AN ABSTRACT OF THE DISSERTATION OF

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Abstract approved:

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In this work, I address foundational concerns at the interface of institutions, governance structure, transaction costs, and efficiency in public-private contracting. Following transaction cost economic perspective, I build and justify the theoretical models explaining that institutions may affect the economic performance of public-private contracting through the effect of transaction costs. I explore to what extent a transaction costs economizing motive pertains in public-private contracting by analyzing: (1) the performance of Design-Build contracting compared to the traditional contracting-out in Oregon transportation infrastructure delivery, (2) the use of forward contracts and market transactions by U.S. investor-owned utilities in the wholesale market for power after divesting their generation assets due to electricity market restructuring and deregulation, and (3) the performance of Indonesia's independent power producers which contracts were made under extractive political institutions promoted by the authoritarian Soeharto regime. I find that a consideration of transaction costs would lead to the efficient performance of the public-private

contracting, however, under extractive political institutions, rent-seeking behavior would temper the transaction cost economizing motive of public-private contracting.

Three main takeaways suggested from the analysis of the three cases. First, institutions affect the performance of public-private contracting not only concerning the transaction costs related to the contracting but also through the rent-seeking behavior that underlies the contracting. Second, the private sector's voluntary action in choosing the best governance structures to meet its transaction cost minimization objective impacts to the performance of public-private contracting. Third, in an authoritarian government, decision making on the choice of governance structure can be made by the state exercising its despotic power; thus, the promise of efficiency in public-private contracting was undermined when personal and political interests override economic and social objectives. I conclude that public-private contracting remains a profound and essential way of delivering public goods and services when the transaction cost economizing motive prevails.

Essays on Public-Private Contracting

by

Yohanna M. L. Gultom

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APPROVED:

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Yohanna M. L. Gultom, Author

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Chapter 1: Introduction

Public-private contracting has become one of the most commonly used alternative governance structures for the provision of public goods and services. Traditionally, both in the U.S. and worldwide, public goods and services are procured and delivered either by relying on in-house resources and expertise or by contracting-out services to private firms. Recently, however, various types of public-private contracting have been deliberately used as a tool to improve the functioning of government in providing public goods and services (Savas, 2000). Public-private contracting refers to institutional arrangements in which a government enters into a contractual relationship with private and/or non-governmental parties to provide public goods and services. In these contractual relationships, the private sector performs what have traditionally been public-sector responsibility. Public-private contracting encompasses a broad spectrum of arrangements for the procurement and delivery of goods and services, spanning from public agency force (through the use of in-house resources and expertise) to full privatization (through the divestiture of public assets to private firms). It includes contracts and franchises between governments as the arranger and provider of public goods and services and the private firms or non-profit organizations as the service producer who performs the work or delivers the service to the consumer (Savas, 2000).[1] The growing use of public-private contracting raises both practical and theoretical questions including: How should governments arrange for the provision and delivery of public goods and services? What factors determine the choice of the arrangements? And

[1] The difference between contracts and franchises is that, in contracts, the governments pay the contract services, however, in franchises, the consumer pays the producers franchise services.

does the quest for efficiency largely explain the growing use of public-private contracting for the provision and delivery of public goods and services?

Williamson's transaction cost economics (1975, 1985) provides a theoretical framework for approaching the above questions. It offers a framework for assessing various institutional arrangements or governance structures based on an economizing on transaction costs argument. This approach has significantly expanded the economic theory of organization and institutions. Originally intended to be an explanation for a decision to make or to buy—should a firm produce its own goods and services to meet its own needs or should it contract out these goods or services in the marketplace—now has been expanded to explain contractual relations beyond the market and hierarchy. In his work on public and private bureaucracy, Williamson (1999, p. 309) argues that "efficiency reasoning can and does apply to politics". From this work, he indicates that transaction cost economizing is not only the main case of contractual issues in economic institutions of capitalism, but also in public sector's bureaucracy.

The following chapters are, in part, an argument that this idea is important and correct. However, what follows is also an argument that efficiency is not the only motive for making political choices. The political science literature suggests that in the political market arena, governance structures are not necessarily created to be socially efficient, either due to the political transaction costs or the rent-seeking behavior of the politicians and policymakers (North, 1990; Moe, 1984, 1994, 1997; Acemoglu & Robinson, 2012; Winters & Page, 2009).

The foundational concerns at the interface of institutions, governance structure, transaction costs, and efficiency in public-private contracting are the main foci in what follows. Three essays present evidence on the extent to which a transaction-costs economizing motive pertains to public-private contracting: (1) the performance of Design-Build (DB) contracting compared to traditional contracting-out in Oregon transportation infrastructure delivery, (2) the use of bilateral forward contracts and market transactions by U.S. investor-owned utilities (IOUs) in the wholesale market for power after divesting their generation assets due to electricity market restructuring and deregulation, and (3) the performance of Indonesia's independent power producers (IPPs) operating within extractive political institutions promoted by the authoritarian Soeharto regime. These essays mainly highlight the main question of does the efficiency motive pertain in explaining contractual relations in the public sector?

The first essay in chapter 2 explores the efficiency motive of design-bid (DB) contracting and offers a comparative analysis of DB contracting with traditional contracting-out, *i.e.* design-bid-build (DBB) contracting. The primary objective of this essay is to analyze whether the efficiency motive helps to explain the use of DB contracting in transportation infrastructure delivery in Oregon. Using the transaction cost economics approach, this essay compares DB and DBB's economic performance. The empirical strategy enables detailed observations of the endogenous characteristic of DB contracting, where public agencies select this contracting for specific economic reasons that would later impact the project's economic performance. The results suggest that when transaction-costs minimization gains are realized through the use of DB contracting, then the economic performance of DB projects may exceed the performance of DBB projects. Thus, these findings are consistent with transaction cost economics theory, suggesting that the transaction costs minimization motive underlies the choice of governance structure in transportation infrastructure delivery in Oregon.

The second essay in chapter 3 analyzes the case when regulators seek to anticipate the potential market power of investor-owned vertically integrated electric utilities, which basically operate as natural monopolies. To create a competitive wholesale market for power, some states in the U.S. have undergone electric market restructuring and deregulation, which required investor-owned utilities (IOUs) to divest their generation assets. This essay examines the effect of the governance structures used to purchase power in the wholesale market, on the technical efficiency of IOUs during post-divestiture period. The underlying question this research seeks to answer is to what extent are the governance structures in a policy-induced market able to promote the efficiency goals of an economic organization. The results show that market restructuring and deregulation, specifically divestiture policy, has a negative impact on utilities' efficiency both in the short- and long-term. Trading arrangements in the restructured wholesale markets that rely on the concept of competition generate transaction costs that make it too costly for the utility to use market transactions. In other words, market transactions fall short of promoting the efficiency goals of an economic organization in this policy-directed market. These findings are also consistent with transaction cost economics, suggesting that when market restructuring and deregulation restrain the IOUs from choosing the most appropriate governance structure for reducing transaction costs, inefficient results will follow.

Finally, the third essay in chapter 4 examines the relationship between political institutions and the economic performance of public-private contracting in the provision of public goods. The discussion addresses how extractive political institutions are associated with the performance of public-private contracting, taking the case of the electricity sector in Indonesia as an example of how a shift in political regime impacts the public-private contracting arrangement of independent power producers (IPPs) in the power generation sector. This essay provides a comparative analysis between IPPs that were endorsed by the authoritarian Soeharto regime and those that were endorsed by the democratic governments that succeeded the regime. As previous studies have shown, IPP projects under the Soeharto regime were hampered by cronyism, corruption, and a lack of competition and transparency. The results, which indicate that the extractive political institutions were associated with reduced efficiency among independent power generators, challenge the assumption that a transaction-cost economizing motive have motivated the use of public-private contracts in power generation sector in Indonesia under the Soeharto regime. Instead, these findings support the political economy argument that extractive political institutions may have created economic policies that allow for the political elite to extract rents from public-private contracting (Acemoglu & Robinson, 2012).

The concluding chapter takes the lessons from this evidence and ventures an educated guess on the primary factors that policymakers and politicians should consider when deciding on the course of public sector contracting in the future. The chapter argues that public-private contracting remains a profound and important way of delivering public goods and services when the transaction cost economizing motive prevails.

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Chapter 2. Transaction Costs and Efficiency in Design-Build Contracting: Empirical Evidence from the Transportation Infrastructure Sector in Oregon

Abstract

Design-bid (DB) contracting as a type of public-private partnerships (PPPs) have been widely used as an alternative for traditional contracting-out and the in-house provisions for the delivery of infrastructure in the U.S. The primary objective of this paper is to analyze whether the efficiency motive helps explain the use of DB contracting in public infrastructure delivery. Utilizing the transaction cost economics approach, this paper examines the economic performance of design-bid (DB) contracting compared to traditional contracting-out, the design-bid-build (DBB), for delivering transportation projects in the state of Oregon. The research question is whether the transaction costs minimization motive underlies the choice of governance structure in public service deliveries. Employing a two-stage empirical strategy (the non-parametric data envelopment analysis and the instrumental variable two-stage regression approach), I examine 59 bridge and combination bridge-roadway projects in Oregon that were completed during 2005-2015 using the DB and DBB contracting. I find, when the transaction is complex, the assets in the transaction are specific, and the size of transaction is large, the use of DB contracting significantly increases the efficiency score by 46 percentage points. The findings suggest that the transaction costs minimization motive underlies the choice of governance structure in public service deliveries.

Introduction

How should public agencies administer infrastructure projects? Traditionally, both in the U.S. and worldwide, most infrastructure projects have been financed, owned, and operated by public agencies that procured and delivered services either by relying on in-house resources and expertise or by contracting-out services to private firms. Recently, however, design-build (DB) contracting, a type of public-private partnership (PPP),[2] has been widely used as an alternative governance structure, especially in the delivery of transportation infrastructure projects. [3] DB contracting refers to government contracts that fold the purchase of design and construction services into one contract with a private firm in a lump sum bid (Whittington, 2012).

While there is a growing interest in PPPs, their application remains controversial. Policy makers and stakeholders are aware of the potential benefits and concerns of PPPs, but they know little the conditions under which those benefits can be realized. Meanwhile, theoretical and empirical knowledge about the comparative efficiency of PPPs, especially DB contracting, is relatively limited. Transaction costs economics offers

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[2] In the U.S., design-bid contracting is considered as a type of PPP with the least private involvement, although it is not common worldwide. As defined by the Federal Highway Administration, "A public-private partnership is a contractual agreement formed between public and private sector partners, which allows more private sector participation than is traditional. The agreements usually involve a government agency contracting with a private company to renovate, construct, operate, maintain, and/or manage a facility or system" (U.S. Department of Transportation, Report to Congress on Public-Private Partnerships, 2004). With this definition, PPPs encompass: 1) Design-Build (DB) and/or Operation and Maintenance (O&M) contracts; 2) Design-Build-Operate-Maintain (DBOM) contracts; 3) Design-Build-Finance (DBF) or other private financing; 4) Design-Build-Finance-Operate-Maintain (DBFOM), Design-Build-Finance-Operate (DBFO), or long-term concession; 5) Build-Transfer-Operate (BTO) or Lease-Build-Operate (LBO); and 5) Build-Own-Operate-Transfer (BOOT) or Build-Operate-Transfer (BOOT) (Rall, Reed, & Farber, 2010 p. 4).

[3] Initially, a growing need for infrastructure that has outpaced the supply of public funds was the key factor that has led public agencies to delegate some of their infrastructure responsibilities to the private sector by using PPP contracts (Savas, 2000, p. 237).

an alternative answer to this puzzle. This approach suggests that every contractual issue can be examined to the advantage of transaction cost economizing motive and that public sector contracting and practices often turn out to have an economizing purpose and effect (Williamson, 1999, 2000). Whether transaction cost economizing motive pertains to public sector contracting ultimately is an empirical question and would be the contribution of this paper.

Utilizing the transaction cost economics approach, this paper examines the economic performance of design-bid (DB) contracting compared to traditional contracting-out, the design-bid-build (DBB). The main question this paper seeks to answer is whether the transaction costs minimization motive underlies the choice of governance structure in public service deliveries, in this case, the DB contracting. To compare DB to DBB contracting, it is important to focus on DB contracting as a type of PPP to shed light on the major issues that make DB contracting different from traditional contracting-out and on the potential transaction costs that may appear if the DB contracting had not been used. The difference between DB and DBB contracting lies on the risk and uncertainty that are transferred from the public sector to the private sector. DB contracting assumes traditional public roles and responsibilities for project delivery, which involve the design and construction of a project. Thus, the private sector becomes responsible for solving potential problems that might arise in project delivery and it also agrees to absorb related financial losses (or gains). These responsibilities come with a transfer of risks traditionally borne by the public sector related to uncertainties in construction costs and scheduling (Rall, Reed, & Farber, 2010 p.5). In DBB contracting, these risks are still borne by the public sector.

Whether DB contracting can lead to more efficient results, compared to the use of DBB contracting, remains debatable. Some studies that compare DB and DBB projects based on costs and time have produced inconsistent results, possibly because some unobservable characteristics of the projects were excluded from the analysis (see for example Warne, 2005; US DOT, 2006; Whittington, 2012; Shrestha et al., 2007; and Daito & Gifford, 2014). Meanwhile, there is still a lack of empirical evidence on how DB contracts may affect efficiency. Nevertheless, a recent study (Wang & Zhao, 2018) show that DB contracting for highway projects is mainly selected for risk reduction in terms of preventing cost overruns and construction delays, thus, efficiency might still be the main case for DB selection.

The efficiency promise of DB contracting is in line with the PPP literature's findings, yet continues to be challenged by findings in political science literature. PPP advocates argue that this arrangement may help governments continue to build and maintain infrastructure in the face of severe budget constraints (see Savas, 2000; Engel, Fischer, & Galetovic, 2014) in addition to helping to provide infrastructure more efficiently (Bennett & Iossa, 2006; Hart, 2003) compared to the traditional contracting-out method. The literature suggests that contracting-out has led to problems such as pork barrel investments (Cadot, Röller & Stephan, 2006; Levin & Tadelis, 2006), project costs underestimations (Flyvbjerg, Holm, & Buhl, 2002, 2005), inadequate maintenance and inefficient pricing (Engel, Fischer, & Galetovic, 2014), and poor choice of government's selection or what is called the problem of "smart buyer" (Kettl, 1993). However, the political science literature suggests that efficiency is not the only motive that drives policy choices: political agents might also need to consider the trade-offs between efficiency and equity (Jones, 2001). Besides, political institutions may generate high transaction costs that make efficient results impossible (North, 1990; Moe, 1984, 1994, 1997; Acemoglu, 2006, 2013).

Meanwhile, public agencies have become increasingly cautious about using PPPs because of the potential risks they pose to their reputations and the nation's economic well-being over the long term. Geddes and Wagner (2013) note that private investments in infrastructure in the U.S. are relatively low compared to global standards,[4] and that the use of PPPs has triggered controversies, due to the fact that some projects conceived as PPP projects failed and had to be restructured under a different management framework. Such reversals have been due to several factors such as a lack of bids, an inability to secure the necessary financing, changes in market conditions, or a winning bid from the public sector (Rall, Reed, & Farber, 2010, p. 88). Take, for example, the case of U.S. Highway 20 in Oregon, which was begun as a DB project, but after a long delay was completed under several DBB contracts.[5] There have also been highway projects launched under a PPP scheme and, due to unexpected problems and unresolved disputes between the government and private firm, were taken over or purchased back by the governments. For example, the construction of a state Route 91 express lane in California was completed and initially operated as a design-build-financed-operated (DBFO) project, but later purchased back by the Department of Transportation and contracted out

[4] The fact that local governments in the US could issue municipal bonds for local infrastructure development could be one of the reasons.
[5] This project was started in 2005 but suspended since 2011. The private sector, Granite Construction, received a notice of default from the Oregon Department of Transportation (ODOT) in 2011 due to delay issues related to the unanticipated and continuing adverse geotechnical conditions and landslides on the project site. The project was completed in 2016, seven years later than the initial projected completion date. It also experiences cost overruns of more than $200 million, more than double its original budget of $153 million (Day, 2016).

to a private firm for its operation and maintenance (Ni, 2012).[6] These unsuccessful experiences have raised further concerns regarding PPP's efficiency and effectiveness.

The application of PPPs in Oregon, which thus far is still limited to the use of DB contracting, provides a particularly good opportunity to evaluate the economic performance of DB projects compared to DBB projects. In Oregon, PPPs are promoted by the Oregon Department of Transportation (ODOT) under Oregon Innovative Partnership Program (OIPP). The legislature created this program to encourage partnerships between the private sector and government agencies, expedite project delivery, maximize entrepreneurship and innovation, and leverage public financing with private capital. Although PPP's enabling statutes have been in place since 2003, implementation of PPPs remains limited. There is no PPP project that includes private financing, but private sector expertise has been tapped to manage the project. Under the DB contracting, design and construction work is bundled into one contract with a private firm, thus allowing the private firm to engage in the project once the basic design has been prepared by the public agency. In contrast, under the DBB contracting, design and construction are awarded separately and sequentially to private firms. Private contractors are invited to bid for a construction project under a specified design prepared in-house by the public agency or contracted-out to private designers. Only 13 DB projects were

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[6] After six years of operation under the DBFO scheme, the California Department of Transportation or Caltrans had to break the non-compete clause in the contract that prohibits Caltrans from developing new highway around the 91 express lanes to guarantee the revenue of the private agency (California Private Transportation Company or CPTC). Demands for additional freeway capacity has pushed Caltrans to build free roads that compete with the State Route 91 express lanes toll way. The dispute between Caltrans and CPTC ended up in court, resulting in the reaffirmation of the non-compete clause in 1999. Due to these lengthy controversies, the facility was finally taken over by the Orange County Transportation Authority (OCTA) in 2003. OCTA acquired the franchise from CPTC, while it retains operation of the toll road (the subsidiary of CPTC) under a short-term contract agreement.

completed in Oregon between 2005-2015. All were major projects for bridge construction or a combination of bridge and roadway construction, conducted in partnership with the Department of Transportation (DOT).

In this paper, I evaluate the extent to which the DB projects would produce more efficient results compared to the DBB projects and assess whether the transaction cost economizing motive underlies the use of DB contracting in Oregon. I rely on the transaction cost economics (TCE) approach (Williamson, 1975, 1976, 1985, 1999, 2000, 2002, 2005, 2010) to reveal how the transaction cost economizing motive influences the choice of DB contracting and thus its economic performance. With this approach, a comparison between DB and DBB contracting, or between PPPs and the traditional public provisions for infrastructure development, will be viewed through a minimization-of-transaction-costs lens. This approach offers an insightful way of comparing DB to DBB contracting by enabling detailed observations of the endogenous characteristic of DB contracting, where public agencies select this contracting for specific economic reasons that would later impact their economic performance. Regarding PPPs in general, previous studies acknowledge that public agencies might choose PPPs to reduce transaction costs related to the risk of renegotiation and the hazard of opportunism (see for example Ross & Yan, 2015). Therefore, without addressing the selection problem, such selection would bias any comparison between DB and DBB contracting in unpredictable way.

To better measure the economic performance of DB projects and shed light on the causality of their performance, I use a two-stage empirical strategy to examine the economic performance of DB and DBB projects in Oregon. Fifty-nine bridge and a combination bridge-roadway projects, built through partnerships between private firms and Oregon Department of Transportation (ODOT), provides the sample for this study. That number consists of 13 DB projects completed between 2005-2015 and 46 DBB projects completed between 2010-2015. At the first stage, the input-saving efficiency index is measured by using the non-parametric data envelopment analysis (DEA) technique (see Farrell, 1957; Charnes, Cooper, & Rhodes, 1978; and Färe & Grosskopf, 1985, 2000, 2004). The measurement considers costs and time duration as the input variables, and the lane miles and square-footage of the bridge deck as the output variables. At the second stage, the efficiency index is analyzed using an instrumental variable two-stage least square regression (IV-2 sls) approach to estimate the effect of transaction costs on the efficiency of the two alternative governance structures, DB and DBB, taking into account the endogenous project selection problem where public agencies might choose DB for specific economic reasons that would later affect their economic performance. The transaction costs are proxied by two instrumental variables: the number of project sites (indicating the complexity of the project and the level of asset and technology specificity) and the presence of county funding, in addition to the federal and/or state government funding (indicating the size of the investment). I use these instruments to generate exogenous variation in the economic performance of DB and DBB projects. The more complex the transaction, the more specific the asset, and the larger the size of the investment, will lead to higher transaction costs that are associated with the choice of DB over DBB contracts. Thus, these two instruments are key elements in the choice of infrastructure delivery methods. I provide evidence from the first-stage regression that these two instruments are highly relevant to the choice of governance structures, DB versus DBB contracting.

This research finds that, when the transaction is complex, the assets in the transaction are specific, and the size of the transaction is huge, the use of DB contracting will significantly increase efficiency. The results suggest that when transaction costs minimization gain is realized through the use of DB contracting, then DB projects' economic performance may exceed the DBB projects' performance. These findings are consistent with the transaction cost economics theory that suggests transaction costs minimization motive underlies the choice of governance structure in public service delivery.

This paper thus contributes to the large body of literature on PPPs and transaction costs economics, providing empirical evidence on how transaction costs affect the performance of DB projects. Moreover, this paper also contributes to the extensive literature on methods for performance evaluation, suggesting a proper way of conducting an empirical comparative study of PPPs by taking into account the selection bias problem.

The paper is structured as follows. First, I will provide a literature review of public-private contracting from a transaction cost economics perspective. Then I will discuss the methods and data to be used to evaluate the DB and DBB projects in Oregon, followed by an analysis of the findings. In the conclusion, I will highlight the effect of transaction costs on the efficiency of the DB projects as a form of PPPs.

Literature Review

Transaction cost economics suggests an approach for comparing DB and DBB contracting, or PPPs and the traditional public provision, from a contractual perspective with a minimization of transaction costs as the driver in the decision-making process. North (1990, p. 27) defines transaction costs as “the costs of measuring the valuable attributes of what is being exchanged and the costs of protecting rights and policing and enforcing agreements.” Transaction costs are central in a contractual relationship. It includes the costs of ascertaining the price of the goods and services being transacted, the costs of negotiating the attributes of the partnership, and the costs of protecting and enforcing the partnership agreement. Williamson (2000, p. 599) suggests that every contractual issue can be examined to the advantage of transaction cost economizing motive. Specifically, he (1999, p. 319) claims that public sector contracting and practices often turn out to have an economizing purpose and effect. This approach resides in the idea that transactions are different in their attributes, i.e. the level of asset specificity, the degree of market uncertainty, and the frequency of the transaction. Therefore, a specific transaction is aligned with a specific governance structure that can best minimize the transaction costs (Williamson 2005, p. 6). Three basic governance structures that are discussed in TCE are: a classical market (simple spot-market exchange), hybrid contracting (with a long-term contract), and hierarchical decision making (rendered by firms and bureaus) (Williamson 2000, p. 7). Williamson hypothesizes that the more complex a transaction is, the higher the cost of doing a transaction becomes (and vice versa).

TCE then uses the concept of bounded rationality[7] (Simon & Barnard, 1947; Simon, 1955) and opportunism as the behavioral assumptions to explain why transaction costs become essential in the choice of governance structure. TCE claims that any contractual relationship would suffer from the problem of an incomplete contract since human actors have cognitive limitations and self-interestedness motives. Opportunistic behavior makes contractual incompleteness more problematic as the problems of adverse selection, moral hazard, shirking, and sub-goal pursuits might happen. These ex-post contractual hazards impose high transaction costs that would lead firms to choose certain governance to reduce transaction costs. Williamson (1985, p. 48-49) states:

> Transactions that are subject to ex-post opportunism will benefit if appropriate actions can be devised ex-ante. Rather than reply to opportunism in kind, the wise [bargaining party] is one who seeks both to give and receive ‘credible commitments.’ Incentives may be realigned and/or superior governance structures within which to organize transaction may be devised.

