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Three Essays on Institutions and Organizations

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Three Essays on Institutions and Organizations

Matthew Joseph Histen, PhD

University of Connecticut, 2016

Abstract: Organizational economics asks the question why are some transactions located in one firm, while in other cases they are located across firms. The classic answer is that market and firms are substitutes, and the boundary between these organizing features depends on transaction costs. The costs of accessing and using the price mechanism can lead to cheaper economic organization with internal governance. But avenues remain to explore through extensions to the theory, novel applications, and empirical work. While transaction cost economics challenged the Marshallian firm as a black box, the market continued to remain a black box itself. Thus chapter one homes in on this piece by exploring the dynamics of the market and firm interaction through corroborating the Vanishing Hand hypothesis. Next, in chapter two, I apply the theory beyond the firm to analyze the organizational archetypes of states and how their temporal boundaries depend on a flavor of transaction costs. Finally, chapter three attempts to empirically validate theories of the firm by proxying for transaction costs with merger and acquisition data.

Three Essays on Institutions and Organizations

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B.A., University of Connecticut, 2008

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1 Introduction

Organizational economics asks the question why are some transactions located in one firm, while in other cases they are located across firms. The classic answer is that market and firms are substitutes, and the boundary between these organizing features depends on transaction costs. The costs of accessing and using the price mechanism can lead to cheaper economic organization with internal governance. And since then, organizational economics and transaction cost economics in particular have become a fruitful and highly researched field.

Nonetheless, there are still avenues to explore through extensions to the theory, novel applications, and empirical work. While transaction cost economics challenged the Marshallian firm as a black box, the market continued to remain a black box itself. Thus chapter one of this essay homes in on this piece by exploring the dynamics of the market and firm interaction through corroborating the Vanishing Hand hypothesis. Additionally, in chapter two, I apply the theory beyond the firm to analyze the organizational archetypes of states and how their temporal boundaries depend on a flavor of transaction costs. Finally, chapter three attempts to empirically validate theories of the firm by proxying for transaction costs with merger and acquisition data.

2 Dynamic Firm Boundaries

2.1 Introduction

Since Coase (1937), the question of the boundaries of the firm has blossomed into a major area of research. The boundaries question is this: why are some economic activities – some stages in the chain of production – carried out through market contracts and some undertaken within a single organization? The vast majority of the literature, especially in economics, casts the problem as a more-or-less-static horserace between market and firm (Gibbons, 2005), both conceived of as fully formed and available alternatives. Which will win the race depends in this literature on a variety of transaction costs and possible problems of strategic behavior. By contrast, business historians are more prone to see the boundaries of the firm as determined by a process that works itself out over time and in response to change, often systemic change. An institutional form may win the horserace not because it is better adapted than other horses but because its competitors simply have not yet shown up to starting gates.

Consider the challenges faced by the entrepreneur Gustavus Swift in the late Nineteenth Century. At the time, transporting meat on the hoof east from Chicago was extremely expensive. Swift recognized that there could be a substantial profit if the system of meat packing, shipping, and distribution were completely redesigned. But claiming these advantages required changing complementary assets throughout the whole system, including refrigerated cars, a network of branch houses, and other changes dependent on changes elsewhere in the process (Langlois 2003). Relying on the market to coordinate these activities would be costly or ineffective, forcing Swift to adopt vertical integration across the stages of production to coordinate the large scale change under one roof. Alfred Chandler (1977) argued that the widespread deployment of the railroad and the telegraph after the Civil War had made systemic change of this kind endemic, leading to a historically significant cluster of large vertically integrated firm that persisted well into the twentieth century. In one reading of Chandler, these large vertically integrated firm represented a mode of organization inherently superior to a decentralized market. Yet just as Chandler's *magnum opus* was issuing from the press, a new era of globalization and expanded markets was

beginning to undo the vertical integration of the multi-unit enterprise that he had described. The visible hand of management was beginning to vanish (Langlois 2003). If Swift wanted to transport commodities today, he could reliably hire one of many third-party logistics suppliers through the market.

In order to theorize about the boundaries of the firm in a way that is consistent with this historical picture, we thus need to think in explicitly dynamic or evolutionary terms. Langlois and Robertson (1995) provide a helpful theoretical account of this dynamic. On the one hand, vertical integration has benefits under circumstances of systemic change – that is, when, as in the case of Swift, many stages of the supply chain need to be altered, replaced, or merged simultaneously. Markets are at a disadvantage under such circumstances, both because it is hard to price activities requiring rich information flow (Baldwin, 2008) and because it takes time for all the many complementary market providers to emerge. By contrast, when markets develop and systemic change slows (which means that innovation becomes more autonomous or modular), markets gain advantage, both because of the economies of specialization a larger market offers (Smith, 1776) and because of the high-powered incentives markets impose (Williamson, 1985). There has not yet been any significant attempt to model this process formally. This paper attempts to fill this gap using an evolutionary simulation model. The model is able to represent, and to shed light on, the response of organizational structures to the ebb and flow of systemic innovation.

