget and EPO application. The study used an empirical approach that matched research and development spending data with EPO patent applications from a 16-country sample between 1990 and 2009 to uncover regulatory variables. Findings showed that vertical separation and EU electric sector deregulation increased patenting. As market barriers drop, corporations may outsource innovation to specialized suppliers.

Chaar (2021) conducted a study to explore how Renewable Portfolio Standards (RPS) affected the cost of electricity. Their empirical research revealed significant findings using data from the US Energy Information Administration (EIA) and the Database of State Incentives for Renewables and Efficiency (DSIRE) from 1990 to 2017. The study concluded that RPS policies, while promoting renewable energy adoption, also increased regulated power prices. This, in turn, had the unintended consequence of limiting consumer choice in the retail electricity market and hindering access to the wholesale market.

Delmas and Tokat (2005) discussed how retail deregulation impacted governance structures, from completely vertically integrated to market transaction arrangements. Their empirical study on FERC Form No. 1 data from 1998-2001 for 177 US electric utilities included company information, financial accounts, and engineering statistics. The study's findings indicated that deregulation shortened electric utility efficiency. Vertical integration is a cost-effective governance system that adapts to changing environments. Non-integrated structures also handle regulatory uncertainty well. Data will determine the effect of deregulation's long-term efficiency.

Fabrizio et al. (2007) conducted an empirical study to examine the effect of efficiency on control group selection, utilizing annual data from US utilities' fossil-fueled generating plants. Their findings revealed that power-generating competition led to a reduction in labor and non-fuel operational expenditures by three to five percent in IOU plants. The authors suggested that further research is necessary to explore the potential increases in fuel efficiency. They concluded that firms that adapt to incentives and invest in both human and physical capital may experience long-term benefits.

Goto and Sueyoshi (2009) examined the impact of deregulation on the electricity industry of Japan using a theory surrounding the economies of scale, technical change, and total factor productivity (TFP). The study used an empirical model with data from 1983 to 2003 of the nine electricity companies in Japan. Findings indicated that economies of scale had a lesser impact than technical change on productivity growth. An unfavorable change in technological growth showed that the companies were investing in technology before deregulation.

Jang (2020) examined deregulation's effects on electricity prices and renewables in the three critical states in the US. This study utilized an empirical approach and showed that natural gas prices and capacity levels boosted Florida electric costs, but federal deregulation had little effect. In addition, retail competition lowered prices in deregulated states like Massachusetts and Texas, while regulated states' competition raised them.

Pierce (1984) discussed the effects of the federal-state relationship on a deregulated electricity market in the United States. The author examined this relationship through game theory, pure theory, economic regulation, and the theory of concurrence and plurality. The empirical approach suggested that Congress had the authority to limit state-level regulation and should use this power to consider regulations from both a national and state-specific perspective carefully.

Sevi (2004) studied the environmental consequences of a deregulated electricity market. The study highlighted the significant role of uncertainty in such markets. Sevi's findings pointed to a potential connection between inadequate investment in research and development (R&D) and negative impacts on the long-term sustainability of the electricity market. This suggests that insufficient R&D funding could impede the progress of cleaner technologies, posing a threat to the market's environmental goals and overall viability.

Agyeman and Lin (2023) examined how technological innovation was affected by power sector deregulation, stressing its role in climate change mitigation. Schumpeter's creative destruction theory suggests deregulation and competitive policies boost innovation, while the escape competition effect suggests monopolies innovate more. Regime innovation and industry life cycle theories suggest small businesses innovate, while energy deregulation and environmental regulations may benefit polluting companies (Porter's Hypothesis). This study showed measurements of deregulation such as nations applying feed-in tariffs after deregulation promoted renewable energy innovation. Technology R&D and demonstration additionally encourage electrical sector innovation.

Gao (2014) examined the impact of economic deregulation on innovation in five U.S. industries from 1972 to 1999. Using patent data from 1967 to 2004 as a proxy for innovation, the study found that deregulation negatively affected innovation across all five sectors. However, the petroleum and natural gas industry responded to deregulation with a distinct innovation pattern compared to the other industries. This suggests that industry-specific factors may influence the relationship between deregulation and innovation.

Marino et al. (2019) examined deregulation impacting electricity sector innovation in 31 OECD countries. This study mentioned several theories of deregulation and innovation. The empirical analysis is used at specific periods that review policy changes and patents which provide companies with long-term incentives for innovation.

Sanyal and Ghosh (2013) examined the impact of deregulation on innovation activities in the electricity market, focusing on the shift of innovation from technology suppliers to electricity producers. Using patent data, the study found that deregulation led to a decline in the quality of patents since deregulation in the electricity market. This suggests that deregulation may have unintended consequences for the direction and nature of innovation in the electricity sector.

Table 2 gives an overview of the methodology and areas of interest in the articles in this literature review.

Table 2

Overview of Methodology and Areas of Interest

Author(s)	**Method**	**Areas of Interest /Findings**
Agyeman and Lin (2023)	Staggered/Difference-in-Differences	Policy changes, patents, innovation behavior
Al-Sunaidy and Green (2006)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Bailey and Baumol (1983)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Borenstein and Bushnell (2000)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Borenstein and Bushnell (2015)	Empirical Approach	Patents, incentives, utility companies
Cambini, Caviggioli, and Scellato (2016)	Empirical Approach	Patents, incentives, utility companies
Carley (2012)	Conceptual Model	Retail sales, capacity
Chaar (2021)	Empirical Approach	Patents, incentives, utility companies
Delmas & Tokat (2005)	Empirical Approach	Patents, incentives, utility companies

Fabrizio, Rose, and Wolfram (2007)	Empirical Approach	Patents, incentives, utility companies
Gao (2014)	Staggered/Difference-in-Differences	Policy changes, patents, innovation behavior
Gencer, Larsen, and van Ackere (2020)	Conceptual Model	Retail sales, capacity
Gillen (2006)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Goto and Sueyoshi (2009)	Empirical Approach	Patents, incentives, utility companies
Gould (2018)	Conceptual Model	Retail sales, capacity
Hosoe (2006)	Conceptual Model	Retail sales, capacity
Jamasb and Pollitt (2005, 2008)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Jamasb and Pollitt (2011)	Conceptual Model	Retail sales, capacity
Jamasb & Pollitt (2015)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Jang (2020)	Empirical Approach	Patents, incentives, utility companies
Jerko (2000)	Conceptual Model	Retail sales, capacity
Littlechild and Kiesling (2021)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Marino, Parrotta, and Valletta (2019)	Staggered/Difference-in-Differences	Policy changes, patents, innovation behavior
Miranda (2003)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Munson and Kaarsberg (1998)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Necoechea-Porras, Lopez, & Salazar-Elena (2021)	Literature Review	Various theories, monopolies, deregulation views (economic, political, competition), consumer rates
Odubiyi and Davidson (2005)	Case Study	Patents
Pierce Jr (1984)	Empirical Approach	Patents, incentives, utility companies
Prentis (2014)	ANOVA Analysis	Electricity Rates
Prez-Arriaga et al. (2017)	Recommendations	Improvements for the industry
Sanyal and Ghosh (2013)	Staggered/Difference-in-Differences	Policy changes, patents, innovation behavior
Schuler (2001)	Simulations	Economic benefits
Sevi (2004)	Empirical Approach	Patents, incentives, utility companies
Smith (1988)	Literature Review	Various theories, monopolies, deregulations views (economic, political, competition), consumer rates
Stokes (2015)	Literature Review	Various theories, monopolies, deregulations views (economic, political, competition), consumer rates

Syed et al. (2020)	Literature Review	Various theories, monopolies, deregulations views (economic, political, competition), consumer rates
Tao et al. (2012)	Comparisons	Various States, Global View
Wade (1999)	Survey	Municipals
Walker and Lough (1997)	Comparisons	Various States, Global View
Wang and Mogi (2017)	Conceptual Model	Retail sales, capacity
White et al. (1996)	Empirical Approach	Patents, incentives, utility companies
Wilson and Tyfield (2018)	Comparisons	Various States, Global View
Woo et al. (2006)	Literature Review	Various theories, monopolies, deregulations views (economic, political, competition), consumer rates

Gaps in Literature

Although there is extensive literature on the impact of deregulation on innovation, there are still a few gaps. First, most of the studies in this area examined deregulation and innovation from the perspective of power tariffs and consumer cost reductions. This provides only a partial picture of the electrical sector rather than a comprehensive one, as these studies do not consider utilities and generating firms. Table 3 provides a sample of research that has been done in examining the relationship between deregulation and innovation in energy industry. This table highlights the research question, the theory and methodology used, and key findings of major studies in this area. The current research sought to examine the influence of deregulation on innovation from utility corporations' perspective.

Second, the literature reveals that most deregulation studies are based on energy companies outside the United States. Most of these studies focus on the OECD nations. Further, many studies that examined numerous inventions through patents were conducted in Europe, as demonstrated in Table 1. Few studies investigate deregulation's influence on innovation by examining patents in the United States. Much of the research conducted in the U.S. focuses more heavily on consumer incentives. Thus, the current research examined patents and other characteristics to see how deregulation has affected innovation in Texas. Texas is among the few states allowing more than 50% of its power to be deregulated. Understanding the impact of deregulation on innovation in Texas can offer other states a platform to decide on their deregulation policies.