Under these assumptions, then a governance structure, which Williamson (2000, p. 599) defines as “an effort to craft order, therefore to mitigate conflict and realize a mutual gain,” will reshape the incentives to minimize the transaction costs. This means that efficiency, in terms of minimizing the costs of a transaction, becomes the underlying motive for the choice of governance of contractual relations.

With this approach, the rationale for the existence of DB contracting, or PPPs in general, is its comparative efficiency over the alternatives. Such efficiency resides in transaction cost minimization motive. Williamson (2000) argues the comparative static

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[7] By definition, bounded rationality is “human behavior [that] is intendedly rational but only limitedly so” (Simon & Barnard, 1947, p. xxiv).

analysis is the only relevant way of comparing between institutionally feasible governance structures, in which all are flawed. If no superior alternative can be implemented to reduce the costs the most, then the existing governance structure is presumed the most efficient one. There is, in effect, no reason to change.

Many studies on PPPs use this approach (see Engel, Fischer, & Galetovic, 2012, 2014; Hart, Shleifer, & Vishny, 1997; Hart, 2003; Grout 2003; Whittington 2012). From the contractual perspective, the literature often defines PPPs as a contractual arrangement between a government and private entities that bundle facility construction and service provisions in a single long-term contract (Hart 2003, p. 71-72; Engel, Fischer & Galetovic, 2014, p. xi). The specific attribute of PPPs that is fundamental in this approach is the bundling nature of the contract. Although this definition describes some forms of PPP that bundle construction and service provision, Whittington (2012, p. 271) explains that within every consortium that engages in PPP there is a sub-contract to design and build the facility so that the DB contract is the basic element of PPP contracts. Therefore, in the case of DB contracting, the bundling attribute is attached to the design and construction of the project. In contrast, in DBB contracting, the design and construction phases are awarded separately and sequentially to private firms. Private contractors are invited to bid for a construction project under a specified design prepared completely in-house by the public agency or contracted-out to private designers. The construction work is awarded based on the lowest bid. Meanwhile, when the design work is contracted-out to a private engineering design firm, the work is awarded based on the best value method. In DB projects, the public agency may prepare a small portion of the design work, which in many cases amounts to 30 percent of the complete design, which is then award to a private firm or consortium to complete the design and manage the construction. The award is given on the best-value basis. With DB contracting, the engineering design firm and construction contractor have an incentive to work as a team. Specifically, they can work in parallel on different segments of the design and construction phases to provide opportunities to speed up the delivery and better control product quality and costs (US DOT 2006, p. I-1). In sum, the bundling work in DB contracting incentivizes the private partner to internalize the work and minimize the cost while controlling for possible schedule delays (Välilä, 2005).

Empirical studies that use transaction costs economics approaches show that the bundling nature of PPP contracts is the key to their efficiency. In the case of PPP projects that bundle facility construction and service provision, studies show that PPP can be more efficient than the traditional public provision when the bundling of construction and management works under a single long-term contract can help project officials to reduce the costs in the management phase (Bennett & Iossa, 2006). Another study (Hart, 2003) shows that efficiency can be achieved as long as the contracts specify the quality of the service and the performance measures upfront. However, in the case of DB contracting, Whittington (2012, p. 277), evaluating two highway interchanges adjacent to one another in Washington State, in which one was built using a DB contracting and the other using a DBB contracting, found that the DB project was not more efficient than the DBB project. This comparison shows that the DB project reduced the cost of design by $400,000 and saved $2.8 million on change orders and disputes, yet paid $3.1 million more on construction compared to the DBB project. Unfortunately, the comparison considers only the differences in various categories of costs, including transaction costs, and does not take into account differences in schedules between the two projects, which could affect the final costs.

Meanwhile, comparing DB and DBB projects, without having a theoretical basis to help understand the underlying motive for selecting the DB contract or PPPs in general, would bias any comparison between the two projects in unpredictable directions. Some studies that compare DB and DBB projects based on costs and time have produced inconsistent results, possibly because some unobservable characteristics of the projects were excluded from the analysis. For example, Warne (2005) studied 21 DB highway projects across the US and found DB projects to be superior to DBB projects. They shortened the duration of the project, displayed better price certainty, and reduced cost overruns. On the other hand, a US Department of Transportation Federal Highway Administration (2006) study, which compared 11 DB highway projects built under Special Experimental Project 14 (SEP-14) to 11 similar DBB highway projects, found that DB projects are shorter in duration but experience more substantial cost increases during construction compared to DBB projects. Furthermore, a study by Shrestha et al. (2007) compared DB highway projects in Texas with DBB highway projects across the US to find that DB projects have significantly lower cost growth than DBB projects, but that there was no significant difference in terms of duration growth between the two projects. Lastly, Daito and Gifford (2014) found that there was no significant difference in the efficiency score between PPP and non-PPP projects. However, they defined DB as non-PPP and compared it with PPP projects that include private financing, while excluding DBB projects from their analysis.

I would argue that transaction cost economics offers an insightful way of comparing DB and DBB contracting, or PPPs and the traditional public provision in general. The approach helps to uncover the underlying motive by which DB contracting is selected in the first place, thus highlighting its endogenous characteristic. According to transaction cost economics, transaction cost minimization motives underlie the reasons for selecting DB or DBB contracting, which subsequently affects the projects' economic performance. Previous studies on PPPs in general acknowledge that PPPs could be selected for specific types of transactions or investments. For example, De Bettignies and Ross (2004, 2010) suggest that PPPs are typically related to a large number of tasks in one single contract. Using a formal model approach, Ross and Yan (2015, p. 462) also show that the PPP model can be more efficient than the public provision model when the "possible efficiencies are large, the probability there will be a need to change the project is small, the gains through project redesign are small and when the government's bargaining power in renegotiation is greater." These studies suggest that some project characteristics might affect transaction costs between public agencies and the private firms. Such characteristics include the risks of uncertainty, which may require a renegotiation of the contract, and the hazard of opportunism on the part of both contractual parties, which may stymie the renegotiation process.

Based on these findings, it is very likely that public agencies might choose DB contracting to reduce such transaction costs. It is the primary contribution of this paper to show whether the prediction of transaction cost economics holds in public sector contracting or whether the selection of DB contracting in Oregon corroborates with such prediction.

Empirical Strategy

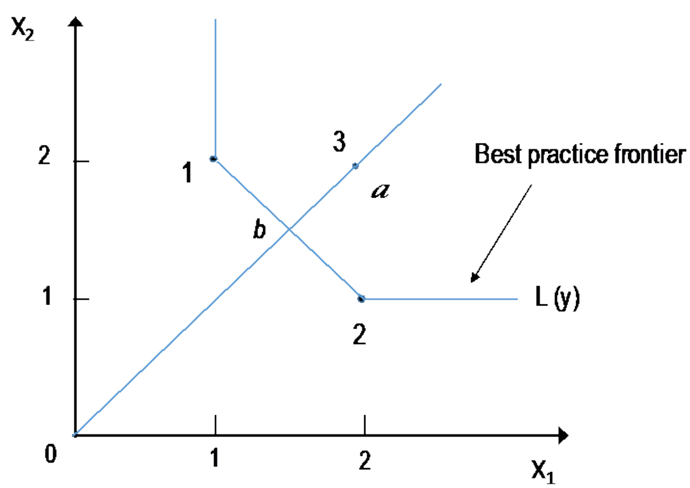
The empirical strategy used in this study is a two-stage empirical strategy consisting of data envelopment analysis (DEA) and instrumental variable two-stage least square regression (IV-2 sls). DEA is used to measure the productive efficiency of Oregon's bridge and a combination of bridge and roadway projects under two different regimes, the DB and DBB contracting. DEA is a non-parametric approach that measures efficiency based on multiple inputs and multiple outputs to construct the best practice frontier. This study uses DEA because, as a non-parametric approach to measuring efficiency and productivity, DEA does not require any functional form for empirical estimation as required by the parametric approach, such as the stochastic frontier analysis (Aigner, Lovell, & Schmidt, 1977). The weakness of DEA is that it assumes that there are no errors, so any error will be reflected in the efficiency score. Moreover, DEA is very sensitive to outliers and can treat them as the benchmark for the efficiency measurement. This study excludes outliers with careful consideration. Meanwhile, one of the advantages of DEA is that it can handle multiple inputs and outputs quite readily and it allows for straightforward calculations of technical efficiency (Kwoka, Pollitt, & Sergi, 2010, p. 95). This feature is particularly advantageous to this study as it allows this study to compare infrastructure projects that have different output mixes. Equally important, the IV 2 sls approach has been used to address the endogeneity problem of DB contracting. The instruments help to generate exogenous variation in the economic performance of DB and DBB contracting.

In the first stage, efficiency is measured by using non-parametric data envelopment analysis (DEA) techniques developed by Farrell (1957), Charnes, Cooper, and Rhodes (1978), and Färe and Grosskopf (1985, 2000, 2004). Efficiency refers to Farrell input-saving technical efficiency, which measures how much more inputs can be saved to produce a given amount of output (Färe and Grosskopf 2000, p. 11). I measured the efficiency index using the On Front 2 software package developed by Färe and Grosskopf (2000). I relied on an input-saving model rather than an output-oriented efficiency because, in the case of transportation infrastructure, the outputs are fixed, e.g. the length of the roadway or the size of the bridge structure. Therefore, what can be savings are more likely to come from the inputs or resources.

The DEA model specifies five input variables: design costs, construction costs, inspection costs, design-time duration, and construction-time duration. Design costs encompass in-house design engineering costs and consultant engineering costs. The construction costs reflect the final construction costs paid to the contractor for the DBB projects. In DB projects, they represent the final design and construction costs paid to the design-build contractor. Meanwhile, inspection costs cover the costs of performing inspection and engineering, conducted either in-house or by consultants, during construction. These inputs represent the costs and time spent to deliver the transportation infrastructure. Costs are measured in U.S. dollars while the time is measured in number of days. Two output variables are employed in the model: lane-mile roadway and square-foot bridge deck built through the projects. Input and output observations will be used to construct the technology in DEA where input will produce output.

DEA measures efficiency index based on how a project, or a decision-making unit (DMU), performs relative to a benchmark. The benchmark for each individual project, the so-called best practice frontier, is constructed based on actual observed achievement in a similar operation. In this case, the benchmark consists of projects that produce similar outputs with the fewest resources or lowest costs. DEA will construct the best practice frontier so that the radial distance of each project to the best practice frontier represents each project input-saving efficiency index. This research assumes a constant return to scale for the measurement and strong disposability of input, which means that an increase in inputs cannot decrease the outputs. See Appendix 1 for the DEA measurement.

Figure 2. 1. The input saving measure of technical efficiency.



Source: Färe & Grosskopf, 2000, p. 13

The inputs and output data from 59 projects will be used to create the best practice frontier to measure the efficiency of each project. Figure 2.1. shows how the best practice frontier is constructed based on observations. Basically, the input-saving technical efficiency is measured as the deviation of each particular project from the best practice frontier in a radial way. In Figure 1, the technical efficiency of project-3 is measured by 0*b*/0*a*, which is the ratio of the size of potential output (at *b*) to the size of actual/observed output (at *a*). With this ratio, 1 will reflects efficiency, while less than 1 means inefficiency (Färe and Grosskopt, 2000, p. 13). The result of the DEA process is a matrix of input-saving efficiency scores for each project. Once the matrix is obtained, the next step is to determine the influence of transaction cost economizing variables on the choice of the governance structure, *i.e.* the choice between DB and DBB contracting.

After creating the efficiency index from the first stage, in the second stage, I adopt an instrumental variable to measure the effect of institutions and transaction costs on efficiency through the variable of the governance structure. Simar and Wilson (2007) suggest the use of a double-bootstrap estimator to account for the bias in the original efficiency scores, as well as for error correlations in the second stage regression. However, in this paper, a robustness check for the efficiency scores is performed by comparing different models and comparing the estimation of the DEA model of this study (measured using five input and two output variables) to the estimation of an alternative DEA model (measured using two inputs, *i.e.* total costs and total time duration, and two output variables). Besides, the consistency of the results is also checked by comparing the full-sample size and the sub-sample size of the 37 bridge-only-projects. The analysis of the sub-sample of bridge only project is important in this study. The fact that DB and DBB projects are not equally comparable is one of the challenge to the analysis. Therefore, this comparison will shed light on the efficiency effect of DB and DBB contracting for the same type of project.

To evaluate whether transaction-cost economizing motives play a role in the selection of DB contracting, I use two instruments as proxies: the number of project sites and the dummy for county government funding (in addition to federal or state government funding). The number of project sites reflects the complexity of the transaction and the specificity of the assets in the transactions. Different project sites may have different conditions that require different designs and constructions. In DB projects, the more project sites included in a contract, the more complex the work becomes. In the case for DBB projects, where the public agency award routine or less difficult projects to private firms, the number of sites would not matter as the work could often be easily repeated. Moreover, the more project sites in a DB contract, the more specific the assets in the transaction is. The more specific the assets (for example, the number of bridges that must be built in a hilly area or the number of curvy roadways that must be built in a circuitous terrain), the more specific and expensive the litany of resources must be in terms of knowledge, skill, and technology. This is why in the case of DB projects, ODOT requires the private firms to have a set of qualifications that include the number of years and type of experience the designer has and whether the designer and the contractor have worked together in a consortium. Assuming that the number of project sites reflects the complexity of the transaction and the specificity of the assets in the transactions, then the number of project sites variable would satisfy the exclusion restriction criteria, that it affects efficiency only through its effect on DB or DBB contracting, not directly.

Meanwhile, the presence of county government funding may reflect both the size of and level of local commitment for the project.[8] Major projects are usually funded by the state and federal government; most do not involve county government funding. In fact, many DB projects in this study were part of the Oregon Transportation Improvement Act (OTIA) III State Bridge Program, in which the state government issued bonds to fund highway modernization and bridge repairs and replacements. Therefore, I assume that the presence of county funding is negatively correlated with, or decreasing the probability of, the choice of DB. With this assumption, the dummy of county funding would satisfy the exclusion restriction criteria that it affects efficiency only through its effect on DB or DBB contracting, not directly.

The reason I use IV-2 sls approach is that the ordinary least square (OLS) estimation will not identify the causal effect of using DB contracting on efficiency, *i.e.* the average treatment effect of using DB contracting or PPP, as long as there are some unobserved factors that determine the choice of using DB or DBB contracting. To anticipate the selection on the unobservable situation, I first control for the unit specific fixed effect (X_i) that includes the type of project, type of work, and rurality of the county. Controlling for the type of project and the type of work is especially important to deal with the fact that the DB and DBB projects are not equally comparable. I also include the

[8] I test this assumption by regressing the award amount on the dummy of county funding and other controls (type of project, type of work, rural county dummy, and the number of change order). The results suggest that the presence of county funding is negatively associated the award amount (the coefficient is -5654448 and is significant at 5% level).

number of change order as a control because this variable could serve as an intermediate output for efficiency, yet it is not included in the efficiency measurement. Although the model had these controls, I am still concerned about the endogenous characteristics of DB contracting that there might be other characteristics of the transaction that could affect the choice of the contracts. To anticipate this identification problem, I instrument for the choice of DB contracting using the two proxies to transaction cost economizing motive (TCE_i). Thus, I assess the relationship of efficiency as the dependent variable (*y*) and the governance structure as the endogenous variable (*x*) by treating transaction cost economizing variables as the instruments (*z*). With the IV-2 sls strategy, the first-stage regression model is:

$$DB_i = \gamma_0 + X_i'\gamma_1 + \gamma_2 TCE_i + v_i,$$

where DB is the endogenous governance structure variable, *i.e.* the dummy for DB project (1 for DB and 0 for DBB), X is the control variables, *i.e.* a dummy for type of project (1 for bridge and 0 for a combination of bridge and roadway), a dummy for type of work (1 for building new and replacing existing infrastructure and 0 for repairing existing infrastructure), a dummy for rural county characteristic (1 for rural county and 0 for urban county), and the number of change orders during the project , TCE is the composite transaction cost economizing variables that serve as the instruments, *i.e.* the number of bridge sites and the dummy for the presence of county government funding in the project (1 for presence and 0 for absence), and v is the random error, for each project i.

The second-stage regression model is:

$$eff_i = \beta_0 + X_i' \beta_1 + \beta_2 \widehat{DB}_i + u_i, \tag{1}$$

where eff is the Farrell input-saving efficiency index resulting from the DEA analysis, X is the control variable mentioned above, $\widehat{DB}$ is the estimated DB variable resulting from the first regression, u is the random error, for each project i.

The identification assumption is that – conditional on the type of project, the type of work, the rurality characteristic of the county, and the number of change order – transaction cost economizing variables do not affect efficiency independently but only through the choice of DB contracting. The use of transaction cost economizing variables as instruments is in line with the transaction cost economics approach that suggests the choice of governance structure is related to the motive of reducing transaction costs (Williamson 1975, 1985, 1999, 2000, 2005, 2010). The strength of these instruments, *i.e.* where they affect the dependent variable eff only through the endogenous variable DB, is assessed through the first stage regression. The rule of thumb for a strong instrument is that the *F* statistic on the instruments in the first stage should exceed 10. Meanwhile, to deal with the exclusion restriction criteria of IV, where the instruments do not correlate with the error terms u_i in the second stage regression, I incorporate the number of change order variable into the model as the control variable. As a control, this variable would help isolate any relationship between TCE as the instruments and the error term in the second-stage regression u_i.

Given that these instruments are valid, $\beta_{2,IV}$ captures the local average treatment effect (LATE) of the economic performance of transportation infrastructure delivery in Oregon. In this research, the type of transaction drives the marginal effect. So, if the type of transaction is complex, specific in term of assets, and huge in terms of size, the use of DB contracting would potentially reduce any future transaction cost that may be faced by the public and private parties in the agreement. And the right governance structure selection would lead to an efficient result. LATE estimates in this research thus indicate the effect of the choice on DB on efficiency which was induced to choose DB contracting because of the complexity, specificity, and size of the transaction or investment. Basically, this estimate shows the effect of transaction cost economizing motive on efficiency. In the next section, I will show the data and the descriptive characteristics of the DB and DBB projects in Oregon.

Data

The cross-sectional database used in this study consists of 59 Oregon Department of Transportation (ODOT) projects, including 13 DB projects completed from 2005-2015 and 46 DBB projects completed from 2010-2015. The sampling strategy uses different time-frames for selecting the DB and DBB projects. The time frame for DB projects is sometimes longer than that of the DBB projects to include all the DB projects available for the analysis. DB projects in the database, moreover, are all the DB projects completed from 2005-2015 in Oregon except for one: U.S. Highway 20 project, which was started as a DB project, but after a long delay due to a dispute between ODOT and the private contractor, was completed in 2016 by using DBB contracting. As a result, this project cannot be considered DB or DBB project and is an outlier in the analysis.

Of the 13 DB projects, six of them were bridge projects and seven of them were a combination of bridge and roadway projects. This study limits the sample for the DBB projects to the same project types so that comparisons can be made between two similar projects. Unfortunately, no combination bridge and roadway project have been delivered using a DBB contracting. Therefore, this study only uses all the DBB bridge projects completed from 2010-2015 in Oregon, which comes to a total of 46 DBB projects.[9] The sample can be classified further based on the type of work, *i.e.* building new or replacing existing infrastructure versus repairing existing infrastructure. In total, 44 projects deal with building new or replacing existing infrastructure work. This encompasses all the DB projects (six DB bridge projects and seven DB combination bridge-roadway projects) and 31 DBB bridge projects. Meanwhile, there are 15 projects deal with repairing existing infrastructure and all of them are DBB bridge projects. Thus, all DB projects deal with building new or replacing existing infrastructure work and none deals only with repairing existing infrastructures. Yet, of the 13 DB projects, 4 include both replacements and repair of existing bridges. Yet, the repair work is minor compared to the replacement work in each project, which is less than 20% of total bridge constructions.

Two DBB bridge projects are excluded from the analysis, because they depend on a different type of technology than the 13 DB projects. The two outliers, in fact, are salt use mitigation for bridge projects that aim to protect the structure from corrosion as part of ODOT's salt use pilot program. The projects are too simple to be included in the analysis. The work mainly consisted of overlaying or sealing the bridge decks as part of a larger effort to mitigate corrosion. Because the technology is simple, it takes little time to design the project. Meanwhile, the same design can be used repeatedly at different bridge sites. With minimal resources in terms of costs and time, these projects generate a large amount of output, in terms of the number of bridge sites and the square footage of bridge

[9] Since ODOT has to prepare all the data on DB and DBB projects, based on the discussion with the performance program manager, this study uses all DBB bridges and roadway projects completed during a shorter period of time, which is 2010-2015, rather than randomly choosing DBB projects completed during the period of DB projects, which is 2005-2015.

decks that are repaired. Since the data envelopment analysis (DEA) method is very sensitive to outlying data, *i.e.* outlying data will be treated as the best practices, these two projects would have been deemed the only efficient projects while the rest would have been deemed highly inefficient. With a confirmation from the performance manager in ODOT, these two projects are excluded.

Table 2.1. shows that DB projects have substantially different characteristics than DBB projects. They differ in terms of size, specificity, and complexity. In terms of size, the average amount of money awarded to DB projects was $32.8 million, much larger compared to an average award of $2.6 million for DBB projects. DB projects are mostly financed by the federal or state governments; only about 20 percent of the projects involve county government funding. In contrast, 40 percent of DBB projects involve county government funding. The size of a projects is related to its complexity. Some DB projects combined bridge and roadway design and construction; all dealt with building new or replacing existing infrastructure. Meanwhile, all DBB projects focused solely on bridge projects and some dealt only with repairing existing infrastructure. The latter often proves simpler than building new or replacing infrastructure work. These differences explain why DB projects tend to be larger in size and high in costs compared to the DBB projects.

DB projects, moreover, tend to be more complex and specific than DBB projects, indicated by the number of sites each project has. DB projects address multiple bridges for both new construction and the replacement of existing construction under a single contract between ODOT and a consortium of private firms. These bridges are dispersed over a large area. On average, a DB project involves at least 7 bridge sites, while a DBB project involves only 1 bridge site. Different sites may require different designs as each site may have specific land gradients, soil composition, drainage, *etc.*

Table 2. 1. Descriptive statistics of DB versus DBB projects.

	DB projects (n = 13 projects)				DBB projects (n = 46 projects)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Award amount (US$)	32,800,000	16,500,000	5,722,127	59,700,000	2,576,807	3,532,425	248,728	21,000,000
Grand total cost (US$)	37,900,000	18,300,000	7,489,786	69,200,000	3,871,098	5,246,518	451,399	32,400,000
Input-output DEA variables								
Design cost (US$)	1,341,628	1,284,285	232,594	4,256,961	539,689	689,850	11,552	2,996,963
Construction cost (US$)	34,900,000	16,800,000	6,977,920	63,800,000	2,644,183	3,797,804	253,227	23,500,000
Inspection cost (US$)	1,496,161	907,350	96,500	3,279,400	452,733	614,958	32,000	3,925,000
Design time (days)	344	188	151	792	728	331	27	1,413
Construction time (days)	1,402	294	947	1,861	677	393	167	2,573
Lane mile roadway	2.4	5.9	0.0	19.1	0.6	1.3	1.3	8.4
Square-foot bridge deck	67,129	42,006	13,166	158,210	13,286	19,620	756	118,455
Control variables								
Type of project	0.5	0.5	0	1	1	0	1	1
(1 = bridge, 0 = combination)								
Type of work	1	0.0	1	1	0.7	0.5	0	1
(1 = build new/replace, 0 = repair)								
Rural county (%)	0.5	0.5	0	1	0.5	0.5	0	1
No of change order	21.8	10.1	0	40	9.0	9.7	0	47
Instruments								
Number of sites	7.3	4.3	1	16	1.2	0.6	1	4
County funding (%)	0.2	0.4	0	1	0.4	0.5	0	1

What also makes DB projects more complex than DBB projects is the number of non-contiguous locations within the project. Since bridges are located in a number of places scattered across the landscape, large areas between the bridges do not require any work at all. The contractor may face a condition that is not anticipated ex-ante contract that requires changes. Meanwhile, this condition occurs only occasionally on DBB projects, as most DBB projects include only one or two bridge sites.