Nelson and Winter (1982) argued that the processes by which traits of organizations, including those traits underlying the ability to produce output and make profits, are transmitted through time. They claimed these traits play the role genes play in biology, and they described the effects of technical change as a Darwinian process. Levinthal (1997, 1999) applied evolutionary ideas to the organizational realm using Stuart Kauffman (1993) *NK* model, taken from theoretical biology. The *NK* model measures the performance of complex interdependent systems based on the contribution of coupled subcomponents. This agent-based simulation traces adaption in response to population level selection through individual changes in decision elements which affect many parts of the system simultaneously. Whereas Levinthal (1997) originally positioned the model to explain differences in firm strategies despite similar markets (e.g., FedEx and UPS), other authors expanded on it to examine human capital dispersion (Rivkin, 2001;

Solow, et al., 2002; Fagiolo, et al., 2005; Marengo, et al., 2005; Caminati, 2006), governance structures (Siggelkow, et al., 2006; Press, 2007; Boiset, et al., 2010); technological change (Auerswald, et al., 2000; Kauffman, et al., 2000; Simon, 2002; Strumsky, et al., 2003); modularity (Ethiraj, et al., 2004; Frenken, 2006; Brusoni, et al., 2007); entrepreneurship (Auerswald, 2008); and other aspects of organizational theory. However, *NK* research has not examined firm scope, nor have evolutionary theories in general carefully examined the boundaries of the firm. In this paper, I attempt to bridge the literature gap by modifying the model to consider the theory of the firm. I find considerable support for the model suggested by Langlois and Robertson (1995) and for the Vanishing Hand interpretation of organization history (Langlois 2003).

2.2 Background

The *NK* model, developed by biologist Stuart Kauffman (1993), explores the performance of agents navigating a rugged landscape. While originally conceived in theoretical biology to describe maturation of genetic interactions, the model has been applied to organizational change through examining the link between interdependencies of components and overall performance of the system. This has led to statements about organizational heterogeneity (Levinthal, 1997), firm strategy (Rivkin, 2000), product design (Ethiraj, et al., 2008), and more.

Parameters N and K determine the features of the landscape, where N counts the number of components in the system, and K measures the degree of interaction between them (Kauffman, 1995). A higher N implies a larger local neighborhood for each vector in the space, while higher K increases the coupling of decision elements, making the space coarser with more local maxima. Each sequence of decision elements (usually watered down to bits without loss of generality) is mapped to a scalar value ranking the fitness of the total design. With high value of K , the landscape emphasizes a high degree of interdependence, implying many other loci affect the fitness of a given locus. The change of a single element will redraw the payoffs of K other elements' performance contributions (Ganco, et al., 2009).

Thus, exhaustive search for optima becomes an NP complete problem, giving priority to the role of agent behavior in the space (Weinberger, 1996).

Agents search for a sequence of decision elements with the highest fitness. While genetic mutation motivated the original search process, other organizational designs navigate the problem analogously. Firms, too, seek higher fitness by modifying their existing structure, where they face similar choices over interconnected components based on complementarities, including product lines, production strategies, and technology (Levinthal, 1997).

The focus of the model is the optimization process by changes in the decisions of agents (Ganco, et al., 2009). However, the agents do not simply “see” the space and select the global optimum. Instead, they must perform some bounded adaptive behavior to improve their fitness over time. Typically, agents use a simple gradient ascent algorithm where they search the space of local neighbors (implying one decision element difference), and only “move” to this new location if it has a higher fitness mapping. This type of adaptive search has been improved by increasing the search radius (Siggelkow and Rivkin, 2006). However, a common and realistic constraint holds: the local maxima trap, where an agent may be at a peak with no higher fitness neighbors, yet higher peaks in the global landscape exist.

Thus, the *NK* model exhibits strong elements of path dependency, where agents’ initial forms lock them onto a specific development path. Historical effects influence the current state of firms in the market. This limits their traverse of the landscape to a subset of the space which may forego global optimization. This ties in with another important facet of the *NK* model: evolutionary selection procedures. Adaptive searchers face selective pressure from the relative positions of competitors in the space. In this time frame, the most efficient forms do not necessarily manifest because of capacity constraints and idiosyncratic initial conditions. This dynamism challenges neo-classical economics by elevating the importance of the developmental process over mere productive efficiency, granting the *NK* model a more natural exploration of real world behavior.

2.3 Contributions

The major contribution of this paper is to use the *NK* model to analyze the Coasean boundaries of the firm, a unique application in the literature. In doing so, the *NK* model was modified in a number of ways. To examine firm scope required creating multiple markets, achieved by creating a multidimensional fitness landscape. The model creates a supply chain arena with firms existing at and across different market segments. Each segment has its own fitness landscape (with slight overlap from the epistatic connections parameter). The effect breaks the cyclical nature of the *NK* chain, which no longer loops back on itself but instead requires firms to search adjacent markets for trade partners to form a connecting supply chain across the entire industry. Each segment creates different pressures on firms due to the different landscapes, which may be independently perturbed.

Thus the model corresponds to classic *NK* fitness landscape models (Kauffman, 1993; Levinthal, 1997), but effectively glues together many of these landscapes and inspects agent performance across these sectors. A complementary modification involved adding in heterogeneous firm scope, implying different levels of integration across the supply chain. Firms randomly generate according to an exponential distribution, stretching from one to many market segments. If a firm does not span the entire market, it must form a trading network with agents from the other sectors. The motivation is to see how coordination devices, be it within firm or through market exchange, influence optimal organizational structure.

To be more precise, the organization is fully characterized by n (binary for simplicity) decision elements. These are interrelated in the sense that switching decision element i from 0 to 1 depends on the current value of other policies (up to $n - 1$). Small changes can result in large changes of rank, thus searching the space is a complex task, further complicated by modifications of agent j influencing the productivity of agent k because agent k 's performance measure depends in part on the overlap of its trading partner agent j 's organizational structure. The interpretation is that changes in design by potential trading partners influence the productivity of the firm upstream. For example, the choice of logistic

distribution technology by one firm (e.g., rail, barge, truck, air) determines in some part the productivity of a trading partner, since they must receive those decision choices (e.g., design docks to suit rail, barge, truck, or air). Or these decision elemental overlaps can be coordinated across segments by vertically integrating lock, stock, and barrel under one roof. Firms face a tradeoff: remove transactions from the market by stretching across the supply chain, or remain small and rely extensively on the market.

