The Solyndra case: an institutional economics perspective on the optimal role of government support for green technology development

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Abstract

More than three years after its highly publicized bankruptcy, Solyndra continues to resonate as an example of well-intentioned government policies gone wrong. This paper examines the Solyndra case using an institutional economics perspective to determine if the government's relationship with the firm was optimal in achieving environmental and energy public policy goals while minimizing risk. The analysis reveals several government deviations from theory prescribed best practice, and illustrates opposing theoretical governance prescriptions for stimulating future technological innovation at the macro and micro levels.

Keywords: photovoltaic solar; Solyndra; Transaction Cost Economics; Agency Theory, Market Failure

"Subsidizing SolarCity. A California solar-panel company could be another Solyndra in the making" – *National Review Online* headline November 25, 2013 (Styles, 2013)

"Obama Restarts Solyndra Program, But Solyndraphobia Could Ruin It" – *Time* magazine headline – July 3, 2014 (Grunwald, 2014).

1.0 Introduction

Solyndra's widely reported 2011 bankruptcy involved a U.S. government loss of $535 million in federal loan guarantees. As the headlines above attest, the Solyndra failure has also become a prominent example in the debate over the degree and manner that government should support socially beneficial firms and industries with minimal financial risk to the government (Ambec et al., 2013; Hardgadon and Kenney, 2012). The purpose of this case study is to examine the U.S. government's relationship with Solyndra using the lens of Transaction Cost Economics (TCE), and Agency Theory (AT). These institutional economic (IE) theories provide useful frameworks for evaluating inter-organizational relationships characterized by difficult contracting environments, and predict that the optimal governance form is dependent on various relationship characteristics such as the presence of specific assets, asymmetric information, and environmental uncertainties (Aghion and Tirole, 1994; de Figueiredo, 2010; Finon and Perez, 2007; Perez and Ramos-Real 2009). By examining the conditions present during the U.S. government's relationship with Solyndra, IE can thereby prescribe the relationship format least likely to produce failure (Coase, 1964; Wolter and Veloso, 2008).

A historic case methodology employing a variety of well-respected media reports during the firm's rise and fall is utilized to provide in-depth insight into Solyndra's

business practices and relationship with the U.S. government. In so doing, the analysis provides perspective in structuring future relationships between the public and private sectors to minimize the inherent risks of innovation development and commercialization. The original promise of the Solyndra technology and notoriety of the Solyndra bankruptcy meant the firm's history was widely covered, which allows key facts to be crosschecked among multiple sources to ensure accurate reporting (Golder and Tellis, 1993). The following section provides a brief history of Solyndra and government support for renewable energy as contextual background for the subsequent IE analysis of the case.

2.0 Solyndra and Market Failure in the Renewable Energy

In 2005 Solyndra was founded to develop cylindrical shaped photovoltaic (PV) solar panels that would utilize silicon-free thin-film, which was expected to make the panels less expensive and more efficient than traditional silicon based flat panels (Leonig and Stephens, 2011). Part of the perceived market opportunity was based on the increasing demand for solar panels, which in turn led to an 800% silicon price increase between 2004 and 2008 and dramatically increased manufacturing costs for silicon based panels (Morales and Roca, 2011). Furthermore, Solyndra's cylindrical panels were expected to be less expensive to install and less susceptible to the wind damage, while prototype testing suggested that the design might be 7% more efficient than flat panels in converting sunlight into electricity (Green, 2008; Scansen, 2011).

Solyndra's projected cost and efficiency advantages were instrumental in attracting $78 million in initial capital from a few prominent investors, yet in 2005 these

design advantages were largely theoretical and would eventually require nearly $600 million in research and manufacturing capability investments before large-scale production started in 2008 (Wang, 2008). Thus in December 2006, Solyndra management applied to the Department of Energy's (DOE) loan guarantee program to secure funding for the commercialization of the new design (Hayward, 2011). Delays in the full implementation of the DOE program and reservations about Solyndra's application from the Office of Management and Budget (OMB) meant that the $535 million loan guarantee did not receive final approval until September 2, 2009. The widely reported application approval and new factory groundbreaking also closely coincided with a further $219 million cash infusion from private investors (Hayward, 2011). In May 2010 U.S. President Obama and California Governor Schwarzenegger turned up at the new factory and stated that 'the true engine of economic growth will always be companies like Solyndra' (Hayward, 2011).