Table 3

Prior Studies in Deregulation and Innovation in Energy Industry

Study	Research Question	Theories	Methodology	Key Finding(s)
Agyeman and Lin (2023)	Examined how technological innovation is affected by power sector deregulation, stressing its role in climate change mitigation	Schumpeter's creative destruction theory suggests deregulation and competitive policies boost innovation, while the escape competition effect suggests monopolies innovate more. Regime innovation and industry life cycle theories suggest small businesses innovate, while energy deregulation and environmental regulations (Porter's Hypothesis) may benefit polluting companies.	Staggered Difference-in-Difference (SDID) of 25 OECD countries from a period of 1988-2015 using policy change and patents as measurements of deregulation.	Findings show that energy deregulation in OECD nations increases technical innovation (patent acquisition) in the sector. The empirical data also show that OECD nations applying feed-in tariffs after deregulation promote renewable energy innovation. Technology R&D and demonstration additionally encourage electrical sector innovation.

Study	Research Question	Theories	Methodology	Key Finding(s)
Al-Sunaidy and Green (2006)	Examined the expansion of energy deregulation in OCED countries	No formal theory	The literature review discusses topics on the monopolist system of the electricity industry (generation, supply, transmission & distribution systems).	Concludes that deregulation swept across the OECD countries; each country has its policies and processes. To break up the electricity industry's monologist characters, an independent factor must help promote competition, investment, and supply.
Bailey and Baumol (1983)	Described and examined the contestability theory, which reviews market efficiency, market circumstances, and regulatory policy.	Contestability Theory	Literature review	Concludes contestability theory focuses on sunk costs to identify deregulation scenarios and suitable regulatory measures. It helps policymakers identify and remove impediments. The idea promotes separating natural monopoly industries from fixed-cost sectors. Reality is complicated; therefore, technology limitations may be wrong.
Borenstein and Bushnell (2000)	Examined the successes and failures of	Contestability Theory	Literature review that discusses deregulation from	Concludes energy industry's move toward less

Study	Research Question	Theories	Methodology	Key Finding(s)
	electricity deregulation that has expanded globally.		political, economic, and competitive perspectives and restructuring of transmission systems.	regulation and more market processes has pros and cons. Deregulation without market power might hinder sector transformation and cause a regulatory reaction. Consumers may pay more soon for restructured markets, but better investment choices will pay off. Comparing restructuring investment efficiency to conventional regulation makes measuring these long-term gains difficult.
Borenstein (2002)	Examined experiences of US states with retail competition in electricity markets to identify lessons for future policy.	contestability theory, industrial organization theory, public choice theory, transaction cost economics, and behavioral economics.	Comparative case study analysis of multiple US states that have deregulated their electricity markets, using regulatory filings, market data, and academic studies to assess the impact of deregulation.	Competition is not guaranteed to lower prices and improve efficiency; market power remains a concern; customer engagement and regulatory oversight are crucial; deregulation requires careful planning, implementation, and ongoing evaluation.
Cambini et al. (2016)	The article examined the regulatory impacts	No formal theory	The methodology uses an empirical approach that	Vertical separation and EU electric sector

Study	Research Question	Theories	Methodology	Key Finding(s)
	on the R&D budget and EPO application.		matches research and development spending data with EPO patent applications from a 16-country sample from 1990-2009 to uncover regulatory variables.	deregulation increase R&D and patenting. As market barriers drop, corporations may outsource innovation to specialized suppliers.
Carley (2012)	Examined DSM policy instruments' impact on electricity savings and which are more effective.	No formal theory	Conceptual model, uses Heckman Selection that analyzes data from 3,090 utilities in 48 U.S. states with positive retail sales and capacity.	State-run DSM programs save power; public benefit funds do not generate savings.
Chaar (2021)	Examined the impact Renewable Portfolio Standards (RPS) has on the cost of electricity	No formal theory	An empirical study using the US Energy Information Administration (EIA) and the Database of State Incentives for Renewables and Efficiency (DSIRE) from the periods of 1990-2017.	RPS raises regulated power pricing, reducing retail choice and wholesale market access.
Delmas and Tokat (2005)	Examined how retail deregulation impacts governance structures, from completely vertically integrated to market transaction arrangements.	No formal theory	An empirical study based on FERC Form No. 1 data from 1998–2001 for 177 US electric utilities includes company information, financial accounts, and engineering statistics.	Deregulation shortens electric utility efficiency, according to a study. Vertical integration is a cost-effective governance system for adapting to changing environments. Non-integrated structures also handle regulatory

Study	Research Question	Theories	Methodology	Key Finding(s)
				uncertainty well. Data will determine deregulation's long-term efficiency effect.
Fabrizio et al. (2007)	Examined efficiency effect and control group selection.	No formal theory	An empirical study uses U.S. utilities' fossil-fueled generating plants' annual data.	Power-generating competition reduces labor and nonfuel operational expenditures by 3-5% in IOU plants. Further investigation is needed to assess fuel efficiency increases. Firms adapting to incentives and investing in human and physical capital may reap long-term rewards.
Ferrero et al. (1997)	Examined pool participants' behavior in the electricity industry in a deregulated market.	Game theory	The game theory identifies players, strategies, and potential coalitions, computes transactions and economic benefits, and encourages coalitions that maximize pool benefits.	Research shows that perfect competition maximizes profits, lowers costs, and makes grand coalitions more attractive.
Gao (2014)	Examined economic deregulations in five US industries from 1972-1999, examining their impact on innovation behaviors.	Tradeoff theory indicates that economic deregulation creates competitive sectors with lesser profitability, growth, and asset	The difference-in-differences (DID) method using patents from 1967-2004 as a variable for innovation behavior.	Economic deregulation hurts innovation in five deregulated sectors. After deregulation, petroleum and natural gas

Study	Research Question	Theories	Methodology	Key Finding(s)
		tangibility, lowering leverage.		companies innovate differently than the other four industries.
Gencer et al. (2020)	Developed a framework that showed the adaption of regulation to the electricity market.	No formal theory	A conceptual framework of the stages of deregulation.	Effective regulatory processes enhance market fit, competition, stability, and capacity sufficiency.
Gillen (2006)	Examined PUC function, stakeholder influence, and creative energy cost recovery strategies.	No formal theory	Literature review of the history of the Texas electricity industry.	Texas' regulatory efforts benefit utilities through innovative financial solutions, but competition from investors and legal challenges impact consumers, resulting in $5-7 billion in costs.
Goto and Sueyoshi (2009)	Examined and measured the impact of deregulation on the electricity industry of Japan.	Economies of scale, technical change, total factor productivity (TFP).	The study uses an empirical model with data from 1983 to 2003 of the nine electricity companies in Japan.	Economies of scale have a lesser impact than technical change on productivity growth. An unfavorable change in technological growth shows that the companies are investing in technology before deregulation.
Gould (2018)	This paper examined the constituent elements of Texas' Competitive Renewable Energy	Scott Victor Valentine – STEP analysis (social, technological, economic, and political) that	STEP analysis that reviews various types of technology and market changes.	The CREZ project was an investment backed by legislation that upgraded the transmission

Study	Research Question	Theories	Methodology	Key Finding(s)
	Zones (CREZ) usable nationally.	reviews elements from these four variables.		system to improve Texas' energy system. Suggest that FERC might need to regulate the electric grid nationally.
Hosoe (2006)	Examined the effects of electricity industries on other industries and their economic impacts	No formal theory	Conceptual simulation model	The total factor productivity generation enhancements lower consumer rates, increase alternative energy sources' usage and reduce carbon dioxide emissions.
Jamasb and Pollitt (2005)	The study examined EU electricity sector liberalization, possible market innovations, and obstacles to a unified European market.	Macroeconomic theory benefits consumers and the economy through competition and efficiency.	Literature review	Due to concentration and capacity issues, European market liberalization causes uncertainty, reduced investments, and reduced innovation.
Jamasb and Pollitt (2008)	Examined the research, development, and innovation in the electricity industry and the causes of the decline in the industry.	No formal theory	Literature review	R&D market failure due to competition, unbundling, privatization, government financing, and increased leverage. Suggest empirical research on liberalization.
Jamasb and Pollitt (2011)	Examined patenting in the UK of the electricity industry.	No formal theory	Analyzing patenting by using multiple approaches (word searches, cataloging, etc.) to	Findings show that innovation is increasing in the energy market, which the regulation mitigated;

Study	Research Question	Theories	Methodology	Key Finding(s)
			find patents in the electricity industry.	however, this decreased spending in research and development that, in return, limits patenting.
Jamasb and Pollitt (2015)	Updates from a previous paper written by Jamasb about UK's electricity patenting activities.	No formal theory	Literature review	Suggest establishing the research and development in innovations that fit the electricity market.
(Jang 2020)	This study analyzed deregulation's effects on electricity prices and renewables in the three critical states in the U.S.	No formal theory	Empirical approach	Natural gas prices and capacity levels boosted Florida electric costs, but federal deregulation had little effect. Retail competition lowered prices in deregulated states like Massachusetts and Texas, while state competition raised them.
Joskow and Tirole (2016)	Examined the effects of competitive wholesale electricity markets on electricity prices in the United States.	Contestability theory, concepts of economic principles related to market competition, supply and demand, and market design.	Employs econometric analysis, time series analysis, and comparative analysis of regions with competitive vs. regulated markets.	Competitive wholesale markets are generally associated with lower electricity prices; natural gas prices significantly influence prices; capacity markets can mitigate price volatility; integrating renewable energy poses challenges and opportunities; well-designed