Again in line with classic *NK* fitness landscape models, each firm receives a performance measure on its architecture. This allows for a ranking of productivity, modified through finance. A cardinal payout system gives different profits to different firms based on their rank, subject to capacity constraints. This moves away from the Marshallian firm equivalence, where only production technology matters, by intensifying a firm's timing and position in a market. When the market is thin or particular firms are of significantly higher fitness (a proxy for cost efficiency), they receive a higher proportion of that segment's surplus. Over time, as the population adapts and improves, the consumer surplus falls to competitive levels.

Firms accumulate savings based on their profitability, which are spent on several activities. First are some flat input costs which serve essentially as participation fees in the market. Firms also can spend money on innovation. Here, they pay a fixed cost to test whether alternating each allele improves their overall fitness, and convert to the new design if affordable (aligning with classic *NK* fitness landscape models with one bit neighborhood mutation algorithms). Depending on that cost and the number of alleles, adaptive behavior slows or may only be available to very profitable firms. There are also market search costs, the manifestation of Cosean transaction costs. Firms search the adjacent segment for the best available trade partner to push their product downstream. Firms greater than scope one avoid some of these transaction costs since their production stages are already linked, guaranteeing a trade partner for the next segment. Lastly, there are costs or bonuses associated with completing the market chain. This becomes an accounts payable story. If a supply chain is not completed, that implies a firm at some segment could not unload its product, which leads to a ripple effect of costs associated with honoring payment agreements back upstream.

At the end of each round, insolvent firms fall out of the population. Gaps in a market segment's carrying capacity are repopulated by a random number of newly generated firms (potentially of large scope depending on the constraints in other segments). This evolutionary pressure promotes a population of highest performers, revealing interesting firm dynamics. Because the purpose is to examine Cosean firm scope, the lens tracks the performance of large, vertically integrated firms spanning several market segments against a market composed of many small firms trading with each other. Of particular interest is how the success of these different architectures changes over time.

2.4 Summary of Simulation

At the beginning of each trial, the simulation initializes the NK space “on the fly,” meaning only points on the space that are visited are generated. This initialization involves specifying a randomly generated fitness value from a uniform distribution between zero and one for the 2^N possible organizational forms that appear. Each possible string can assume 2^{K-1} values depending on the value of K (Levinthal, 1997). Organizations can alternate the bits in the string, but the fitness landscape remains fixed for each element unless perturbed.

The initial number involves generating random N -length strings with equal probability of zero and one for a specified amount of firms in each market segment. Along with each unique string, a firm scope variable is drawn from an exponential distribution for up to the remaining possible market segments. If greater than one, strings are generated in consecutive segments all associated under a unique identifier.

After these initializations, the model iterates the following procedure. Firms perform a market search to match their segment edges with a symmetric preference ordering over matches (except for the last sector, which just receives a payout based on ranked fitness). Search fees accumulate as they probe, except for large firms where segments are already coordinated. Firms that cannot afford the transaction costs are randomly matched at the end provided open firms are still available on both sides of the market.

Next, firms adaptively search the space in an attempt to improve their fitness, provided they can afford the innovation costs, including coordinating with a prospective contracted partner if the epistatic connections are sufficiently large. Adaption is simply a one neighbor search, but each examination requires paying a fixed cost.

Finally, the model aggregates the connections, and supply chains fully spanning the market receive a bonus based on the accounts payable story above. Firms accumulate profits based on their relative position in the fitness landscape in each sector, with more profits going to higher ranked firms (subject to a ceiling on the total amount of windfall they can receive to reflect production capacity constraints). Similarly, savings are capped at some fixed amount to avoid wealthy firms which cannot spend accumulated earnings from insulating against the entire simulation run.

At the end of each round, firms are collected and their net savings are calculated across all the segments in which they exist. Any with negative equity go bankrupt and exit the market. A new population of entrepreneurs of varying string and firm scope are generated, and if there are gaps in the carrying capacity of a market segment, firms from this new population are randomly selected and added.

For each set of parameter values in the results, a hundred simulations were run, implying a hundred different multidimensional landscapes and population histories. The results generally focus on examining the upper quartile of firms. This removes the noise associated with the volatility of trivial firms that last only for a few periods, and allows analysis to home in on the most successful strategies in each iteration.

2.5 Results

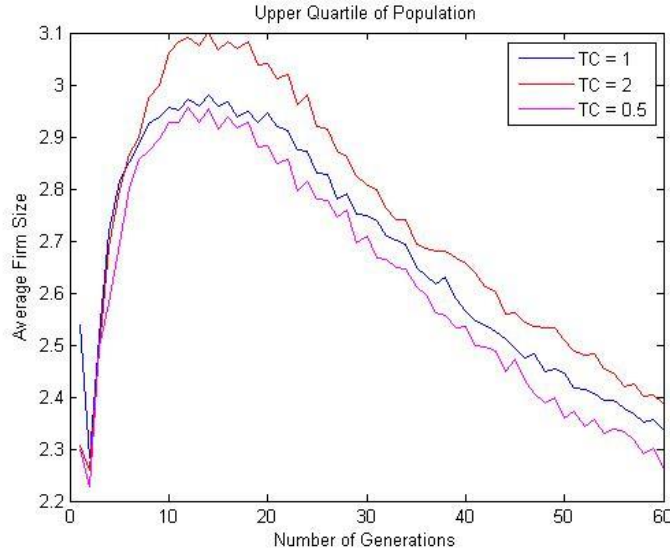
The purpose of the model is to measure how firm scope affects profitability overtime under different scenarios. Firm scope refers to the amount of market segments one entity stretches across. Several simulations examine the effects of varying parameters and different types of shocks on the landscape.

