Winning by routine?

An empirical study of the solar panel industry in Austin, TX

by

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Existing research on entrepreneurial strategy points to a key tension that entrepreneurs face: When to pursue efficiency, structure and routine; and when to prioritize flexibility, experimentation and bricolage. Building on recent entrepreneurial strategy research on the microfoundations of firm success, this paper tests whether adding elements of structure and routinization in the early days of a nascent market is associated with improved firm performance. Using as a case the solar panel installation market in Austin, Texas from 2004-2014, the paper employs a linear panel regression model to determine the association of efficiency in installation time, pricing and cost estimation are correlated with greater firm revenues and market share. Results suggest that minimizing variation in the time required to install panels is associated with higher revenues, but not market share; other measures of routinization, however, are not correlated with firm success. If future works concludes that these results are consistent across other geographies and markets, then entrepreneurs, incubators and policymakers would do well to update how they train entrepreneurs and support nascent markets.

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Introduction

At the federal, state and local level, US taxpayers spend a considerable amount of money each year supporting the growth of young industries, typically under the banner of job creation for voters (Martin and Sunley 2003). In 2011, for example, the federal government spent $24 billion dollars—over three times what would be spent on the 2012 US presidential campaign (Dinan and Webre 2012, Part et al 2013). When such efforts fail, they can have political consequences in addition to economic ones—as in the case of California-based solar manufacturer Solyndra, whose bankruptcy after receiving half a billion dollars in federal loan guarantees became ammunition for the political allies of fossil fuel companies against Barack Obama in the 2012 presidential campaign (Kao 2012). In the Solyndra example as in others, while the survival of firms may seem at first to be a primarily economic question, it is also an important question for understanding politics and for making policy.

Research on entrepreneurs shows that multiple factors figure into entrepreneurial success, including the characteristics of entrepreneurs, the context in which they operate, and the market formation strategies taken by entrepreneurs (Carland et al 2002, Hall and Jones 1999, Santos and Eisenhardt 2009). The more specific literature on entrepreneurial strategy has identified a number of strategies by which entrepreneurs acquire and recombine resources, how they create markets, and how they learn (Hallen and Eisenhardt 2012, Rindova and Fombrun 2001). That learning process involves reducing to a manageable level the ambiguity present in a nascent market, “continuously morphing” until finding the right fit between a product they can offer and a market that will accept it (Rindova and Kotha 2001). Such adaption has its limits, however: Recent research on experimentation-based entrepreneurial strategies suggests that continued experimentation can create a drag on young companies as they grow, rather than providing an edge (Fisher 2012). Such work suggests that experimental strategies may be necessary for the development of initial business models. However, it also argues that continued experimentation may prove detrimental over time: Experimentation is costly, while effective routinization saves time and money.

The absence of data on nascent markets makes empirical research on firm performance in such markets difficult: In new markets, turnover of firms is rapid, knowledge management is low priority, and competitive information is often tightly held. As a result, survivorship bias necessarily plagues quantitative studies of nascent markets. The US solar industry is different: Thanks to the presence of federal and local subsidies, solar industry databases include information on every panel installed in the United States since the early days of the market. This paper makes use of that installation-level data to test the hypothesis that early systematization leads to success in nascent markets. The paper tests two dependent variables: Revenue growth and market share. As independent variables, the paper tests systematization of: (1) time required to install a solar panel, (2) accuracy in estimated final price, and (3) variation in size of system.

The results of the study suggest that of the measures used above, only variation in the time required to install a solar panel is associated with firm success; even then, it is only associated with increasing revenues, rather than increased market share. In the early days of a nascent market, it may be continued and varied experimentation, rather than the pursuit of efficiency and routine, that is associated with firm success.

Literature Review

Beginning in the mid-2000s, an increasing number of strategy scholars began to articulate a fundamental tension in the decision-making of corporate executives: Should they focus on exploiting the market position they had already carved out, or on exploring new opportunities in ever-changing competitive environments? Scholars named the capacity to manage this tension *organizational ambidexterity*. Subsequent empirical research on organizational ambidexterity examined its causes and consequences. Research on organizational ambiguity moved in the 2010s from supporting case studies to industry-level empirical work showing that organizational ambidexterity leads to greater firm performance over time, especially under conditions of market ambiguity (O’Reilly and Tushman 2013, Geerts et al 2012, Goosen et al 2012).