A basic characteristic of DB projects, which cover multiple bridges at different sites in non-contagious locations, makes these projects more prone to change. Bundling design and construction works in DB contracting, has allowed these projects to reduce the number of change orders per bridge site compared to DBB projects. In Table 1, the average number of change orders for DB projects is more than twice as high as DBB projects: 21.8 compared to 9. However, the ratio between change order and number of sites shows that, on average, DB projects have a lower change order per site ratio than DBB projects: 3 compared to 7.5. This shows that as the number of sites increase, bundling design and construction work into a single contract reduces potential transaction costs due to the potential for change orders during the contract.

The bundling feature of DB contracting has also allowed projects to internalize various costs of construction into the design, so that cost changes following the award can be minimized. DB projects average a 16-percent increase in costs (from an average of award amount of $32.8 million to average total costs of $37.9 million), while DBB projects average a 50-percent increase in costs (from an average award amount of $2.6 million to average total costs of $3.9 million). The fact that DBB projects have a higher cost increase in this study is in line with the Bajari, Houghton and Tadelis' (2006) findings. The study shows that firms bid strategically low on selected items to be awarded the contract, and then request of a 10-percent increase in payments to cover the actual costs. This practice is possible since, in DBB contracting, funds are first given for the design, while the majority of funds, on average of 75 percent, is reserved for construction. In contrast, with DB contracting, the full amount of funding (covering both design and construction) is obligated at the time of the award.

Lastly, bundling design and construction in DB contracting has decreased the overall project time. Compared to DBB projects, DB projects take more time (1,746 days versus 1,405 days), with a shorter design phrase (344 days versus 728 days) and a longer construction time phrase (1,402 days versus 677 days). However, considering the number of project sites, the overall time duration per sites shows that on average, DB projects have a shorter time duration than the DBB projects: 239 days/site compared to 1,175 days/site. Time-saving is made possible in DB contracts because design and construction work can be done in parallel on different elements of the work. Once the basic amount of the design work has been completed, construction can begin in parallel with the remainder of the design work.

While DB projects have on average shorter time durations and lower cost increases, in terms of output DB projects have on average smaller square-foot bridge decks per site as an output compared to DBB projects: 9,186 square feet compared to 11,112 square-feet bridge deck per site. The fact that some DBB projects concentrate on repairing existing infrastructure may account for the differences in output. Therefore, I will further analyze the efficiency of each project by controlling for various characteristics of the projects. I deal with endogenous project selections, to show how these two types of project differ in their economic performance.

Results

I will present the results as follows. First, I will cover the descriptive statistic of the efficiency score resulting from the DEA analysis. Second, I will discuss the selection of the DB contracting over the DBB contracting based on the first-stage estimates for the effect of the DB dummy variable on efficiency, instrumenting DB with transaction costs variables. Third, I will discuss the effect of transaction costs on efficiency through the use of DB contracting.

Efficiency index: DEA results

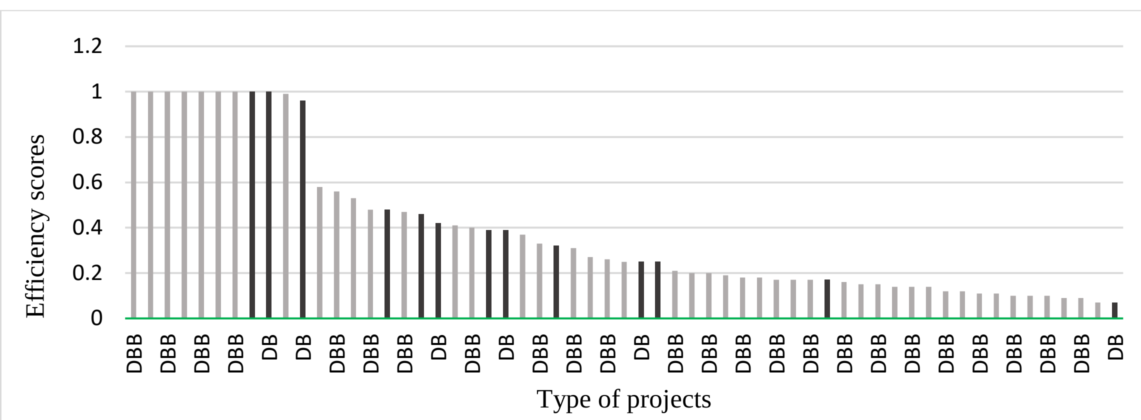
Table 2.2. shows the descriptive statistics of the efficiency score, based on the input and output datasets assembled from the 59 projects that served as the basis of this study. Analyzing the DEA results based on two different regimes, *i.e.* the DB and DBB contracting, I find that the mean efficiency for the DB projects is higher than that of the DBB projects: 0.47 compared to 0.36. This shows that on average, DB projects are more efficient than DBB projects. The non-parametric Wilcoxon rank-sum test also confirms that DB projects and DBB projects do not have the same distribution of efficiency scores (z-value = -1.549 and p-value of 0.9012). Meanwhile, both DB and DBB projects have the same maximum and minimum efficiency scores, which are 1 for the highest score and 0.07 for the lowest score, with a relatively equivalent standard deviation.

Table 2. 2. Descriptive statistics of Farrell input-saving technical efficiency score.

	DB projects	DBB projects
Mean efficiency	0.47	0.36
Min.	0.07	0.07
Max.	1	1
SD.	0.31	0.32
Obs.	13	46

Figure 2.2. shows the distribution of DB and DBB projects based on the efficiency scores produced by DEA. It shows there are DB projects that are efficient and there are projects that are very inefficient. Based on the DEA result, there are nine projects (encompassing two DB projects and seven DBB projects) are deemed efficient, with an efficiency score of 1. It is important to note that DEA constructs the benchmark based on actual observed achievements in similar operations. In this case, these efficient projects become the benchmark for the other projects that achieve a similar output, yet, use more resources or higher costs.

Figure 2. 2. Farrell input-saving technical efficiency scores for 59 DB and DBB projects.



Notes: In the scale from 0 to 1, 1 reflects efficiency while less than 1 means inefficiency.

A regression of DEA scores for Farrell input-saving technical efficiency Eff on the control variables as well as the instruments for DB serves as the next step in this empirical research.

The choice of DB contracting in transportation infrastructure delivery

For second-stage analysis, I estimate the effect of the choice of DB on efficiency, using the IV-2 sls model with two instrumental variables. First-stage estimates for the selection of DB in transportation infrastructure delivery are presented in Table 2.3. The outcome variable indicates whether DB contracting is used as a delivery method. The coefficient on the number of sites indicates that as an additional site is added to the transaction, the probability of using the DB contracting increases by nearly 10 percentage points. Meanwhile, the coefficient on county government funding shows that the presence of county government funding decreases the probability of using DB contracting by 15.7 percentage points. Both coefficients are significant at 1 percent level.

Across columns, the size of the coefficients does not change substantially with the addition of more controls or instruments, while the precision of the estimates remains high. Meanwhile, the joint F statistic of the two instruments in columns 1, 2, and 4 exceeds the rule of thumb 10. The F statistic for each instrument is also high and significant at the 1 percent level, especially for the number of sites that is always beyond the rule of thumb 10. This indicates that these instruments are strong instruments that can consistently help predict the choice of DB. The inclusion of controls, especially the type of project and type of work, in the first stage is important, as a large amount of the variation in the use of DB contracts comes from whether the projects are bridge only or a combination of bridge and roadway, and whether the projects are designed to build new or replace existing infrastructure or only repair the existing infrastructure. By controlling for the type of project and the type of work, the first stage compares the use of DB contracting for the same type of project and the same type of work.

Table 2. 3. The choice of DB contracting: first stage OLS estimates.

Dependent variable: DB (1 = DB, 0 = DBB)	(1)	(2)	(3)	(4)
IV-1: *No of sites*	0.099***	0.070***	0.073***	0.074***
	(0.012)	(0.017)	(0.022)	(0.018)
IV-2: *County funding*	–0.157***	–0.171***		–0.199***
(1 = presence, 0 = absence)	(0.058)	(0.061)		(0.072)
Type of project		–0.387**	–0.405**	–0.428***
(1 = bridge, 0 = combination)		(0.150)	(0.184)	(0.155)
Type of work		0.133**	0.105**	0.155**
(1 = build new/replace, 0 = repair)		(0.057)	(0.049)	(0.068)
Rural county		0.008	–0.025	–0.012
(1 = rural, 0 = urban)		(0.059)	(0.076)	(0.070)
Change orders			–0.001	–0.005
			(0.004)	(0.004)
Constant	0.028*	0.345**	0.336	0.428**
	(0.062)	(0.170)	(0.224)	(0.195)
N projects	59	59	59	59
R^2	0.65	0.73	0.69	0.73
F-statistic on no of sites	70.23	16.52	11.39	17.71
Pr > F	*0.00*	*0.00*	*0.00*	*0.00*
F-statistic on county funding	7.29	7.92		7.62
Pr > F	*0.01*	*0.01*		*0.01*
Joint F-statistic on instruments	64.54	16.21		14.46
Pr > F	*0.00*	*0.00*		*0.00*

Note: Robust standard errors are within the bracket. Type of project, type of work, the rurality of the county included in column 2, change order included in columns 3 and 4, only number of sites used as an instrument in column 3, and both number of sites and county government funding used as instruments in column 4.

Significance levels: * 10 percent; ** 5 percent; *** 1 percent.

It is interesting to note that the change order and rural county characteristics have no significant relationship with the choice of DB, while the type of project and type of work do. Across specifications, the influence of the type of project and the type of work is robust and significant. Based on the specification in column 4, the coefficient of the type of project indicates that when the project is a bridge only project, the probability of using DB contracting decreases by 42.8 percentage point. While when the type of work includes build new or replace infrastructure, the probability of using DB contracts increases by 15.5 percentage points. Thus, the choice of DB contracting is determined by the type of the project and work, but not by the rurality characteristic of the county.

These DB selection regressions show that the DB contracting are positively selected when the projects include a combination of bridge and roadway construction, and when the projects involve a building new or replacing infrastructure work. There is no evidence to suggest that the DB contracting is selected based on whether the area is rural and has a low population density.

The effect of using DB contracting on the efficiency of transportation projects

To show that the choice of governance structure, in this case, DB contracting as a form of PPPs, matters to the economic performance of transportation infrastructure delivery in Oregon and that the effect is consistent, I present the results from OLS and IV regressions. Table 2.4. presents the coefficients from OLS and IV regressions of efficiency. Columns 1 to 3 present OLS results and columns 4 to 7 present the IV results (reduced form coefficients derived from the regressions of efficiency score on the instrumental and control variables). The table includes coefficients, standard error and the significance level of the p-value. The dependent variable for each model specification is the Farrell input-saving technical efficiency index Eff.

Table 2. 4. Effects of DB contracting on efficiency

	Farrell Input-saving Technical Efficiency						
	OLS regression coefficient			IV regression coefficient			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DB	0.109	0.455***	0.443***	0.1268	0.501**	0.391*	0.460**
(1=DB, 0=DBB)	(0.098)	(0.144)	(0.151)	(0.093)	(0.203)	(0.203)	(0.199)
Type of project		0.351**	0.381**		0.389*	0.342*	0.394**
(1=bridge, 0=combination)		(0.151)	(0.164)		(0.200)	(0.200)	(0.196)
Type of work		–0.481***	–0.491***		–0.489***	–0.484***	–0.493***
(1=build new, 0=repair)		(0.096)	(0.097)		(0.092)	(0.094)	(0.092)
Rural county		–0.015	–0.002		–0.015	–0.001	–0.002
(1=rural, 0=urban)		(0.063)	(0.066)		(0.060)	(0.062)	(0.063)
No of change orders			0.002			0.003	0.002
			(0.003)			(0.003)	(0.003)
N projects	59	59	59	59	59	59	59
R^2	0.020	0.479	0.484	0.02	0.477	0.482	0.484
Wald Chi^2				1.87	31.91	28.68	32.46
F-statistic	1.25	8.73	7.06				

Notes: Robust standard errors are within the bracket. For IV regression models, DB is instrumented with the combination of two variables: number of sites and the presence of county government funding. Column 4 is the basic IV model with two instruments (number of sites and county funding) and has no control variables, Column 5 is the basic model with all the control variables except the number of change orders, column 6 uses one instrument only (number of sites) with all the controls, and column 7 uses two instruments with all the controls.
Significance levels: * 10 percent; ** 5 percent; *** 1 percent.

The coefficient on DB in column 1 shows that DB contracting has no significant effect on efficiency. However, controlling for type of project, type of work, rural county in column 2, as well as the number of change order in column 3, the coefficients increase and become statistically significant at 1 percent level. The positive coefficient of DB suggests that efficiency score is higher for DB projects compared to the DBB projects, after controlling for the type of project and type of work that also have a significant effect on Eff.

IV estimates of efficiency are not substantially different from OLS estimates. Notice that in both OLS and the IV models, the DB coefficient becomes significant as controls are added to the model. The control variables, especially the type of project and the type of works, have made the DB estimate larger in magnitude and more precise. Although OLS estimates of DB in columns 2 and 3 are statistically more significant than IV estimates in columns 5, 6, and 7, the IV models are preferred to the OLS models due to the endogeneity of DB contracting, even if the results of the IV model are ultimately similar to those of the OLS (see columns 3 and 7). Given that the two instruments for DB in the IV model are relevant and satisfy the exclusion restriction criteria, IV models are the best predictor of the effect of DB contracting on efficiency.

Comparing across the IV specifications, my preferred estimate is in column 7, where the two instruments and all controls are used to estimate the efficiency score. Including the two instruments into the model is necessary because they are both relevant predictors for DB contracting. The additional instruments will allow for a better approach to the potential transaction costs that may appear if the DB contracting had not been used. The coefficient of DB in column 7 is also larger compared to the one in column 6 that uses only one instrument (0.460 compared to 0.391). And although the coefficient of DB in column 5 is larger than the coefficient in column 7, the specification in column 7 is still preferred because the use of change order variable as a control is necessary. The change order variable can isolate any relationship between TC as the instruments and the error term in the second-stage regression to anticipate further the endogeneity of DB contracting. Meanwhile, the specification in column 7 has the highest R^2 value of 0.484, showing that 48.4 percent of the variation in the data can be explained by the model.

The positive and significant coefficients of DB in columns 5, 6, and 7 indicate that DB projects are more efficient than DBB projects. Based on the specification in column 7, the use of DB when the transaction is complex, the assets are specific, and the size is huge (as indicated by the two instruments) will lead to a 46 percentage point increase in efficiency and is significant at the 5 percent level. Including the number of change order as a control reduces the PPP coefficient from 0.501 in column 5 to 0.460 in column 7. This suggests that without incorporating the change order variable, the estimate is biased upward. The results also show that change order and the county's rurality have no significant effect on efficiency. Yet the type of project and type of work have a significant effect on efficiency. The coefficient of the type of project indicates that when the project is a bridge only project, the efficiency score increases by 39.4 percentage points. While the coefficient of the type of work indicates that when the type of work involves building new or replacing infrastructure, the efficiency score decreases by 49.3 percentage points. These coefficients are significant at the 5% and 1% level, respectively.

These results suggest that if the type of transaction is complex, specific in term of assets and huge in terms of size, the use of DB contracting would potentially reduce any future transaction cost that may be faced by the public and private parties in the agreement, and that the selection of the right governance structure would lead to an efficient result. LATE estimates in this research, which is the DB coefficient, thus indicate the effect of the choice on DB contracting on efficiency which was induced to choose DB because the transaction is complex, the assets are specific, and the size is huge, as reflected by the two instrumental variables.

There are two concerns about this result. The first concern is that the DB and DBB projects are not equally comparable. The fact that only DB projects involved a combination bridge and roadway construction and that only DBB projects involved with the repairing existing infrastructure work would raise concerns as to whether controlling for type of project and type of work are sufficient to have a comparable dataset. To anticipate this problem, I tested whether the results are consistent if I only use the 37 sub-sample of the bridge only projects that specifically build new or replace existing infrastructure (comprising 6 DB projects and 31 DBB projects). I use the same specifications as the one in column 3 of Table 2.4. for the OLS model and the one in column 7 of Table 4 for the IV model, dropping the type of project and type of work variables. The second concern is that the DEA estimation can be sensitive to the number of input and output variables used to measure efficiency. To check the robustness of the DEA estimation in producing a consistent result at the second-stage empirical research (IV 2 sls), I re-run the DEA estimation using only two instead of five input variables, *i.e.* total costs (the sum of design costs, construction costs, and inspection costs) and total time duration (the sum of design-time duration and construction-time duration). Then I regress the new efficiency scores on the variables of interest using the same specifications as the one in column 3 of Table 2.4. for the OLS model and the one in column 7 of Table 2.4. for the IV model.

Table 2. 5. Robustness test with sub-sample and alternative DEA estimation

	Farrell Input-saving Technical Efficiency			
	Building new or replacing bridge project		*Alternative DEA estimation (2 input and 2 output variables)*	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
DB	0.193*	0.074	0.255	0.352**
(1 = DB, 0 = DBB)	(0.100)	(0.131)	(0.154)	(0.174)
Type of project			0.251	0.324*
(1 = bridge, 0 = combination)			(0.170)	(0.175)
Type of work			–0.337***	–0.350***
(1 = build new/replace, 0 = repair)			(0.084)	(0.079)
Rural county	0.039	0.043	0.071	0.069
(1 = rural, 0 = urban)	(0.081)	(0.077)	(0.054)	(0.054)
No of change orders	0.005	0.006	0.008***	0.008***
	(0.003)	(0.003)	(0.003)	(0.003)
N projects	37	37	59	59
R^2	0.152	0.120	0.388	0.376
Wald Chi^2		4.69		39.38
F-statistic	2.25		6.71	

Notes: Robust standard errors are within the bracket.
Significance levels: * 10 percent; ** 5 percent; *** 1 percent.

Table 2.5. shows the results of the robustness tests. For the sub-sample of bridge only projects, the sign of DB coefficients for the OLS model in column 1 and for the IV model in column 2 does not change. The use of DB contracting still positively correlates with higher efficiency scores. However, in column 2, the coefficient loses its significance. I assume it is related to the small sample size for DB projects. Comparing the DB coefficients in Table 2.5. to the one in column 7 of Table 2.4., I would argue that the latter is more important because they represent the complete set of DB projects, which include not only bridge projects but also the combination of bridge and roadway

projects that are very specific to DB contracting. Table 2.4. shows that the bridge-roadway projects (the positive coefficient of the type of project variable) always correlates with a lower efficiency score across specifications (columns 2, 3, 5, 6, and 7). Therefore, excluding the combination bridge and roadway project from the analysis would bias the result.

Meanwhile, columns 3 and 4 of Table 2.5. show, respectively, the OLS and IV estimates of the new efficiency scores resulting from the alternative DEA estimation. The sign of DB coefficients does not change as well, confirming that the use of DB contracting still positively correlates with higher efficiency scores. The OLS estimate of DB in column 3 is not significant, while the IV estimate in column 4 is significant at 5% level. The results in column 4 of Table 2.5. are consistent with the results in column 7 of Table 2.4., suggesting that the main results in Table 2.4. are robust. The use of DB when the transaction is complex, the assets are specific, and the size is huge (as indicated by the two instruments) will increase the efficiency by 35.2 percentage points.

Conclusion

This article uses the application of PPPs in Oregon to assesses whether the use of DB contracting can lead to more efficient transportation infrastructure delivery compared to the use of traditional contracting-out or the DBB contracting. The empirical strategy used in this research allows the measurement to consider the endogenous selection of DB contracting, where public agencies might choose DB for specific economic reasons that would later affect their economic performance. The use of transaction cost economics approach helps to reveal the transaction cost minimization motive of the selection process. The results suggest that the type of transaction drives the marginal effect. When the type of transaction is complex, specific in term of assets, and huge in terms of the investment, the use of DB contracting is likely to reduce any future transaction cost that may be faced by the public and private parties in the agreement. The right governance structure selection would lead to an efficient result.

Using the two-stage empirical strategy, I show that the use of DB contracting increases the efficiency score by 46 percentage points. This estimate indicates the effect of the choice of DB contracting on efficiency, which was induced to choose DB when the transaction is complex, the assets are specific, and the size of the investment is large. Basically, this estimate shows the effect of transaction cost minimization on efficiency. These findings are consistent with the transaction cost economics theory that suggests the transaction costs minimization motive underlies the choice of governance structure. In this case, the choice is DB contracting. However, it is important to note that this result is based on unequally comparable DB and DBB project and on a small sample size of DB projects. Besides, the key limitation for the generalizability of the results is the fact that this study focuses on one state.

The main finding of this paper suggests that transaction cost economics' arguments hold in public sector contracting. This empirical research contributes to the extended application of this theory on public policy literature. In term of policy implication, the main finding highlights the problem of infrastructure delivery method. Although PPPs are not a panacea for transportation infrastructure delivery, this paper shows under what conditions the use of PPPs, in this case, the DB contracting, could produce more efficient results compared to the traditional contracting-out method.

Unfortunately, it is beyond the scope of this research to assess under what condition DB contracting may fail. The case of U.S. Highway 20 in Oregon, which was never completed as a DB project, requires further research. Another contribution of this paper is to provide valuable insights for policymakers and researchers working on PPPs on how to address the endogeneity of PPP to properly conduct project evaluation research.

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Appendix 1

The DEA Model

I provide a technical discussion on how to measure the Farrell input-saving technical efficiency by using DEA model. Following Färe and Grosskopf (2000), Farrell input-saving technical efficiency of each project is measured based on the input and output dataset from all observations. Let

$$x = (x_1, \dots, x_N) \in \mathbb{R}_+^N ,$$

represent inputs, and

$$y = (y_1, \dots, y_M) \in \mathbb{R}_+^M,$$

represent outputs. The model then constructs the reference technology, or the best practice frontier, based on the input requirement set, $L(y)$, which show all the combination of outputs that can be produced by the input vector x. The input requirement set is defined as

$$L(y) = \{x : x \; can \; produce \; y\}.$$

In this research, suppose there are $k = 1, \dots, K$ observation of transportation infrastructure project

$$(x^k, y^k) = (x_{k1}, \dots, x_{kN}, y_{k1}, \dots, y_{kN}),$$

then the DEA formulation of $L(y)$ is

$$L(y|C,S) = \{(x_1, \dots, x_N):$$

$$\sum_{k=1}^{K} z_k \, x_{kn} \leqq x_n, \mathrm{n} = 1, \dots, N,$$

$$\sum_{k=1}^{K} z_k y_{km} \geqq y_m, m = 1, \dots, M,$$

$$z_k \geqq 0, k = 1, \dots, K\},$$

where z_k are the intensity variables that "construct" the input set.