Three types of shocks are explored. At exogenously specified periods, shocks alter the *NK* landscape by affecting the fitness payout for firm genotypes. In each case, the aftershock landscape

becomes the weighted average between the existing payoff and a random draw (Gavetti, et al., 2005). The first type of shock, Type A, hits a random number of market segments but with only a small percentage of the new roll averaging against the landscape (10% or less), resulting in mild changes to the overall landscape. Consider this a typical business environment, where slow changes occur overtime. A Type B shock hits all of the market segments and the new landscape takes on up to 90% of the new roll, potentially drastically changing its form. Consider this a radical alteration in the business environment, such as technological innovation or regulatory change. A Type C shock hits only one segment but the same one repeatedly, and again alters the landscape there by up to 90%. Consider this a supply chain with a volatile component somewhere along the way. Calibration was kept consistent across the simulations to compare the difference of interest.

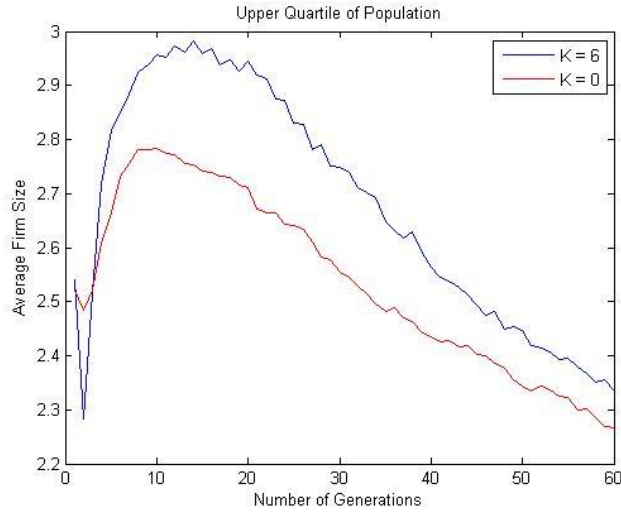
Figure 2.1 displays a meaningful result of the paper. In this simulation, the landscape experiences the Type A shock with a small amount of randomness every other period. Each curve has $N = 10$, $K = 6$, and $S = 7$, the number of market segments. The blue line serves as a benchmark across simulations. The market search cost, a proxy for transaction costs, is doubled and halved for the lines above and below it, respectively. Higher transaction costs do indeed bring about larger firm scope, yet firm scope changes even though transaction cost remain fixed. Thus the model reinforces Coase's story, but calls attention to the role of dynamism. At first, in the novel landscape, larger firms succeed more as they are better able to coordinate production stages. As the iterations continue, however, the smaller firms realize more advantages as production stages develop in all segments, rewarding flexibility as the market becomes more reliable. When the transaction costs are higher, firm scope is larger, and never falls as far in the long run. And when transaction costs decrease, firm scope is indeed smaller, but with diminishing effect. This reveals that transaction costs are not the full story behind firm scope, and the stage in the environment has significant influence.

Figure 2.1



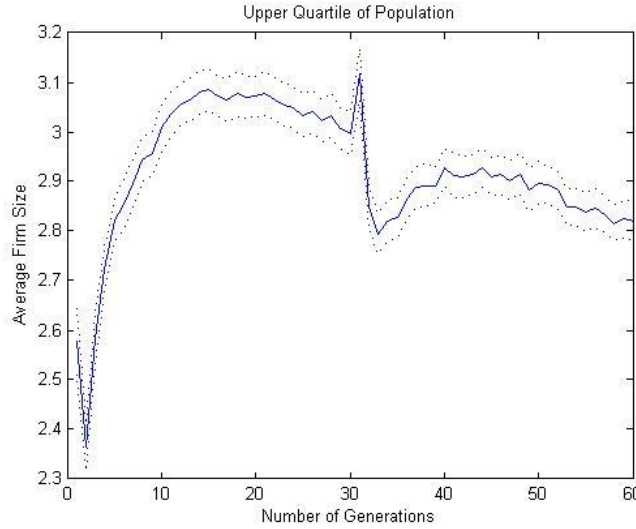
In Figure 2.2, the landscape also experiences the Type A shock. The blue line is the same blue line from Figure 1, and the transaction cost term stays at that setting for the remaining simulations. As above, $N = 10$ and $S = 7$, the number of market segments. Thus the only tweaked parameter in this simulation is K , the interconnectedness component. This run presents K 's effect on firm scope. If production stages are more intertwined, implying higher K and thus less modularity, larger firms retain profit advantages for longer because of their built in production coordination. If not, autonomous firms can more easily interact. This results in firm scope peaking quicker, and the market overtaking the firm faster, aligning with the systems literature on the effects of interconnectedness of production stages and the role of standards in coordinating production across firms (Simon, 1962; Glassman, 1973; Ashby, 1960; Weick, 1979). This captures a part of Williamson's theory, for firms upstream innovate according to their trade partner's design (recall that a decision element's fitness depends on K neighboring elements, which crosses into the trade partner's choices at $K \geq 1$). They then risk that specialization as sunk in later periods if the firm they tailored to fails or trades with someone else. Alternatively, locating production exchanges under one roof secures investment across production stages. Note that this cost to smaller firms arises even without self-interested guile on the part of the downstream firm.

Figure 2.2



In Figure 2.3, the simulation was run with the same calibration at $N = 10$, $K = 6$, and $S = 7$, the number of market segments. Again identical to the first simulation, a Type A shock occurs every other period, hitting a random number of segments but altering them by no more than 10%. The blue line represents the trial quartile average, while the dotted line is a 95% confidence interval. A Type B shock perturbing the entire landscape up to 90% hits at period 30. The trend from above persists, where initially, in novel landscapes, larger firms have more success from their advantages in coordinating across thin or weak markets. However, firm scope peaks as efficient small firms develop in these segments, and begins to decline as the market replaces the firm in organizing trade activity. Note that when the perturbation hits, firm scope temporarily spikes since larger firms have more capital to weather contingencies and rely less on other firms in a collapsing market, but become insolvent a few periods later. However, the inverted U-shape again appears, for initially large firms are better at coordinating across the novel landscape until markets sufficiently develop, causing firm scope to decline from thicker markets advantaging smaller firms.