In parallel, scholars of nascent markets and began to formulate the concept of *dynamic capabilities* to explain how organizations operate in contexts of high ambiguity. In stable markets, they argued, organizations can build expertise in a particular set of capabilities that create market advantage. In ambiguous and dynamic markets, however, organizations must develop a special ability: The ability to master new concepts and build new capabilities quickly and successfully in response to a changing environment. Empirical work testing the dynamic capabilities framework has upheld this view—but suggests that they are related to firm performance in all markets, not just those typically described as nascent or ambiguous. (Teece and Pisano, 1994, Fainshmidt et al 2016).

Some scholars of dynamic capabilities have since begun to turn their attention to the question of why some firms are able to build dynamic capabilities better than others. They look for answers to *microfoundations*, the cognitive habits and relational structures of individuals inside of organizations. One result was to examine organizations’ ability to balance *efficiency* and *flexibility*, reworking the language of organizational ambidexterity to nascent markets. Empirical work on the relationship between microfoundations and firm performance is less than a decade old, and as of 2015 had not examined the empirical relationship between microfoundations and firm performance (Teece 2007, Eisenhardt et al 2010, Felin et al 2015).

A strikingly similar tension pushes through recent theoretical work on entrepreneurial strategy. In their 2017 paper, Ott et al gather over a dozen entrepreneurial strategy frameworks into two categories: Strategy by “thinking” and strategy by “doing.” In the former, entrepreneurs engage in forward planning, using mental models and analogs to simplify decision-making. In the latter, entrepreneurs plan while in motion: Experimenting as they go, gathering unexpected resources along the way, and reshaping their plan in process. One of these frameworks, *entrepreneurial* *bricolage*, borrows language from Levi-Strauss to depict entrepreneurs as scavenging underutilized resources and recombining them into new business models and value chains. But in the bricolage framework, the flexibility/efficiency remains: empirical work suggests that *parallel bricolage*, or experimenting across multiple facets of the business at once, could become a drag on performance. Too much exploration can hamstring exploitation; too much flexibility can stymie the development of efficiency (Ott et al 2017, Baker and Nelson 2005, Fisher 2012, Senyard et al 2009).

In this way bricolage and microfoundations (with its emphasis on the development of routines), stand somewhat at odds with work on dynamic capabilities and Eisenhardt et al’s emphasis on flexibility over efficiency. In the latter, the authors argue that by their nature, organizations tend toward greater efficiency and lower flexibility; as a result, to balancing the two requires fighting to maintain flexibility. Previous work on the US solar industry has shown this to be the case with regard to supply chains: Installers that maintain diversity in their manufacturing base are more likely to succeed. This article aims to contribute to this ongoing conversation, asking whether routinization in two other parts of the solar installer business model—installation and pricing—are correlated with firm success. (Eisenhardt et al 2010, Maiyya 2016).

Design

In order to test the relationship between routine and success, this paper makes use of an unusual dataset from Austin Energy, the municipal electricity regulator in Austin, TX. In 2004, Austin Energy began offering rebates for homes and businesses that installed solar panels. In conjunction, it began collecting information on all the solar panels installed in the city. In the early stages of the solar panel ecosystem, few companies installed solar panels in multiple municipalities. Put together, this means that Austin Energy has a near-complete record of the activity of the entire solar panel installation industry from its first days in 2004 to 2014, the last complete year in the dataset.

The most important feature of the dataset is that it includes the full price of each installation, from which I generate the annual revenue and market share of every company in the industry. The dataset also includes a number of measures that I operationalize as measures routinization: (1) Variation in the time required to install one kilowatt of solar capacity, (2) Variation in the price charged per watt of installed capacity, and (3) Variation in the accuracy of the initial cost estimates that firms provide to customers. I use a linear panel regression, a type of linear regression model that accounts for the effect of time in examining the relationship between success and routinization. I hypothesize the following:

**H1**: Firms that are able to routinize installation, as measured by lower variation in the amount of time required to install a kW of solar capacity, will be more successful, as measured by increased revenue and market share.