In this measurement, it assumed that $z_k \geqq 0, k = 1, \ldots, K$ is just restricted to be non-negative as this model assumes for constant returns to scale (CRS) for the reference technology, i.e.,

$$L(\lambda y) = \lambda\, L(y), \lambda > 0.$$

Furthermore, this model also assumes strong disposability of input, suggesting that an increase in inputs cannot decrease the outputs, which is modeled by

$$x \geqq x' \in L(y|C,S) \; implies\; that\; x \in L(y|C,S).$$

With the input requirement set, the Farrell input-saving measure of technical efficiency is then defined as

$$F_i\ (y, x|C,S) = \min\ \{\lambda :\ \lambda x \in L\ (y|\ C,S)\},$$

suggesting that a project is technically input-saving efficient when

$$F_i\ (y^k x^k|C,S) = 1,$$

and inefficient if less than 1.

Chapter 3. Governance Structures and Efficiency in the U.S. Electricity Sector After the Market Restructuring and Deregulation

Abstract

While some states in the U.S. continue to regulate vertically-integrated investor-owned utilities (IOUs) which do business in them, other states have undergone electricity market restructuring and deregulation in order to create competitive wholesale and retail markets for power. In these later states, IOUs are required to divest the majority of their generation assets in order to purchase power from merchant generators, independent power producers, and power marketers competing in the new market. This paper examines the effect divestiture policy on the technical efficiency of IOUs during the post-divestiture period. It focuses on the impact that governance structures have on IOU's efficiency, paying special attention to bilateral forward contracts and market transactions for purchasing power in the wholesale market. Using a two-stage empirical strategy (the non-parametric data envelopment analysis and the difference-in-differences regression approach), I analyze the performance of 152 distribution utilities in the U.S. from 1994 to 2015. The results show that while the use of contracts has no significant effect, the use of market transactions after the divestiture has a significant negative effect on IOU technical efficiency. Trading arrangements in the restructured wholesale markets that rely on the concept of competition generate transaction costs that make it more costly for the utility to use market transactions rather than other alternatives. Thus, market transactions fall short to promote the efficiency purpose of an economic organization in this policy-induced market and the adverse effect persists until 20 years after the divestiture.

Introduction

U.S. policymakers seek to limit the exercise of market power by the vertically integrated investor-owned utilities (IOUs) which operate as natural monopolies.[10] Traditionally, states have regulated electric utilities and regulatory commissions have been empowered to oversee utilities and set retail prices to protect the public interest. However, in the late 1990s, some states have undergone electricity market restructuring and deregulation that sparked a major shift from a regulated electricity industry to a competitive electricity market. The main purpose of the market restructuring process was to create a competition in the power generation sector by separating power generation and sales industries from transmission and distribution services and allowing independent generators to compete in the wholesale market. The process later sought to promote fair access to transmission supported by an unbiased system operation and the creation of a competitive retail market for power.[11] In these states, investor-owned utilities (IOUs) were required to divest the majority of their generation assets and they were required to turn control of their transmission assets over to an independent system operator and/or particpate in a region transmission organization. While IOUs had previously relied on their own generation plants to produce most of the electric power needed to supply their customers, under the competitive wholesale market structure, they purchased power from

[10] By definition, market power is "the ability of an electricity supplier to raise prices profitably above competitive levels and maintain those prices for a significant time." In theory, the utilities that exercise market power would force the consumer to pay a higher electricity price than a competitive market price (EIA, 2000, 78).

[11] By the end of 2001, 23 states had enacted electricity restructuring legislation in the U.S (Ishii and Yan, 2007). However, following the California electricity crisis in 2001, the movement toward market restructuring and deregulation has experienced a significant slowdown: No additional states have adopted restructuring policies while some states had decided to delay, cancel, or significantly scale back their programs (Joskow, 2006).

merchant generators, independent power producers, and power marketers competing in the new market using two governance structures available: the bilateral forward contracts and market transactions.[12]

This paper examines the effect of the governance structures, which are used to purchase power in the wholesale market, on the technical efficiency of IOUs during the post-divestiture period. It pays special attention to bilateral forward contracts and market transactions.[13] The underlying question this research seeks to answer is to what extent are the governance structures in a policy-induced market able to promote the efficiency purpose of an economic organization.[14] This research is significant because the primary purpose of electricity market restructuring and deregulation has been to benefit the customer through the lower costs and lower prices of electricity (Joskow, 2006, p. 2).[15] The troubles experienced by some states that have undergone market restructuring and deregulation notably, the California electricity crisis in 2001, combined with higher market-based prices of electricity compared to prices in the regulated states, show the adverse effects of the reform, thus have reduced the enthusiasm of consumers and

[12] IOUs also purchased power from independent generators or other utilities using bilateral forward contracts and market transaction, especially since the Public Utilities Regulatory Policy Act (PURPA) of 1978 mandated IOUs to purchase power from the qualified generators at the utility's avoided cost rate, which is the cost the utility would pay to generate power in the absence of the independent generator. However, the majority of the generation is supplied by the utilities' own generating facilities.

[13] Two important differences between the two governance structures are, first, market transactions involve a third party, a middleman, between the buyer and seller, whereas bilateral transactions do not. Second, bilateral forward contracts are generally voluntary, whereas under market restructuring utilities are generally forced to use market transactions.

[14] I called the wholesale markets for power a policy-induced market because the market mechanism is set and promoted by government policies.

[15] Although, since the early 2000s, the policy focus of the electricity market restructuring has shifted from the efficiency motive toward environmental concerns (Borenstein and Bushnell, 2015).

policymakers for the competitive market reform (see Joskow, 2001, 2005, 2006, Borenstein and Bushnell, 2015).

The empirical evidence that has been published on the effect of divestiture policy on IOUs' efficiency shows some mix results. Delmas and Tokat (2005) find that retail deregulation has a negative impact on utilities' productive efficiency, especially for utilities that adopt a hybrid structure, i.e. having their own vertically integrated generations but at the same time also relying on the market to supply the electricity, compared to those utilities that rely more on either one. Kwoka, Pollitt, and Sergici (2010) also show that major divestiture of generation assets has a large adverse effect on utilities' distribution operating efficiency, especially when the divestitures are mandated by state regulation instead of a utilities' own initiative. To the contrary, regarding the generation sector, Fabrizio, Rose, and Wolfram (2007) show that market restructuring and deregulation has improved the operating performance of the investor-owned power plants, suggesting a modest efficiency gain in this sector. Trying to measure the net benefit of divestiture on utilities' overall distribution, transmission, and power sourcing performance, Triebs, Pollitt, and Kwoka (2010) show that, although divestiture reduces distribution efficiency while increasing power sourcing efficiency, the net benefit of divestiture on the electric utilities is positive. This finding indicates that the relatively lower costs of power outweigh the restructuring costs.

While these studies suggest that there is a significant effect of market restructuring and deregulation on the efficiency of electric utilities, empirical evidence on the underlying mechanism through which this reform affects the economic performance of IOUs is still lacking. To uncover this particular missing link is the main contribution of this paper, which is to examine the effect of the shift in governance from "to make" toward "to buy" governance—that is, from producing power internally, within an existing integrated corporate structure, to buying power from external and independent sources in the market place—and the effect of this governance shift to utilities' efficiency. The theoretical works devoted to the analysis of governance structure and efficiency in the competitive market model is referred to as transaction cost economics approach (Coase 1937, Williamson 1975, 1983, 1985, 2000, 2002, 2005, 2010). It suggests that in the markets that facilitate a private ordering,[16] private parties engaged in a transaction would choose governance structures (or economic institutions) that would minimize transaction costs. Regarding the vertical integration, this approach suggests that this governance structure is advantageous for a transaction when there is a bilateral dependency due to a high level of specialized assets and a high level of uncertainty in the market, as this type of governance is able to avoid the risk of costly repeated bargaining and opportunism. With this approach, this paper tries to examine whether the governance structures used in a policy-induced wholesale power market are able to achieve the efficiency goal of an economic organization.

I use a two-stage empirical to examine the performance of 152 distribution utilities in the U.S. from 1994 to 2015. Given the data's lengthy time duration, the analysis is able to capture both the short-term and the long-term effect of the divestiture of generation assets that mostly took place during 1996-2003 when the state utility

[16] Private ordering refers to a devise that is used by the private parties in a contractual relationship to resolve disputes outside the court by resignation, avoidance, exit, or self-help (Williamson, 1983, p. 520). Private ordering also refers to a self-enforcing agreement institution that underlies bilateral contractual relationships in the capitalist market system in contrast to a court order or a government regulation order (Williamson, 2005).

commissions require utilities to divest their generation assets. At the first stage, utilities' input-saving efficiency index for each year is measured using the non-parametric data envelopment analysis (DEA) technique (see Farrell, 1957; Charnes, Cooper, & Rhodes, 1978; and Färe & Grosskopf, 1985, 2000, 2004). The efficiency scores represent each utility's performance in terms of input use relative to the benchmark, which is the best practice among all the utilities in each particular year. At the second stage, the efficiency index is analyzed using difference-in-differences approach, to compare the performance of the utilities that experienced major divestiture before and after the divestiture with the performance of the vertically integrated utilities during the study period. The presence of vertically integrated utilities in the states that did not undergo market restructuring and deregulation is an advantage to this study as it serves as a natural control group to the treatment group, i.e. the divested utilities.

The results show that although the use of contract has a negative effect on efficiency, this effect is not statistically significant. Meanwhile, the use of market transactions after the divestiture has a significant negative effect on utilities' efficiency. These results suggest that the characteristics of power transaction make it economical for the utilities to use bilateral forward contracts for augmenting their purchasing power, but not for the (day ahead or real-time) market transactions. Trading arrangements in the restructured wholesale markets that rely on the concept of competition generates transaction costs that make it more costly for the utility to use market transactions rather than other alternatives. In other word, market transactions fall short to promote the efficiency purpose of an economic organization in this policy-induced market and the adverse effect persists until 20 years after the divestiture.

The U.S. Electricity Market Restructuring and Deregulation

Electricity market restructuring and deregulation in the U.S. continue to generate opposition (see Blumsack, Apt, and Lave, 2006). Nearly 40 years after the first federal law allowed independent generator to sell power into utility grid and more than 20 years after the Federal Energy Regulatory Commission (FERC) introduced a competitive wholesale market for power, the pro-competition agenda has not yet been adopted by and implemented in all states. Many states, notably the West (except for California) and the Southeast, still use the traditional regulation approach, allowing the vertically integrated utilities to provide the generation, transmission, and distribution of electricity in an integrated system and granting them exclusive franchises to supply electricity to the end-use customer with the price regulated by the states. A vertically integrated utility is believed to be able to benefit from economies of the interdependency between generation, transmission, and distribution in at least three ways. First, it would allow a form of coordination of scheduling shutdowns, a joint optimization of the investments, and better information flows between the vertical stages for a real-time operation. Second, it would reduce the transaction costs resulting from using contracts or market transaction for highly specific assets in the light of opportunistic behavior. Third, it would avoid double marginalization from the pricing mark-ups in each stage of production (Kwoka, Pollitt, & Sergici, 2010). Nevertheless, in some states that have undertaken major restructuring and deregulation, the electricity industries have been significantly transformed (Joskow, 2005, 2006a, 2006b).

Basically, the first move toward restructuring began when the Federal government enacted the Public Utilities Regulatory Policy Act (PURPA) in 1978 that required the investor-owned utilities (IOUs) to buy capacity and energy from independent generators at the "avoided cost" of production, which is the cost the utility would otherwise pay had it generate the power itself. The Energy Policy Act of 1992 further encouraged the competition by allowing independent power producer to sell power to entities other than the local utility, giving FERC the authority to order wheeling,[17] and requiring the utilities to consider the purchase of power as well as construction of power plants. These laws have spurred the creation of new wholesale power market with a high number of merchant generators, independent power producers (IPPs), and power marketeters. Furthermore, FERC Order 888 in 1996 required all transmission owners to provide wholesale transmission services to all parties in the wholesale market with open-access tariffs. Besides requiring utilities to open the access to their transmission line, FERC Order 888 also forced IOUs to functionally separate generation, transmission, power control, and distribution activities, as well as to turn the power control function to independent System Operators (ISOs) who control and manage the transmissions.[18] This effort was made to make sure that utilities that own the transmission line would not favor the power from their own generation over the power from other parties during the high usage of transmission line. Later on, FERC Order 2000, issued four years later, fostered the role of system operator in a larger market (across states) by encouraging the

[17] By definition, wheeling is the transmission of power across a utility system on behalf of a marketer or generator (Shively and Ferrare, 2012, p. 214).
[18] This functional unbundling of generation, transmission, and distribution was a less intrusive alternative to divestiture.

formation of the Regional Transmission Organizations (RTOs) (Shively & Ferrare, 2012). Under these regulations, electric utilities establish an open access transmission tariff, separate rates for wholesale generation, transmission, and ancillary services, [19] and openly provided information on the availability of the transmission capacity through an electronic information network (EIA, 2000).

Following the FERC Orders, some states started to require the traditional utilities under their jurisdiction to divest their generation plants and turn the control of transmission assets to an ISO or an RTO.[20] As a result, during 1997-2000 period, 51 of the 161 IOUs owning generation capacity have divested their generations assets that accounted for 22% of all generation capacity in the U.S. (EIA, 2000). The divestiture policy is central to the market restructuring agenda as it serves at least three purposes. First, it prevents incumbent utilities from exercising their market power in the new wholesale market by having their own generation facilities. Second, it provides a basic formula for evaluating the "stranded costs" related to the generation assets acquired prior to the restructuring that are no longer competitive in the new restructured market. Third, it encourages broader entry and investment by IPPs since they are able to participate in the wholesale market immediately as they buy the divested assets (Ishii & Yan, 2007).

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[19] Ancillary services are the services required by system operators to ensure safe and secure operation of the electric grid that include automatic generation control, load-following resources, and electricity reserves (Shively and Ferrare, 2012).

[20] In fact, there is a variety of channel through which divestitures took place. There are states that enacted state laws mandated divestiture, while some states used divestiture as a requirement for other regulatory approval such as approval for mergers, recovery of stranded costs, or other incentive regulation. However, in some other states such as Pennsylvania, New Jersey, and Maryland, utilities divested their generation assets voluntarily in the absence of such mandate or regulation (Kwoka, Pollitt, & Sergici, 2010).

The divestiture of generation assets and the divestiture of control, but not of ownership, of transmission assets have has transformed vertically integrated utilities into mainly distribution utilities.[21] To supply electricity to end-use customers, the divested utilities purchase power from independent power producers, merchant generators, power marketers in the wholesale market using a variety of governance structures that can be classified into two groups: bilateral forward contracts and market transactions. Bilateral forward contracts may include the long-term, intermediate-term, and short-term contracts, while market transactions may include the day ahead and real time transactions. Utilities usually obtain power from IPPs using long-term contracts, as IPPs usually finance the construction of power generation facilities and then contract all their generation capacity to the utility until they achieve payback on their investments. Meanwhile, with merchant generators, long-term contracts are seldom used as merchant generators sell power to a variety of market participants using market prices.[22] With electric marketers who purchase electricity from generators and then resell it to utilities, end users, or other marketers, it is very likely for the utilities to use a short-term contract or a market transaction for the power transaction. Meanwhile, market transactions are used to balance the electricity supply and demand through day ahead or real time transactions. Utilities may buy and sell electricity using market transactions from or to other utilities, independent generators, power marketers, and ISOs or RTOs. In states where the electricity system has been deregulated, the ISO or RTO facilitate day-ahead or real time market transactions to balance the supply needs of utilities and sometimes run a bilateral

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[21] Many utilities that have divested the majority of their generation assets still retained a small portion of their generation assets, mainly their hydro or other renewable projects.

[22] Merchant generators also offer a number of services besides electricity, such as capacity and ancillary services to utilities, marketers, ISOs, or ultimate customers.

forward contract for capacity to ensure sufficient generation is built (Shively & Ferrare, 2012, p. 115).

What makes the competitive wholesale market really different from the vertically integrated monopoly structure is basically the trading arrangement mechanism (see Shively & Ferrare, 2012). A vertically integrated monopoly uses a wheeling method, while a wholesale market uses the decentralized or integrated methods. A trading arrangement mechanism is central to electricity generation, transmission and distribution, as the special characteristics of electricity[23] suggests the importance of carefully managing the schedules of generation, load, power flow to balance the highly volatile demand for electricity (Griffin and Puller, 2019). While in wheeling the utility's system operator is the one who centrally plan and coordinate the trading arrangement, in decentralized or integrated methods, it is the ISO or RTO who play the central role of operating and governing the trading arrangement among various players in the market by using an auctioning system.

The wheeling is a central planning method, where generation of electricity, purchased power, and ancillary services are managed and scheduled centrally and in an integrated manner by the utility's system operator with the objective of providing the lowest-cost services. The utility allows other parties to use its transmission system on an open-access basis to the extent that it does not impact utility's own customers' need. Utilities usually have a certain long-term capacity adequacy to make sure for a reliable

[23] Electricity has special characteristics that make its transaction different from other commodities. One important fact is that the injection and withdrawal of energy to and from the transmission grid should always be balanced as energy cannot be stored economically. The problem is that imbalances of supply and demand cannot be easily overcome and could cause a disruption to the entire system (Griffin and Puller, 2019).

delivery. Then, the generation and purchase of power are scheduled in the day ahead based on the utility's load forecast. The utility's system operator manages imbalances between scheduled generation and electricity demand by ramping up or down utility-owned or contracted generating units. Real time imbalances can also be overcome by buying and selling electricity from or to other utilities or independent generators.

Meanwhile, under the competitive wholesale market structure, the central planning role of utility's system operator is eliminated and replaced by the role of an ISO or an RTO as an operator, which coordinates multiple buyers and sellers in a competitive market. Under the decentralized trading arrangement, the role of an ISO or RTO is simply a scheduler and an arbiter of free markets that handles the scheduling of power, the acquisition of ancillary services, access to transmission, and management of the system in real time. Most importantly, the ISO or RTO uses auction methodology to manage the transmission access, to acquire ancillary services needed, and to create the stack of unit available to provide real-time balancing of energy supply and demand.[24] Under this trading arrangement, there is no provision that ensures long-term capacity adequacy. Market transactions are expected to clear up any surplus or deficiency in the market. With this arrangement, the costs for ancillary services, transmission access, and real-time energy fluctuate every hour often in an unpredictable way. Transaction costs

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[24] This auction mechanism is used to create market clearing prices that will serve as the bases for: (1) granting access to transmission when there is a congestion due to imbalances between power schedules and loads, (2) charging the customers that do not supply their own ancillary services with the pro-rata share of ancillary services costs that are based on the lowest bid price for ancillary services in the auctions, and (3) managing the imbalances of generation in real time by paying or charging the scheduling coordinators who create imbalances with the prices that are based on the prices paid to the units ramped up or down in real time schedule (Shively & Ferrare, 2012, p. 113).

incurred in the competitive wholesale markets with the decentralized trading arrangements are high, thus the use of repeated market transactions only create inefficient transactions.

To find a middle ground between central planning and auction-based market, some states have turned to an integrated trading arrangement.[25] Within this arrangement, ISOs operate both real time and day ahead energy markets in one integrated system. This system is basically the one used in the wheeling method, with a modification related to the way input costs are determined, which is no longer based on marginal costs, but rather on the market clearing prices set through the auction mechanism. The ISO still manages imbalances through real-time market transactions based on the bid prices, however, it conducts the scheduling a day ahead.

It is obvious that market transactions become central under the decentralized and integrated trading arrangements, especially to overcome energy market (real-time) imbalances. Meanwhile, under the wheeling mechanism, market transactions are not the primary choice. Since the long-term capacity adequacy is ensured and regulated by the states, energy market imbalances are more likely to be anticipated. Power purchased using market transactions accounts for a small portion compared to power produced by utilities' own generation or purchased using bilateral forward contracts. In a decentralized and integrated system, price volatility can be high as prices are set based on an auction method, while in the wheeling system, prices tend to be stable because they are set by the regulators.

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[25] The ISOs in California and Texas have recently shifted from using the decentralized trading arrangement to the integrated one (Shively and Ferrare, 2012).

Literature Review

Transaction costs economics (Coase, 1937; Williamson, 1975, 1976, 1985, 2000, 2002, 2005, 2010) and its applications (Joskow, 1985, 1991, 1997) help explain how a vertically-integrated natural monopoly promotes efficiency in electricity sector. The basic argument is that in a capitalist market system that fosters private ordering, a specific transaction that has certain basic attributes is aligned with a specific governance structure that can minimize the transaction costs the most. Those certain basic attributes include the level of the asset specificity, the degree of market uncertainty, and the frequency of the transaction (Williamson, 2005). By definition, governance structure refers to "an effort to craft order, therefore to mitigate conflict and realize a mutual gain" (Williamson, 2000, p. 599). Basic governance structures include market exchange, hybrid contracting, and hierarchy (firms and bureaus). Thus, the higher the level of asset specificity, uncertainty, and frequency of a transaction, the more complex the transaction becomes. Meanwhile, the more complex a transaction is, the higher the cost of doing a transaction (and vice versa).[26] Furthermore, this approach suggests that any contractual relationship would suffer from the problem of an incomplete contract as human actors have a cognitive limitation and self-interestedness motive. Meanwhile, opportunistic behavior makes contractual incompleteness more problematic as the problems of adverse selection, moral hazard, shirking, and sub-goal pursuit might take place. These contractual hazards impose high transaction costs that would lead firms to choose certain governance that

[26] Transaction costs are "the costs of measuring the valuable attributes of what is being exchanged and the costs of protecting rights and policing and enforcing agreement" (North 1990, 27).

would reduce such burdens. Thus, a governance structure will reshape the incentives as to minimize the transaction costs. This means that efficiency, in terms of minimization of the costs of doing a transaction, is the underlying motive for the choice of governance structure in a capitalist market.

Transaction costs economics has been a long-time proponent of “non-standard” vertical contracting practices to challenge the standard neo-classical economic approach that is fairly hostile to vertical integration phenomena. The problem of incomplete contract and the hazard of opportunism are the grounds for the analysis of ex-post performance problem in non-standard contracts. This approach suggests that vertical integration is advantageous for a transaction when there is a bilateral dependency due to a high level of specialized assets and a high level of uncertainty in the market, as this type of governance is able to avoid the risk of costly repeated bargaining and the hazard of opportunism.

Empirical research in electricity sectors confirms this theory. Analyzing the U.S. coal market, Joskow (1985) shows how basic characteristics of coal transactions affect the choice of governance structures in coal market transaction. Long-term contracts rather than spot market and short-term contracts are the most preferred governance structure used by electric utilities for coal transactions. Meanwhile, he also finds that vertical integration for coal supply transactions is prevalent for mine-mouth plants that involve a durable transaction-specific investment and a high level of uncertainty about coal demand. Furthermore, observing 277 coal contracts, Joskow (1991) confirms the importance of relationship-specific investment in determining the length of the contractual relationship to support cost-minimizing exchange. The coal transaction-specific investment includes the fact that the plant is site-specific and highly immobile, that the equipment is specific to the transaction and thus have lower value for alternative uses, and that the general investment was a dedicated asset, made with the prospect of selling a significant amount of the product to the other party in the agreement over a long period of time. Therefore, this approach suggests that it is necessary to understand the transactional characteristics of electricity production and transaction that make it economical for utilities to integrate vertically. And it is unsound to assume that non-standard governance structures, such as vertical integration, are always related to market power, or that competitive markets will always lead to an efficient solution (Joskow, 1991).