Figure 2.3



In *Figure 2.4*, the simulation was again run with the same calibration at $N = 10$, $K = 6$, and $S = 7$. The same Type A partial landscape shock happens every other period. However, the unique component in this run was the introduction of a Type C shock, where a single market segment was affected with a 90% landscape perturbation. Segment 4 was hit every period by this type of shock, and *Figure 2.4* shows the effects on firm scope in the three market segments before and after.

In essence, spamming one market segment over and over allows larger firms to choke out market development around that point. This results in a natural seizure of the entire supply chain through only one market segment without any strategic play.

The perturbed sector saw an initial rise in firm scope, then virtually no change. Small firms were unable to survive in that sector due to the volatility, so only large firms that could stretch across the middle sector and absorb losses survived. The need to subsidize the volatile segment with profits from other sectors eliminated the development of smaller firms there, which in turn hindered development elsewhere, rippling up and down stream. The effect was for only larger firms to align production stages across the supply chain. As this severed the market's ability to connect firms on either side, the growth of smaller firms filling the market faced much resistance, as evidenced in *Figure 2.4*.

The blue line represents the quartile average firm scope before the perturbed market segment. While firm scope initially increases, as in previous runs, it only slightly declines afterwards. Firms on this side of the supply chain cannot rely on the development of smaller firms in the market to connect production stages downstream since these firms cannot survive the choke on the middle sector. Being unable to rely on the market connecting the production stages, the advantages to smaller firms are squeezed out, and the decline never really happens. Firms here also seem to hit a ceiling at the Type C shock, where they needed to be small enough to trade with a firm stretching the sector, or large enough to stretch across themselves.

The red line represents the quartile average firm scope after the spammed market segment. Somewhat surprisingly, firm scope was larger than the other side of the market. This left some room for smaller firms to develop and trade with those who controlled the middle sector, and as such the declining trend in firm scope is noticeable. However, firm scope could not decline as much because of the reliance on large firms in the middle sector, which had an even greater effect on the second half of the market. The simulation results point to the greater disturbances downstream from a market chokehold, as firm scope was demonstrably larger in market segments after the Type C shock than before.

Figure 2.4

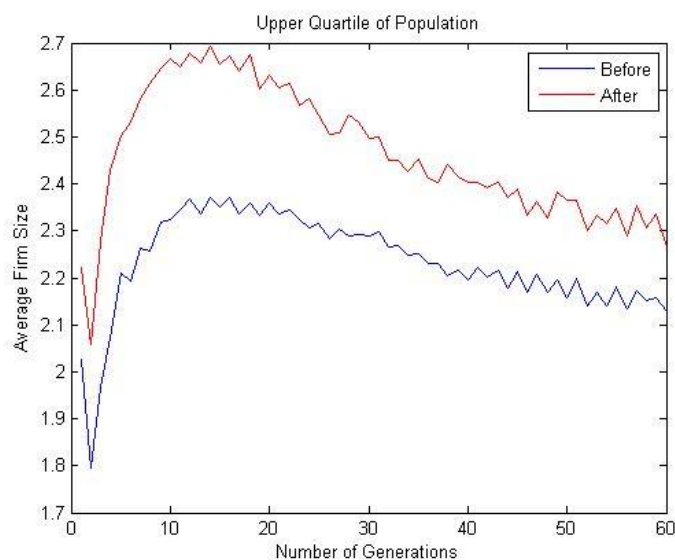
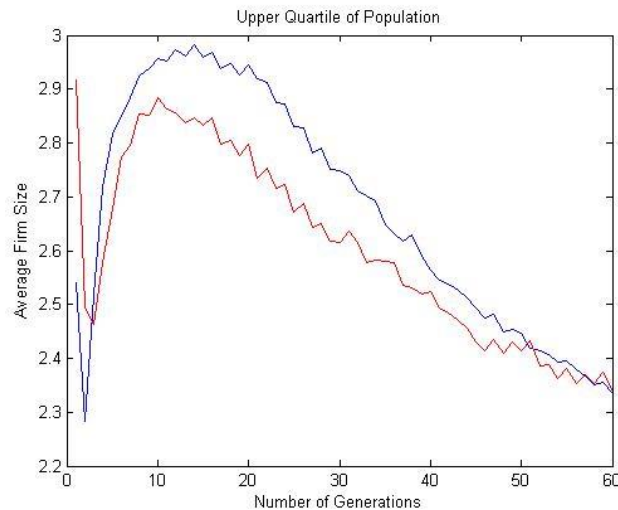


Figure 2.5 looks at the effect of initial capital on market development. As firms bust, entrepreneurs reenter in their place with a random amount of starting capital as a small reflection of heterogeneous borrowing costs. The purpose of this simulation is to tease out early advantages some firms have by being high up on a small hill, which translates to inefficient firms surviving by crowding out more efficient ones simply because of timing. Limits in capital access can constrain efficient firms from developing their investments, which asymptotically may be higher than currently successful firms.

Figure 2.5 demonstrates how capital can buffer relative fitness and lend time for true optimization. The blue curve is the same blue curve from *Figure 2.1*, while the red curve is the same calibration but with starting capital increased by 300%. Both have $N = 10$, $K = 6$, and $S = 7$, with a Type A shock every other period. The results show that higher capital constraints shrink the curve, leading to a quicker decrease in firm scope by letting smaller, efficient firms compete for longer. This allows the simulation to achieve a more efficient allocation of firms and firm scope faster as the market can develop more quickly.