Study	Research Question	Theories	Methodology	Key Finding(s)
				market rules and effective regulatory oversight are crucial.
Jerko (2000)	The study examined the heteroskedasticity models in deregulated electricity markets in three essays.	Regulatory theory, economic theory	The study uses the King and Cue Approach to examined market price convergence in geographically separated marketplaces.	Suggests further research using weather and time variables and other models to have a more holistic approach to understanding the effects of deregulation.
Ka and Teske (2002)	The study examined deregulation through policy changes and rate ranging from 1973-late 1990s.	No formal theory	Pooled cross-sectional analysis	Findings show that monopoly energy rates and services regulated by the state PUCs could respond to non-incremental changes and legislatures.
Littlechild and Kiesling (2021)	Examined the Texas blackout that occurred, determining if this was due to a market or regulatory failure.	Hayek's theory of complex phenomena, creative destruction,	Review of Texas blackout events	Suggests improvements in forecasting and analysis in blackouts and brownouts (supply and demand).
Marino et al. (2019)	Examined deregulating impacting electricity sector innovation in 31 OECD countries.	Mentions several theories of deregulation and innovation	The difference in differences (empirical) analysis at specific periods that review policy changes and patents.	Findings show that market forces cannot provide companies with long-term incentives for innovation.
Markard et al. (2004)	Examined electricity market liberalization's impact on utilities and the sector	Evolutionary economics	Literature review	Market liberalization promotes innovation, customer-oriented products, and

Study	Research Question	Theories	Methodology	Key Finding(s)
	innovation processes.			organizational changes, forming new networks and professional management.
McCalley (2006)	Impact of retail competition on innovation in the Texas electricity market.	Christensen's innovation theory, industrial organization, public economics, regulatory economics.	Empirical analysis using patent counts as a proxy for innovation.	Deregulation had mixed effects on innovation, with an initial negative impact followed by a positive one.
Miranda (2003)	Examined how companies in the electricity industry can minimize the harmful effects of deregulation	Economic theory	Literature review of rates, structures, and processes	Deregulated electric power industry demands manufacturers' knowledge of regulations, market responses, power quality, and location consumption for better returns and consumer satisfaction.
Munson and Kaarsberg (1998)	Discussed the various barriers to making improvements to the electricity industry	No formal theory	Review of literature	Suggests several barriers be removed for the electricity industry to improve, such as in requirements for suppliers, grid, financial, and environmental.
Necoechea-Porras et al. (2021)	Analyzed deregulation policies' impact on the energy sector, analyzing literature and macroeconomic effects.	Various theories and models were reviewed.	A systematic and comprehensive review of the literature.	Findings show that government deregulation performs better than other reforms and must communicate effectively with stakeholders. Tariffs help in improving efficiency and producing energy.

Study	Research Question	Theories	Methodology	Key Finding(s)
Newbery (2002)	This study examined the regulation of the U.S. and EU generation production.	No formal theory	Literature review	Suggests that the EU would need to improve the capacity of transmission and generating plants.
Newbery (2018)	The study examined the electric utilities' capacity, renewables, and regulatory provisions.	Principal agent theory, transaction cost economics, theory of public finance	Empirical approach	Finds renewables and capacity to provide long-term solutions to various information and regulators but still be complex in rate setting.
Odubiyi and Davidson (2005)	Analyzed electricity market success in England and Wales.	No formal theory	Case study	The UK changed contracts from pool to bilateral, which helped make their industry more affordable and increased customer quality.
Pierce (1984)	Discussed the effects of the federal-state relationship and its effects nationally in a deregulated electricity market.	Game theory, pure theory, economic regulation, theory of concurrence and plurality	Empirical approach	Congress has control to limit the regulation in the states that should use their power to carefully look at regulations that view it nationally as well by each state.
Pollitt (2019)	Examined how distributed energy resources (DERs) are disrupting the traditional, centralized model of electricity generation and distribution.	Christensen's theory of disruptive innovation, concepts related to industrial organization and regulatory economics.	Qualitative analysis of case studies and industry trends, drawing on a variety of sources, including academic literature, industry reports, and policy documents.	DERs are leading to a more decentralized electricity system; they pose challenges for incumbent utilities but create opportunities for new entrants; policymakers need to adapt regulatory frameworks to

Study	Research Question	Theories	Methodology	Key Finding(s)
				accommodate this new reality.
Prentis (2014)	Analyzed ERCOTs mission of ensuring reliability and efficiency in Texas' pricing rates before deregulation and compares them to US rates.	No formal theory	ANOVA analysis used U.S. electricity rates ranging from 1970-2011.	Findings show that ERCOT is not meeting its mission in set reliability and efficiency. Suggest legislation should pass laws to help in Texas' electricity market.
Prez-Arriaga et al. (2017)	Summarized two years of findings that focus on various elements of the electricity industry.	No formal theory	Discusses 16 recommendations for improvements in the industry.	Recommendations include enabling efficient power services for distributed and centralized energy resources and eliminating obstacles and market flaws.
Sanyal and Ghosh (2013)	Examined the deregulation shift of innovation activities from technology suppliers.	Escape competition, appropriation effect	Difference in differences (DID) using patents.	The decline in the quality of patents since deregulated the electricity market.
Schuler (2001)	Analyzed transmission capacity and consumers' price options in a deregulation energy market.	No formal theory	Simulation experiments	Changes in the market by expanding it could increase more small-scale innovations to build up the market or create more generations.
Borenstein and Bushnell (2015)	Analyzed the elements of restructuring in the deregulated electricity market.	No formal theory	Empirical approach	Finds a decline in some renewables since deregulation.
Sevi (2004)	Examined the environmental effects of a	No formal theory	Empirical approach focusing on uncertainty	Not having sufficient R&D can lead to changes in

Study	Research Question	Theories	Methodology	Key Finding(s)
	deregulated electricity market.			sustainability in the electricity market.
Smith (1988)	Gave historical background on electricity deregulation.	No formal theory	Literature review	Rate-of-return regulation failures reveal least-cost discipline challenges, with competition and alternative power sources impacting rates and asset restructuring.
Stokes (2015)	Compared Ontario, California and Texas policy and renewables in the electricity market.	No formal theory	Review	In-depth political case studies are crucial for understanding policy decisions affecting energy system transformation, renewable energy policies, and utilities' economic models. Combating climate change requires institutional change for technological advancement in the electrical sector.
Syed et al. (2020)	Examined the functionality of the smart grids	No formal theory	Review and definitions of smart grid technology	This paper gives an overview of how to manage data when using smart grid technology and gives its view of which technology to use in handling data.
Tao et al. (2012)	Examined wind power's effect in the Texas electricity market.	No formal theory	Comparison of installations of wind power in	Incentives like tax credit really drove the expansion of wind energy.

Study	Research Question	Theories	Methodology	Key Finding(s)
			Texas, Iowa and California.	
Wade (1999)	Examined Texas municipal utilities data, examines attitudes, opinions on retail electric competition, and potential differences.	No formal theory	Used a survey to gather information from various officials and offices in the municipal	Senate Bill 7 requires municipal officials to make citizen-affecting decisions.
Walker and Lough (1997)	Examined electricity rates from a global view	No formal theory	Comparisons from various areas of the global	British, Norwegian, Argentinean, and Chilean experiences show limited support for U.S.-style electric utility reform due to their abundant hydroelectric power and privatization of publicly owned facilities. Price reductions after reform may be short-lived, and restructuring may be more difficult due to privately owned utilities.
Wang and Mogi (2017)	Examined nine Japanese utilities analyzed for innovation, deregulation, and market competitiveness.	Schumpeter's theory that is about economic development suggests that big enterprises stimulate innovation, while monopolies promote it due to reduced uncertainty. Competition and innovation studies show inconsistent results, with an	Basic concept model and literature review	Deregulation reduces R&D but boosts patent applications, indicating short-term productivity gain.

Study	Research Question	Theories	Methodology	Key Finding(s)
		inverted-U shape between competitiveness and innovation.		
White et al. (1996)	This article examined economics-backed state-by-state consumer benefits and losses from deregulatory changes.	Stigler hypothesizes that long-lived assets and average-cost pricing cause decreased demand, leading to new plant capital costs.	Empirical approach	Retail choice reform limited to high-price jurisdictions like California, New England, and New York is expected to broaden in the next decade, with additional states having significant consumer incentives.
Wilson and Tyfield (2018)	Examined disruption and disruptive innovation and how they are crucial for energy transformation.	Christensen’s Innovation theory	Ten critical reviews of Christensen's breakthrough innovation concept explored the energy, climate, and discrete business model, analyzing.	Suggests further research should be done on disruptive innovation and energy transformation, considering social, systemic, emissions, and distributional effects.
Woo et al. (2006)	Documented and analyzed challenges in deregulatory initiatives and lessons learned.	No formal theory	Comprehensive literature review	Questions restructuring's viability in global deregulation study suggests governments pursue deregulation to address constraints.

Theoretical Background

To develop the current study’s research model and hypotheses, the researcher drew on Schumpeter’s theory of creative destruction, Contestability theory, and Christensen’s disruptive innovation theory. This section provides a brief overview of the theories used for developing the hypotheses.