**H2**: Firms that are able to routinize pricing, as measured by lower variation in the price per watt they charge customers, will be more successful.

**H3**: Firms that are able to routinize estimating the cost of installation, as measured by lower variation in the difference between their initial cost estimates and final price, will be more successful.

The linear panel regression allows us to include two important effects: Changes over time that would affect all firms (such as the decline in the cost of solar panels) and aspects of individual firms that are consistent over time (such as organizational culture).

This design has its limits: First, there are many ways to measure efficiency that are unavailable, including in human resources, financing practices, and geographic concentration of installations. Second, a number of solar panel installers in Austin also have other lines of business, such as home construction or electrical work. It may be that solar makes up a small part of a company’s strategy, changing the way it strategizes about that product. Third, a small but increasing number of companies install in multiple geographies, which could have the same distorting effect as having another line of business. Lastly, this model cannot determine causality, only the association between efficiency and success.

Data

The Austin Energy dataset is a record of 4,046 solar panel installations completed by 68 companies from 2004-2015. Each installation represents a single job, installed on one roof; and together, these 4,046 represent all of the grid-connected solar panels installed over that period in Austin. After I exclude 2015 data (which is incomplete) and what I take to be data entry errors, the remaining dataset has information on 3539 installations.[[1]](#footnote-1) From that dataset of installations, I construct a panel dataset in which each observation is the activity of one firm in one year. Given the turnover in the solar panel market, the final panel dataset includes 168 firm-year observations over the ten-year period.

Dependent variables

As outcome variables, I test two different measures of firm success: Revenue and market share in a given year. The first dependent variable, *Revenue*, is the sum total of money earned in a given year by a firm. The second dependent variable, *Market share*, is the percentage of the revenue of the solar industry earned by a firm in that year.

These two measures are highly correlated (r = .71), though they exhibit an interesting relationship: Higher revenue in one year is associated with an increase in market share in the following year (significant at the p<0.05 level), but higher market share in one year is *not* associated with higher revenue in the subsequent year.

Independent variables

In order to examine the relationship between routinization and success, I create three concepts of routinization from the variables available in dataset: *Time to completion, per watt cost,* and *cost estimate error*. In the models below I examine the coefficient of variation of each variable in a given firm-year. Like standard deviation, the coefficient of variation is a measure of spread. It is calculated by dividing the standard deviation of a variable by its mean, resulting in a measure of volatility that can be compared across variables.

Time to completion: How long does it take a firm to install a kW of solar capacity?

The first concept of routinization, *Time to completion,* is the total length of time of an installation normalized by the size of the installation. As a start date, I use the variable *App Received Date*. Of the other two candidates for start date, *Aerial Assessment Date* and *LOI [Letter of Intent] Date*, the first is only occasionally entered and the second consistently lags *App Received Date*. As an end date, I use a combination of *Final Inspection Date* and *Final Approval Date*, taking whichever comes later. The relationship between *Final Approval Date* and *Final Inspection Date* changes over time: From 2004-2010, they are the same date. In 2010, *Final Approval Date* lags *Final Inspection Date*. This makes sense: Inspection tends to precede approval. In 2012, however, that flips: Sites were approved before being inspected. In order to capture the full time to completion, I use as an end date whichever of these two variables comes later. The other potential end date is *Work Complete Date,* which is available only after 2011. The result:

*Time to Completion* = (End date – App received date) / Size of installation (kW AC)

In the models below, I use two variables constructed from *Time to completion*. The first is *Mean of* *time to completion*, which is the average time to completion for a given firm in a given year. The second is *Coefficient of variation in time to completion*, which is the standard deviation divided by the mean.

Per watt cost: How much does a firm charge per watt relative to other firms in that year?