Figure 2.5



2.6 Discussion

The model reinforces several classical remarks on firm scope, but establishes that they are not the full story. It bolsters the theory of the vanishing hand (Langlois, 1988, 1992, 2003). In the short run, the

economic environment may present too many challenges for external mechanisms of coordination through the narrow visions of local participants (Langlois, 1988). In these circumstances, centralized control may better accommodate the required reorganization (Langlois, 1988). With high uncertainty, as demonstrated in a novel *NK* landscape, “cephalization” through internal organization becomes the course of successful firms (Knight, 1921). Vertical integration serves management by buffering uncertainty in other market segments (Langlois, 1988). This captures the visible hand notion: the Chandlerian firm in which management successfully coordinates stages of production in place of decentralized market activity (Chandler, 1977).

So while vertical integration can overcome systemic change in the short run, the extent of the market increases with time. And the advantage of the market surfaces from its flexibility and modularity, captured in the model by its ability to more easily adjust to the landscape’s local maxima. The trend of the simulations shows how firm scope declines overtime, a result of the improving efficiency of the market. As uncertainty attenuates, smaller firms are not limited to the internal capabilities of larger firms (Langlois, 1992). The glue holding together the production stages becomes too stiff to fully internalize advantages found in thicker markets where new technologies achieve higher fitness outside the scope of locked in large firms. Furthermore, the modular aspect of decentralization allows for retooling in one segment to leave undisturbed participants in another segment, while reorganization of a large firm necessarily disrupts its coordination. Thus, the visible hand of management vanishes with the extent of the market.

This market wide behavior implies strategies for firms based on the current position of the environment. On the one hand, timing of mergers and acquisitions should consider the trend of the market, and management should combine production stages when uncertainty is highest. Similarly, firms burgeoning in new fields outperform when locating most transactions within their own borders rather than relying on underdeveloped markets. Yet as maturity within those markets increases, firms that use the market are able to capture gains associated with its flexibility and high-powered incentives. Firm scope, in sufficiently large industries, should ultimately reflect some aspect of maturity in the sector.

An example surrounds firm organization across country borders. In the U.S., 50% of imports and 30% of exports are done intrafirm (U.S. Census Related-Party Trade Database, 2014), implying that managers see value to increasing the boundary of the firm across these borders. To align with the framework of the paper, this represents the equivalent of a novel landscape, where the fitness across the market segments changes too drastically too often to allow for markets to form efficiently and stably. Instead, organization must coordinate processes within its own boundaries to succeed profitably in these conditions. Overtime, however, as countries improve business relations through more interactions and better policies, the amount of transactions within firms will decline, as the novelty of the landscape becomes familiar enough to hand over coordination to smaller firms. While weak institutions motivate a reason to organize in house as well, most of U.S. trade goes through Canada, Mexico, and the E.U.

Another implication of the model surrounds the effects of a chokehold on firm scope. When there is a bottleneck preventing smaller firms from developing, that ripples across the rest of the supply chain. The advantage of the market is its many small moving pieces, which can externalize technological advantages to any participant. However, those small moving pieces rely on other small moving pieces, and when that development is blocked in one place, it hinders growth elsewhere. Astute managers must accurately predict the reliability of other market participants. And that reliability depends on thickness, which is crippled during these types of chokeholds. As such, the best strategy against a volatile sector in a supply chain seems to involve coordinating that production within the firm's borders. This becomes even more important based on the directional location of the firm. Firms downstream held more advantage by being larger, hedging against the higher risk of market instability.

Lastly, the strength of financial markets in an environment affects firm scope. With stiff capital constraints in place, a head start becomes more important than efficiency. The longevity of firms depends on their fitness relative to their competition, not their Marshallian asymptotic technology. When small firms cannot muster the capital to innovate and develop, large firms retain their advantage for longer. Thus the sophistication of lending and access to capital in an environment has important effects on the

optimal scope of a firm. Weaker financial markets extend the advantage to larger firms by obstructing the extent of the market.

2.7 Conclusion

Transaction-cost economics explain the boundary of the firm through changes in coordination technology. This approach faces the shortcomings of being too static and ignoring the extent of the market. The Vanishing Hand hypothesis expands the analysis by examining how Coasean firm scope changes over time and tracing the movement from centralized to decentralized coordination. However, the coupling of the components of that process and their different rates of change make empirical support challenging.

The *NK* model poses the complex process of organizational change by creating a concrete mechanism between the interdependencies of components and the overall performance of the system. It allows for tuning the navigable space through various coupling strengths, and examines the role of agent adaption in dynamic environments. As such, the *NK* model has found many applications in the strategy literature, and incorporates important organizational concepts ranging from path dependency to technological change to modularity.

This paper modifies the *NK* model to develop a framework for analyzing firm scope. In creating a multidimensional sequential landscape, adding in finance, innovation, and market search, and creating an ordinal payout system, heterogeneous firm scope becomes an important factor for agent performance. The simulations examined the optimization ability of the firm versus the market overtime and in response to various perturbations, connecting several literatures related to the boundary of the firm.

The results both reinforce transaction-cost economics and point to considerations beyond it when determining the border of an organization. The simulation results support the Vanishing Hand hypothesis, where initial advantages of centralized control in a novel landscape encourage firm growth, but large organizations eventually succumb to smaller firms as the market thickens and becomes more capable at coordinating production by externalizing flexibility. Firm scope reflects not only the level of coordination technology, but also the market's maturity.

