The Essential DNA of Electricity Regulation

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Abstract

We examine the key features of utility regulation, with an eye towards what should be kept and what can be discarded in electricity market reforms. Enterprises are considered public utilities if they are monopolistic and perform an essential public function. Governments create independent regulatory agencies to address two fundamental problems in the control of public utilities, namely the dampening effect that politics has on investment and the value of specialized knowledge. Agencies are more effective in stimulating investment if they are insulated from political pressures to behave opportunistically and if they have sufficient resources to overcome information asymmetries with operators.

Keywords: Regulation, Energy, Natural Monopoly, Public Utility.

JEL codes: K23, L51, L94

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I. Introduction

Changes in technologies, policy priorities, and world energy markets have led to calls for a rethinking of electricity regulation. In the United States, for example, the State of New York is seeking to develop what it calls a comprehensive and consistent economic framework for future electricity system investments and tariff rate designs that would support a reform of the energy vision for the state. (Viscusi 2014). The State of California recently adopted policies for expanding the use of energy storage in its electric grid. (California Public Utilities Commission 2013) There are numerous proposals for incentive regulation that some believe will provide a more appropriate framework for market reform than traditional rate of return regulatory methods,[1] some of which are put forward by advocates for particular technologies or specific market outcomes.

In this context it is important to consider the essential DNA of electricity regulation, which is a metaphor for keeping what is fundamental and letting go of what holds us back. (Jamison and Castaneda 2011; Heifetz, Grashow, and Linsky 2009) We human beings share more than 90% of our DNA with chimpanzees, but those few strands of DNA that are different make a tremendous difference. Sappington and Weisman (2012) find that regulators sometimes struggle to let go of regulatory mechanisms that are outdated, but nevertheless have some value to the agency or to politicians. Our goal in this paper is to identify some of those essential strands. In doing so we limit ourselves to three topics: understanding the meaning of public utility, the role of the regulatory agency, and the foundations for ratemaking.

Economic regulation addresses the questions: Who will provide the electricity? How will the market be organized? How will the electricity be produced? Who will receive electricity and

[1] See for example Aggarwal and Harvey (2013), Lehr (2013) and Newcomb, Lacy, Hansen and Bell (2013).

under what conditions? And how will costs be covered? The word "independent" should not be taken literally as it is not meant to imply that the regulatory agency is sovereign. Rather it means that the agency is directed by laws rather than by day-to-day political imperatives and, under law, is required to perform its work at arm's length from the government, politicians, operators, customers, and other stakeholders.

This paper proceeds as follows. It begins with an explanation of the features of electricity providers that cause them to be considered public utilities. It then examines the motivations for regulating public utilities, the important features of an effective regulatory system, and the empirical evidence. It then draws lessons for today's reform efforts.

II. Public Utilities

A public utility is a natural monopoly whose performance has such a significant impact on customers and the country in general that effective regulation can provide substantial public benefit. Also, a utility generally receives a special designation from the government, perhaps in the form of a concession or franchise that provides the utility with specific rights that it must possess to perform well, such as access to rights of way, as well as special obligations such as an obligation to serve that are needed to limit the utility's ability to exploit its market power.

A utility is a monopoly in that it provides 100% of the output for its market, the service has no close substitutes, and that the monopoly status endures over time. Bonbright et al. (1988) goes further to conclude that the enterprise must be a natural monopoly in the sense that the firm "cannot be operated with efficiency and economy unless it enjoys a monopoly of its market,"

although customers may have options at the margin, such as self-supply through small generators or solar panels.[2]

The most common approach to determining whether a firm is a natural monopoly is to examine the market from a production technology perspective. By this view, a monopoly is a natural monopoly if a single firm represents the least cost arrangement for serving the entire relevant market demand (Sharkey 1982). This implies significant economies of scale if the utility provides a single service or dominant cost subadditivity[3] if the utility provides multiple services. (Baumol 1977; Jamison 1999)