Even before finishing the new factory in 2010, however, Solyndra was selling only about half the existing plant's capacity as the cylindrical panel shape was proving to be a incompatible with large market segments consisting of electric utility installations requiring millions of panels, as well as most residential installations (Scansen, 2011). High development costs also meant that Solyndra's panels were costing about $4 per watt to manufacture, which was far higher than the 75 cents per watt charged by makers of flat panels that were benefiting from the falling price of silicon (Morales and Roca, 2011). Yet the government loan guarantee approval and publicity from the presidential visit helped Solyndra raise another $175 million in private equity during this same time frame (Hayward, 2011).

By early 2011, Solyndra management argued that debt subordination was necessary for the firm to successfully attract the additional private capital needed for survival, and in February 2011 the DOE approved a restructuring of the loan guarantee that put private equity investors ahead of the U.S. Government in the event of bankruptcy liquidation (Hayward, 2011). Although the debt restructuring did attract further private investment, it was insufficient to prevent the September 2011 bankruptcy declaration, which resulted in the termination of the firm's entire workforce and a U.S. Government loss on the $535 million loan guarantee (Hayward, 2011).

As the brief history of Solyndra attests, government support in financing the development and commercialization of what was thought to be a promising solar panel technology also proved to be influential in attracting additional private investments. In fact the DOE loan guarantee program that Solyndra benefited from was designed 'to support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risks' (Hayward, 2011).

2.1 Government Intervention in Renewable Energy

Market failure is a term that is commonly used to describe high-risk cases that do not attract adequate levels of private investment for meeting the future needs of society, and is a common rationale given for government intervention that can include subsidies and other types of support designed to reduce private sector investment risks (Grossman, 2009; Hayley and Schuler, 2011). From an economic perspective, rent appropriation and development uncertainty are two major types of risks often behind the market's failure to

adequately respond to energy security and environmental threats with appropriate amounts of green technology investment (Grossman, 2009; Lipton and Kraus, 2011).

Rent appropriation occurs when investors are not able to garner a fair share of their investment's expected returns, typically due to 'public goods' related issues (Aghion and Tirole, 1994; Grossman, 2009; Sovacool, 2011). Public goods issues occur with many green technologies when investors are unable to charge higher prices to customers for the value provided by environmental benefits such as cleaner air that could result from widespread adoption of green technologies. Thus a public good cannot be fully contracted for and appropriated by green technology investors unless there are long-term guarantees of governmental subsidies or other supports (Aghion and Tirole, 1994; Haley and Schuler, 2011; Langniss and Praetorius, 2006). Rent appropriation is particularly relevant with renewable energy investments, because renewably generated electricity offers no tangible quality advantages over carbon-based sources besides the 'public good' lower emissions that could otherwise provide innovators with compelling selling points (Olson, 2014).

Uncertainty is defined by the inability to accurately predict future outcomes, which can create investor risk when the uncertainty brings the possibility of a negative consequence. Thus development uncertainty is based on the degree to which technology investments are uncertain to yield a marketable product from which to pay back the investment. Development uncertainty is higher when the relative development speed of competing technologies is high, which may mean that any current competitive gaps in costs/efficiency will not be sufficiently closed with further investments in a particular technology, such as Solyndra's cylindrical thin-film panels. Development uncertainty

can also be increased due to unstable market conditions that influence the likelihood of achieving an attractive ROI, such as decreasing carbon-fuel prices, or changes in government policies towards various energy alternatives (Lipton and Krauss, 2011). Thus development uncertainty means an increased risk that any individual technology can become obsolete and/or uncompetitive, and also means that investors will not wish to be locked into long-term relationships. The desire to correct market failure is what leads government agencies into relationships with firms such as Solyndra as a means to reduce private investors' risk (Haley and Schuler, 2011).

3.0 Institutional Economics

Although the DOE loan guarantees reduce private investor risk, this does not mean that the government does not also seek to minimize its contractual hazards (or risks) in providing support to individual firms such as Solyndra. Institutional economic theories were developed to provide an analytic framework for minimizing the failure rate of organizational relationships characterized by incomplete contracts (Aghion and Tirole, 1994; Coase, 1964; Grossman, 2009). IE holds that institutions are man-made interdisciplinary creations that structure political, economic, and social interactions through both informal constraints (i.e. sanctions, taboos, traditions), and formal rules (i.e. laws) (North 1991; Williamson 1996). Thus a key question to be answered is whether the form and type of relationship between the U.S. government and Solyndra was least likely to result in government financial losses, while at the same time continuing to support public policy goals for the development and commercialization of renewable energy**.** The next sections will analyze the Solyndra case using two major IE schools: 1)

Transaction Cost Economics (TCE), and 2) Agency Theory (AT). TCE and AT offer complementary conceptual frameworks for understanding economic organization, and both approaches use the contract as a metaphor to examine the efficiency of inter-organizational relationships (Bergen, Dutta, and Walker, 1992; Williamson, 1988; 1996).