3 Swords and Crosiers: Strategies in Polity Governance

3.1 Introduction

State and religion have had an intricate and entangled relationship throughout civilization. For thousands of years, they banded tightly together, then grew apart at different rates. We attempt to explain the interaction of state and religion by developing a political economy account that focuses on enforcement, and we build an agent based model to simulate this theory. We then match the model's predictions with a recently constructed data set containing political and religious variables over two millennia. We argue that transaction costs and changes in the composition of agent populations are the key drivers in the dynamic relationship between state and religion.

“The distance between the throne and the altar can never be too great,” wrote Diderot (1992). For much of history, the political authority was an imperial cult. Often rulers claimed to the instantiation of deities, and assumed titles of divine inspiration. This implied the use of religion to legitimize the political authority – what we would now think of as a state religion, even if the ideas of state and religion were not always clearly separated. There is evidence that, over time, state and religion have become less integrated. In 2000, around 40% of countries still held de facto state religions, down from 60% in 1900 (Barro and McCleary, 2005) and from more than 90% before the 1600s.

What motivates this vertical integration, and what causes it to decline? Unlike the literature on religious markets and the production of religious versus secular goods (Finke and Stark, 1992; Iannaccone, 1991; Finke and Iannaccone, 1993), we focus instead on social cooperation. In our account, the state and religion coordinate on the choice of institutions and on mechanisms of enforcement, which we think of in terms of a Pareto-dominated prisoner's dilemma game. The state enforces laws through soldiers and police, the Weberian monopoly over legitimate use of physical violence. Religion, in turn, enforces its institutions through clerics and priests with a monopoly over the legitimate use of *spiritual* violence. A polity leveraging swords and crosiers – the integration of church and state – may achieve gains from social cooperation more cheaply than either alone.

There is an existing literature that uses the concept of legitimacy to explain the fusion of state and religion: the political authority increases its power or resources by adopting a state religion (Johnson and Koyama, 2013; Cosgel and Miceli, 2009). This paper takes the same basic approach, but changes the optimization problem from the perspectives of both the religious authorities and the state leaders. The existing literature can explain the decline in integration between state and religion only by appeals to intellectual movements, such as the Enlightenment and the Protestant Reformation (MacCulloch, 2003; Zagorin, 2003; Gregory, 2012), or to the elasticity of fiscal capacity (Johnson and Koyama, 2013). By contrast, the focus here is on the strategic incentives of the state and religion as autonomous organizations. In our account, it is the transaction costs associated with maintaining a state religion that cause a collapse in response to compositional changes in the population of agents. The evolutionary agent-based model we use to simulate this mechanism examines this collapse as well as the conditions more generally under which theocracy-type governance outperforms secular states and vice versa. Empirical analysis supports the general findings of the model.

3.2 Background

Scholars have generally sought the purpose of the state in enforcing property rights and providing public goods, without which economic transactions would face severe frictions. Hobbes (1998) claimed the state necessary for achieving social cooperation to avoid the warring state of nature. In the Hobbesian story, an agency capable of creating the social cooperation generates rents. Max Weber saw the state as an organization extracting those rents from its citizens. For Weber (2015), “statehood” is the monopoly over physical violence that both enforces social cooperation and enables rent extraction. Mancur Olsen famously described this state as a sedentary bandit that maximizes the rent it can extract (McGuire and Olson, 1996; Wintrobe, 1998). Since a sedentary bandit effectively owns the rights to extract rents, a state extracts resources from the populace over a longer horizon, correcting the tragedy of the commons problem that “roving bandits” would face in a more Hobbesian world. The state as a military natural monopoly extends then its borders to the minimum efficient scale (Tilly, 1985).

We combine this with an account of organization as a conduit for interaction in a way that maintains the importance of enforcement and expands on how members and rulers interact. We then insert state and religion. The sovereign manages a platform, a set of governance institutions that define the rules of the game, which generates value for members through better coordination. Joining a state allows agents to escape the disorganized Hobbesian state of nature. This potential value positions the managers of the platform to extract rents from participants. A successful organization thus generates value to both its members and its managers.

The platform generates value to members for several reasons, all centering on improved interaction. Members overcome exchange frictions as they do not have to reinvent or renegotiate terms with each exchange through enforced standards. Members can assert, define, and defend ownership claims to property rights, the exclusive authority to select how a resource is used from some non-prohibited class of uses (Alchian 1965; Skarbek, 2014). By standardizing interaction with prespecified conflict resolutions, members can overcome problems with impersonal exchange, as membership serves as a screening device *ex ante* secured by enforcement *ex post*. The group defines a set of impersonal characteristics to preserve relations between agents, rather than relying on expensive local knowledge, allowing the group to represent the individual, and the organization becomes a tool for individuals to increase their productivity (North, et al., 2009).

Furthermore, the platform can help members act collectively when certain goods are difficult to produce privately because of free riders (Skarbek, 2014). The organization charges a price for participation, a tax base, which can fund expenditures for public goods which benefit members but are hard to craft property rights to incentivize individuals to produce them privately. The higher the value to members, the more managers can charge for participation.

But this process requires that members adhere to the governance institutions. An effective organization enforces its rules by making it more expensive to break them than to follow them. One credible enforcement mechanism is a hostage bond paid upon becoming a member. In joining, then, an agent puts up capital over which the organization can seize if she breaks its rules. In the end, the hostage

boils down to the threat of a deleterious action by the organization. But the organization has incentives not to capriciously execute threats because of reputation effects. Its managers want to accumulate new members and keep incumbent ones because of the ability to collect taxes from them in exchange for using its platform (Skarbek, 2014).