The importance of the utility to its customers and the economy is captured by the concept of a firm "affected with the public interest", which is a notion that evolved in the late 1800s and early 1900s in the United States. The effective starting point[4] was an 1876 court case, *Munn v. Illinois*,[5] involving Illinois grain elevators that the U.S. Supreme Court found were situated uniquely between a river harbor and railroad tracks. The grain elevators' location gave them control over grain movements from farmers in certain Midwestern states to markets on the East Coast. It was practically impossible to move either the harbor or the rails, so the elevators were "virtual monopolies" for storing and transferring grain coming from the "seven or eight of the great States of the West." Customers of the elevators asserted that the elevators had market power and exercised it in a way that significantly hindered the economic wellbeing of farmers and others. In developing its foundation for deciding on behalf of the plaintiffs, the Court found

[2] As we explain later, it is the utility's ability to exploit monopoly power that gives rise to its form of regulation. For the enterprise to be able to exercise that market power, i.e., exploit or extort its customers (Werden 1998), there can be no close substitutes for the monopoly's product or service and there must be barriers to entry so that the monopoly's status persists over time (Harris and Simons 1989).
[3] Subadditivity extends the concept of scale economies to multiple products. More specifically, cost subadditivity incorporates the situation where a single firm represents the least-cost method for producing multiple products, perhaps because the products share inputs or human resource skills.
[4] Legal concepts that helped formulate the notion of a firm affected in the public interest have roots in British common law dating back to the Middle Ages.
[5] Munn v. Illinois, 94 U.S. 113, 130–32 (1876).

that the elevators exercised "a sort of public office" and stood at the "gateway of commerce" because of their unique position that made farmers dependent on the elevators and without alternatives if grain was to be moved from the Midwestern states to the East. The Court concluded that it was proper for governments to use their policing powers to control the conduct of such businesses whose actions had such broad consequences, making them affected with the public interest. This public interest concept has both expanded and shrunk over time, but the essential core of the Court's finding has remained, namely that the firm must have an unusually significant impact on customers and the economy, provide an essential infrastructure upon which important segments of the economy rest, and have such a control over its market that, should it exercise its market power, it can do serious harm. (Trebing 2001)

The peculiar importance of energy to a modern or modernizing economy is well known. A survey of business managers in 137 economies found that they consider getting electricity to be the second biggest obstacle to their business success. Furthermore the managers estimated that power outages decrease their business's annual sales about 5.1% on average.[6] Calderon and Servén (2003) and Dollar, Hallward-Driemeier and Mengistae (2005) show that poor electricity supply hinders firms' productivity and diminishes investments.[7] Limi (2008) estimates that eliminating the electricity outages in Eastern Europe and Central Asia would increase gross domestic product or GDP by 0.5%. The consulting firm IHS (2013) estimated that reductions in

[6] World Bank, "Getting Electricity," http://www.doingbusiness.org/data/exploretopics/getting-electricity/whymatters (accessed September 25, 2014). World Bank Enterprise Survey results are available at http://www.enterprisesurveys.org/.

[7] See also Reinikka and Svensson (1999), Eifert (2007), and Limi (2008).

energy costs added about $1200 to the annual discretionary income of the average family in the United States in 2012.[8]

Asafu-Adjaye (2000), Paul and Bhattacharya (2004), Soytas and Sari (2003), and Lee (2005) find a causal relationship between energy consumption and income. Figures 1 and 2 illustrate how electricity consumption is a contributor to economic growth and a consequence of that growth. Figure 1 compares per capita income to both total electricity consumption and residential energy consumption by country, showing strong, positive correlations. That residential consumption is higher with higher income illustrates how consumers improve their standards of living by consuming more electricity. The difference between the total consumption and residential consumption represents the electricity used to produce goods and services in the economies. This difference is greater when income is higher, indicating that stronger economies use more electricity for government and industry than do economically weaker countries. Figure 2 illustrates this point more directly. The vertical axis represents the per capita electricity consumption by non-residential customers. The strong, positive correlation between this consumption and per capita income illustrates the effective role of electricity in a modern economy. The data also show that the visual variance in consumption by government and industry is greater for lower income countries than for higher income countries, illustrating the opportunities for some low-income countries to make progress in their effectiveness of electricity use.