Joseph Schumpeter's Theory of Creative Destruction

Schumpeter's theory of innovation suggests innovation as a driving force for economic growth. This theory focuses on the part played by firms that bring forth novel goods, procedures, or business plans that interrupt the patterns of instituted markets and outdated technology. Schumpeter (1942) called this process of constant innovation and replacement creative destruction.

Several studies have investigated Schumpeter's theory related to deregulation and innovation. Wang and Mogi (2017) studied the correlation between deregulation, innovation, and competition by using patents to measure innovation in the Japanese electricity market. Findings indicated that deregulation and increased competition drove firms to decrease spending in research and development for firms but showed an increase in the quality and application of patents.

Agyeman and Lin (2023) examined negative emission technology, focusing on carbon capture and storage affected by deregulation in the electricity industry. The study focused on the European market and discovered that deregulatory policies could mitigate climate change by promoting innovation in carbon capture and storage (CCS) and renewable energy. Schumpeter's theory, which highlights market rivalry's role in fostering innovation, is consistent with this conclusion.

Marino et al. (2019) also studied the European market, focusing on the impact of deregulation innovation. The research indicated that deregulation lowered the number of patents, making the market more contestable. However, the authors discovered evidence of an inverse U-shaped link between regulation and innovation, indicating that the impact of deregulation on innovation was contingent upon the original configuration of regulation. This finding is consistent with Schumpeter's theory, which holds that a balance between market power and competition best supports innovation.

These studies reveal that the link between deregulation and innovation in the electricity industry is far from straightforward. The effects of deregulation can vary significantly depending on the specific market conditions. While deregulation might lead to short-term benefits like lower prices and increased competition, weighing these against potential long-term consequences for sustainability and investment in new technologies is crucial.

Christensen's Disruptive Innovation

Christensen's theory of disruptive innovation expands upon Schumpeter's idea. The disruptive innovation theory states that established businesses are susceptible to being surpassed by new entrants who offer easier-to-use, more reasonably priced, and frequently subpar goods or services that initially appeal to a niche market. Christensen first presented this theory in his 1997 book *The Innovator's Dilemma*. These disruptive technologies improve with time and finally replace the incumbent's products.

This theory has been used in understanding deregulation of the Texas electricity market through disruptive innovation. McCalley (2006) examined the effects of deregulation on the retail electricity market in Texas, a move that opened the market to new companies called Retail Electric Providers (REPs). These REPs offered innovative services like diverse pricing plans, renewable energy options, and enhanced customer support, disrupting the established utility model. This case aligns with Christensen's theory of disruptive innovation, where new entrants offer alternative solutions that appeal to a specific niche. In this context, REPs cater to consumers seeking choices and sustainable energy options.

The study found that the emergence of REPs pressured existing utility companies to adapt and innovate to remain competitive. Green Mountain Energy, a REP specializing in renewable energy, is a prime example of successful market disruption, gaining substantial market share due to its focus on renewable energy. The study concluded that deregulation fostered competition and innovation in the Texas electricity market, benefiting consumers through increased choice and improved services.

Another example of deregulation in innovation is a study by Pollitt (2019), which examined how deregulation in the electricity sector has spurred the growth of Distributed Energy Resources (DERs) like solar panels and home batteries. This aligns with Christensen's theory of disruptive innovation, as DERs offer a simpler, consumer-centric alternative to the traditional power grid. Deregulation fostered competition, allowing companies like Sunnova and Tesla to thrive in this market. The rise of DERs signifies a potential shift toward a more decentralized and resilient energy system.

These examples illustrate the potential of deregulation to ignite disruptive innovation. By dismantling barriers to entry and fostering a more competitive landscape, deregulation empowers new players to challenge established incumbents. This intensified competition acts as a catalyst, driving innovation and benefiting consumers through enhanced products, services, and lower prices.

Contestability Theory

The contestability hypothesis was developed by economists Baumol et al. and focused on prospective market players rather than present or past market participants in order to maximize market efficiency (Bailey & Baumol, 1983). According to the theory of contestable markets, incumbents may be forced to act competitively by the prospect of new entrants, even in industries with a small number of dominant businesses. This could result in lower pricing and more innovation. This is particularly important in markets that have been deregulated when entry barriers are reduced (Bailey & Baumol, 1983).

Joskow and Tirole (2016) examined how deregulation and competition influenced Texas's Electric Reliability Council of Texas-managed wholesale energy market. According to contestable market theory, competition can force incumbent firms to lower prices and innovate even in markets with few dominant companies. Generators compete to sell power in deregulated Texas' ERCOT-managed wholesale market. The paper states Texas wholesale electricity costs were cheaper than those of regulated markets due to their competitive structure. The study found that competitive forces lowered Texas wholesale electricity prices 20% below the national average. This study showed that deregulation and competition lower customer prices, proving contestability. Competitive wholesale markets have cut Texas power system costs and enhanced efficiency.

After deregulation, Borenstein (2002) examined U.S. electricity market retail competitiveness. Contestability theory promotes market entry and price deregulation. This concept suggests that new entrants can compel incumbents to compete in small markets. Since retail electricity market deregulation lowered entry barriers, new REPs may compete with utilities. The author indicated REPs offered a number of schemes, including 100% renewable energy, to attract clients. To compete, incumbent utilities had to develop and provide similar choices, giving consumers more choice and possibly reduced pricing. The study supports contestability theory by showing that deregulation generates a more competitive environment where new entrants innovate and bring consumers more choice and reduced pricing.

These examples showcase how deregulation can stimulate a vibrant and competitive environment. By reducing or eliminating regulatory barriers, deregulation paves the way for new businesses to enter the market and challenge established players. This heightened competition forces all firms to innovate and improve their offerings to attract customers, ultimately leading to lower prices, increased choices, and improved quality for consumers.

Hypothesis Development

Prior studies have shown mixed results with regard to the impact of deregulation in the energy sector. Proponents of deregulation argue that it can lead to better innovations. For example, Agyeman and Lin (2023) suggested that deregulation can lead to market liberalization, which has the potential to foster innovation as a strategic response for competitive advantage. Similarly, Gencer et al. (2020) argued that there exists a dynamic relationship between electricity markets and regulation, where deregulation has the potential to create an environment that is conducive to innovation.

However, some studies suggested that deregulation could negatively impact the energy sector. For example, Delmat and Tokat (2005) argued that deregulation can hamper efficiency, which may result in stifling innovation. Similarly, Smith (1998) and Newbery (2002) argued that the unintended consequence of liberalizing the power business and deregulation was inhibiting innovation. Additionally, Bolinger and Wiser (2009) suggested that deregulation will harm innovation.

In the current study, the researcher drew on Schumpeter’s Theory of Creative Destruction (1942), Christensen’s disruptive innovation theory (1997), and contestability theory to state that deregulation will positively impact innovation. Schumpeter’s Theory of Creative Destruction suggests that innovation is essential for economic growth, and this happens through the development of new technologies and business models that can replace old ones (Schumpeter, 1942). Along the same lines, Christensen’s Theory of Disruptive Innovation posits that easily accessible, cheap, and simple technologies have the potential to disrupt established markets (Christensen, 2015). Contestability theory examines the circumstances under which markets are contestable. This theory suggests that the threat of potential entry by new firms has the potential to keep prices competitive and foster innovation (Bailey & Baumol, 1983).

Deregulation can potentially lessen the barriers to entry, which Christensen (1997) and Schumpeter (1942) contended is was critical for nurturing innovation. Further, contestability theory posits that deregulation has the potential to make markets more contestable, thereby increasing competition. Electric companies facing high competition may resort to innovation to hold onto their market position. Further, Schumpeter's and Christensen's theories suggest that a well-established firm must be innovative to survive deregulation (Christensen, 1997; Schumpeter, 1942). Even well-established electric companies may have to produce new technologies in order to be competitive in a deregulated environment.

Thus, in the state of Texas, energy deregulation can lower the barriers to entry for new firms and increase competition among existing firms. Firms may be required to be innovative to be competitive. Regardless of whether a company is situated in a regulated area or deregulated area, when faced with deregulation, companies may opt for innovation to stay ahead of their competitors. This led to the hypotheses:

H1: Deregulation will have a positive impact on innovation in deregulated areas in the state of Texas.

H2: Deregulation will have a positive impact on innovation in regulated areas in the state of Texas.

The next chapter contains a discussion of the research methodology for evaluating these hypotheses.

CHAPTER III

METHODOLOGY

This chapter outlines the research methods employed to investigate the hypotheses put forth in Chapter II. It offers a comprehensive look at the data sources that informed the study, the careful process of selecting the sample, the specific variables examined, and the overall research design. By providing these details, the chapter aims to give a clear picture of how the research was conducted and how the hypotheses were tested.

Data Sources

This study used two different sets of data. The first set of data was from the United States Energy Information Administration (EIA) (Energy Information Administration, 2000). This data is surveyed annually and collected from approximately 1,700 utility firms in electricity from the United States. The data, ranging from 1990 – 2022, has over 1,000,000 records that are categorized by advanced metering, balancing authority, delivery companies, demand response, distribution systems, dynamic pricing, energy efficiency, mergers, net metering, non-net metering, operational data, sales to ultimate customers, sales to ultimate customers – customers-sited, service territory, short form, utility data, demand-side management (DSM), and green pricing. In this study, four main groups, delivery companies, operational data, sales to ultimate customers, and sales to ultimate customers – customers-sited, were used to construct the base of the firms to be analyzed.