The second concept of routinization in the model is *per watt cost*, measured in dollars per watt paid by the customer to the firm. I construct this from two measures in the data, *Total Payment* and *kw AC*:

*Per watt cost* = (Total Payment / (kw AC \* 1000)

The price of solar panels dropped dramatically over the ten-year period from 2004-2014, so I then standardize the variable by subtracting it from the mean per watt cost in a given year, then dividing it by the standard deviation of per watt costs in that year.

As with Time to Completion, I construct two variables from Per watt cost: Mean of per watt cost (standardized) and Coefficient of variation in per watt cost (standardized), both measured per firm per year.

Cost estimate error: How accurate is a firm at predicting the final cost of an installation?

The third set of variables is cost *estimate error*, a measure of how off-the-mark a firm’s initial cost estimates are. I measure this by comparing the difference between the *Total Payment* and the *LOI* [*Letter of Intent] Amount*:

Estimate error = [(*Total Payment* – *LOI Amount*) / *LOI Amount* ] \* 100%

Firms face competing pressures in the estimates they give to customers: Lower estimates may win more clients, but higher estimates leave room for cost overruns. On balance, I hypothesize that these competing pressures will lead firms to want to accurately estimate their installation price. Looking again at annual firm-level activity, I generate a third set of variables, *Mean cost estimate error* and *Coefficient of variation in cost estimate error*:

Methods

For both dependent variables of success (*Revenue* and *Market share*), I run a panel regression with each of the six independent variables listed in the section above, in addition to quadratic terms for each. A panel regression accounts for unobserved changes over time that would affect all companies equally: The price of supplies, for example, or the kind of collapse in the market that occurred in 2010 as Austin Energy pulled back its subsidies (Ankrum 2009).

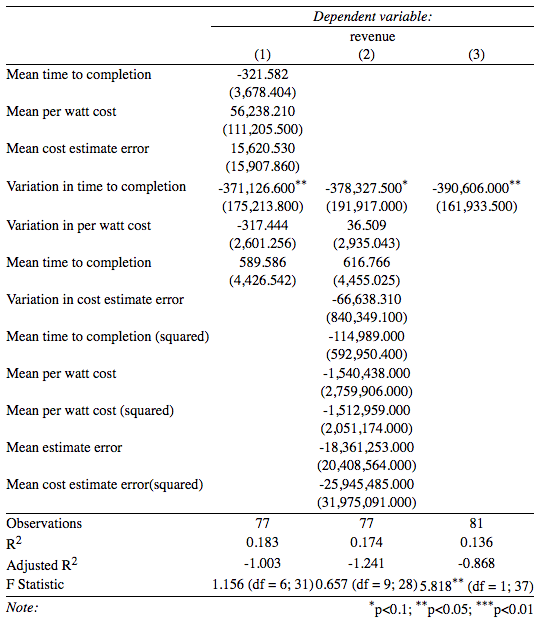
In addition to controlling for year, I include fixed effects at the company level, which controls for unobserved differences across firms that stay consistent over time, such as organizational culture or leadership. Because I suspect that routinization leads to growth, rather than vice versa, I lag each of the dependent variables by one year, such that the models ask “Does routinization this year precede success next year?”

Results

Below are results for the two dependent variables: *Revenue and Market Share*. Taken together, the results suggest that while lower variation in installation time is associated with revenue growth, it is not associated with higher market share—and none of the other routinization variables are associated with either.