This approach is very insightful to this research that seeks to examine the effect of governance structures on efficiency in the electricity sector because it offers the way of comparing different governance structures in order to find a superior feasible alternative. Williamson (2000) claims that all governance structures are flaw, yet one that minimizes transaction costs the most should be considered as the superior governance structure. However, it is worth to always note that transaction cost economics assumes an advanced capitalist market. The concept of private ordering as a self-enforcing agreement institution that underlies bilateral contractual relationships becomes central in this approach because. Transaction cost economics suggests that when a market can facilitate spontaneous but intentional private ordering, then private parties engaged in a transaction would choose governance structures (or economic institutions) that would minimize transaction costs. Thus, it is important to be aware that the electricity market restructuring and deregulation in the U.S. has created a policy-induced market that departs from the basic conception about a competitive private market. The governance structures used under this market might not be the ones able to minimize the transaction costs nor able to capture sufficient benefits to outweigh the costs.

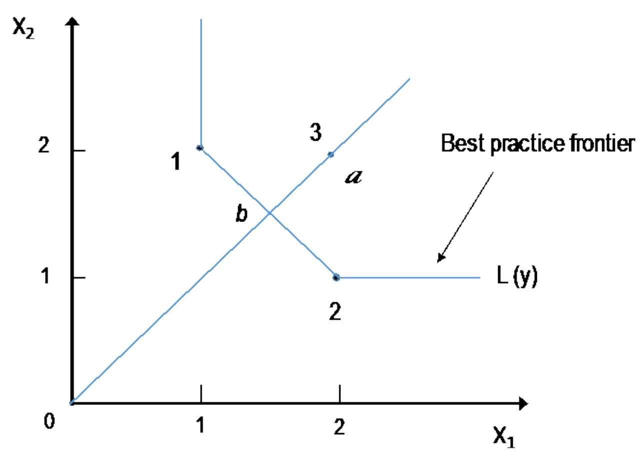
Empirical Strategy

The empirical strategy used in this study is the two-stage analysis consisting of data envelopment analysis (DEA) and the difference-in-differences (DD) regression approach. DEA is used to measure the productive efficiency of the utilities, while the DD approach to compare the performance of the utilities that experienced major divestiture before and after the divestiture, to the performance of the vertically integrated utilities during the study period.

Data envelopment analysis

At the first stage of analysis, utilities' input-saving efficiency index for each year is measured using the non-parametric data envelopment analysis (DEA) technique (see Farrell, 1957; Charnes, Cooper, & Rhodes, 1978; and Färe & Grosskopf, 1985, 2000, 2004). This approach has been widely used by scholars and practitioners to evaluate industry-wide or firm-specific productivity, including in the electricity sector (Delmas & Tokat, 2005; Kwoka, Pollitt, & Sergici, 2010; Triebs, Pollitt, & Kwoka, 2010). As a non-parametric approach to measuring efficiency and productivity, DEA does not require any functional form for empirical estimation as required by the parametric approach. Moreover, DEA can also handle multiple inputs and outputs to perform the straightforward calculations of technical efficiency. Basically, DEA measures efficiency index based on how a firm performs relative to a benchmark. The benchmark for each individual utility, the so-called best practice frontier, is constructed based on observed achievements in a similar operation. In this case, the benchmark consists of utilities that produce similar outputs with the least resources or lowest costs. This study uses the assumptions of a constant return to scale for the measurement and strong disposability of input, which means that an increase in inputs cannot decrease the outputs. See Appendix 2 for the DEA measurement.

Figure 3. 1. The input saving measure of technical efficiency.



Source: Färe & Grosskopf, 2000, p. 13

Efficiency in this study refers to Farrell input-saving technical efficiency, which measures how much more inputs can be saved to produce a given amount of output (Färe & Grosskopf 2000). Figure 3.1. shows how the best practice frontier is constructed based on observations. The input-saving technical efficiency is measured as the deviation of each particular project from the best practice frontier in a radial way. In Figure 3.1., the technical efficiency of utility-3 is measured by $0b/0a$, which is the ratio of the size of potential output (at b) to the size of actual/observed output (at a). Given output y, 1 reflects efficiency while less than 1 means inefficiency (Färe & Grosskopt, 2000, p. 13).

This study follows Kwoka, Pollitt, and Sergici (2010) for the choice of variables used for the efficiency measurement. However, unlike their study, which focuses only on the distribution expenses of the utilities, this study covers total production, transmission, and distribution expenses that are reported by the utilities. Since this study analyzes the effect of utilities' divestiture and the purchasing power activity on their performance, focusing only on distribution will not reflect the total effect on the overall performance before and after the divestiture.[27] Moreover, this study excludes the use of distribution line length in utilities' efficiency measurement, as this study covers total expenditures rather than just distribution expenditure.

The DEA model includes two input variables and two output variables. The input variables represent capital expenditure (capex) and operational and maintenance expenditure (opex). Both capex and opex cover all production, distribution, and transmission expenses. In addition, the opex includes salaries and wages. Following Kwoka, Pollitt, and Sergici (2010), current capital expenditure (measured by the additional plant in each particular year) is used rather than the total capital expenditure as it has the advantage of being a controllable expense and more related to the yearly investment program of the utilities. However, unlike Kwoka, Pollitt, and Sergici (2010) this study does not use the sum of capex and opex as a single variable to be able to distinguish the separate effects of the prices of capex and opex. Meanwhile, the output

[27] A direct result of the divestiture of generation assets is a significant reduction in production expenditures and a significant increase in the purchase of power. These effects will be reflected in the production expenditures rather than distribution expenditure. Meanwhile, as a result of the vertical separation, there will be changes in transmission expenditure as well.

variables represent total sales of electricity and total customers. Regarding the data for the output variables, this study uses FERC data that accounts for bundled sales and customers.[28] Since this analysis covers all production, distribution, and transmission expenses, the use of bundled sales and customers data will help capture the total performance of the utilities, because they receive payment from every delivery using their transmission line. The result of the DEA process is a matrix of input-saving efficiency scores for each utility yearly for the period of 1994-2015.[29]

Regression analysis

In the second stage of analysis, the efficiency scores obtained in the first stage are regressed on the amount of power purchased by the utilities using various types of bilateral transactions (non-firm service, short-tern firm, or long-term firm service) and market transactions.[30] The effect of governance structures for purchasing power after divestiture on utilities' efficiency is identified using the variation in efficiency within utilities between the treatment and control groups. While divested utilities were selected non-randomly following the policies of market restructuring and deregulation, factors that led the state to adopt those policies are not discussed in this paper. The use of within-utility variations allows this study to account for all time-invariant characteristics common to electric utilities and their various geographical characteristics, such as the

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[28] To measure distribution efficiency, Kwoka, Pollitt, and Sergici (2010) and Triebs, Pollits, and Kwoka (2010), adjust the bundled sales and customer data reported to FERC, as those data are not consistent with the actual number after the introduction of retail competition in some state.
[29] In this study, DEA was performed using the On Front 2 software package developed by Färe and Grosskopf (2000).
[30] Simar and Wilson (2007) suggest the use of a double-bootstrap estimator to account for the bias in the original efficiency scores as well as error correlations in the second stage regression. However, in this paper, a robustness check for the efficiency scores is performed by comparing different models to check the consistency of the result.

geographical characteristics, political affluences, the presence of the ISOs or RTOs and retail choice policies, and, most likely, customer preferences toward renewable energy. Within utilities, treatment assignment, i.e. major divestiture of generation assets, should be uncorrelated with time-varying unobserved characteristics affecting efficiency as the outcome. The basic DD regression model is:

$$eff_{it} = \beta_0 + \beta_1\, contract_{it} + \beta_2\, market_{it} + \beta_3\, divested_{it} + \beta_4\, contract_{it} \times divested + \beta_5\, market_{it} \times divested + \gamma_i + \delta_t + u_{it}, \quad (1)$$

where eff is the input-saving technical efficiency index resulted from the DEA analysis, contract is the amount of power purchased using bilateral forward contracts (MWh), market is the amount of power purchased using market transaction (MWh), divested is the dummy for divestiture whereas 1 equal the year of divestiture and the year thereafter and 0 otherwise, γ is the utility fixed effect, δ is the year effect, and u is the random error for each project i in time t. The inclusion of utility and time fixed effect (γ and δ, respectively) captures mean outcomes within utilities and years, thus ensuring that the coefficients of interest, β_4 and β_5, measure the differential change in outcomes between divested utilities and vertically integrated utilities by years. This study uses cluster standard errors by utilities as the unit of treatment. Furthermore, the inclusion of the year effect δ is important to capture factors affecting efficiency that are common to all utilities in a particular year. As the movement toward electricity competitive market was introduced by policies at the Federal level, including the year effect δ will take into account confounding changes at the national level that affect all utilities.

The identifying assumption for the inclusion of control groups, i.e. the vertically integrated utilities, is that the efficiency trends in both divested utilities and vertically integrated utilities would be identical in the absence of divestiture policy. To test the plausibility of this assumption, this study check for differential pre-treatment outcome trends using the following regression:

$$eff = \beta_0 + \beta_1 t + \beta_2 \, t \times divestedever + \gamma_i + \delta_t + u_{it}, \qquad (2)$$

where the sample is limited to pre-treatment period, i.e. the years before the major divestiture took place for the divested utility and the years before 1997 for the vertically integrated utilities,[31] while t is the time rescale variable where 0 is the divestiture year for divested utilities and 1997 for the vertically integrated utilities, and $divestedever$ is the dummy for whether or not the utility underwent divestiture, whereas 1 equal divested utility and 0 otherwise. The coefficient β_2 captures any differential pre-treatment outcome trends between utilities that later undertake divestiture and those that remain vertically integrated. The null hypothesis $\beta_2 = 0$, therefore, corresponds to the identifying assumptions that there was a common trend between the outcomes of the divested utilities and vertically integrated utilities.

Relying on this technique, the research will estimate the effect of using bilateral forward contracts and market transactions for purchasing power in the wholesale power market before and after the divestiture by comparing it with the efficiency of the

[31] Since the year the utilities underwent major divestiture varies across utilities, but mostly around 1997-2003, then this study uses 1997, a year after the issuance of FERC Order 888 of 1996 that requested utility to vertically separate generation, transmission, and distribution, as the treatment year for the control group, i.e. the vertically integrated utilities.

vertically integrated utilities during the study period. The coefficients β_4 and β_5 in equation (1) represent the average of the treatment effect, thus are expected to show the effect of governance structures on efficiency after divestiture. The null hypotheses $\beta_4 = \beta_5 = 0$, therefore, corresponds to the assumption divestiture has no impact the manner in which contracts and market purchases influence efficiency. The effect of market transactions on efficiency is expected to be negative to show that transaction costs exist in the wholesale power market. However, the effect of bilateral forward contracts on efficiency could be positive in a competitive wholesale market with the absence of a vertically integrated industries, while it could be negative in a traditional vertically integrated industry since most utilities have their own generating facilities that could be more efficient.

Data

This study employs a rich and comprehensive database provided by the U.S. Federal Energy Regulatory Commission (FERC) Form No. 1 that contains the annual reports of major electric utilities to examine the performance of 152 distribution utilities in the U.S. during the period from 1994 to 2015. In addition, this study uses additional data from the U.S. Energy Information Administration (EIA) Form No. 861 on the total number of customers to replace some missing values in the FERC database. Distribution utilities are selected from the total of 320 utilities available in the database based on the presence of expenses for distribution plants in service and distribution electric operation and maintenance. Focusing on the distribution utilities allows this study to precisely measure the effect of divestiture and restructuring on the economic performance of the utilities, as these utilities experience the shift from vertically integrated firms to stand-alone distribution firms. As the result of this selection, independent generators and power marketers are excluded from the data set. In addition, this study excludes cooperatives or customer-owned utilities, distribution utilities that are located in Alaska and Hawaii, as well as those that have only been subject to one year of observation. Given the data's lengthy time duration, the analysis is able to capture both the short- and the long-term effect of the divestiture of generation assets that took place from 1996 to 2003 period when state utility commissions required utilities to divest their generation assets. Finally, this study uses an unbalanced panel data to include observations with different time periods, thus make use of all data available.

The data covers total capital expenditure and total operation and maintenance expenditure that include the generation, transmission, and distribution costs, salaries and wages for electric operation and maintenance, total production plant expenditure (to measure divestiture), sales of electricity, total customers, and power purchased by types of contracts. The definitions and sources for all variables are presented in Table 3.4. in Appendix 2. The Handy-Whitman index for public utility construction costs is used to determine the real value for each expenditure, while the Producer Production Index (PPI) is used to normalize salary and wage data.[32] This study approaches the actual divestiture experienced by the utilities by referring to the value of the total production plant yearly. Following Kwoka, Pollitt, and Sergici (2010), a major divestiture is defined as a year-over-year decline in the amount of utility's production plant expenses of at least one-half

[32] For the Handy-Whitman index, since after 2001 the indices are reported twice a year, in January and July, then yearly index is measured following Makholm, Ros, and Case (2012) using this formula: $HW_t = (HW_{jan,t} \text{ x } 2 \ (HW_{jul,t}) \text{ x } HW_{jan,\ t+1})/4$.

of the value of previous year. Therefore, divestiture variable is a dummy variable that identifies the year in which a major divestiture occurred and the year thereafter. By this definition, out of 152 utilities in the sample, 126 utilities underwent major divestiture of their generation assets, while 26 utilities remained vertically integrated.

This paper follows the category of bilateral relations for purchasing power used in FERC Financial Report Form 1 to define bilateral forward contract and market transaction variables. Accordingly, this study defines bilateral forward contracts to include: 1) the requirements service contracts, 2) long-term “firm” service contracts, 3) intermediate-term “firm” service contracts, 4) long-term services from a designated generating unit, and 5) intermediate-term services from a designated generating unit. By definition, the requirement service is service in which the supplier plans to provide all the energy and capacity required by the buyer, including the necessary transmission. The term “firm” means that the seller has provided a fixed amount of energy and has reserved transmission capacity to deliver the power to the seller. It also means that the service cannot be interrupted for economic reasons and will remain reliable even under adverse conditions. In this paper, long-term refers to 5-10 years and intermediate-term to 1-5 years.

This study does not include short-term contracts—that is, contracts with the duration of one year or less—in the category of forward contract. This is because short-term contracts have very different characteristics compared to the long-term and intermediate-term firm contracts in terms of transaction cost minimization. According to FERC Form 1, short-term contracts are not as ‘firm’ as long- and intermediate-term contracts and thus can be interrupted and are not as reliable. Some of utilities’ power purchase transactions with the ISOs or RTOs also use short-term service contracts, indicating that this type of contract can include transactions related to the ISO's or RTO's balancing electricity purposes. Therefore, in this paper, contracts, which are one year or less, are included in the market transaction.

Market transactions are referred to not only real time market transactions and day ahead market transactions, but also transactions using one year or less contracts. In reference to FERC Form 1 classification, market transactions encompass: 1) exchange of electricity that involves a balancing of debits and credit for energy, capacity, other services, 2) other service transaction which include all non-firm service regardless of the length of the contract and service from designated units of less than one year, and 3) short-term contracts (FERC Form 1). However, the analysis performs a robustness check by measuring how market transaction in the absence of the short-term contracts affect utilities' efficiency.

Table 3. 1. Descriptive statistics of divested utilities versus vertically integrated utility

	Divested Utilities		Vertically Integrated Utilities	
	Observation	Mean	Observation	Mean
Addition to capital costs (US$)	2561	55,700,000	327	7,274,666
Operation & maintenance costs (US$)	2561	377,000,000	327	66,200,000
Total production plants (US$)	2561	437,000,000	327	23,300,000
Total sales (MWh)	2561	46,900,000	327	3,087,747
Total customers (monthly average)	2561	768,708.5	327	164,104
Power purchased using contracts (MWh)	2487	2,985,482	321	1,771,220
Power purchased using market transaction (MWh)	2487	6,916,318	321	976,605.1

Summary statistics on the divested and vertically integrated utilities reported in Table 3.1. show that in terms of the scale of business, divested utilities have, on average, much larger expenditures for capital investments, operation and maintenance, and production plants compared to the expenditures of vertically integrated utilities. Divested utilities also produce more outputs in terms of sales of electricity and the average number of customers compared to the outputs of vertically integrated utilities. Moreover, as a consequence of the divestiture of generation assets, divested utilities purchase almost twice as much power using bilateral forward contracts and seven times more power using market transactions compared to the vertically integrated utilities.

Figure 3. 2. MWh purchased using bilateral forward contracts (in million MWh)

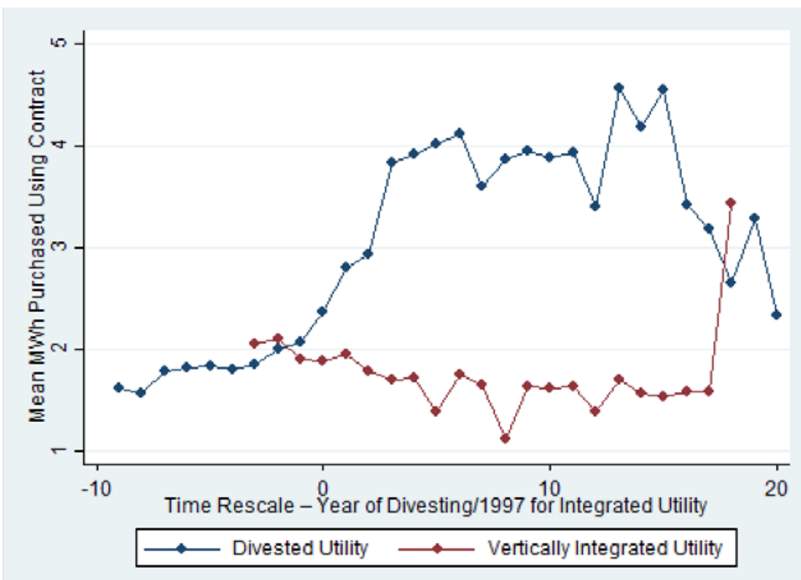
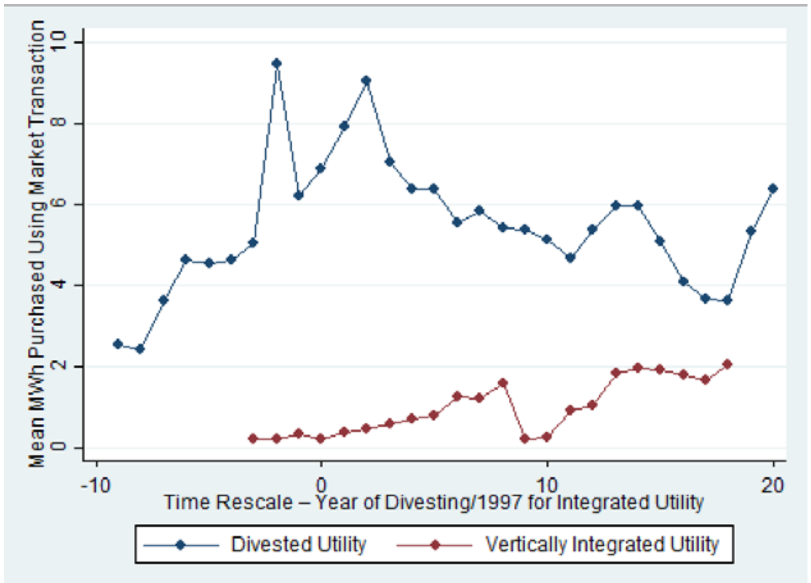


Figure 3. 3. MWh purchased using market transactions (in million MWh)



Furthermore, Figures 3.2. and 3.3. show the trends of purchasing power using bilateral forward contracts and market transactions. Before divestiture (time rescale < 0), the trend of purchasing power using bilateral forward contracts is similar for both the divested and vertically integrated utilities. However, after divestiture (time rescale > 0), the divested utilities have a significant increase in the average amount of power purchased using bilateral forward contracts, although 15 years after divestiture this trend started to decline. Meanwhile, the trend for power purchased using market transactions tend to be more stable for both the divested and vertically integrated utilities, with a sharp increase for the divested utilities at a year before divestiture, where some utilities has started divesting few of their generation assets and purchased power from the market.

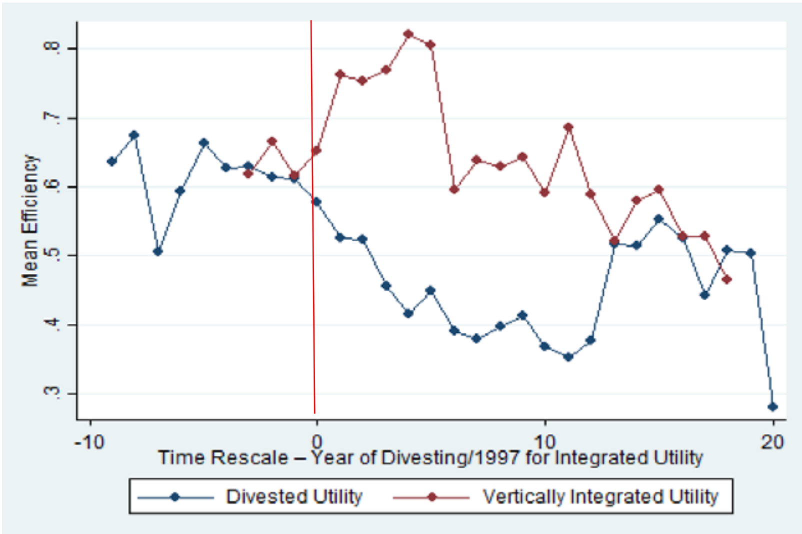
Results

Before presenting the main result, it is important to show that including the control group, i.e. the vertically integrated utilities, in analyzing of the effect of governance structures on the efficiency scores of divested utilities is justifiable. Including this control group is appropriate if the efficiency trends would have been identical, on average, in divested and vertically integrated utilities in the absence of market restructuring and deregulation, more specifically associated with divestiture policy. To check the plausibility of this assumption, I conduct a common pre-treatment test to see whether the outcome trends were parallel between treatment and control group prior to the divestiture policy. I ran regression (2) using the pre-divestiture period only, which is the year of the divestiture for the divested utilities and 1997 for the vertically integrated utilities.

Results show that the interaction term (β_2) is not statistically distinguishable from zero at 5% significant level with the coefficient of –0.049, suggesting that there was no pre-treatment difference in trends of efficiency between the divested utilities and the vertically integrated utilities (see Table 3.5. in Appendix 2). Thus, the choice of including vertically integrated utilities in the sample is a sound strategy.

This result is also supported by the common pre-treatment graph. Figure 3.4. shows the common pre-treatment trends for the average efficiency within the treatment and the control groups. Using the time rescale variable, where 0 represents the year of major divestiture for the divested utilities and 1997 for the vertically integrated utilities, the graph shows the trend during the pre-treatment period. It shows that there is no differential in the trend of average efficiency between divested utilities and vertically integrated utilities. This graph also shows that the average efficiency fluctuates a great deal year by year.

Figure 3. 4. The average efficiency trends for the divested utilities and vertically integrated utilities



Notes: 0 represents the divestiture year for divested utilities and the year 1997 for the vertically integrated utilities.

Additional investigation on the trends of all the input and output variables used to measure the efficiency scores (capex, opex, total sales, and total customers) suggests that the fluctuating trends in efficiency corresponds to the fluctuating trends in capex, opex, and especially in terms of total sales of electricity that has sharp spikes (see Figures 3.5. – 3.8. in Appendix 2).