The second dataset utilized in this research originated from the United States Patent and Trademark Office (USPTO). This data set encompassed a vast collection of patent data, ranging from 1976 to 2022, and was obtained from csv.zip and annualized files. This extensive dataset comprised numerous files and records, each containing valuable information about patents. To provide a comprehensive overview of this data, a detailed breakdown of its contents can be found in Table 3 within Chapter II. This table serves as a roadmap to navigate the wealth of information within this dataset, aiding in understanding its structure and relevance to the study. (Graham, et al., 2018; United States Patent and Trademark Office, 2024). (Please see Table C in Appendix.)

Sample Selection

The models in this study were structured similarly to the models of Bessen (2009) and Gao (2014). The EIA data was parsed to provide the firms that served Texas accounts for approximately 410 firms and 72,089 records from 1990-2022. The data were categorized into three variables: revenues in terms of thousands of dollars, sales in terms of megawatt hours, and the customer count for each firm (Energy Information Administration, 2000). The entity names matched the EIA data to the USPTO data. A master key list of entities' names was created to ensure each firm's entity names were accounted for.

The firms were categorized as either regulated or deregulated firms. The classification used the subtitles in the EIA data column named EIA_OWN_STUCTURE. The firms that were classified as regulated were those labeled cooperatives, municipal, transmission and distribution, and unregulated. These firms were identified as operating under set rules established by a governing entity. The firms were identified as behind-the-meter, investor-owned, and retail electric providers. These firms were identified as offering various services and are highly competitive (Joskow, Lessons learned from electricity market liberalization, 2008; Puller, 2007; Zarnikau, 2010). Each observation is marked as 0 (regulated – control group) or 1 (deregulated group – treated**).**

Table 4

Variable Construction

Variable	Type	Description
DEREG_IMMEDIATE (2002)	Explanatory	Denotes the immediate impact of deregulation in the year 2002. Uses the years 2002 and the immediate year after 2003.
DEREG_AFTER (2002)	Explanatory	Denotes the after impact of deregulation in the year 2002. This uses the years 2004 to 2006.
DEREG_IMMEDIATE (2007)	Explanatory	Denotes the immediate impact of deregulation in the year 2007. Uses the years 2007 and the immediate year after 2008.
DEREG_AFTER (2007)	Explanatory	Denotes the after impact of deregulation in the year 2007. This uses the years 2009 to 2011.
INNOVATION = #Patents	Dependent	Denotes the number of patents that is filed by a firm *i* in year t, a count variable

INNOVATION = #Citations	Dependent	Denotes the number of citations that is filed by a firm *i* in year t, a count variable
log(REVENUE in $thousands)	Control	The natural logarithm of firm's revenue measured in thousand dollars
log(SALES in MWh)	Control	The natural logarithm of sales, measured in megawatt-hours (likely relevant for energy industries).
log(#CUSTOMERS)	Control	The natural logarithm of the number of customers.

Data Analysis

The dependent variable, the number of patent applications, used in this study was a discrete non-negative count datum. Therefore, Poisson regression analysis was used to test the hypotheses. Poisson regression is a generalized linear model (GLM) used for analyzing count data. It models the relationship between the expected count of events and a set of predictor variables (Cameron & Trivedi., 2013; Cameron, 2022). Specifically, it assumes that the logarithm of the expected count is a linear function of the predictor variables (Cameron & Trivedi, 2013). The Poisson regression model for the study is as follows:

$$\log\,(INNOVATION_{i,t}) = \alpha + \beta_1 \times DEREG\_IMMEDIATE_t^k + \beta_2 \times DEREG\_AFTER_t^k + \boldsymbol{\Gamma} \times \boldsymbol{Z_{i,t}} + \varepsilon_{it}; \qquad (1)$$

where,

$INNOVATION_{i,t} = \#Patents_{i,t}$ or $\#Citations_{i,t}$ – the number of patent applications or citations for firm *i* in year *t*,

$DEREG\_IMMEDIATE_t^k$ and $DEREG\_AFTER_t^k$ are the deregulation years indicators for the deregulatory event *k*, and

$\boldsymbol{Z_{i,t}}$ is the vector control variables – e.g., log(*REVENUE*), log(*SALES*), and log(*CUSTOMERS*).

There were two deregulatory events, one in the year 2002 and another in the year 2007. For each deregulatory event *k* in year *s*: $DEREG\_IMMEDIATE_t^k$ equals one for years *s* and *s* +1, and zero otherwise; and $DEREG\_AFTER_t^k$ equals one for years *s* +2 to *s* +4. The model is estimated for each event *k* =1, 2 (2002 and 2007, respectively), and separately for the subsamples of *deregulated* companies to test *H1* and *regulated* companies to test *H2* (Cameron & Trivedi, 2013; Cameron, 2022; Hausman, 1984).

Prior studies have shown firm characteristics to be an important predictor of innovation (Bailey & Baumol, 1983; Bolinger & Wiser, 2009; Gao, 2014; Delmas & Tokat, 2005; Schumpeter, 1942). The focus of this study was to examine the impact of deregulation on innovation. Therefore, the researcher controlled for firm characteristics. The indicators used for firm characteristics in the current study were *Revenue, Sales,* and *Customers.*

CHAPTER IV

RESULTS

This chapter presents the core findings of the study. It begins by providing a clear summary of the data's key features. Next, it explores the tests' results to check the study's main ideas, showing how different factors are connected. Finally, it highlights additional tests that prove the findings are solid and reliable, even if there are changes or uncertainties. This chapter summarizes the entire research process, offering valuable insights and opening doors for future research in this area.

Descriptive Statistics

Table 5

Descriptive Statistics Table

Variable	Observations	Mean	Standard deviation	Min	Max
Number of patents	6,185	1.018432	28.8634	0	1727
Number of citations	6,185	0.536459	16.53221	0	1006
Total Revenue (thousand dollars)	6,183	165602.4	590634.3	0	7747741
Total Sales (megawatt hours)	6,151	1960695	7812227	0	1.49E+08
Customer Count	6,109	59881.37	233967.5	0	3867910

As seen from Table 5, there were a total of 6,185 observations. The maximum number of patents filed by a company is 1727, with an average of 1.02 per entity with a standard deviation of 28.86. The average number of citations per patent is around 0.54 with a wide range from 0 to 1006 with a standard deviation of 16.53. The average Total Revenue (thousand dollars) is $165.6 million, with a standard deviation of $590.6 million, and the maximum value $7.75 billion. Total Sales (megawatt hours) had an average of 1.96 million MWh and a maximum exceeding 149 million MWh. Customer Count had an average customer base of around 59,881, and the range is from 0 to 3.87 million.

Table 6

Correlation Table

	Number of patents	Number of citations	Total Revenue (thousand dollars)	Total Sales (megawatt hours)	Customer Count
Number of patents	1				
Number of citations	0.9903	1			
Total Revenue (thousand dollars)	-0.0088	-0.0081	1		
Total Sales (megawatt hours)	-0.0076	-0.0069	0.8914	1	
Customer Count	-0.0091	-0.0084	0.9306	0.9533	1

Table 6 provides the correlation among the variables used in the study. As seen from the table, there is a high correlation between the control variables used in the current study. Therefore, the researcher had a separate regression model for each control variable.

Deregulation and Innovation: Main Findings

Table 7 provides the results of hypothesis H1. As suggested in the methodology section, for measuring innovation, the researcher examined the number of patents that were filed. Columns (1), (2), and (3) examine the impact of deregulation on innovation for the year 2002. Columns (4), (5), and (6) examine the impact of deregulation on innovation for the year 2007. Further, Column (1) and Column (4) include log (revenue) as the control variable. Column (2) and Column (5) include log (sales) as the control variable. Column (3) and Column (6) include log (customer) as the control variable.

Table 7

H1. The Impact of deregulation on innovation in deregulated areas (2002 and 2007)

	(1) INNOVATION = #Patents	(2) INNOVATION = #Patents	(3) INNOVATION = #Patents	(4) INNOVATION = #Patents	(5) INNOVATION = #Patents	(6) INNOVATION = #Patents
INNOVATION = #Patents						
DEREG_IMMEDIATE (2002)	-5.099^{***} (0.724)	-5.103^{***} (0.725)	-5.454^{***} (0.715)			
DEREG_AFTER (2002)	-19.589^{***} (1.016)	-19.236^{***} (1.015)	-20.656^{***} (0.993)			
DEREG_IMMEDIATE (2007)				1.218^{***} (0.101)	1.186^{***} (0.092)	1.042^{***} (0.175)
DEREG_AFTER (2007)				2.225^{***} (0.086)	2.201^{***} (0.076)	2.213^{***} (0.169)

log(REVENUE in)	-0.067* (0.026)			-0.090** (0.031)		
log(SALES in MWh)		-0.012 (0.028)			-0.020 (0.032)	
log(#CUSTOMERS)			-0.372*** (0.038)			-0.367*** (0.047)
Constant	2.173* (1.019)	1.644 (1.044)	3.600*** (0.969)	1.354 (1.027)	0.712 (1.059)	2.500* (0.979)
Observations	1421	1420	1424	1421	1420	1424
Pseudo R^2	0.0361	0.0328	0.2211	0.1044	0.0986	0.2765

Standard errors in parentheses

$^{\$}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Hypothesis H1 suggests that there exists a positive relationship between deregulation and innovation in deregulated areas. The researcher examined the impact of innovation immediately after deregulation in 2002, that is the years 2002 and 2003. As seen in Table76, DEREG_IMMEDIATE (2002) had a significant negative impact (p<0.001) on Innovation. The researcher also examined the long-term effect of deregulation in 2002 (includes the years 2004 to 2006), finding that DEREG_AFTER (2002) had a significant negative impact (p<0,001) on innovation. This is contrary to the hypotheses that deregulation would have a positive impact on innovation.