PLACE FIGURE 1 ABOUT HERE

PLACE FIGURE 2 ABOUT HERE

[8] This represents a 2% increase, based on the authors' own calculations using data from the U.S. Department of Commerce Bureau of Economic Analysis and the U.S. Census Bureau.

As we discuss in more detail in a later section, empirical studies demonstrate that greater quality of regulation has a positive impact on electric industry performance.[9]

III. Motivations for and Problems in Regulation

Governments subject utilities to significant regulatory oversight because the lack of competition often results in inefficiency, low service quality, limited investment, and high and exploitive prices, the effects of which are significant because of the importance of the sector in the economy. Lack of competition matters because market power allows a utility's management to pursue its own private objectives, which may be different from those of its customers or of the government, regardless of whether the utility is privately owned or state owned. Customers are generally concerned with adequate investments for efficient and adequate service, and with economical prices. However, a privately owned monopoly is likely to want to maximize profit, an objective that, left unchecked by either competition or regulation, is generally understood to be inconsistent with adequate supply and low prices across the board. Because of this tendency of privately owned utilities, some governments adopt state ownership, perhaps believing that it will result in a greater focus on customer needs. This belief doesn't seem to align with actual results. State-owned operators often want to satisfy key political supporters, maintain high levels of employment for politically powerful unions, or secure large budgets, all of which are inconsistent with customers' interests.[10]

Today most governments respond to these problems of market power and private objectives by imposing economic regulation on the utility, even if it is state owned. In the early

[9] See, for example, Cubbin and Stern (2006).
[10] Summaries of the literature can be found in Cuervo and Villalonga (2000), Newbery (2004), and Henisz and Zelner (2001).

days of such regulation, government bodies such as legislatures and ministries performed this regulation directly. This proved to be ineffective for two reasons. First, the political bodies lacked expertise and the outcomes tended to be: (1) Prices became outdated as technology and economic conditions changed, often resulting in financial distress for the operator and poor service for consumers; (2) Politicians were out-negotiated by their utility counterparts, resulting in high prices and profits – in at least one instance the profits were so high that the utility was embarrassed and lowered its prices below the maximum negotiated by the politicians, resulting in embarrassment on the part of the politicians; and (3) Utility services were withheld from political opponents or given free (or nearly free) to political friends.[11]

These problems result in part from information asymmetries, i.e., the situation where the agent (in this case, the utility) knows more about its ability to perform and the effort it exerts than does the principal (in this case, the government). There are two information asymmetries that make regulation by political bodies unsuccessful. The first is that the utility knows more about its business than do the politicians. This information gap is sizeable because of the large number of issues that politicians address and because politicians are more focused on knowing constituents than on knowing utilities. The second information asymmetry is between the politicians and the citizens, i.e., politicians are able to pursue private agendas because citizens are unable to monitor all that the politicians do.

The second reason that regulation by political bodies is ineffective is because these government organizations behave opportunistically. Opportunism is commonly referred to as the hold-up problem. With respect to privately owned utilities, hold-up results from the absence of

[11] See generally, Glaeser (1927).

credible commitments by the government not to expropriate assets or the returns they generate.[12] Expropriation occurs in electricity when, once an operator has sunk its investment, the government effectively takes at least some portion of the value of that investment for its own uses. Examples of expropriation include keeping prices at noncompensatory levels, clawing back profits, or making new, uncompensated demands, such as adding environmental regulations. For example, when the Labour Party took control of the U.K. government several years after the country had privatized its power sector, the Labour government instituted a windfalls profits tax to capture some of the profits that the private owners had received since privatization. This claw-back of profits led some foreign investors to withdraw from the country shortly thereafter. (Jamison 2007) As another example, the potential for a hold-up problem was considered sufficiently problematic in Florida that the government instituted particular laws that increased investor certainty for how regulators would treat the investments in pricing. (Holt and Kury 2009)

As the Florida and U.K. examples illustrate, a government's inability to commit to allowing a utility to recover its costs increases risks associated with investments, and in particular investments that: (1) Are largely sunk, i.e., that cannot be reversed without significant loss of value; (2) Have economies of scale and scope,[13] which decreases the number of operators the political actors have to monitor; and (3) Have large political interest, i.e., political actors can attract positive public attention by challenging the recovery of the investment costs. (Spiller 2005) Electric utility systems have these characteristics and, unless properly addressed through

[12] Henisz and Zelner (2001).