3.1 Transaction Cost Economics

TCE focuses on organizing relationships between parties that can range from arm's length market transactions to various types of formal hierarchies (Williamson, 1985). TCE prescribes the type of contractual relationship that is most likely to minimize the dangers and associated transaction costs posed to either side by bounded rationality (e.g. inability to gather and process all relevant information) and opportunism (e.g. self interest seeking with guile) (Williamson, 1985; 1996). Bounded rationality and opportunism are most problematic when the relationship features: a) high transaction complexity due to development uncertainty, b) a need for specific investments, and c) performance measurement difficulties (Williamson, 1996). Such conditions are frequently present during new product development, which can allow management to opportunistically misrepresent their technological and organizational capabilities and thereby expose investors to higher risk (Flyvbjerg, Garbuio, and Lovallo, 2009; Teece, 1996; Williamson, 1985).

The Solyndra case presented investors with a number of macro and micro level uncertainties leading to high transaction complexity. On the most macro level, the attractiveness of renewable energy is largely dependent on the certainty of predictions regarding reduced supplies and rising prices for carbon-based fuels, but the many

government predictions regarding the imminent depletion of such supplies during the past 100 years have so far proven to be ‘false alarms’ (Grossman, 2009). Similarly, climate model predictions of dangerous global warming have been called into question by the lack of measurable warming since the late 1990s, creating uncertainty and lowering public support for renewable energy subsidies that help make the industry attractive to private investors (Economist, 2013; Mead, 2011). At the micro-level, a great deal of the uncertainty concerns the relative progress of competing renewable energy technologies such as solar or wind in reducing costs and/or improving efficiency (Evans, Strezov and Evans, 2008; Kannon et al., 2006). Similarly within the solar technological arena there is uncertainty regarding the development potential of silicon versus thin-film panel technologies, photovoltaic versus concentrated solar power, and flat versus cylindrical panels. These macro and micro-level uncertainties for renewably generated electricity create difficulties for policy makers as they try focus support on the technologies that will provide the most cost-efficient means of achieving environmental and energy security policy goals.

Specific investments are represented in the Solyndra case by the specialized equipment and processes required for the manufacture of the innovative cylindrical solar panels, which were incompatible with traditional flat panel manufacturing and therefore valueless to other solar panel manufacturers (Styles, 2011). TCE assumes higher efficiency for assets that are designed for specific applications versus general-purpose assets, but specific investments create conditions ripe for opportunistic behavior since they are not easily redeployed in the event of relationship failure and thereby increase the risk of capital investment loss (Langniss and Praetorius, 2006; Williamson, 1987).

Performance measurement problems occur when investors have difficulty assessing whether firm management has fulfilled relationship obligations. The problems are magnified by asymmetric information that can create the possibility for opportunistic gain on the part of management, which is in the best position to know about certain risks pertaining to the achievement of technology, quality, or financial goals. Asymmetric information based opportunism is suggested by Solyndra management's almost continuous use of overly optimistic sales projections to secure additional private and public financing right up to the firm's bankruptcy declaration (Leonig and Stephens, 2011; Wald, 2011).

TCE typically classifies debt investments as representing market transactions, and equity investments as representing hierarchical governance (Pisano, 1989; Teece, 1996; Williamson, 1988; 1996). With respect to the DOE and Solyndra relationship, the DOE loan guarantee to Solyndra is thus representative of an arm's length relationship with Solyndra management, because the only future interaction between the parties was a specified repayment plan to prevent default. In contrast, the presence of high uncertainty, substantial specific investments, and performance ambiguity in the Solyndra case means TCE would predict that hierarchical governance, such as a contract specifying performance milestones for both sides, and close monitoring of firm management through investor board membership, would be a more efficient relationship format (Teece, 1996; Williamson, 1988; 1996). Yet the DOE loan guarantees can also be classified as a hierarchical relationship with Solyndra's private investors, because the guarantees provided long-term risk exposure to the government in the case of a Solyndra default on the debt held by private investors.