The researcher further examined the impact of innovation immediately after deregulation in 2007, including the years 2007 and 2008. The results were in line with the hypothesis H1 for the year 2007.

As seen from Table 7, DEREG_IMMEDIATE (2007) had a statistically significant positive impact ($p<0.001$) on Innovation. The researcher also examined the long-term effect of deregulation for the year 2007, including the years 2009 to 2011. DEREG_AFTER (2007) had a statistically significant positive impact ($p<0.001$) on Innovation as hypothesized.

Table 7 provides the results of hypothesis H2. As suggested in the methodology section, for measuring innovation, the researcher examined the number of patents that were filed. Columns (1), (2), and (3) examined the impact of deregulation on innovation for the year 2002. Columns (4), (5), and (6) examined the impact of deregulation on innovation for the year 2007. Further, Column (1) and Column (4) include log (revenue) as the control variable. Column (2) and Column (5) include log (sales) as the control variable. Column (3) and Column (6) include log (customer) as the control variable.

Table 8

H2 The impact of deregulation on innovation in regulated areas (2002 and 2007)

	(1) INNOVATION = #Patents	(2) INNOVATION = #Patents	(3) INNOVATION = #Patents	(4) INNOVATION = #Patents	(5) INNOVATION = #Patents	(6) INNOVATION = #Patents

INNOVATION = #Patents						
DEREG_IMMEDIATE (2002)	-16.842*** (0.920)	-16.675*** (0.939)	-18.798*** (0.956)			
DEREG_AFTER (2002)	-3.450* (1.352)	-3.695** (1.361)	-18.750*** (0.960)			
DEREG_IMMEDIATE (2007)				-16.362*** (0.908)	-16.905*** (0.930)	-18.691*** (0.959)
DEREG_AFTER (2007)				-16.636*** (0.901)	-17.062*** (0.927)	-18.683*** (0.964)
log(REVENUE in)	-0.773*** (0.105)			-0.777*** (0.105)		
log(SALES in MWh)		-0.610*** (0.091)			-0.611*** (0.091)	
log(#CUSTOMERS)			-0.292*** (0.027)			-0.287*** (0.027)
Constant	4.552*** (1.249)	4.983*** (1.395)	0.695 (0.931)	4.531*** (1.248)	4.969*** (1.393)	0.641 (0.929)
Observations	4757	4711	4684	4757	4711	4684
Pseudo R^2	0.3851	0.2949	0.1092	0.3817	0.2933	0.1057

Standard errors in parentheses

$^{\$}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Hypothesis H2 suggests that there exists a positive relationship between deregulation and innovation in regulated areas. The researcher examined the impact of innovation immediately after deregulation in 2002, that is, the years 2002 and 2003. As seen from Table 8, DEREG_IMMEDIATE (2002) had a significant negative impact ($p<0.001$) on innovation. The researcher examined the long-term effect of deregulation in 2002, including the years 2004 to 2006, DEREG_AFTER (2002) had a significant negative impact ($p<0,001$) on innovation. This is contrary to the hypotheses that deregulation would have a positive impact on innovation.

The researcher further examined the impact of innovation immediately after deregulation in 2007, including the years 2007 and 2008. As seen in Table 7, DEREG_IMMEDIATE (2007) had a significant negative impact ($p<0.001$) on innovation. The long-term effect of deregulation in 2007 including the years 2009 to 2011, DEREG_AFTER (2007) had a significant negative impact ($p<0,001$) on innovation. This is contrary to the hypotheses that deregulation would have a positive impact on innovation. Thus, although hypothesis H2 provided significant results, the directions were opposite to what was hypothesized.

Robustness Test

As a robustness check, the researcher replaced the number of patents filed with the number of citations for measuring innovation for hypothesis H1. Table 9 provides the results of the robustness test for hypothesis H1. Columns (1), (2), and (3) examine the impact of deregulation on innovation for the year 2002, with innovation being measured by the number of citations. Columns (4), (5), and (6) examine the impact of deregulation on innovation for the year 2007, with innovation being measured by number of citations. Further, Column (1) and Column (4) include log (revenue) as the control variable. Column (2) and Column (5) include log (sales) as the control variable. Column (3) and Column (6) include log (customer) as the control variable.

Table 9

H1: The impact of deregulation on innovation in deregulated areas (2002 and 2007, Poisson)

	(1) INNOVATION = #Citations	(2) INNOVATION = #Citations	(3) INNOVATION = #Citations	(4) INNOVATION = #Citations	(5) INNOVATION = #Citations	(6) INNOVATION = #Citations
INNOVATION = #Citations						
DEREG_IMMEDIATE (2002)	-19.610*** (1.028)	-17.989*** (1.026)	-19.774*** (1.022)			
DEREG_AFTER (2002)	-19.592*** (1.016)	-17.989*** (1.015)	-19.649*** (0.993)			
DEREG_IMMEDIATE (2007)				1.255*** (0.100)	1.225*** (0.092)	1.083*** (0.172)
DEREG_AFTER (2007)				2.347*** (0.086)	2.324*** (0.075)	2.335*** (0.166)
log(REVENUE in)	-0.063* (0.026)			-0.086** (0.032)		
log(SALES in MWh)		-0.006 (0.029)			-0.014 (0.033)	

log(#CUSTOMERS)			-0.364^{***} (0.038)			-0.359^{***} (0.047)
Constant	1.519 (1.019)	0.966 (1.045)	2.963^{**} (0.968)	0.627 (1.029)	-0.048 (1.062)	$1.787^{\$}$ (0.980)
Observations	1421	1420	1424	1421	1420	1424
Pseudo R^2	0.0345	0.0317	0.2054	0.1099	0.1047	0.2688

Standard errors in parentheses

$^{\$}\ p < 0.10$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

As seen from Table 9, the results for hypothesis H1 are very similar to the ones found using the patents filed for measuring innovation. For the year 2002, both DEREG_IMMEDIATE (2002) and DEREG_AFTER (2002) had a significant negative impact (p<0.001) on innovation. For the year 2007, both DEREG_IMMEDIATE (2007) and DEREG_AFTER (2007) had a significant positive impact (p<0.001) on innovation (Table 6).

As a robustness check, the researcher replaced the number of patents filed with the number of citations for measuring innovation for hypothesis H2. Table 9 provides the results of the robustness test for hypothesis H2. Columns (1), (2), and (3) examine the impact of deregulation on innovation for the year 2002, with innovation being measured by the number of citations. Columns (4), (5), and (6) examine the impact of deregulation on innovation for the year 2007, with innovation being measured by the number of citations. Further, Column (1) and Column (4) include log (revenue) as the control variable. Column (2) and Column (5) include log (sales) as the control variable. Column (3) and Column (6) include log (customer) as the control variable.

Table 10

H2: The impact of deregulation on innovation in regulated areas (2002 and 2007, Poisson)

	(1) INNOVATION = #Citations	(2) INNOVATION = #Citations	(3) INNOVATION = #Citations	(4) INNOVATION = #Citations	(5) INNOVATION = #Citations	(6) INNOVATION = #Citations
INNOVATION = #Citations						
DEREG_IMMEDIATE (2002)	-17.405*** (0.983)	-16.790*** (0.991)	-17.164*** (0.998)			
DEREG_AFTER (2002)	-17.007*** (0.981)	-16.785*** (0.987)	-17.108*** (0.997)			
DEREG_IMMEDIATE (2007)				-15.394*** (0.983)	-23.585*** (0.987)	-18.050*** (0.997)
DEREG_AFTER (2007)				-15.775*** (0.978)	-23.752*** (0.986)	-18.036*** (0.997)
log(REVENUE in)	-0.862*** (0.118)			-0.867*** (0.119)		
log(SALES in MWh)		-0.651*** (0.095)			-0.653*** (0.095)	
log(#CUSTOMERS)			-0.298*** (0.026)			-0.293*** (0.025)
Constant	4.057** (1.253)	4.440** (1.390)	-0.098 (1.007)	4.044** (1.253)	4.430** (1.388)	-0.152 (1.005)
Observations	4757	4711	4684	4757	4711	4684

Pseudo R^2	0.4868	0.3469	0.1093	0.4828	0.3441	0.1058

Standard errors in parentheses

$^{\$} p < 0.10$, $^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

As seen from Table 10, the results for hypothesis H2 are very similar to the ones found using the patents filed for measuring innovation. For the year 2002, both DEREG_IMMEDIATE (2002) and DEREG_AFTER (2002) had a significant negative impact (p<0.001) on Innovation. For the year 2007 as well, both DEREG_IMMEDIATE (2007) and DEREG_AFTER (2007) had a significant negative impact (p<0.001) on innovation.

The next chapter contains a detailed discussion of the study results and their implications.