[13] Economies of scope are cost savings that occur because of producing multiple products. It is an element of cost subadditivity.

strong property rights laws and independent regulatory agencies, the risks of the hold-up problem cause utilities to under invest. (Heinisz and Zelner 2001)

The hold-up problem also exists for state-owned utilities, although there is evidence that the effects are less pronounced than for privately owned firms, at least in the electricity sector. (Cubbin and Stern 2006) For state-owned utilities, short-term political pressures can lead to budgetary restrictions that benefit current taxpayers, but cost future customers because the investment delays lead to shortages, poor quality, and higher maintenance costs. Political actors often promise that money will be forthcoming in the future when political pressures ease, but the promised budgetary relief rarely arrives. Sometimes the restrictions directly limit investment, but in other situations the knowledge that budgets will be insufficient leads managers to limit their political exposure by restricting the scale of their operations, perhaps by limiting coverage and expansions that would depend upon further technology investments. (Savedoff and Spiller 1999; Heinisz and Zelner 2001).

IV. Empirical Evidence

Empirical studies of the effects of regulatory independence issue examine the effects of elements of regulatory governance and firm characteristics on infrastructure services, normally using cross-country comparisons. The telecommunications industry has been the most frequently studied sector, primarily because of the availability of data. In this sector, polity, economic freedom and regulatory governance[14] are associated with increases in the penetration rate of telephone lines and mobile phones. For example, Gutierrez and Berg (2000) found for a sample spanning Latin America and the Caribbean that an increase of one standard deviation for these

[14] Regulatory governance in this study is a measure representing enforcement of power and independence of the regulator.

variables increased the penetration rate by 8.8 lines per 100 inhabitants. Ros (2003) also found that having an independent regulator is positively associated with operating efficiency and teledensity for main telephone lines in Latin America. For mobile phones, Maiorano and Stern (2007) found evidence linking the existence of an independent regulator to increased penetration rates for developing countries, while Gutierrez (2003) found that a well-governed regulatory environment in Latin America and the Caribbean was associated with higher teledensity for main lines. Montoya and Trillas (2007) studied the relationship between regulatory independence and fixed line penetration in Latin America and found that regulatory independence appeared to have a positive impact on penetration and estimated that "the predicted penetration for Colombia would be 38% higher if it had the independence level of Argentina as compared to the lowest independence level (that of Surinam)."

Several studies suggest a relationship between regulatory governance and positive outcomes in electricity, even though these effects sometimes have a time lag, illustrating the importance of experience and intervals between the time when a policy is enacted and when results come to fruition. For developing countries in Africa, Asia and the Caribbean that experience unsatisfied demand, the estimated impact of measures of regulation on per capita electricity generation capacity in the long run is around 15-25% (Cubbin and Stern 2006). Andres et al. (2003) examined labor productivity in electric utilities from Latin America and the Caribbean and found that utilities governed by a regulatory agency had higher labor productivity.