Table 3.2. presents the main results from estimating equation (1) based on 152 utilities for the period of 1994-2015. The outcome variable indicates the input-saving technical efficiency scores of the utilities by year. The coefficients of the interaction term between contract and divested dummy shows that the use of contract does not have a

significant effect on efficiency. Meanwhile, the use of market transaction in purchasing power by divested utility after the divestiture reduces the efficiency scores by 0.002 points and it is significant at 1% level. This effect is even greater when market transactions does not include power purchased using short-term contract, which reduces the efficiency scores by 0.006 and it is significant at 1% level.

Table 3. 2. Effects of governance structures on efficiency

Dependent variable: Technical efficiency	All Sample	Market Transactions Without Short-Term Contract
Contract (in million MWh)	0.003	0.004
	(0.003)	(0.003)
Market (in million MWh)	0.002***	0.002***
	(0.001)	(0.001)
Divested	–0.035	–0.037
	(0.027)	(0.027)
Contract × Divested	–0.002	–0.002
	(0.001)	(0.001)
Market × Divested	–0.002***	–0.006***
	(0.001)	(0.003)
N observations	2,808	2,808
N groups	152	152
R^2	0.32	0.32

Notes: Cluster standard errors by utility are within the bracket.
Significance levels: * 10 percent; ** 5 percent; *** 1 percent.
Contract include requirement services, long-term firm services, intermediate-term firm services, long-term services from a designated generating unit, and intermediate-term services from a designated generating unit. Market include short-term services, market exchange, and other services.

These findings suggest there are possible positive aspects of forward contracts in contrast to the clearly negative aspects of market purchases. The characteristics of power transaction make it economical for the utilities to use bilateral forward contracts for augmenting their purchasing power, but not for the market transactions that include the day ahead and real-time transactions and one year or less contractual transactions. Trading arrangements in the restructured wholesale markets that rely on the concept of competition generate transaction costs that make it too costly for the utility to use market transactions. Thus, market transactions are not the efficient governance structure to facilitate power transactions in the policy-induced wholesale markets for power.

I explore these results further in Table 3.3., by running the regression (1) with specific types of contracts and market transactions as well as by regions. I follow the category of US geographic regions used in the Journal of Handy-Whitman Index for Public Utility Construction Costs (2017) that divides the 48 continental US states into six geographical regions of North Atlantic, South Atlantic, North Central, South Central, Plateau, and Pacific regions. This mapping is helpful as it is almost identical with the mapping of ISOs and RTOs (see Borenstein and Bushnell, 2015). Thus, each region represents whether or not ISOs or RTOs are present, except for the South Atlantic and Pacific regions where there are states that do have and those that do not have ISO or RTO. The presence of ISOs and RTOs basically indicates that the states have experienced electricity market restructuring and deregulation. Thus, among those 6 regions, North Atlantic, North Central, and South Central are the regions underwent market restructuring and deregulation, while Plateau is the regulated region,[33] and Pacific and South Atlantic are the mixed regions.

The results show that in all regions, the two categories of market transactions, i.e. exchange of electricity and other services, have a significant effect on divested utilities'

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[33] There are small parts of Montana that are affected by the presence of Midcontinent ISO (MISO) and small parts of New Mexico that are affected by Southwest Power Pool (SPP) according to the map of ISOs and RTOs in Borenstein and Bushnell (2015).

efficiency scores after divestiture. However, the use of exchange of electricity transaction increases the efficiency scores by 0.077 points and it is significant at 1% level, while other services transaction reduces the efficiency scores by 0.002 points and it is significant at 1% level.[34] Meanwhile, no type of bilateral forward contracts has a significant effect on efficiency after divestiture.

A closer look at these effects in the six US regions clearly shows that both exchange of electricity and other services transactions have a significant negative effect on divested utilities' efficiency after divestiture in two of the three regions that have restructured and deregulated their electricity market (North Atlantic and North Central). Meanwhile, the effect of exchange of electricity on efficiency is not significant in either the regulated region (the Plateau) or the mixed regions (South Atlantic and Pacific). For the use of other services transaction, the significant negative effect on divested utilities' efficiency after divestiture is found in almost all regions, except for Plateau and Pacific.

These results suggest that in general across regions, the use of market transactions is less efficient compared to the use of bilateral forward contracts. Meanwhile, the significant negative effect of bilateral forward contracts, especially in the regulated or mixed regions, suggests that bilateral forward contracts are also less efficient compared to the vertically integrated generation. These results confirm that governance structures for purchasing power after market restructuring and deregulation have significantly affected divested utilities' input-saving technical efficiency. The significant negative effect of market transactions suggests that there is an adverse effect of the divestiture

[34] Although not statistically significant, the positive effect of the exchange of electricity transaction is found only in South Atlantic and Pacific regions, the mixed regions consist of states that underwent market restructuring and deregulation as well as states that still regulate the electricity industry.

policy on utilities' economic performance, and this effect persist after 20 years after divestiture.

Conclusion

The paper shows that market restructuring and deregulation, specifically divestiture policy, has a negative impact on utilities' efficiency both in the short- and long-term. The channel through which divestiture affect efficiency is the governance structure used in the wholesale market for power, where utilities purchase power from various sellers in the market using bilateral forward contracts and market transactions. While bilateral forward long-term and intermediate-term contracts do have positive but not significant effects on efficiency, market transactions for purchasing power reduce divested utilities' efficiency scores after divestiture.

Trading arrangement mechanisms under the competitive wholesale market for power, i.e. the decentralized and integrated methods, have forced utilities to rely heavily on day ahead and real time market transactions that are facilitated by the ISOs and RTOs to overcome energy imbalances. Even more, these trading arrangements have forced utilities to balance the long-term energy and peak capacity requirements of their customers with the resources available from short-term market transactions. This energy imbalance market imposes high transaction costs that subsequently affect the extent to which utilities are able to save the input costs in order to produce their outputs in terms of sales of electricity and the average number of customers. The role of the ISOs and RTOs as auctioneer for pricing, dispatching of generation resources, and controlling transmission operations is not costless and it many cases may not replace functions within the utility. Therefore, the use of market transactions in the competitive wholesale market for power is proven to have an adverse effect on utilities' efficiency, which persists for two decades after the initial divestiture.

This paper concludes market transactions have not been an efficient governance structure to facilitate transactions in the policy-induced wholesale markets for power. Will they become more efficient, will they provide cost-savings for their members, and possibly others, at some point in the future? As ISOs and RTOs nevertheless are not static organizations and will learn and adapt over time, and this research only covers a twenty-year period, which is only about half the economic life of a generating plant and a third of the life of a transmission line, the answer is: it depends on how ISOs and RTOs may evolve to suit their members' needs and it is the challenge of future researches to evaluate the effect.

Table 3. 3. Effects of governance structure on efficiency by types of contracts, market transaction, and regions

Dependent variable: ***Input-saving Technical efficiency***	**All regions**	**North Atlantic**	**South Atlantic**	**North Central**	**South Central**	**Plateau**	**Pacific**
Divested	–0.026	0.043	–0.016	–0.107**	0.069	0.137*	–0.045
	(0.028)	(0.036)	(0.053)	(0.045)	(0.116)	(0.062)	(0.028)
Divested interacted with							
Contract:							
Requirement Services	–0.006	0.013**	–0.042**	–0.011	0.060	–0.061	3.513**
	(0.015)	(0.006)	(0.019)	(0.012)	(0.073)	(0.064)	(1.249)
Long-term firm service	–0.001	–0.005	0.001	–0.020	–0.047***	–0.001	0.020***
	(0.005)	(0.017)	(0.006)	(0.035)	(0.012)	(0.051)	(0.006)
Intermediate-term firm service	–0.009	–0.016	–0.045***	–0.109***	0.175	–0.390*	–0.037*
	(0.019)	(0.019)	(0.013)	(0.030)	(0.145)	(0.185)	(0.017)
Short-term service	–0.001	0.016***	–0.037*	0.011	–0.048	–0.007	–0.006**
	(0.004)	(0.001)	(0.018)	(0.031)	(0.039)	(0.006)	(0.002)
Long-term services from a designated generating unit	–0.005	–0.006	0.001	–0.018	–0.019	–0.018*	–0.008
	(0.004)	(0.012)	(0.003)	(0.030)	(0.013)	(0.009)	(0.009)
Intermediate-term services from a designated generating unit	0.023	0.019	0.028	0.241***	–0.003	0.042	0.735
	(0.053)	(0.055)	(0.034)	(0.072)	(0.016)	(0.053)	(0.420)
Market:							
Exchange of electricity	0.077***	–0.078**	0.390	–0.763***	–1.738	–0.157	1.059
	(0.020)	(0.037)	(1.192)	(0.212)	(1.106)	(0.187)	(0.616)
Other services	–0.002***	–0.003***	–0.003**	–0.002***	–0.009***	–0.001	–0.005
	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.007)	(0.004)
N observations	2,808	880	408	965	235	137	183
N groups	152	48	20	51	15	9	9
R^2 *overall*	0.34	0.34	0.72	0.40	0.83	0.63	0.77

Notes: Cluster standard errors by utility are within the bracket; The single terms of contracts and market transactions are included in the regression but not reported; Significance levels: * 10 percent; ** 5 percent; *** 1 percent.

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Appendix 2

The DEA Model

I provide a technical discussion on how to measure the Farrell input-saving technical efficiency by using DEA model. Following Färe and Grosskopf (2000), Farrell input-saving technical efficiency of each project is measured based on the input and output dataset from all observations. Let

$$x = (x_1, \dots, x_N) \in \mathbb{R}_+^N ,$$

represent inputs, and

$$y = (y_1, \dots, y_M) \in \mathbb{R}_+^M,$$

represent outputs. The model then constructs the reference technology, or the best practice frontier, based on the input requirement set, $L(y)$, which show all the combination of outputs that can be produced by the input vector x. The input requirement set is defined as

$$L(y) = \{x : x \; can \; produce \; y\}.$$

In this research, suppose there are $k = 1, \dots, K$ observation of transportation infrastructure project

$$(x^k, y^k) = (x_{k1}, \dots, x_{kN}, y_{k1}, \dots, y_{kN}),$$

then the DEA formulation of $L(y)$ is

$$L(y|C,S) = \{(x_1, \dots, x_N):$$

$$\sum_{k=1}^{K} z_k \, x_{kn} \leqq x_n, \mathrm{n} = 1, \dots, N,$$

$$\sum_{k=1}^{K} z_k y_{km} \geqq y_m, m = 1, \dots, M,$$

$$z_k \geqq 0, k = 1, \dots, K\},$$

where z_k are the intensity variables that "construct" the input set.

In this measurement, it assumed that $z_k \geqq 0, k = 1, \dots, K$ is just restricted to be non-negative as this model assumes for constant returns to scale (CRS) for the reference technology, i.e.,

$$L(\lambda y) = \lambda\, L(y), \lambda > 0.$$

Furthermore, this model also assumes strong disposability of input, suggesting that an increase in inputs cannot decrease the outputs, which is modeled by

$$x \geqq x' \in L(y|C,S)\ implies\ that\ x \in L(y|C,S).$$

With the input requirement set, the Farrell input-saving measure of technical efficiency is then defined as

$$F_i\ (y, x|C, S) = \min\ \{\lambda :\ \lambda x \in L\ (y|\ C, S)\},$$

suggesting that a project is technically input-saving efficient when

$$F_i\ (y^k x^k|C, S) = 1,$$

and inefficient if less than 1.

Table 3. 4. Variable Definitions and Sources

Variable		FERC Name	Source	Page-line*
Current capital expenditure (Capex) = IP+PP+TP+DP+TMP+GP	IP	Additions to intangible plant (US$)	FERC	204-5c
	PP	Addition total production plant (US$)	FERC	206-42c/204-46c
	TP	Additions to total transmission plant (US$)	FERC	206-53c/58c
	DP	Additions to total distribution plant (US$)	FERC	206-69c/75c
	TMP	Addition to total transmission & market operation plant (US$)	FERC	206-84c
	GP	Additions to total general plant (US$)	FERC	206-83c/99c
Operation & maintenance expenditure (Opex) = PE+TE+RTM+DE+CA+CSI+SE+AGE+SW	PE	Total power production expenses (US$)	FERC	322-80b
	TE	Total transmission expenses (US$)	FERC	322-100b/112b
	RTM	Total regional transmission and market expenses (US$)	FERC	322-131b
	DE	Total distribution expenses (US$)	FERC	322-126b/156b
	CA	Total customer accounts expenses (US$)	FERC	322-134b/164b
	CSI	Total customer service and information expenses (US$)	FERC	322-141b/171b
	SE	Total sales expenses (US$)	FERC	322-148b/178b
	AGE	Total administration and general expenses (US$)	FERC	322-168b/197b
	SW	Total operation and maintenance for electric salaries and wages (US$)	FERC	354-25b/28b
Total sales of electricity		Total sales of electricity (MWh)	FERC	301-12d
Total customer		Average number of customers per month	FERC	301-12f
		Total customers	EIA	n/a
Total production plant		Total production plant expenditure (US$)	FERC	206-42b/204-46b
Governance Structure Bilateral forward contract = the sum of MWh purchased using RQ, LF, IF, LU and IU Market transaction = the sum of MWh purchased using SF, EX, and OS		Purchased power (MWh) with the statistical classification of: RQ for requirement service LF for long-term firm service IF for intermediate-term firm service SF for short-term service LU for long-term service from a designated unit IU for intermediate-term service from a designated unit EX for exchange of electricity OS for other service	FERC	326-327

* The old version of FERC Form 1 covers the data for the period of 1994-2005 while the new version of 2006-2015.

Table 3. 5. Pre-treatment Trends

Dependent variable: Technical efficiency	All Sample
Time	0.048*
	(0.025)
Time × Divested ever	–0.049*
	(0.025)
N observations	941
N groups	143
R^2 *overall*	0.12

Note: Cluster standard errors by utility are within the bracket.
Significance levels: * 10 percent; ** 5 percent; *** 1 percent.

Figure 3. 5. The average Capex for electric utilities (in US$)

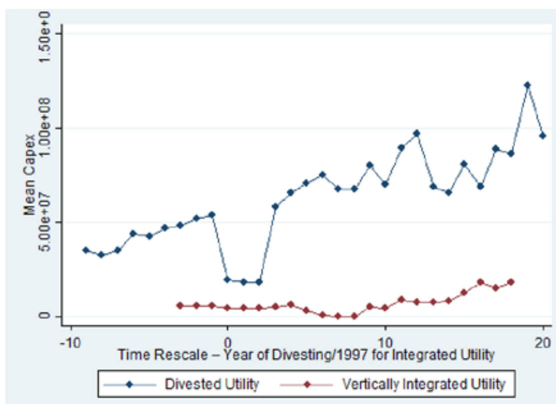


Figure 3. 6. The average Opex for electric utilities (in US$)

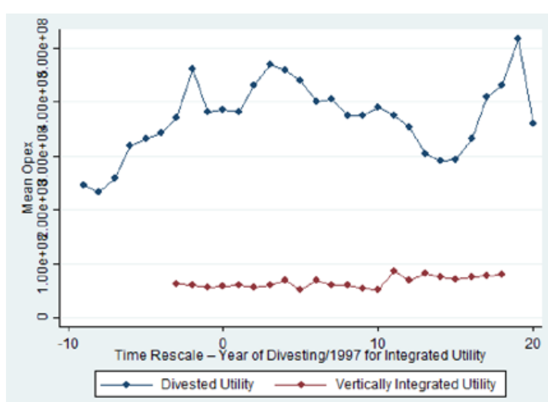


Figure 3. 7. The average total sales of electricity for electric utilities (MWh)

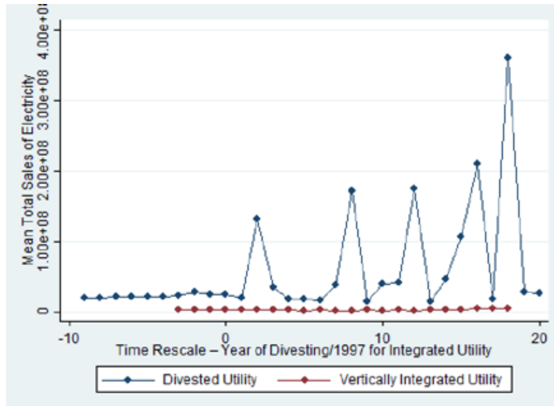


Figure 3. 8. The average total customer for electric utilities

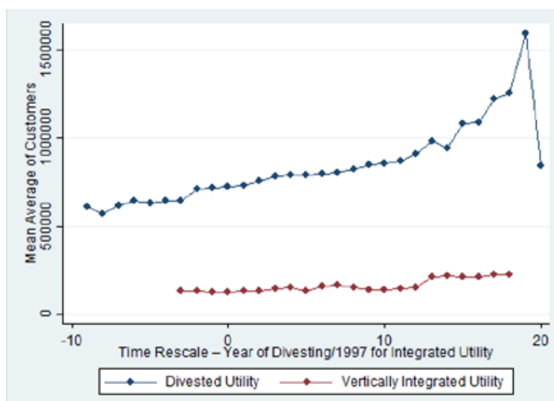
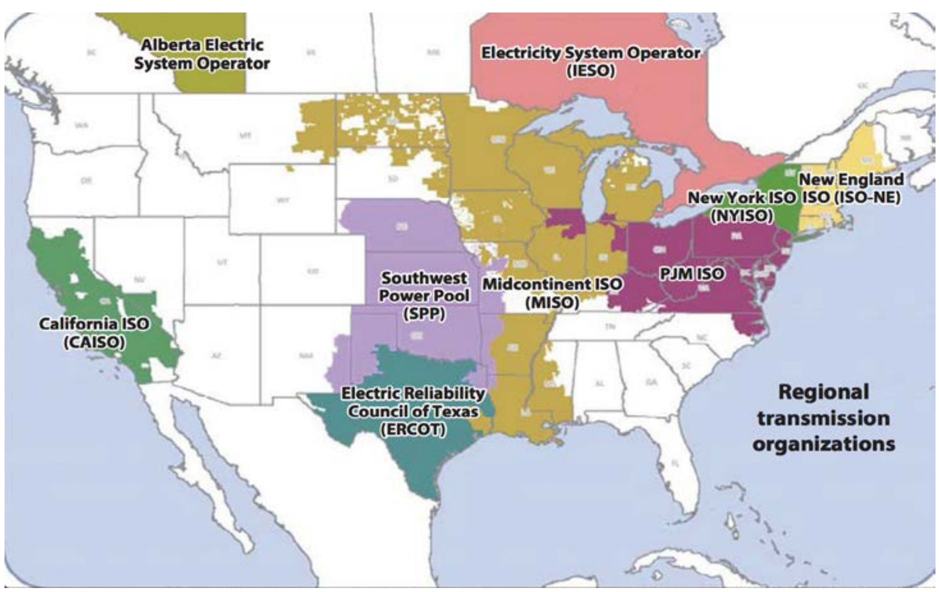


Figure 3. 9. Geographic Regions for Public Utility Construction Costs

Source: Handy-Whitman Index of Public Utility Construction Costs Journal (2017)

Figure 3. 10. U.S. Independent System Operators and Regional Transmission Organizations as of 2012



Source: Borenstein and Bushness (2015, p. 442).

Chapter 4. When Extractive Political Institutions Affect Public Private Contracting: Empirical Evidence from Indonesia's IPPs Under Two Political Regimes

Abstract

This paper examines the relationship between political institutions and the economic performance of public-private contracting in the provision of public goods. Transaction cost economics argues that in a capitalist market, the institutional environment imposes constraints on the choice of governance of contractual relations and that efficiency, in terms of transaction costs minimization, becomes the underlying motive for the choice. The political science literature, however, suggests that in a political market, the governance structures are not necessarily created to be socially efficient, either due to the political transaction costs or to the rent-seeking behavior of the politicians and policymakers. This paper test how extractive political institutions is associated with the performance of public-private contracting using the case of the electricity sector in Indonesia, where a political regime shift has impacted public-private contracting arrangement in the power generation sector. Using a two-stage empirical research, namely data envelopment analysis and the difference-in-differences regression, I examine the economic performance of 20 coal-fired plants for the period of 2010-2016 that consists of the independent power producers (IPPs) endorsed by the two political regimes, the authoritarian and the democratic governments, and the state-owned power plants. The results indicate the extractive political institutions are associated with a reduced efficiency of the first generation of IPPs by –0.135 points, or 0.16% of the mean. The findings challenge the assumption that a transaction cost economizing motive might underlie the use of public-private contracts in power generation sector. Instead, these findings are consistent with the political economy argument that extractive political

institutions might have created economic policies that allow for the political elite to extract rents from public-private contracting.

Introduction

How do differences in political institutions affect the performance of public-private contracting, *i.e.* the contractual relationship between public agencies and private companies to provide and deliver public goods and services? Transaction cost economics (Williamson 1975, 1985, 2000) maintains that in a capitalist market, the institutional environment imposes constraints on the choice of governance structures to facilitate a transaction, and that efficiency, in terms of minimization of the costs of doing transaction, is the underlying motive for the choice of whether a firm will obtain the goods or services in a spot market transaction, through a contractual relation, or instead produce the goods or services within the firm. The political science literature, however, suggests that in a political market, the governance structures that facilitate a political transaction are not necessarily created to be socially efficient. The political transaction cost approach (see North, 1990; Moe, 1984, 1994, 1997; Wilson, 1989; Dixit, 1998, 2003; Williamson, 1999; Wood & Bohte, 2004; Weber, 2007; Spiller, 2008, 2013; Spiller & Moszoro, 2012; and Jones, 2001) claims that democratic political institutions, characterized by the separation of power, periodic elections, and majority rule, may create a high level of political transaction costs, and are thus very prone to inefficiency. Meanwhile, the political economy approach (see Acemoglu, 2006; Acemoglu & Robinson, 2012; Winters & Page, 2009) suggests that extractive political institutions and the political elite may favor economic policies that are inefficient, i.e. do not maximize the growth potential of a society, in order to transfer resources from the society to themselves. Acemoglu and Robinson (2012) define extractive political institutions as those that fall short from being sufficiently centralized, to prevent chaos, but at the same time, are also pluralistic in terms of distributing power broadly to society and subject it to constraints. Under extractive political institutions, inefficiency in public policy may exist due to a misuse of power and rent seeking behavior performed by a narrow elite who has the power.[35] The actual effect of these political motives on the economic performance of public-private contracting ultimately is an empirical question.

This paper examines the relationship between political institutions and economic performances of public-private contracting. Using data derived from Indonesia's electric generation sector, I test how extractive political institutions are correlated with the performance of independent power producers (IPPs), the public-private contracting in the sector. A change in political regimes in 1999[36] has prompted a policy shift regarding public-private contracting in power generation sector, which is reflected in the two types of IPP projects that are currently operating: the first generation IPPs that were endorsed by the authoritarian Soeharto regime and the second generation IPPs that were endorsed by the democratic government.[37] To overcome the problem of severe power shortages in

[35] Meanwhile, they (2012) define political institutions as the rules that govern incentives in politics, determine how the government is chosen and the rightful duty of each part of government, and determine who has power in society and to what ends that power can be used. The political institutions are absolutist when the distribution of power is narrow and unconstrained and pluralistic when power is distributed broadly in society and subject to constraint (pp. 79-80).

[36] Although Soeharto fell from power in 1998, he was replaced by his vice president Habibie who continued ruling under the same regime. A transition from an authoritarian regime to a democratic government happened in 1999 when the first true free election was held. Abdurrahman Wahid took the power through popularly elected system and became the first president under the new democratic government.