CHAPTER V

DISCUSSION AND IMPLICATIONS

This dissertation investigated how deregulation affected innovation within Texas' electric utility companies. This chapter begins by discussing the key findings of this research. It then highlights the significant contributions and implications of the study, showcasing its potential impact on the industry and future research.

Discussion of Research Findings

Impact of Deregulation on Innovations in Deregulated Areas

Hypothesis H1 proposed that deregulation would have a positive impact on innovation in deregulated areas. The researcher examined two events of deregulation in the state of Texas, one that occurred in the year 2002 and another that occurred in the year 2007. For the year 2002, although enough evidence was found to suggest that deregulation had a significant effect on innovation, it was in the opposite direction. Thus, in the year 2002, deregulation had an opposite effect, that is, deregulation led to a reduction in innovation.

One possible explanation for this is that the initial announcement of deregulation could have caused uncertainty in the electricity sector. This would lead companies to focus on short-term survival rather than long-term innovations. For example, a study conducted by Fabrizio et al. (2007) showed that deregulation in the U.S. electricity sector led to a decrease in labor and non-fuel operational expenditures. Thus, companies, in order to focus on stability and restructuring, may have reduced their spending in R&D, and thus the reduction in innovations.

The current findings, however, are consistent with the hypothesized relationship between deregulation and innovation in deregulated areas for the year 2007. For the year 2007, I found enough evidence to support the hypothesis that deregulation had a positive impact on innovation. This is in line with prior studies that suggest deregulation can foster innovations (Agyeman & Lin, 2023; Marino et al., 2019). Firms take advantage of deregulation to develop new digital technologies and introduce new business models that can help them stay ahead of their competitors (Gencer et al., 2020).

Contradictory findings resulted for the first hypothesis for the years 2002 and 2007. Thus, the first deregulation in the year 2002 may not have been sufficient for the companies to foster innovation. On the contrary, it had a negative effect wherein electric utility companies may have been more concerned about their short-term survival and stability rather than focusing on innovation. This may have led to the subsequent additional deregulation in 2007, within just a short span of five years. This deregulation, however, did have the intended consequence, wherein electric utility companies focused on innovation.

Impact of Deregulation on Innovation in Regulated Areas

Hypothesis H2 proposes that deregulation would have a positive impact on innovation in regulated areas. In the state of Texas, the researcher examined two events of deregulation, one that occurred in 2002 and another that occurred in 2007, for regulated areas. For both years, although enough evidence was found to suggest that deregulation had a significant effect on innovation, it was in the opposite direction. These findings are interesting, as it was expected that deregulation would have a positive impact on innovation.

One of the reasons for this could be that in regulated areas electric utility firms may not be subjected to high competition; thus, there may not be enough incentives for them to innovate (Jamasb & Pollitt, 2008). Further, in regulated areas, utility companies may be more risk averse (Jamasb & Pollitt, 2011). Thus, rather than investing in new innovations, they may focus more on reliable technologies. Utilities usually have a definite fixed rate on return on investments in regulated areas (Jamasb & Pollitt, 2015). Therefore, they may not be motivated to invest in disruptive innovations.

Research Contributions and Implications

This study has theoretical and practical implications. From a theoretical perspective, it contributes to the literature on the impact of deregulation on innovation in the energy industry in United States, specifically in the state of Texas. Further, this study shows that Schumpeter's theory of creative destruction, Christensen's innovation theory, and contestable theory can be used as strong bases for understanding the impact of deregulation on innovation.

The results obtained in this dissertation also have practical implications. The results showed that deregulation in 2002 had a negative impact on innovation; however, deregulation in 2007 had a positive impact on innovation. Therefore, regulatory agencies in charge of policy making can examine the policy changes that occurred during 2002 and 2007 and can introduce deregulation policies that can improve innovations. Further, the results also indicated that innovation went down in regulated areas, suggesting to regulatory agencies that deregulation has the potential to improve innovation in energy sectors. The results are also relevant to electric utility company managers. Electric utility company managers can examine the policy changes that occurred in 2002 and 2007 and be prepared to strategize and foster innovation in the event of future deregulatory policies.

CHAPTER VI

CONCLUSION

This dissertation examined the impact of deregulation on innovation in the Texas electricity market. This chapter will present the limitations of this study. It will then conclude by providing directions for future research.

Limitations of this Study

This study is subject to some limitations with respect to its generalizability. The focus of this study was the impact of deregulation on innovation in the state of Texas. Thus, generalizability of the results to other states may be an issue. Therefore, other states deciding on deregulation policies to foster innovation should examine other characteristics affecting innovation.

Another limitation may be related to the data collection method used to conduct this study. This study used publicly available datasets on the USPTO and EIA website. These are still survey data. While these data can provide valuable insights, they are still subject to potential biases. Thus, future studies in this area should focus on collecting proprietary data and using a multi-trait, multi-method approach to provide deeper insights. Finally, this study focused on the effects of deregulation on innovation in the Texas electricity market. However, the broader phenomenon of deregulation is complex and multifaceted. Factors not considered in this study, such as the shift and history of large monopolies, the impact of laws through the time period, operational costs, and other such financial factors, may contribute to the observed outcomes.

Future Research Directions

This study investigated the impact of deregulation on innovation in the state of Texas. Expanding this study to other states with similar characteristics is a future research direction. Further, this study only examined the relationship between deregulation and innovation and did not consider other factors that can also influence innovation, such as competition and monopolies. Thus, one avenue of future research is to examine the mediating effect of competition and monopolies on the relationship between deregulation and innovation. This would provide a greater understanding of whether deregulation directly influences innovation or whether it influences competition, which in turn fosters innovation. Furthermore, in this study, the number of patents filed acted as a surrogate measure for innovation. Another avenue for future study would be to examine the actual innovation that occurred due to deregulation.

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APPENDIX

Appendix A: Definition of Terms

The following terms are used throughout this study.

Term	Acronym	Definition
Electric Reliability Council of Texas	ERCOT	The Electric Reliability Council of Texas (ERCOT) oversees electricity distribution to over 26 million customers in Texas, accounting for approximately 90 percent of the state's total electricity demand. ERCOT, as the independent system operator for the region, manages the scheduling of power on an electric grid that encompasses over 52,700 miles of transmission lines and 1,100 generation units, which includes private-use networks. Additionally, it carries out financial settlement for the highly competitive wholesale bulk-power market. It manages retail switching for a total of 8 million locations in areas where consumers have the option to choose their energy provider. ERCOT is a 501(c)(4) nonprofit corporation that operates on a membership basis. A board of directors governs it and is accountable to the Public Utility Commission of Texas and the Texas Legislature. The organization comprises diverse participants, including consumers, cooperatives, power generators, power marketers, retail electric providers, investor-owned electric utilities, transmission and distribution providers, and municipally owned electric utilities (ERCOT, 2023)
Federal Energy Regulatory Commission	FERC	The Federal Energy Regulatory Commission (FERC) is the governing body responsible for overseeing and regulating the sale of electricity across state lines, determining wholesale electricity prices, granting licenses for hydroelectric power projects, setting prices for natural gas, regulating rates for oil pipelines, and certifying gas pipelines. FERC is an autonomous regulatory agency operating under the Department of Energy and is the successor to the Federal Power Commission (ENERGY INFORMATION ADMINISTRATION, WASHINGTON & DC. OFFICE OF ENERGY MARKETS AND END USE, 2000).
Independent System Operator	**ISO**	An autonomous, federally overseen organization created to manage regional transmission fairly and impartially and guarantee the security and dependability of the electrical grid (ENERGY INFORMATION ADMINISTRATION, WASHINGTON & DC. OFFICE OF ENERGY MARKETS AND END USE, 2000)
Investor-Owned Utilities	**IOU**	An IOU refers to a privately owned electric utility company offering stock shares to the public for trading. The entity is subject to rate regulation and has been granted authorization to achieve a specified rate of return. is a privately owned electric utility whose stock is publicly traded. It is rate-regulated and authorized to achieve an

		allowed rate of return. (ENERGY INFORMATION ADMINISTRATION, WASHINGTON & DC. OFFICE OF ENERGY MARKETS AND END USE, 2000)
Organization for Economic Cooperation and Development	**OECD**	The OECD is an international organization that helps governments tackle the economic, social, and governance issues that arise from a globalized economy. This organization has a membership of around 30 countries. Its extensive network of connections with around 70 other countries, non-governmental organizations (NGOs), and civil society gives it a worldwide presence. With its active collaborations with civil society, non-governmental organizations (NGOs), and approximately 70 other nations, it possesses a global presence. The OECD is a global organization that helps governments tackle the economic, social, and governance issues that arise from a globalized economy. Its membership consists of approximately thirty countries. It has achieved a global presence through its active collaborations with civil society, non-governmental organizations (NGOs), and approximately 70 other countries. (ENERGY INFORMATION ADMINISTRATION, WASHINGTON & DC. OFFICE OF ENERGY MARKETS AND END USE, 2000).
Public Utilities Commission	**PUC**	The Public Utility Commission (PUC) in the United States regulates the rates and services offered by utility companies. More precisely, it refers to a governmental organization that may be referred to by various names, such as the Utilities Commission (UC), Public Services Commission (PSC), or Utility Regulatory Commission (URC) (Electric Choice, 2022).
Retail Energy Provider	**REP**	Retail energy providers (REPs) are a significant category of companies that should be acknowledged in energy markets. REPs, also referred to as competitive retail electric service providers or CRES, offer energy consumers the opportunity to buy electricity in bulk from power plants that their current electric utility company does not provide.