Disentangling the effects of regulatory governance on firms with differing types of ownership is important. Several studies compared the influence of regulatory governance as it relates to both private and public ownership. Edwards and Waverman (2006) found that regulatory independence acts as an important check on governmental influence. More

specifically they found that governments in the European Union sought to give favorable treatment to government-owned telecom operators relative to their privately owned rivals. Bortolotti et al. (2011) found that having an independent regulatory authority has different implications for private and publicly owned firms in infrastructure industries. Specifically, they found that firms with some degree of state ownership have higher market values if they have an independent regulator, implying that investors value the presence of the regulator. They further found that in instances where there was political interference despite the presence of a regulatory agency, investors valued some degree of government ownership, presumably in the belief that the state would be easier on the utility if the state was a partial owner. This finding points to the importance that investors place on political opportunism. Andres et al. (2003) found that "the mere existence of a regulatory agency, regardless of the utilities' ownership, has a significant impact on performance" in a study of electric utilities of Latin America and the Caribbean.

Estache, Goicoechea, and Trujillo (2009) found mixed results for the effects of independent regulators. Using a sample of developing countries, their study suggests that, ignoring corruption, establishing an independent regulatory authority influences performance in electricity and telecoms, but not in the water sector. They also found that the creation of an independent regulatory authority in electricity and telecoms was associated with a deterioration of quality indicators for developing countries. This suggests that either performance worsened or the creation of an independent auditor led to improved measurements of actual performance. If performance is measured more accurately in periods following the creation of independent regulatory agencies, it becomes difficult to compare performance before and after the change accurately. An important implication of these findings is that caution must be taken in suggesting uniform models of regulation for countries with differing institutional environments. Estache

and Wren-Lewis (2009) suggest that attention should be paid particularly in countries exhibiting modest market contestability and when dealing with politically sensitive services, such as water and transportation.

The importance of private investments in developing countries is well known, being one of the benefits commonly associated with credibility of institutions. Pargal (2003) found that, for telecoms in Latin America, private investment is positively associated with having a credible and independent regulator. The ability of the regulator to make reliable commitments was emphasized. Additional evidence about the importance of commitments in the electricity sector was provided by Bergara, Henisz, and Spiller (1998), who found that "well-defined and credible political institutions are positively and significantly correlated with national electricity generating capacity." This finding implies that countries pursuing investments in renewable energy, which in many instances is more costly than traditional forms of energy supply, will be more successful if they have independent regulatory agencies.

As mentioned earlier, one reason why regulation by political bodies is ineffective is that government organizations can behave opportunistically. Another aspect of regulatory governance that has been studied is its relationship to political opportunism and corruption. Upon examining the framework of concessions for infrastructure services of the water and transportation sectors in Latin America, Guasch et al (2007, 2008) found that "strong and experienced regulators are likely to act as barriers against political opportunism."

In regards to corruption, the evidence suggests that both the content of regulation (regulatory substance) and regulatory governance are associated with reduced levels of corruption, with the exception of Estache, Goicoechea, and Trujillo (2009) who upon examining water, electricity, and telecom industries, found that the introduction of independent regulatory

authorities had, "at best", only partial effects on the consequences of corruption for performance output. Other studies find higher quality regulation lowers corruption levels. For example, Berg, Jiang, and Lin (2012) found that regulatory strategies that reduce information asymmetry and increase accountability tend to reduce corruption. They specifically found that a one standard deviation increase in regulatory governance led to an 8.51 percentage point decrease in the probability that a telecom firm reports it needs to pay an extra unofficial payment from "seldom" to "mostly", where "seldom" and "mostly" were answers to survey questions. Wren-Lewis (2013) examined 153 electricity distribution firms in Latin America and the Caribbean and found that, while greater corruption was associated with lower firm labor productivity, this association was lower when there was an independent regulatory agency. Furthermore, when these electricity distribution firms operated under an independent regulatory agency with greater regulatory governance, they were found to operate more productively.