[37] The third generation IPPs were introduced in 2009 following the new law of public-private partnerships, yet no projects have been completed as of 2016.

the 1980s-1990s, the 1985 Electricity Law permitted IPPs to develop and supply power solely to Perusahaan Listrik Negara (PLN), the state-owned electric monopoly. However, the introduction of IPPs in the generation sector was tempered by politics. Previous studies (Wells, 2007; Wu & Sulistiyanto, 2006; Bosshard, 2002) show that the IPP projects under the Soeharto regime were hampered by cronyism, corruption, as well as lack of competition and transparency. The political regime shift, prompted by the 1998 Asian economic crisis, from the authoritarian regime ruled by the former president Soeharto to the democratic government led by Aburrahman Wahid, has set the stage for a policy shift regarding IPP projects that led to the introduction of the second generation IPPs. Although both generations of IPPs use a Build-Own-Operate (BOO) contract with a duration of 20-30 years, differences between the two lie mainly on the risk allocation and the forecast returns terms in the power purchased agreements (PPAs). For first generation IPPs, the PPA shifts major risks onto Indonesians, granting private companies sovereign guarantees covering PLN's payment obligations, while promising high returns to investors (20% - 25% internal rates of return).[38] Second generation IPPs shift major risks onto private companies, providing no sovereign guarantee, and granting investors lower forecast returns (12% - 14% internal rates of return) (PWC, 2017).

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[38] Wells (2007) reports that rough calculations for the first IPP project in Indonesia, Paiton I project, suggest investors were expecting more than a 20% return on total assets and around 35% on equity. She claims that the returns were far higher than the cost of sovereign borrowing at the time, especially because the investors did not bring new technology, open access to export markets, or bring management skills that might have justified high returns regardless of risk allocation. With these returns, even in the absence of the currency crisis, PLN might have found it difficult to pay their obligation as they need to pay more than the electricity rate they charge to customers" (p. 343).

Empirical evidence is lacking on how first generation IPPs were endorsed by the Soeharto regime perform compare to second generation IPPs endorsed by the democratic government or PLN-owned power plants procured using traditional contracting-out methods. The closest studies to this paper compare IPPs in overall to PLN-owned power plants that were built using the traditional public procurement method without considering the differences between first and second generation of IPPs that practically have characterized by different risks allocation and forecast returns. Focusing on project construction times and costs and plant operating reliability in their first two year of operation, Atmo *et al.* (2017) compare 28 IPPs and 28 PLN's plants and find that IPPs had superior time and operating reliability compared to PLN plants while there was no significant difference in terms of construction costs. A study by Atmo, Duffield, and Wilson (2015) based on the case of two IPP projects commercially operated in 2009 and 2012 (second generation IPPs) and two PLN plants commercially operated in 2006 and 2012, also cites the superiority of IPPs in terms of construction schedule and operating reliability compared to PLN plants. These two studies indicate that IPPs tend to have a better performance record than PLN plants in terms of the construction schedule and operational reliability in two years of operation. The question of the extent of different political institutional arrangements are associated with the performance of the two generations of IPPs remains open. This study provides the first substantial analysis of how the political economy background of IPPs is correlated with their comparative performance. As such, it has direct policy relevance for policy makers dealing with electricity market restructuring and deregulation, while it contributes to the broad debate on the role of public-private contracting in the provision of public goods and services.

This paper examines the economic performance of 20 coal-fired power plants located in Java and Bali between 2010 and 2016, based on the performance of six IPPs (three endorsed by the Soeharto regime and three by the democratic government) and 14 PLN-owned plants. Regarding the comparative analysis, the main concern of this study is the endogenous characteristic of IPPs that public agencies select this contracting for specific economic reasons that would later impact their economic performance. Such selection problem would bias any comparison between first generation and second generation IPPs and between IPPs and PLN-owned plants in unpredictable ways. To better measure the economic performance of IPPs and shed light on the causal effect of political institutions on IPPs' performance, I use a two-stage empirical strategy: the data envelopment analysis and the difference-in-differences regression. In the first stage, I measure input-saving technical efficiency using the non-parametric data envelopment analysis (DEA) technique (see Farrell, 1957; Charnes, Cooper, & Rhodes, 1978; and Färe & Grosskopf, 1985, 2000, 2004). The efficiency scores represent each plant's performance in terms of input use relative to the best practice among all the utilities during 2010-2016. In the second stage, I analyze the efficiency index using the difference-in-differences approach to highlight the association between extractive political institutions and IPP's efficiency. Having the PLN-owned plants that were procured during both the Soeharto regime and the democratic government is advantageous to this study as they serve as a natural control group to IPPs as the treatment group in this study. The treatment effect, *i.e.* the effect of extractive political institutions on first generation IPP's performance is measured by comparing the difference in mean efficiency between the first and second generations of IPPs to the difference in mean efficiency between PLN-owned plants that were procured during the Soeharto regime and the plants procured during the democratic government.[39]

The results indicate that the treatment effect is negative and significant, showing that the extractive political institutions are associated with reduced efficiency of the first generation of IPPs by –0.135 points, or 0.16% of the mean. This finding challenges the assumption that a transaction cost economizing motive might underlie the use of public-private contracts in the power generation sector. Instead, these findings are consistent with the political economy argument that extractive political institutions might have created economic policies that allow for the political elite to extract rents from public-private contracting. This work also highlights the importance of considering the endogeneity problem in comparing IPPs to the traditionally procured power plants. While endogeneity concerns have long been recognized in the economics literature, this paper is one of the first studies that analyze public-private contracting in electricity sector to control for this by using a difference-in-differences approach.

The remainder of this paper is organized as follow. First, I will describe the political economy of IPPs in Indonesia and discuss how extractive political institutions might affect IPPs' efficiency. Then I discuss the empirical methodology for testing these predictions and describe the strategy for identifying the political institution's effect on

[39] Although IPPs were endorsed under the Soeharto regime and PLN plants were procured during the Soeharto regime, the commercial operating dates of those plants were the years after Soeharto fell from power in 1999. The first generation IPPs that were endorsed by the Soeharto regime had the commercial operating date (COD) between 2000 to 2006. The study uses 2006 as the cutting time for the operating date of first generation IPPs. Consequently, for the analysis purposes, the same cutting year of 2006 is used to classify the PLN-owned power plants, between plants that were procured during the Soeharto's leadership and during the democratic government.

IPP's performance, followed by the data. Finally, I will report the results of the empirical analysis. I then conclude.

Political Economy of Indonesia's IPPs

While in Indonesia previously electricity generation, transmission, and distribution were vertically integrated and run by the state-owned electric company Perusahaan Listrik Negara (PLN), with the introduction of the 1985 Electricity Law, independent power producers (IPPs) are permitted to develop and supply power solely to PLN.[40] IPPs were considered as a policy option to overcome the problem of severe power shortages in the 1980s and 1990s, as PLN fell short to adequately finance the generating capacity expansion to meet the fast growing demand for electricity during those times.[41] This electricity law was considered as a crucial step toward a more competitive generation sector. Proponents believed that the presence of IPPs would lead to a more efficient and reliable power generation and ultimately to lower electricity prices for consumers.[42] By 1997, when Indonesia was hit by the economic crisis, 26 power

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[40] The implementation of the 1985 Electricity Law, Government Regulation (GR) No. 10/1989 on the Provision and Utilization of Electricity, which was amended by GR No. 3/2005 and GR No. 26/2006, holds PLN as the Authorized Holder of an Electricity Business License and the Authorized Holder of an Electricity Supply for Public Use Business License.

[41] During 1994/95 the demand for electricity in Indonesia grew at 11.8%, and according to PLN's forecast, the growth rate could reach 16.7% to 17.8% annually up to year 2005 (Wu & Sulistiyanto, 2006). Meanwhile, by 1988, PLN has only 8,200 MW of installed capacity, thus only able to provide electricity to 54% of urban household and 13% of rural household, which accounted for a total of 24% of electrification rate. With this limited capacity, PLN was unable to provide electricity to the industrial sector, so that the private businesses owned their own generations with about 7,000 MW of installed capacity to support their industries. PLN planned to generate 1,300-1,500 MW every year until the year 2000 to increase the electrification rate to 54%, to cover 81% household in urban area and 40% in rural areas (Schwarz, 1990).

[42] Wu & Sulistiyanto (2006) describe how the convergence of interests of the private investors, development agencies, and politicians has created a unique of policy window for the fast growing IPPs. Foreign investors saw this initiative as a big opportunity for business expansion; the Government expected that IPPs could potentially relieve their budget constraint for capacity

purchased agreements (PPAs) had been signed between PLN and private companies, representing about 11,000 megawatts (MW) of power and at least $13 billion in investment (Wells, 2007). The agreement holds PLN to buy electricity from IPPs in the future at prices determined at the outset. These first generation IPPs, which were launched by contracts signed during 1991-1997 under the Soeharto regime and has the commercial operating date (COD) during 2000-2006, involved reputable American investors such as CalEnergy, Florida Power & Light, Caithness Energy, and Enron. The partnerships used Build-Own-Operate (BOO) contracts with the duration of 20-30 years.

However, the introduction of IPPs in the sector was tempered by politics, specifically through the presence of extractive political institutions. Cronyism was evident in IPP projects from the very start. At least 16 IPPs (out of a total of 19 IPP projects) were built by foreign investors that partnered with local elites, who were members of Soeharto's family, his business cronies, and relatives of other powerful officials (Wells 2007, p. 353).[43] Moreover, the contracting process suffered from a lack of transparency and competition: as 26 of the 27 IPP projects were granted licenses without undergoing a competitive bidding process (Bosshard, 2002). PPAs were also arranged through exclusive bilateral negotiations and the outcomes of the agreements were not made available to public, thus shielding them from public scrutiny (Wu & Sulistiyanto, 2006). When the 1997-98 economic crisis struck Indonesia, most of the projects were under construction. PLN suddenly found itself in deep financial trouble in

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expansion in power sector; meanwhile, development agencies also supported and even facilitated this initiative as it was in line with their liberalization and privatization of public sector's proposal.

[43] Two IPPs have local partners that could not be identified and one IPPs has partnered with a local firm that was widely viewed as not corrupt and has put up its own money for the shares (Wells, 2007).

honoring PPAs as the value of the Rupiah went down from 2,450 to 18,000 for a dollar and the price of electricity increased 70% from its pre-crisis level. Indonesia's government tried to renegotiate the contracts to lower prices and to re-schedule the production. Yet, most of the renegotiations did not go smoothly and the damaging disputes ended up in a big loss from the side of the Indonesian government. By June 2003, 7 projects were terminated, 14 projects were renegotiated, 2 projects were acquired directly by PLN, 2 projects were acquired by the Government, and 1 project was acquired by Pertamina (Wells, 2007, p. 342).

A change in political regimes in 1999, from the authoritarian Soeharto regime to the democratic government, led to a shift in political institutions, including the regulatory framework regarding IPP contractual arrangements. Between 1999 and 2002, when a new Electricity Law was enacted,[44] Indonesia had three presidents, four PLN heads, five economic coordinating ministers, and three mine and energy ministers (Wells, 2007). Meanwhile, new legislation regarding public-private partnerships was enacted in 2005 to attract private investment to the energy sector (PWC, 2017). The new regulatory framework has led to the introduction of second generation IPPs, launched by contracts signed between 2005-2009 under the new democratic government. These IPPs have been operating since 2007.

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[44] In 2002, the Government enacted the 2002 Electricity Law that allowed IPPs to produce and sell electricity directly to customers in areas that are designated as "competitive." However, the Constitutional Court annulated this law in 2004 while re-enacted the 2005 Electricity Law for the reason that the 2002 Electricity Law violated article 33 of Indonesian Constitution, which states that electricity is a strategic commodity, thus its generation and distribution remain under the exclusive control of the Government. Currently, the regulatory framework is the 2009 Electricity Law and its implementing regulations GR No. 14/2012 (as amended by GR No. 23/2014) on Electricity Business Provision, GR No. 42/2012 on Cross-Border Sales and Purchases, GR No. 62/2012 on Electricity Support Business, and other electricity sector-related regulations.

Second generation IPPs still used the BOO contract. The procurement process was conducted using a bidding mechanism; however, most of the projects did not have sufficient financial support. Many projects that had won the tender process, in the end, could not get financial support from the banks.[45] Unlike first generation IPPs that had attracted major investors from the US, second generation IPPs involved new players in the power generation business from China with a lower quality of machineries compared to first generation IPPs. The new law of public-private partnership enacted in 2009 led to the introduction of third generation IPPs in Indonesia. However, no project had been completed at the time of this study.

Institutional and policy changes following the new democratic government have altered IPP contractual agreements. Under the Soeharto regime, the agreements shifted major risks onto Indonesians while promising high returns to investors, which is around 20% - 25% of internal rates of return. The agreement also granted private companies a sovereign guarantee, that is a support letter from the government guaranteeing PLN’s obligations under the PPAs. Meanwhile, under the democratic government, the agreements shifted major risks, especially the *force majeure* risks, onto private companies. Investors were granted lower forecast returns, often between 12% and 14%, with no government guarantees to protect their investments (PWC, 2017).

[45] Kettl (1993) discusses that governments may fall short from being a “smart-buyer,” i.e. being an intelligent consumer of the goods and services it has purchase, in public-private partnerships and this is the reason why such partnerships rarely solve the problem of inefficiency.

How Might Political Institutions Affect IPP's Performance?

Given that the power purchase agreements (PPAs) over the course of the first generation of independent power producers (IPPs) granted private companies a higher forecast returns and lower risks, inefficient behavior by private companies that raises capital and operating costs above the minimum cost levels generally would be reflected in the economic performance of first generation IPPs compared to second generation ones. There were at least three political economic factors associated with such inefficient performance, which indicates the presence of an extractive political institution during the Soeharto regime. The first indication is reflected in the rent-seeking behavior of the political elite; the second indication is the weak regulatory framework; and the third is the lack of law enforcement.

The involvement of Soeharto's family and cronies as the local partners of foreign investors was clear evidence of the underlying rent-seeking motive in first generation IPPs. This motive explains why arrangements so unfavorable to Indonesia were included in the first generation IPPs. That rent-seeking motive as an underlying factor driving reforms in the electricity sector is not exclusive to Indonesia's experience. White (1996) and Joskow (1997) suggest that politicians in the U.S. may have been motivated in large part by rent-seeking efforts in the U.S. electricity restructuring program in the late 1990s and early 2000s. What makes Indonesia's first generation IPPs interesting is the political patronage and cronyism that were so evident in virtually all of the projects. Among the 19 first generation IPPs, 11 partnered with five of Soeharto's children. In addition, two IPPs partnered with the children of the vice president and the coordinating minister, two partnered with Soeharto closest crony businessman (for the complete list, see Wells, 2007, p. 353). PLN's involvement in the negotiation was minimal, if not totally absent. Wells (2007, p. 351) explains that PPA deals were, in fact, negotiated not by PLN but the government, mainly the director general of the mines and energy ministry. He (2007, p. 352) further describes how the local partners extracted rent from the contractual agreement with the foreign investors to obtain benefits for themselves:

> "Managers told me that investors had a choice: a foreign company could simply give a designated local partner 5–10% of the equity or transfer 15–20% under a 'loan' arrangement. The 'loan' would come from the foreign equity holders; borrowers would service loans by allowing the 'lenders' to retain a portion of future dividends (65% was the figure in one project). If the project made no profits, the 'borrower' should receive no dividends, but the partner had no further obligation to service the loans. Thus, the arrangement amounted to no more than a delayed gift of the shares."

Equity share or transfer were not the only "payments" made to the local partners. Payments, in fact, can take the form of buy-backs of shares, consulting fees, and advanced dividends (Mills 2002). Acemoglu and Robinson (2012) suggest that extractive political institutions mostly work closely with extractive economic institutions and the case of Indonesia's first generation IPPs strengthen this argument. In the case of Indonesia, in the absence of an economic crisis and political turmoil, such extractive political and economic institutions are likely to prevail.

Meanwhile, the weak regulatory framework and the enfeebled law enforcement under the Soeharto regime could also explain the inefficient performance of first generation IPPs. The weak regulatory framework during the Soeharto regime was revealed by, among others, the absence of procedures for screening prospective investors and weak administrative and technical requirements for the electricity supply licensing.

Wells (2007) adds that an experienced advisor to the mines and energy ministry had led efforts to create effective screening procedures for prospective investors, yet the government never applied them. The absence of such measures has led to a lack of knowledge and information about how similar contracts concluded in other countries and the characteristics of the prospective investors, which are important in determining how firms behaved when disputes arose (Wells, 2007). This problem was exacerbated by the fact that law enforcement acted in a highly political fashion in its “oversight” of IPPs. The lack of a bidding process in first generation IPPs was due to a lack of enforcement not the absence of regulations. The government decree of 1992 called for a bidding process. However, most first generation IPPs were not tendered under such a process because the mines and energy ministry had not completed documents for tenders and had postponed the issuance of the decree until the negotiation processes were completed (Wells, 2007). This case shows how the political elite could exercise their power without constraints.

On the contrary, under the democratic government, the regulatory framework for IPPs, especially following the 2009 Electricity Law amendment, led to a more accountable procurement process, which is indicated by at least two factors. First, there is a clear and enforceable regulation for the administrative, technical, and environmental requirements to obtain both a license and permit. Second, the regulatory framework also clearly defines procurement methods, which are mandated under an open and competitive tender basis.[46]

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[46] Direct appointments are possible for mine mouth projects, hydroelectric power plants, expansion of project in the same location of the same system, while direct selection for energy diversification to renewable energy and expansion of project in the different location of the same system (PLN, 2016).

The existing evidence on the association between an extractive political institution and the performance of power projects is sparse, although the effect of institutions on public-private contracting has been widely discussed. Humphreys and Bates (2005) show that, globally, competitive institutions are associated with less extractive policies. Regarding Indonesia's IPPs, Voelker *et al.* (2008) find that stakeholders view the political risk for Indonesian power projects as relatively high, due to its legal and regulatory risk and breach of contract risk. This finding supports other studies on private participation in infrastructure (PPI) that suggest institutions and political factors play a crucial role in determining the level of PPI participation. For example, Araya *et al.* (2013) show that private participation, in terms of the number of commitments as well as the level of investment, is related with the country risks. They find that a higher country risk index is associated with a lower private investment level, especially when the investment is related to assets that are difficult to secure. Hammami *et al.* (2006), employing the World Bank PPI Database, also show that the number of PPI projects is determined by the level of corruption and the effectiveness of the rule of law in a particular country. Meanwhile, Moszoro et al. (2015) further show that the level of PPI financing increases not only with a higher level of freedom from corruption, better rule of law, and strong regulations, but also with a lower number of court disputes.[47]

These findings suggest that political institutions, characterized by freedom from corruption, rule of law, and good governance, are significant determinants of private participation in infrastructure projects, both in terms of the number of projects and the

[47] They use the World Bank PPI database for PPI level of commitment, The Quality of Governance Standard Database (Teorell et al. 2013) for the measures of freedom from corruption, government effectiveness, rule of law, and regulatory quality, and UNCTAD Database of Treaty-based Investor-State Dispute Settlement Cases for the measure of the number of court dispute.

levels of investment. This paper attempts to measure these political institutions impacts on the performance of existing power generations. The implicit null hypothesis is that extractive political institutions are associated with the reduced efficiency of first generation IPP projects. Under the null, there should be no difference in IPP's efficiency measures associated with different type of political regimes. I discuss the methods for estimating IPP's efficiency scores and assessing the relationship between political institutions and IPP's efficiency scores. To assess the efficiency of first generation IPPs, I need to estimate how IPPs would have performed in the absence of extractive political institutions, which I will describe below.

Empirical Strategy

To test the hypothesis that extractive political institutions may be associated with the reduced efficiency of IPPs, this study employs a two-stage empirical strategy comprised of data envelopment analysis (DEA) and the difference-in-differences (DD) regression approach. DEA is used to measure the productive efficiency of the power plants, while DD is used to highlight the association between the extractive political institutions and the efficiency of first generation IPP.

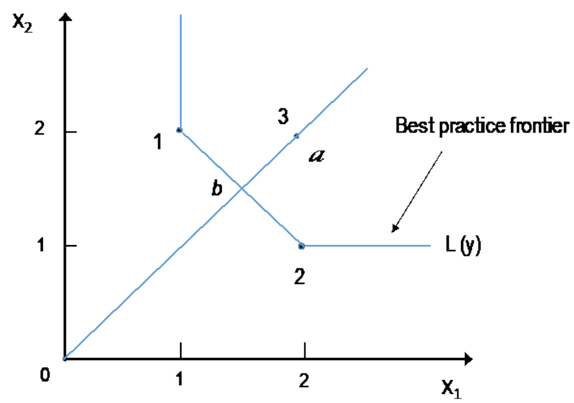
Data envelopment analysis

In the first stage, efficiency is measured by using non-parametric data envelopment analysis (DEA) techniques developed by Farrell (1957), Charnes, Cooper, and Rhodes (1978), and Färe and Grosskopf (1985, 2000, 2004). This method has been widely used by both scholars and practitioners to evaluate industry-wide and/or firm-specific productivity, including the efficiency of power plants in various contexts and countries (see for example Sueyoshi, Goto, & Ueno, 2010; Sueyoshi & Goto, 2013; Sarica & Or, 2007; Chitkara, 1999; Golany, Roll, & Rybak, 1994).

There are some advantages of using DEA compared to the parametric approach. First, a non-parametric approach to efficiency and productivity measurement, as provided by DEA, does not require a functional form for empirical estimation as required by the parametric approach, such as the stochastic frontier analysis (Aigner, Lovell, & Schmidt, 1977). Second, DEA can also handle multiple inputs and outputs to perform straightforward calculations of technical efficiency based on how a firm performs relative to a benchmark. This feature is particularly advantageous to this study as PLN measures the performance of power plants based on their economic and reliability values. DEA analysis needs to consider these two values as the outputs of the power plants. Meanwhile, the weaknesses of DEA include: that it assumes for no errors, so any error will be reflected in the efficiency score; that it is very sensitive to outliers and can treat them as the benchmark for the efficiency measurement; and that it is sensitive to missing values. The later reason that makes this study excludes observations with missing values from the measurement.

Efficiency in this study refers to Farrell input-saving technical efficiency, which indicates how much more inputs can be saved to produce a given amount of output (Färe and Grosskopf 2000). Using Farrell input-saving technical efficiency is consistent with the cost efficiency objective of a power plant that try to reduce costs in generating power. This study uses a metafrontier DEA approach that measures efficiency based on all annual observations available from the 20 power plants during 2010-2016.[48] The benchmark for each plant, the so-called best practice frontier, is constructed based on observed achievements in a similar operation. In this case, the benchmark consists of power plants that produce similar variations in outputs with the fewest resources or lowest costs. In measuring efficiency, this study uses two assumptions for the measurement. The first is a constant return to scale, assuming that the production possibility set is formed without any scale effect. The second is the strong disposability of input, which means that an increase in inputs cannot decrease outputs (see Appendix 3 for the DEA measurement).

Figure 4. 1.The input saving measure of technical efficiency.



Source: Färe & Grosskopf, 2000, p. 13

Figure 4.1. shows how the best practice frontier is constructed based on observations. The input-saving technical efficiency is measured as the deviation of each

[48] As many as 21 observations are excluded from the analysis because they do not have a complete input and output data, thus will bias the DEA measurement. As a result, this study uses 101 observations representing the performance of each specific power plant in a specific year to measure the efficiency scores.

particular plant from the best practice frontier in a radial way. In Figure 4.1., the technical efficiency of power plant-3 is measured by 0*b*/0*a*, which is the ratio of the size of potential output (at *b*) to the size of actual/observed output (at *a*). With this ratio, 1 reflects efficiency while less than 1 means inefficiency (Färe and Grosskopt, 2000, p. 13).