Table B

Texas Regulated and Deregulated Cities Form the Current Electricity Plans. (Electricity Plans, 2023)

Deregulated Cities (390)
Abilene, Addison, Alamo, Albany, Aledo, Alice, Allen, Alpine, Alvarado, Alvin, Alvord, Andrews, Angleton, Anson, Aransas Pass, Archer City, Argyle, Arlington, Arroyo City,Aspermont,Athens,Atlanta,Aubrey,Austwell,Azle,Bacliff,Baird,Balch Springs, Ballinger,

Balmorhea, Barksdale, Bay City,Baytown,Bedford,Beeville,Bellaire,Bellmead,Belton,Benbrook,Big Lake, Big Spring, Bishop, Blooming Grove, Bonham, Booker, Brackettville, Brazoria, Breckenridge, Bronte, Brookshire, Brownwood, Buffalo, Burkburnett, Burleson, Cameron, Canton, Carrizo Springs, Carrollton, Cedar Hill, Cedar Park, Centerville, Channelview, Childress, Christoval, Cisco, Clarendon, Clarksville, Cleburne, Clifton, Clute, Clyde, Collinsville, Colorado City, Columbus, Comanche, Commerce, Comstock, Cooper, Coppell, Copperas Cove, Corpus Christi, Corsicana, Cotulla, Crane, Crockett, Crosby, Cross Plains, Crossroads, Crowell, Crystal City, Cypress, Dallas, De Leon, De Soto, Decatur, Deer Park, Del Rio, Denison, Devine, Diboll, Dickens, Dickinson, Dilley, Donna, Dublin, Dumas, Duncanville, Eagle Lake, Eagle Pass, Early, Eastland, Eden, Edgewood, Edinburg, Edna, Edom, Egypt, El Campo, Eldorado, Electra, Elgin, Ennis, Escobares, Etoile, Euless, Eustace, Falcon Heights, Falfurrias, Farmers Branch, Flint, Flo, Forest Hill, Forney, Fort Davis, Fort Stockton, Fort Worth, Freeport, Freer, Frisco, Fulton, Gainesville, Galena Park, Galveston, Gatesville, George West, Goliad, Graford, Graham, Granbury, Grand Prairie, Grandview, Grapevine, Gun Barrel City, Hallettsville, Haltom City, Hamilton, Hamlin, Harker Heights, Harlingen, Haskell, Hebbronville, Henrietta, Hidalgo, Hillsboro, Hitchcock, Houston, Hubbard, Hudson, Humble, Huntington, Hurst, Hutchins, Ingleside, Iraan, Irving, Italy, Jacksboro, Jersey Village, Jewett, Johnson City, Jourdanton, Junction, Karnes, City, Katy, Kaufman, Keene, Keller, Kemah, Kennedy, Kermit, Killeen, Kingsville, Knox City, La Feria, La Marque, La Porte, Lacy Lakeview, Ladonia, Laguna Park, Lajitas, Lake Jackson, Lake Whitney, Lake Worth, Lamesa, Lancaster, Laredo, League City, Leakey, Leona, Lewisville, Lindale, Liverpool, Log Cabin, Los Fresnos, Lufkin, Lytle, Mabank, Magnolia, Malakoff, Malone, Manor, Mansfield, Marfa, Mathis, Mc Allen, Mc Gregor, Mc Kinney, Memphis, Menard, Mercedes, Merkel, Mesquite, Midland, Midlothian, Milano, Milford, Mineral Wells, Mission, Monahans, Muenster, Munday, Nacogdoches, Nassau Bay, Neches, Nocona, North Richland Hills, Northlake, Odem, Odessa, Olney, Orange Grove, Ozona, Paducah, Paint Rock, Palacios, Palestine, Palmer, Palmview, Paris, Pasadena, Pearland, Pearsall, Pecos, Penitas, Perryton, Pharr, Pilot Point, Plano, Pleasanton, Port Aransas, Port Isabel, Port Lavaca,

Port Mansfield, Port O Connor, Portland, Pottsboro, Prairie View, Premont, Presidio, Quanah, Quinlan, Quintana, Rachel, Rainbow, Rancho Viejo, Ranger, Rankin, Raymondville, Red Oak, Refugio, Reklaw, Richardson, Richland, Richland Hills, Richmond, Rio Grande City, Rio Hondo, Riviera, Riviera Beach, Roanoke, Robert Lee, Rockdale, Rockport, Rocksprings, Rockwall, Roma, Rosenberg, Rotan, Round Rock, Round Top, Rowlett, Royse City, Ruidosa, Rule, Sabinal, Saginaw, Saint Jo, Salado, San Angelo, San Benito, San Juan, San Leon, Sandia, Santa Anna, Sargent, Seabrook, Seadrift, Seagoville, Sealy, Seguin, Shamrock, Sheffield, Sherman, Sinton, Snyder, Sonora, South Houston, South Padre Island, Spearman, Spring, Springtown, Spur, Stafford, Stamford, Stephenville, Sugar Land, Sulphur Springs, Surfside Beach, Sweetwater, Synder, Taft, Taylor, Temple, Terlingua, Terrell, Texas City, The Colony, Three Rivers, Throckmorton, Tivoli, Tomball, Tuleta, Tyler, Uvalde, Van, Van Alstyne,Vernon,Victoria,Waco,Waxahachie,Webster,Wellington,Weslaco,West Columbia, West Tawakoni, Westlake, Wharton, White Settlement, Whitewright, Whitney, Wichita Falls, Wills Point, Wimberley, Winters, Wolfe City, Woodway, Yantis, Yorktown, Zapata, Zavalla
Regulated Cities (69)
Bartlett, Bastrop, Bellville, Boerne, Bowie, Brady, Brenham, Bridgeport, Brownfield, Brownsville, Bryan, Burnet, Caldwell, Castroville, Coleman, College Station, Cuero, Denton, Electra, Farmersville, Flatonia, Floresville, Floydada, Fredericksburg, Georgetown, Giddings, Goldsmith, Golthwaite, Gonzales, Granbury, Greenville, Hallettsville, Hearne, Hemphill, Hempstead, Hondo, Jasper, Kerrville, Kirbyville, LaGrange, Lampasas, Lexington, Liberty, Livingston, Llano, Lockhart, Lubbock, Luling, Mason, New Braunfels, Newton, Robstown, San Antonio, San Augustine, San Marcos, San Saba, Sanger, Schulenburg, Seguin, Seymour, Shiner, Smithville, Timpson, Tulia, Waelder, Weatherford, Weimar, Whitesboro, Yoakum

Partially Regulated Cities (2)
Austin, Garland

Table C

United States Patent and Trademark Data Variables

File Name – assignee.csv (from csv.zip) – 6,154,150 records	
Variable Name	Description
rf_id	Reel Frame ID Number
ee_name	Patent Assignee Name = Entity Assigned TO
ee_address_1	Patent Assignee Address Line 1
ee_address_2	Patent Assignee Address Line 2
ee_city	Patent Assignee City
ee_state	Patent Assignee State
ee_postcode	Patent Assignee Postal Code
ee_country	Patent Assignee Country
patent_number	The patent's identification number. All bulk datasets contain the patent number, which we utilized to generate the annualized datasets.
grant_year	The year in which a patent was granted
application_number	The application number assigned to the granted patent
application_year	Denotes the year in which the granted patent was applied for.
d_assignee	Equal to one if that patent observation has assignee information.
d_location	Equal to one if that patent observation has location information on the assignee(s)
assignee	The name of the organization or individual that owns the corresponding patent at the date of issuance.

assignee_ind	Equal to one if the assignee is an individual and 0, otherwise. The vast majority of assignees are organizations
country	The country where the assignee is located.
city	The city where the assignee is located.
state	The state in which the assignee is located, if in the United States.
county	The county where the assignee is located, if in the United States.

CURRICULUM VITAE

Millicent D. Delaney

millicentdelaney@gmail.com

EDUCATION

- M.B.A. – Business Administration, Keller Graduate School of Management, Irving Texas, 2013
- B.S. Mechanical Engineering, The University of Tulsa, Tulsa, Oklahoma, 2002

WORK EXPERIENCE

- Company: Oncor Electric Delivery, LLC
  Position: CI Consultant Analyst, 2013 – Present
  Job: Benchmarking company data for analysis

- Company: Oncor Electric Delivery, LLC
  Position: Engineer, 2002 – 2013
  Job: Design, plan, and analyze load shed for the electric grid

PROFESSIONAL, TECHNICAL AND WORK-RELATED EXPERIENCE AND SKILLS

- Skilled in analytic tools such as Tableau, Alteryx, Minitab, Smartsheet, and Simul8
- Lean Six Sigma Greenbelt trained (certification expected – 2025); Yellow belt, certification - 2023)
- Skilled in Project Management
- Proficient in Data Analysis
- Skilled in Microsoft Office Suite (Word, PowerPoint, Excel)

PUBLICATIONS AND PRESENTATIONS

Adams, N. A., Delaney, M., Goldsberry, T., & Bell, R. L. (2023). Gaslighting Female Leadership: All Gas, No Brakes!. *Journal of Business Diversity, 23*(3).