Given the goals of the DOE loan program, however, it is not difficult to speculate why the DOE relationship with Solyndra is primarily based on the less efficient arm's length transaction. First, the DOE loan program was designed to not only aid a wide variety of green technology firms, ranging from wind power developers to electric car manufacturers, but also serve as an economic stimulus by deploying aid as quickly as possible (Hayward, 2011). Putting together contracts with well defined performance milestones for a large numbers of disparate green technology firms would certainly slow the process of allocating financial aid, particularly under conditions with so much macro and micro-level complexity and uncertainty. Yet as TCE predicts, a market based relationship under these conditions also decreased the DOE's ability and incentive to monitor Solyndra's performance and created the potential for the opportunistic behavior demonstrated by Solyndra management.

From a portfolio perspective, however, TCE does support the DOE's market governance based investments in a wide variety of competing technologies, but only if such support could be quickly withdrawn when particular technologies, such as Solyndra's thin-film cylindrical panels, prove to be uncompetitive (Wolter and Veloso, 2008). Yet the DOE hierarchical relationship with Solyndra's private investors prevented such quick withdrawal due to the necessity of providing long-term reassurance to attract private capital. Given the public policy desirability of supporting cleaner and more secure energy sources, such long-term reassurances in the Solyndra case were provided by the loan guarantees, the subordination of government claims on Solyndra assets relative to private equity investors, and the high profile visits of top government officials as a form of reputational hostage-taking (Langniss and Praetorius, 2006; Williamson,

1983). Thus these longer-term government reassurances to private Solyndra investors locked the government into a relationship with an unviable firm and technology.

3.2 Agency Theory

While the transaction is the basic TCE unit of analysis, the agent is AT's focus of attention (Bergen et al., 1992; Williamson, 1988). In the current case, Solyndra's management is the agent, and the DOE is the principal that depends on Solyndra to undertake the task of developing efficient solar panels to achieve the DOE's public policy goals. AT assumes that the principal and agent have bounded rationality, partly differing goals and risk preferences, and information asymmetry with the agent knowing more about its own abilities, motivation, and actions than the principal (Eisenhardt, 1989). The principal's task is to determine the most efficient means of: 1) selecting agents that have the desired qualities (a.k.a. adverse selection), and 2) monitoring the agent's performance to ensure the fulfillment of contractual obligations (a.k.a. moral hazard) (Akerlof, 1970; Eisenhardt, 1989).

Overcoming adverse selection means selecting a qualified agent and avoiding the unqualified, which is typically accomplished through some combination of: (1) screening for qualified candidates; (2) examining quality signals from potential agents; or (3) providing opportunities for self-selection (Bergen et al., 1992; Kirmani and Rao, 2000). During the screening process, potential principals (i.e. investors) can reduce adverse selection risk by utilizing experts to validate the prospective agent's technological and market claims (Teece, 1996). Such an evaluation might have utilized a macro-level approach by comparing the potential of Solyndra's new panels to compete with other

renewable energy technologies, as well as with the carbon-based energy supplies they hope to displace. For example, recent empirical comparisons of PV solar generated electricity versus natural gas, coal, and nuclear generated electricity find that PV solar costs would need to be reduced by over 50% for solar to be competitive (Olson, 2014, 2015), which is well beyond the 7% best case efficiency improvements promised by the Solyndra panel innovation. On a more micro-level, experts might also have noted that Solyndra's economic prospects could be severely limited by cylindrical panel incompatibility with the needs of large solar panel market segments (Scansen, 2011).

For a number of practical reasons, the DOE loan guarantee program relied on screening as the primary method for dealing with the adverse selection problem, and during the last days of the Bush administration the OMB found Solyndra's application deficient for a number of reasons, but deferred the final decision to the incoming Obama administration (Hayward, 2011). The Obama inauguration brought the passage of the American Recovery and Reinvestment Act, which also set a deadline of September 30, 2011 to spend all the program's money as a means of stimulating the economy. This put all undecided applications for DOE loan guarantees on a fast review track that bypassed 'quality control' steps according to a 2010 audit of the DOE program (Saunders, 2011).