V. Implications

A fundamental challenge for reforming electricity markets is defining the utility service. The scope of the service should include all of the features and functions that: (1) comprise the critical role that the utility function provides for the economy; and (2) a single entity represents the least-cost arrangement for supply. In the early days of electricity reforms in the United States, markets were established for kwhs, apparently based on the belief that all utilities did was produce and distribute kwhs. This premise proved to be faulty and policymakers have responded by trying to develop markets for ancillary services.[15]

[15] For example, PJM operates two ancillary markets in the United States: (1) Synchronized reserve, which "supplies electricity if the grid has an unexpected need for more power on short notice"; and (2) Regulation, which seeks to

The failure to properly define the utility service can be devastating to market reforms. By way of analogy, consider a situation where a public utility is established to provide white paint that cannot be stored in any meaningful quantities and so must be produced in real time for all practical purposes. The white color is produced by combining paints of various colors in the proper mix to produce white.[16] With complete control over the system, the utility has no problem supplying the white paint at the proper rate given customer demand. Suppose that the regulator believes that the supply of paint into the system should be competitive and so allows suppliers of various colors of paint to bid into the utility system. This might include, for example, some customers who self-supply paint part of the time and, when they have more than they need, want to put their surplus paint into the utility system. How does the utility ensure that paint it delivers is white? It cannot unless it has complete control over the dispatch of the colored paints that enter the system. If customers are allowed to choose their paint suppliers, i.e., contract with color paint suppliers who inject their paint into the utility system, the utility cannot ensure that the paint coming out of the system is white unless it can circumvent the customers' choices and choose which colors are dispatched, in what quantities, and at what times. Even the customers' providing white paint into the system affect the market for the colored paints, meaning that the utility has to constantly monitor all of the paint entering the system to ensure that the only paint that leaves the system is white.

The paint analogy illustrates the critical nature and complexity of defining the utility service. The service must be carefully defined and, if the utility is to be held accountable for providing the service, the utility must be allowed the information and communication system and

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correct "for short-term changes in electricity use that might affect the stability of the power system." See PJM http://www.pjm.com/markets-and-operations/ancillary-services.aspx accessed February 20, 2015.

[16] Applying the analogy, the white paint represents the power of particular qualities (voltage, stability, reliability, etc.) and the color paint sources represent generating and storage assets.

the control over system assets needed to supply the service. Continuing the analogy, if the service is mistakenly defined as paint, customers do not get white paint except by accident. If the utility service is defined as transport of paint – similar to the notion that a utility is simply a wires company – then the utility does not have sufficient authority to provide the service.

The paint analogy illustrates another challenge in reforming energy markets, namely the circumscribing of the utility service to those functions that are indeed foundational to the economy. Once a government has identified an enterprise as a regulated utility, policymakers are tempted to expand the roles of the utility and its regulator. This might occur, for example, if the government finds the utility to be a convenient credit card for providing constituent services that voters value, but would object to paying for if the costs were to show up in the form of taxes. (Byatt 2103) Said differently, policymakers find the utility and its regulators as convenient mechanisms for imposing taxes without being blamed for doing so, and for subsidizing favored projects or constituents. (Peltzman 1971, 1976; Posner 1971, 1974) While these redistributive functions of utilities and utility regulation may have political value, they distract from the core purpose of public utilities, decrease efficiency, and increase politicization. (Yarrow 2010) Current issues driving utility reforms, such as promotion of particular technologies, would fall into this category.

Another lesson from history is the importance of the ratemaking process, which should provide the utility with commercial viability when the utility performs its duties, and provide incentives for efficiency that recognize (rather than fall victim to) the utility's information advantage. The challenge of financially sound ratemaking leads to at least some reliance on the utility's actual operations, as reflected in the accounting records, even when regulators have used forms of incentive regulation such as price caps. (Jamison 2008; Sappington and Weisman 2010)

A challenge with relying upon the utility's actual records is that it could diminish incentives for efficiency. However, as experiences and studies have shown, forms of incentive regulation, such as price or revenue caps, or earnings sharing, can improve efficiency even while utilizing the utility's records as grounding in reality. (Sappington and Weisman 2010) Although there is some interest in the RIIO (Revenue Incentives Innovation Outputs) model adopted in the U.K. (Ofgem 2010), it remains to be seen how its incentives work in practice. It would appear that the RIIO processes of government and public involvement in utility budgeting, and of the regulator choosing outcomes rather than providing frameworks for incentives, would be a reinstitution of some of the systems that allowed utilities to leverage their information advantage, as well as political control of utility decision making.