The DEA model includes three input variables and two output variables. The input variables represent capital (capex), operational and maintenance (opex), and fuel expenditures in Indonesian Rupiah. These expenditure variables are commonly used as input variables in the DEA approach for measuring the performance of coal-fired power plants. For example, Sueyoshi, Goto and Ueno (2010) use these three expenditure variables, in addition to the number of employees as the input variables in DEA approach to measure the performance of U.S. coal-fired power plants. This study excludes the number of employee as an input since the data is not available. All input variables constitute cost components included in power purchased agreements (PPAs), except for the transmission expenditures that are not included in the DEA measurement.[49] While capex refers to component A in PPA, opex refers to the sum of component B (fixed operation and maintenance costs) and component D (variable operation and maintenance costs). Fuel expenditure is the component C in PPA. All expenditure data is in Indonesian Rupiah. Although IPPs charged fuel expenditure to PLN monthly, the fuel cost represents the economic value of the plants. Meanwhile, the output variables include the economic value of power generation measured by the megawatt-hours of generated power (MWh) and the reliability value of power generation measured by the equivalent availability factor (EAF). Power production is the primary and desirable output of a power plant.

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[49] Since this study measures the efficiency of power plants in producing electricity, transmission expenditures are not included.

Meanwhile EAF represents the plant's availability and reliability for electric production and delivery.[50] These two output variables are also commonly used in measuring the performance of coal-fired plants (see Yang & Pollitt, 2009).[51] The result of the DEA process is a matrix of input-saving efficiency scores for each power plant yearly from 2010 to 2016.

Regression analysis

In the second stage of analysis, I analyze the efficiency index using the difference-in-differences (DD) approach to highlight the effect of extractive political institutions on first generation IPP' efficiency. Having PLN-owned plants procured during both the Soeharto regime and the democratic government is advantageous to this study since they serve as a natural control group to IPPs as the treatment group in this study. The association between political institutions and efficiency is then identified using the variation in efficiency within power plants between the treatment and control groups. The treatment effect, *i.e.* the effect of extractive political institutions on first generation IPPs' economic performance is measured by comparing the difference in mean efficiency between first and second generation IPPs to the difference in mean efficiency between PLN power plants that were procured under the Soeharto regime and

[50] The availability factor (AF) refers to the amount of time a power plant is able to produce electricity over a certain period, divided by the amount of the time in the period. However, a power plant may run at less than full capacity, and according to the contact person in PLN, this is very typical to the coal-fired power plants. Therefore, this study uses equivalent availability factor (EAF) which has considered the occasions where only partial capacity is available.

[51] Many studies using DEA approach to measures the undesirable outputs of coal-fired power plants. In this case, power production is sometime used as an input variable while the environmental emissions are the output variables (See for example Sarica & Or, 2007).

the plants procured under the democratic government. Since first generation IPPs, although had the agreement signed before Soeharto fell from power in 1998, commercially operated between 2000 and 2006, this study uses commercial operating date (COD) of 2006 as the cutting year for first generation IPPs.[52] Second generation IPPs are those that have COD after 2006. To perform the DD analysis, this study uses the same COD cutting year for classifying PLN power plants, between those procured under the Soeharto regime and those under the democratic government. The first group has a COD of 2006 or earlier, while the second group has a COD after 2006.

While IPPs were selected non-randomly following the electricity law of 1985 and the regulatory framework for power generation in Indonesia, factors that led the Indonesian government to adopt these policies are not discussed in this paper. However, since the IPP-PLN and COD categories do not vary over time within a plant, this study cannot use a power plant fixed effect in the model because the fixed effect will drop these two dummy variables in the regression. The basic DD regression model is:

$$eff_{it} = \beta_0 + \beta_1\, ipp_{it} + \beta_2\, operatingyear_{it} + \beta_3\, ipp \times operatingyear_{it} + \delta_t + u_{it},$$

where eff is the input-saving technical efficiency index resulted from the DEA analysis, $operatingyear$ is the treatment variables, i.e. the dummy for operating year of the power plants, whereas 1 equals the year of 2006 or earlier (indicating that the power plants were endorsed by the Soeharto regime for IPPs or procured during the Soeharto regime for PLN plants) and zero equals the year after 2006 (indicating that the power

[52] The long gap between the sign of the contracts and the operating date of the plants is due to the renegotiation process as well as the construction.

plants were endorsed by the democratic government for IPPs or procured during the democratic government for PLN plants), δ is the year effect, and u is the random error for each project i in time t. The coefficient of interest, β_3, indicates whether the change in efficiency between first and second generation IPPs is different from the change in efficiency of PLN power plants under two periods of years. This study uses cluster standard errors by power plants as the unit of treatment. The inclusion of the year effect δ is important for capturing factors that affect efficiencies common to all power plants in a particular year, thus ensuring that the coefficients of interest, β_3, measure the differential change in outcomes between treatment and control groups after netting out common factors affecting the efficiency of all plants within a year. The year effect will take into account confounding changes related to government policies or economic trends in particular years that affect all power plants simultaneously.

Relying on this technique, this research will estimate the association between the political regime and IPPs' economic performance. The association with the extractive political regime is captured by β_3 as the DD estimator or the treatment effect. The results will show to what extent the extractive political institutions that were promoted by the Soeharto regime are correlated with the efficiency of first generation IPPs. The relationship between the extractive political institutions and efficiency is expected to be negative showing that rent seeking behavior is associated with inefficient behavior by first generation IPPs to raise capital and operating costs above the minimum cost levels, which at the end are correlated with their efficiency.

The identifying assumption for the inclusion of control groups, *i.e.* the PLN power plants, is that efficiency trends in both IPPs and PLN power plants would be identical in the absence of the political shift in 1999. However, this study cannot examine the differential pre-treatment outcome trends test as usually performed in studies using a DD approach since IPP or PLN plants' status does not change over time. The policy or political regime shift did not change the status and characteristics of first generation IPPs, in large part because the agreements hold for the duration of the contracts, which usually lasts 20 to 30 years. In this case, the policy shift introduced a new contracting form for IPPs. Instead of performing the differential pre-treatment outcome trends, this study observes the trends for the average efficiency within groups of plants to get insights about the nature of the unobserved characteristics of the plants.

Data

This study uses the state-owned company PLN database recording the operation of the existing 20 coal-fired power plants in Java and Bali region between 2010 and 2016. These plants consist of six IPPs, three endorsed by the Soeharto regime and three by the democratic government, and 14 PLN-owned power plants. Detailed metrics on expenditures and quality of PLN power plants are only available for plants in Java and Bali region. Thus, this study focuses on Java and Bali region only in order to have a better comparison between IPPs and PLN power plants. Yet, Java and Bali region are the most populated regions in Indonesia. The power generated in this region accounts for about 75% of the total power produced in the country. Therefore, the power plants in this region can represent the whole population. The data is yearly data of the inputs and outputs for each power plant during 2010-2016.[53] Finally, this study uses an unbalanced panel data to include observations with different time periods, thus making use of all data available for IPPs as well as PLN power plants. The data covers capital costs, fixed and variable operational and maintenance costs and fuel costs as the input variables, as well as the amount of produced power and plant's operational reliability measured by the equivalent availability factor as the output variables. All of this data is used to measure the Farrell input-saving technical efficiency scores for each power plants.

Table 4. 1. Descriptive statistics of divested utilities versus vertically integrated utility

	IPPs (observation = 33)		PLN Plants (observation = 68)	
	First generation	Second Generation	Commenced 2006 or earlier	Commenced after 2006
	Mean	Mean	Mean	Mean
Capital costs (US$)	177,142,857	103,571,429	90,000,000	53,142,857
Operation & maintenance costs (US$)	27,000,000	14,714,286	25,500,000	11,142,857
Fuel costs (US$)	166,428,571	96,428,571	219,285,714	90,714,286
Power produced (MWh in year)	6,210,000	4,040,000	8,180,000	3,300,000
Equivalent Availability Factor/EAF (%)	0.88	0.91	0.87	0.64

Note: While the original data was in Indonesian Rupiah, this table shows the US dollar equivalent by May 2018 (1 US$ equals to around 14,000 Indonesian Rupiah).

The statistical summary on IPP and PLN power plants under two political regimes, shown in Table 4.1., shows that in overall first generation IPPs have, on average, much larger expenditures compared to second generation IPPs. Specifically, it shows that first generation IPPs have, on average, around US$ 70 million more capital

[53] This study uses data for the period of 2010-2016 because data from the previous years are not available in PLN computer system yet.

expenditure and US$ 12 million operational and maintenance expenditures compared to second generation IPPs. In terms of fuel costs, they also have on average, on average, more expenditures compared second generation IPPs. With more expenditures, first generation IPPs then produced more outputs in terms of MWh generated (6,21 million MWh compared to 4,04 MWh). However, first generation IPPs are less reliable (0.88% compared to 0.91% in EAF) compared to second generation IPPs.

The statistics also show how first generation IPPs have, on average, much higher expenditures in terms of capital costs and operational and maintenance costs, compared to second generation IPPs and all PLN power plants. This figure indicates that first generation IPPs are more capital intensive and are expected to produce more outputs than other IPPs or PLN power plants. However, in terms of output, first generation IPPs on average produced less power than PLN power plants launched during the same period (2006 or earlier). Meanwhile, in terms of operating reliability, first generation IPPs are, on average, less superior than second generation IPPs, although more superior than the overall PLN power plants. Since first generation IPPs and PLN power plants launched in or before 2006 have a similar reliability score (EAF of 88% compared to 87%), the age of the plants might not be the reason why first generation IPPs are less reliable than second generation IPPs. It is also worth noting that while second generation IPPs are, on average, more reliable than first generation IPPs, PLN power plants launched after 2006 are, in fact, less reliable than PLN plants that were launched earlier (64% compared to 87% in EAF). Thus, for IPPs, the later the better, while for PLN power plants, the later the worst in terms of operational reliability.

Results

Before presenting the main results, it is important to show the trends for the average efficiency within the treatment and the control groups, IPPs and PLN power plants in general, as well as within the first and second generation IPPs and PLN power plants commenced in two periods of years. While this study is unable to conduct a common pre-treatment test because the treatment (IPP’s policy shift) did not change the status of first generation IPPs but introduce second generation IPPs, observing the trends for the average efficiency within groups of plants may give more insights about the nature of the unobserved characteristics of the plants. Figure 4.2. shows that the trend for the average efficiency of IPPs and PLN power plants are similar, except in 2012 when PLN plants’ average efficiency dropped for about 0.15 points compared to IPPs’ average efficiency that dropped by less than 0.05 points.

A closer look at these trends in Figure 4.3., shows the trends for four groups of power plants in this study. Specifically, it shows that trends for average efficiency within the three groups of plants, which are first generation IPPs, and the two groups of PLN power plants, are similar. Meanwhile, the trend of second generation IPPs is less similar to the trends of the other three groups, especially from 2013 to 2015. I would argue that similar trends between PLN power plants launched after 2006 and before 2007, and between the two groups of PLN plants with first generation IPPs, indicate that in the absence of a political and policy shift in 1999, the trends of first and second generation IPP and PLN power plants would have been identical. Thus, including PLN power plants as a control to IPPs as the treatment group in the sample is a sound strategy. Meanwhile, the difference in trends for average efficiency between first and second generation IPPs suggests that such a difference might be correlated with the political and policy shift.

Figure 4. 2. Average efficiency trends for IPPs and PLN power plants

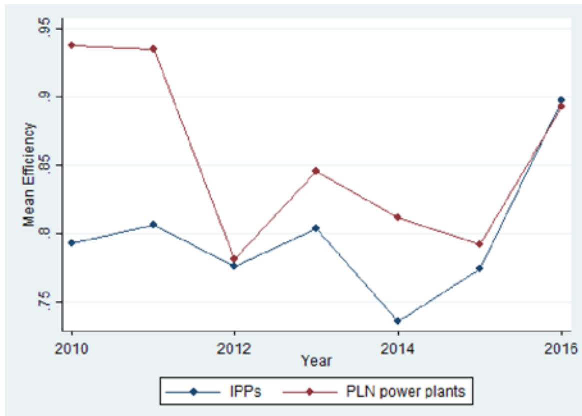

Figure 4. 3. Average efficiency trends for first and second generation IPPs and PLN power plants operated before 2007 and after 2006

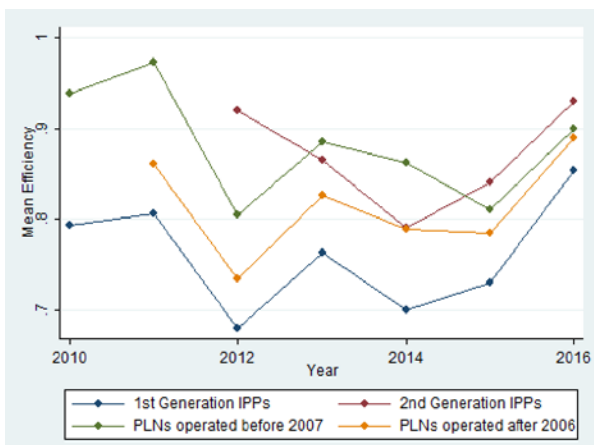

Table 4.2. presents the main results from estimating the difference-in-differences (DD) regression model on 20 power plants during 2010-2016. The outcome variable indicates the meta frontier input-saving technical efficiency scores of the power plants. The coefficients of the interaction term between the IPP dummy and the operating year

dummy suggest that there is a negative correlation between extractive political institutions underlying first generation IPPs with their efficiency scores. The interaction term in column 1 of Table 4.2. shows that extractive political institutions are associated with the reduced efficiency of the first generation of IPPs by –0.135 points and it is significant at a 5% level. This coefficient of interest shows that changes in efficiency of IPPs under the two political regimes is different from change in efficiency of PLNs during your sample period.

Table 4. 2. Effects of political institutions on efficiency

Dependent variable: Technical efficiency	Metafrontier DEA	DEA without EAF	DEA without Capex
	(1)	(2)	(3)
IPP	0.014	0.002	0.035
(1 = IPP, 0 = PLN)	(0.045)	(0.045)	(0.054)
Operating year	0.034	0.069**	–0.032
(1 = 2006 or earlier, 0 = after 2006)	(0.033)	(0.031)	(0.044)
IPP × Operating year	–0.135**	–0.137**	–0.056
	(0.057)	(0.062)	(0.074)
N observations	101	101	101
N groups	20	20	20
R^2	0.39	0.36	0.32

Notes: Cluster standard errors by plant are within the bracket.
Significance levels: * 10 percent; ** 5 percent; *** 1 percent.
Column 1 uses metafrontier DEA approach with three inputs (capex, opex, and fuel costs) and two inputs (Megawatt hours power produced and operating reliability measured by equivalent availability factor/EAF). In column 2, the DEA drops operating reliability from the output variables, while in column 3, the DEA drops capex from the input variables.

The result is consistent when the DD model uses the efficiency scores resulting from a DEA measurement that excludes operating reliability (the equivalent availability factor variable) from the output variables, thus considering the MWh produced as the only output in the measurement. However, it loses its significant when the DD model uses efficiency scores that exclude capital expenditures from the input variables. It suggests that including capital expenditures in DEA measurement matters to IPP's performance, especially first generation IPPs. I would argue that including capital expenditures in the input variables, and operating reliability in the output variables, in the DEA estimation is necessary to measure efficiency. Operating reliability of a power plant, measured by the equivalent availability factor, can capture when the plants have the problem of a high derating level, *i.e.* operating a plant at less than its rated maximum capability in order to prolong its life. A high derating level is one of the performance indicators of power plants, especially for coal-fired power plants. Meanwhile, capital expenditure is also necessary for the efficiency measurement since it represents the size of the investment in producing outputs. Therefore, excluding these two variables from the DEA measurement would bias the efficiency scores. For these reason, the results in column 1 of Table 4.2. are preferable for explaining the association between political institutions and IPP's performance.

This finding suggests that extractive political institutions under the Soeharto regime are a significant correlate of an inefficient performance of first generation IPPs. The involvement of Soeharto's family and cronies as local partners of foreign investors, and the lack of a strong regulatory framework and it enforcement, are, in fact, associated with first generation IPPs' reduced efficiency during 2010-2016.

Conclusion

This paper shows that extractive political institutions are associated with the reduced efficiency of the inefficient performance of first generation IPPs. The rent seeking behavior underlying first generation IPP contracting, accompanied by a lack of a strong regulation and enforcement regarding IPP projects, may explain the inefficient behavior by these IPPs, which generally raises capital and operating costs above the minimum cost levels. It is too early to conclude that there is a causal effect of extractive institutions on the efficiency of first generation IPPs due to limited coverage of the data and the lack of control variables in the model specification. However, an adverse policy treatment effect of the interaction term between the dummy for IPP and the dummy for operating year suggests that the negative association between extractive political institutions that propelled first generation IPPs and their efficiency performance is valid.

These findings suggest that under extractive political institutions, a rent seeking motive may overweigh the transaction cost economizing motive in public sector contracting. These findings are consistent with the political economy argument that extractive political institutions may create economic policies that allow for the political elite to extract rents from public-private contracting.

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Appendix 3

The DEA Model

I provide a technical discussion on how to measure the Farrell input-saving technical efficiency by using DEA model. Following Färe and Grosskopf (2000), Farrell input-saving technical efficiency of each project is measured based on the input and output dataset from all observations. Let

$$x = (x_1, \dots, x_N) \in \mathbb{R}_+^N ,$$

represent inputs, and

$$y = (y_1, \dots, y_M) \in \mathbb{R}_+^M,$$

represent outputs. The model then constructs the reference technology, or the best practice frontier, based on the input requirement set, $L(y)$, which show all the combination of outputs that can be produced by the input vector x. The input requirement set is defined as

$$L(y) = \{x : x \; can \; produce \; y\}.$$

In this research, suppose there are $k = 1, \dots, K$ observation of transportation infrastructure project

$$(x^k, y^k) = (x_{k1}, \dots, x_{kN}, y_{k1}, \dots, y_{kN}),$$

then the DEA formulation of $L(y)$ is

$$L(y|C,S) = \{(x_1, \dots, x_N):$$

$$\sum_{k=1}^{K} z_k \, x_{kn} \leqq x_n, \mathrm{n} = 1, \dots, N,$$

$$\sum_{k=1}^{K} z_k y_{km} \geqq y_m, m = 1, \dots, M,$$

$$z_k \geqq 0, k = 1, \dots, K\},$$

where z_k are the intensity variables that "construct" the input set.

In this measurement, it assumed that $z_k \geqq 0, k = 1, \dots, K$ is just restricted to be non-negative as this model assumes for constant returns to scale (CRS) for the reference technology, i.e.,

$$L(\lambda y) = \lambda\, L(y), \lambda\ > 0.$$

Furthermore, this model also assumes strong disposability of input, suggesting that an increase in inputs cannot decrease the outputs, which is modeled by

$$x\ \geqq x' \in L(y|C,S)\ implies\ that\ x\ \in\ L(y|C,S).$$

With the input requirement set, the Farrell input-saving measure of technical efficiency is then defined as

$$F_i\ (y, x|C,S) = \min\ \{\lambda :\ \lambda x\ \in\ L\ (y|\ C,S)\},$$

suggesting that a project is technically input-saving efficient when

$$F_i\ (y^k x^k|C,S) = 1,$$

and inefficient if less than 1.

Chapter 5. Conclusion

"Privatization as defined in this book is not merely a management tool but a basic strategy of societal governance. It is based on a fundamental philosophy of government and of government's role in relation to the other essential institutions of a free and healthy society. Privatization is a means, not an end; the end is better government and a better society" (Savas, 2000, p. 238).

Public-private contracting, which includes government contracts and franchises, has become one of the most popular institutional arrangements used by governments worldwide to leverage private sector knowledge, experience, and financing capacity to meet society's demand for public goods and services. Historically, the use of public-private contracting, especially the ones that include private financing, was mainly related to the limited ability of government to finance infrastructure development that is needed to encourage and maintain the economic development. More recently, the increasingly broad use of public-private contracting is more related to a reform in public management aiming to infuse market principles, such as efficiency, market, and competition, into the political world (Savas, 2000). Growing use of public-private contracting requires further justification for their efficiency basis, in which Williamson's transaction cost economics (1975, 1985) provides a theoretical framework to assess various institutional arrangements and governance structures based on an economizing on transaction costs argument. Three takeaways suggested from the previous chapters.

First, this dissertation demonstrated that institutions affect the performance of public-private contracting not only in terms of the transaction costs related to the contracting, but also through the rent-seeking behavior that underlies the contracting. As long as transaction costs minimization motive underlies the choice of governance structures, the use of public sector contracting is likely to lead to efficient outcomes. In

Oregon’s transportation sector, for example, the use of design-bid contracting aimed at economizing transaction costs has led to the efficient delivery of transportation infrastructure projects. Specifically, when the type of transaction is complex, specific in terms of assets, and huge in terms of the investment, the use of design-build (DB) contracting is likely to reduce any future transaction costs that may be faced by the public and private parties in the agreement. Therefore, the right governance structure selection would likely lead to an efficient result. However, electricity market restructuring and deregulation in some U.S. states, which pushed investor-owned utilities to divest their generation assets and to purchase power from the wholesale power market, failed to consider the transaction cost economizing purpose of an economic organization. Therefore, the use of market transactions in the competitive wholesale market for power has proven to have an adverse effect on utilities’ efficiency. In an extreme case, Indonesia’s authoritarian Soeharto regime created political institutions in the 1980s and 1990s that allowed for the political elite to extract rents from public-private contracting in electric generation sector. Thus, rent-seeking, not a transaction cost minimization motive, underlay the public-private contracting. As a result, extractive political institutions were associated with an inefficient performance of independent power producers, the public-private contracting in the sector.

Second, the dissertation also demonstrated that the private sector’s voluntary action in choosing the best governance structures to meet its transaction cost minimization objective impacts to the performance of public sector contracting. In the case of Oregon transportation infrastructure delivery, the private sector voluntarily participated in the use of DB contracting. In the case of the U.S. wholesale market for power, investor-owned utilities (IOUs) were forced to divest their generation assets and to purchase power from the competitive market using market transactions. In the first case, the voluntary participation of the private sector indicates that the private sector responded to the incentives of DB contracting after considering the related transaction costs. In the second case, IOUs were not given the autonomy to choose the governance structure that could reduce transaction costs the most. As a result, market transactions for purchasing power reduced IOU' efficiency after divestiture. Thus, trying to infuse market principles in a natural monopoly industry does not always lead to efficient results, especially when such efforts ignore the transaction cost minimization goals of an organization. In other words, market principles are not a panacea for the provision of public goods and services.

Finally, this dissertation demonstrated that while private sector's participation is voluntary, government's motives matter. Who decides in public policy is the basic question challenging the application of transaction cost economics in public policy. The decision-making process in the political sphere, where the government or the state has more authoritative power than the non-state agent, is different than the decision-making process in the economic sphere, where agents have more autonomy to make decisions in response to free and competitive markets. In an authoritarian government, decision making on the choice of governance structure can be made by the state exercising its despotic power. The case of Indonesia's power projects shows that promises of efficiency in public-private contracting was undermined when personal and political interests override economic and social objectives. In this case, the extractive political institutions are associated with reduced efficiency of public-private contracting.

Unlike the first and second takeaways, which confirm the conclusions of Williamson's analysis of transaction cost economics in public policy, the third takeaway of this dissertation challenges Williamson's conclusions. The transaction cost economizing motive becomes less persuasive in explaining the use of public-private contracting under extractive political institutions. This takeaway suggests that the use of public-private contracting is not necessarily motivated by transaction costs minimization motive, and therefore does not necessarily produce the most efficient result.

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