While the DOE time pressure was responsible for the rushed and incomplete screening of Solyndra's prospects, the fact that Solyndra and many of the other DOE applicants were newly established firms also meant that other methods of dealing with adverse selection were difficult to effectively deploy. For example, the DOE could not rely on signals of quality or self-selection in the Solyndra case, because the firm and its private investors had no previous history in developing renewable energy technology,

while also having few resources to survive a lengthy and onerous application process. On the other hand, it could be argued that Solyndra successfully employed false signals to favorably influence the DOE during the application review by spending more than $1 million in government lobbying and Obama presidential campaign donations. This spending resulted in the head of the loan guarantee program pushing the DOE to move faster in approving the Solyndra application (Hayward, 2011; Leonig and Stephens, 2011; Mosk and Greene, 2011). Although Solyndra's substantial private capitalization would ordinarily be seen as an example of credible 'skin in the game' commitments, the use of campaign donations to pressure DOE officials into a hurried application approval suggest this signal was not an accurate indication of agent quality. This false signal in combination with the political desire to quickly stimulate the economy with green industry financial aid, was clearly at odds with the AT suggestion to carefully screen Solyndra's prospects to reduce adverse selection risk.

Once the agent is selected, the next problem is to avoid post-contractual opportunism or moral hazard, which is most typically associated with an agent's shirking attempts by claiming high quality output when it has not actually been achieved (Klein and Leffler, 1981; Mishra, Heide, Cort, 1998). Environmental uncertainty makes it impossible to write a contract that foresees and provides for all contingencies, and thus forces principals and agents to keep the resulting risks in mind when structuring the details of a contractual relationship (Bergen, et al., 1992). After the DOE approval of Solyndra's application, several actions provide evidence of moral hazard problems related to management incompetence and opportunism. For example, Solyndra management failed to provide DOE officials with an accurate picture regarding their

financial prospects when applying for government support (Hayward, 2011; Leonig and Stephens, 2011). Furthermore, many Solyndra employees wondered why a new manufacturing plant was being built when the old plant was running at only 50% of capacity, and why management was spending heavily on lavish offices and experimental manufacturing equipment that no one knew how to use (Hayward 2011; Leonig and Stephens, 2011). Private investors in Solyndra might also argue that moral hazard existed going the other direction due to government shirking regarding the failed implementation of promised cap and trade policies that would make carbon-based energy more expensive and renewable energy sources relatively more competitive (Mead, 2011).

To prevent these moral hazard problems, AT suggests that contracts provide incentives that align the interests of both the principal and agent (Eisenhardt, 1989). For example, the DOE might have followed venture capital practice through the use of equity or equity convertible forms of financial aid. Such an ownership position would have provided Solyndra private investors and management with reassurance of the government's relationship commitment, while providing the government with further incentive to monitor Solyndra's business practices to increase the chances of receiving an equity owner's share of future dividends or public stock offering returns (Hargadon and Kenney, 2012).

4.0 Discussion and Conclusion

Moving from a carbon-dominated energy economy to one based on clean renewable technologies, such as solar energy, has been seen as key to achieving energy security and environmental public policy goals for several decades, yet significant progress in making such a transformation is likely to require many more decades (EIA,

2013). In contrast to this multi-decade green transformation perspective, the desire to stimulate an ailing economy meant that months instead of years were used to dispense green technology financial aid to firms such as Solyndra, and such speed was further encouraged through Solyndra's lobbying efforts. From an IE perspective, the current analysis suggests that the U.S. government made less than optimal policy choices in their relationship with Solyndra, and this conflicting time perspective is likely an important reason for the relationship failure.

The TCE analysis of the Solyndra case finds a number of uncertainties with regards to the renewable energy sector, together with specific investments required to manufacture the unique panel design, which created a situation that was unlikely to attract substantial private-sector investment. The DOE loan guarantees and the very public endorsement of Solyndra and the solar industry by top government officials provided risk reducing assurances to attract private investment to at least some degree, but was likely a less efficient option than the contractual relationship with performance benchmarks suggested by TCE analysis. AT analysis of the Solyndra case found less than optimal government oversight of the selection and monitoring process that likely created adverse selection and moral hazard problems, which would have been more efficiently resolved by a contractual relationship offering incentives to Solyndra management to provide the low cost and efficient renewable energy technology desired by government policy makers. Perhaps the biggest IE criticism of the DOE's loan guarantee program comes from the fact that poor macro-level screening was done to determine if any applicant's solar technology was likely to be competitive with carbon-based energy sources. Government incentives to commercialize green technologies will

make adverse selection inevitable if the particular technology, such as the Solyndra panels, is not cost competitive versus the ‘brown’ alternatives they are expected to displace. Thus when screening reveals a particular green technology/firm to be very uncompetitive with conventional alternatives, it will likely be more cost efficient if IE analysis is utilized to structure government relationships with R&D providers that might generate innovations that can close current financial and technical gaps (Hargadon and Kenney, 2012; Olson, 2015; Victor and Yanosek, 2011).

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