Success as Revenue

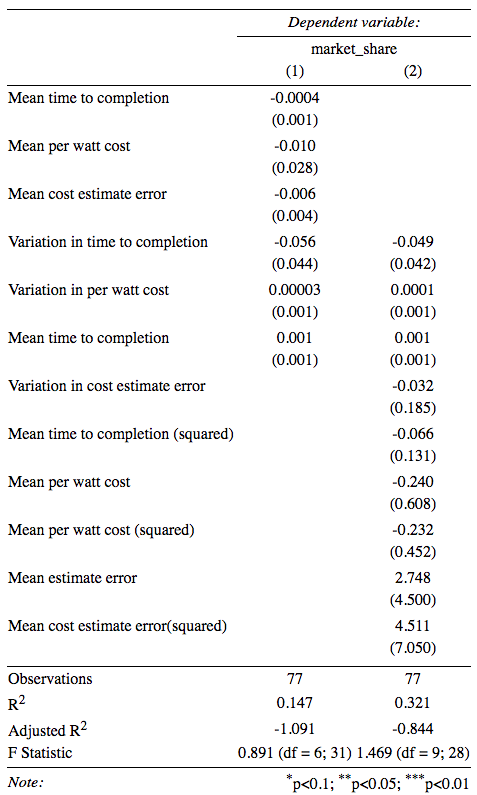
The models below test the association between routinization and revenue growth. As above, this group of models lags each independent variable (Model 1), then includes the square of each mean variable (Model 2), and then removes those quadratic terms and the cost estimate error, as they proved not significant (Model 3).

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From these models, I draw the following conclusions: The only coefficient significant at the 0.05 level is the coefficient of variation in the mean time to completion, standardized by installation size. This model supports only one hypothesis, H2: That firms which reduce variation in installation times will be more successful. It fails to support any of the routinization hypotheses.

Success as Market Share

The models below test the association between routinization and market share. As above, this group of models lags each independent variable (Model 1), then includes the square of each mean variable (Model 2).



This set of models supports only none of my above hypotheses, as it shows no statistically significant association between the routinization variables and increased market share in the following year.

Discussion

Related bodies of literature (entrepreneurial bricolage, dynamic capabilities, the microfoundations of firm performance) hypothesize different relationships between routines and firm performance. In this paper, I set out to test what types of routinization would be associated with firm success in the nascent solar panel installation market in Austin, TX, from 2004-2014. I make use of a peculiar database: Thanks to its tax rebate program, Austin’s municipal utility maintains a comprehensive database of solar panel installations, including the size, price (estimated and actual), and timeline of work.

I use this database to build a panel dataset that includes the annual revenues and market share of every company in the Austin solar installation market. I also construct a set of firm-level variables of routinization: In a given year, how much variation is there in the time required for a firm to install a kW of solar panel capacity? How much variation is there in a firm’s ability to accurately estimate the price of an installation? Lastly, how much variation is there in the price per watt charged to customers? Using market share and revenue as dependent variables, I test whether there is an association between these measures of routinization and firm performance. Only one of those—lowering variation in total installation time—is associated with higher revenues. It is not, however, associated with greater market share.

Combined with previous work suggesting that routinization of supply chain is similarly uncorrelated with firm success, these results suggest that it is routinization of operational process, rather than supply chains or pricing, that is associated with success in the technology-driven, ambiguous market of solar panel installations. In the framework of entrepreneurial bricolage, operational processes would represent one area of the business model in which firms limit parallel experimentation, engaging instead in what entrepreneurial strategy research calls *selective bricolage*. Further research could look in three potential directions: First, research could test more measures of routinization, such as the customer acquisition process or the geographic locations of installation. Second, it could examine multiple ecosystems, such as solar panel installation across multiple geographies, in order to control for the effects of a particular city or state on the development of an industry. Third, the gap in empirical work on microfoundations suggests that an even closer look at these firms might reveal some of the individual-level characteristics and routines that led to the rise of firm-level characteristics associated with success in the solar industry.

If these results hold across geographies, what might this mean for entrepreneurs, business incubators and policymakers? For entrepreneurs, it may provide a clue about which business areas in which to continue experimenting, and in which to seek efficiency and routine. For business incubators, it could provide support for the idea of training entrepreneurs both in operational efficiency and in experimentation. For policymakers interested in supporting nascent markets with the minimal amount of market distortion, it might suggest where to focus financial support and training: In areas of business that see earlier and greater routinization within an industry. Such focus could help bolster industry growth where efficiency is most important, leaving entrepreneurs room to build the capacities necessary to continue to experiment in dynamic markets.

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1. Anonymized data and documentation available upon request. [↑](#footnote-ref-1)