VI. Conclusion

This paper examines the essentials of electricity regulation, drawing lessons from the past and from empirical research to provide guidance for future reforms. It describes the motivations and institutions for economic regulation of the electricity sector by an independent regulatory agency. Regulatory oversight is justified by the lack of competition in infrastructure industries, which can lead to inefficiency, low quality, high prices, and limited investment. Independent regulatory agencies appeared as a response to the information, expertise and opportunism problems facing countries over the years.

This paper also describes the main characteristics of successful agencies and shows the empirical evidence of studies examining the effectiveness of independent regulatory agencies. Higher quality regulatory governance is associated with improvements in sector performance, less corruption, more investment, and less political interference. Improved sector performance

takes the form of greater efficiency, more effective investment patterns, greater output, and improved quality.

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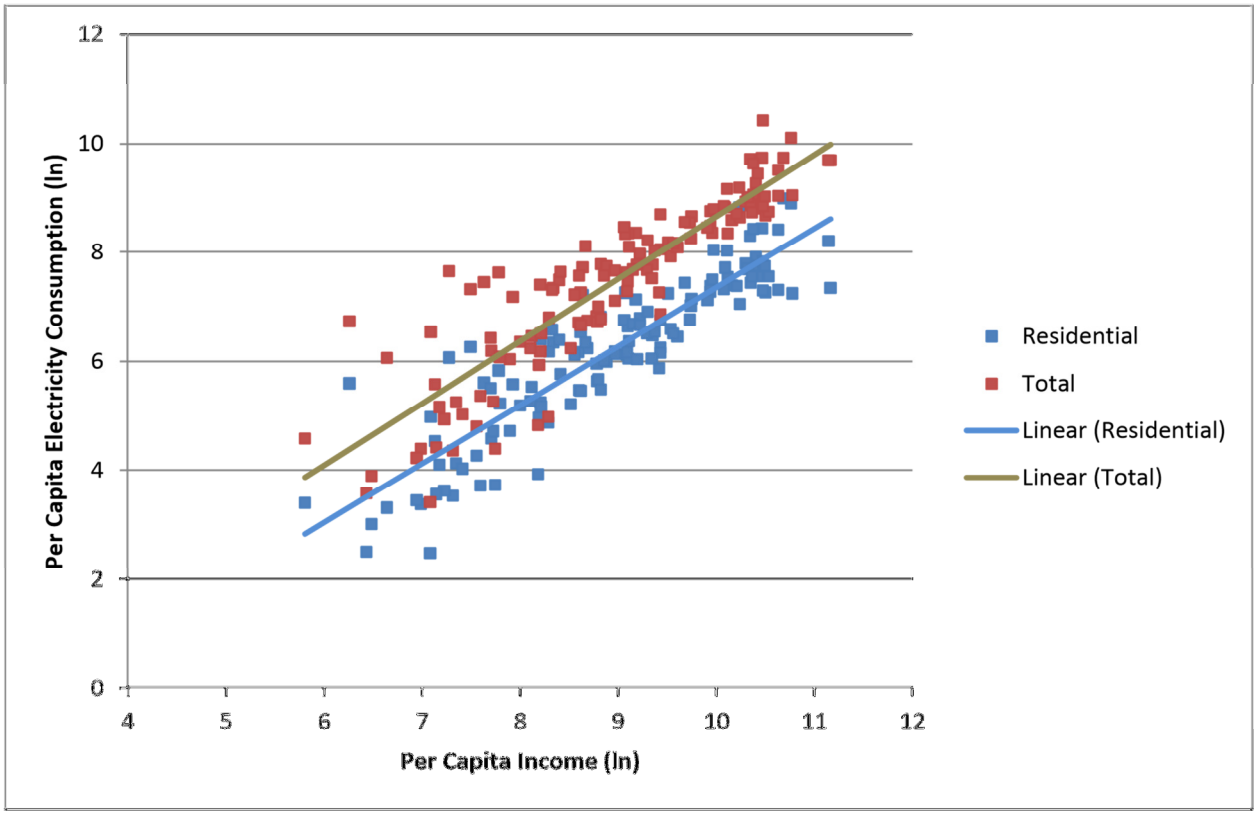
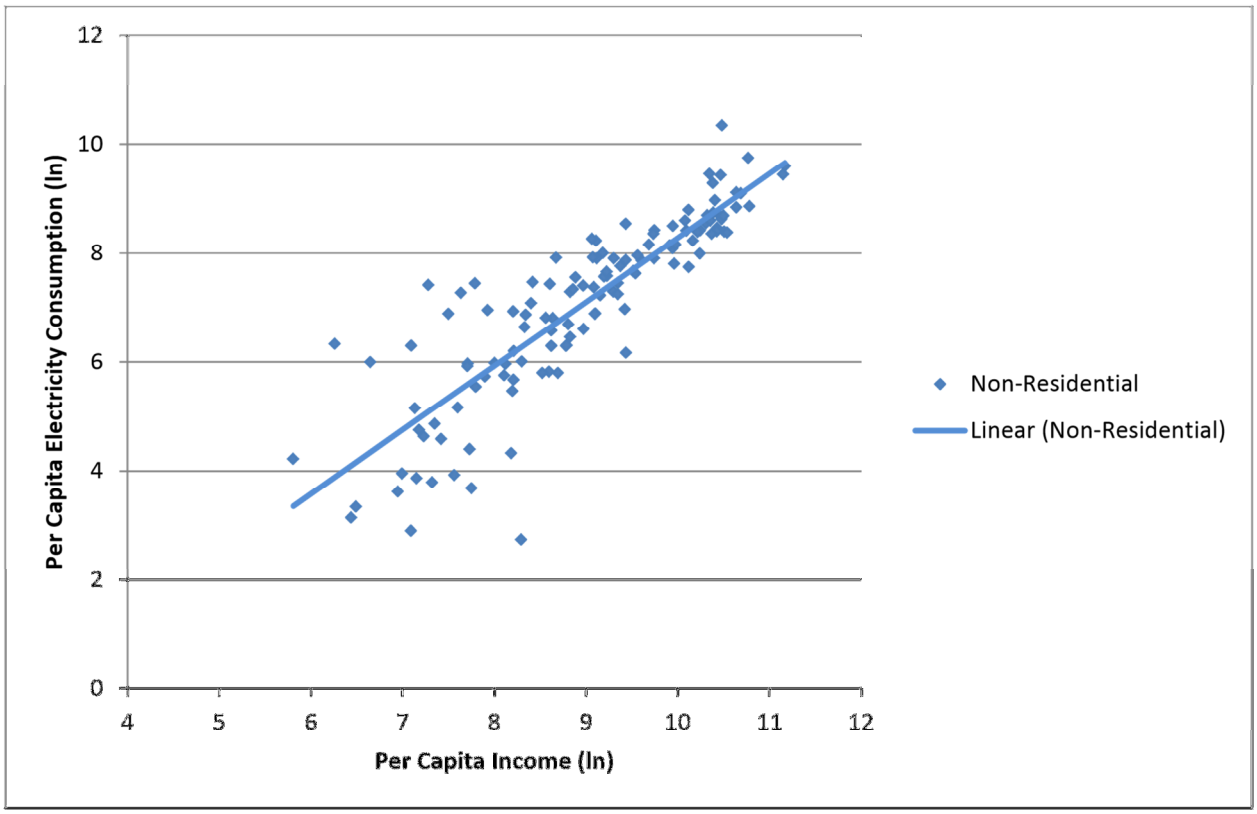
Figure 1. Worldwide Per Capita Income and Electricity Consumption by Country, 2003-2007



Source: U.S. Energy Information Administration and The World Bank, as cited by Gapminder.

Figure 2. Worldwide Per Capita Income and Non-Residential Electricity Consumption by Country, 2003-2007



Source: U.S. Energy Information Administration and The World Bank, as cited by Gapminder.