In summary, agents join an organization because the benefits exceed the costs. In this paper, the benefits are modeled as achieving the dominated but Pareto superior outcome in a prisoner's dilemma game by making defection more costly for members. This outcome can be interpreted as the value created from the governance institutions, including enhanced exchange, protection, and public goods, while the costs reflect some form of seizure of the hostage bond. Alternatively, we can think of managers operating an organization because the tax base collected from cooperation exceeds the cost of enforcement and expenditures. If either side does not operate profitably, the organization collapses.

3.2.1 Extralegal Organizations

When official governance institutions fail or are incomplete, participants may turn to extralegal governance, effectively creating an alternative organization to solve the shortcomings. For example, marginalized members of a state may lack access to official governance channels, or may be engaging in activities not legitimized by the state. Participants in illicit markets (like drugs), who cannot call on police support if they are not paid, may turn to an organized-crime gang for help with enforcement. The alternative (extra-legal) organization provides another set of governance institutions for member benefits and manager tax revenue, institutions with their own enforcement mechanisms, also requiring a hostage to threaten members into obedience. Interactions previously without legal recourse gain credibility through enforcement by the new organization.

Agents may preserve membership in multiple organizations depending on the nature of the governance institutions, enforcement hostage, and the level of exclusivity established by their managers. If rules conflict, then multi-membership is likely infeasible. The enforcement mechanisms can also leverage the same hostage. In this case, however, both organizations cannot simultaneously make credible

threats – an asset cannot have multiple liens and retain its full value. Alternatively, if the governance institutions and enforcement mechanisms do not conflict, organizations can mutually coexist or embed ad infinitum subject to the discretion of the various managers.

Managers may seek openness and compatibility with other organizations because they may benefit from lower costs, but at the expense of the loss in some control. Lower costs arise from expenditures on enhancing organizational value, both in terms of providing goods and enforcing rules. The tradeoff, the loss of control, refers to the organization's institutional effectiveness over its members. As it leverages other channels, other organizations wield influence on its members. In reality, governance institutions are fluid. Thus, initial benefits of organizational nesting may decline as the institutions change over time. The overlap among institutions can create conflict to the extent that the organizations pressure members into contradicting actions. Furthermore, agents may relinquish their original membership in favor of the new organization, decreasing the revenue for managers.

3.2.2 Swords and Crosiers

The state fits easily into this model. It offers amenities to its citizens through its governance institutions, such as national defense, property rights, court of law, etc., for the participation fee of taxation, which its managers use to fund expenditures and extract resources for themselves. By joining the state, an agent places her physical self as hostage because she subjects to the state's authorized use of physical violence (Weber, 2015). If she breaks the rules it can execute its hostage over her with the threat of violence or deportation. Because of the role of physical violence in its enforcement mechanism, a state is naturally incompatible with other organizations trying to leveraging that hostage: in reality dual citizenship is a rarity. Underground organizations leveraging violence for enforcement, like the mafia or gangs, are incompatible as well.

States do not provide all the needs of its members, however. Participants often turn to extralegal governance when they must rely on local expertise and information (Skarbek, 2014) or, again, when they face high costs using legal channels or when their activities are not sanctioned by the state. They also may

need to use extralegal governance for transactions across state borders, where neither organization is capable of enforcement. Greif (2006) describes medieval ethnic networks that operated across multiple jurisdictions and possessed their own legal and other state-like institutions. Institutions like guilds or social clubs, which enforce more specialized rules and provide more specialized amenities, can also be embedded within larger state-like organizations.

A religion, too, is a type of organization with its own platform and enforcement mechanisms. Religion functions the same as any organization: it must provide governance institutions that add value to its members and a tax base for its managers. Managers of a religion fund its infrastructure with tithes or alms from members. Successful religions thus generate value to both members and managers. In some cases, religions arose to provide secular as well as spiritual goods when existing states were unable to provide those secular goods. Many religions provide their own property right systems and allocative decisions over resources, and define and enforce rights outside the state's jurisdiction, such as inheritance or family laws. For example, in Europe during the Middle Ages, the Church was primarily responsible for education and welfare, including poor relief, hospitals, disaster relief, and food storage. It was responsible for the provision of justice of certain claims, and owned and managed categories of lands beyond the secular authorities (North, et al., 2009). In many instances, religion arose even before an identifiable separate state system. Religion has been important in facilitating trade across regions: ethnic trading networks often relied on religious courts for dispute resolution (Greif 2006). Western markets gained their footholds in China through Muslim and Jewish traders

Religion's uniqueness stems from its enforcement mechanism. It maintains a hostage of the soul, a monopoly over the threat of legitimate *spiritual violence*. By joining a religion, a member pledges an abstract hostage to the organization, an intangible asset. If the agent violates the governance rules, the religion may threaten damage to that asset, for example by damning the soul to a hell.

Again, a religion cannot be compatible with another organization that uses the same hostage. And just as with states, many other religions authorize spiritual violence as enforcement, and thus are naturally incompatible. Dual membership in different religions is virtually absent, at least in the West. However,

states and religions do not typically rely on the same hostage and set of enforcement mechanisms, and therefore agents may be members of both. We now turn to the strategic incentives of membership in both state and religion.

3.3 Theory

An organization offers profit opportunities to members and managers of its infrastructure. Members can circumvent the Hobbesian state of nature, and managers can tax them on some portion of that value achieved. We model this interaction as an extension of a simple modified prisoner's dilemma put forth by Minkler and Miceli (2004). Agents can achieve the Pareto optimal outcome in a one shot prisoner's dilemma game with a hostage.

3.3.1 Model

A pool of agents randomly sort into association with others. Each agent makes public her affiliation. The agents can then decide whether to play the game or exit. Each agent has an exit option, which makes membership a kind of voluntary exchange in this model (Minkler & Miceli, 2004). Agents with affiliation must receive some payoff for cooperating, that is, for obeying their organization's institutions. Agents also receive a payoff for defecting, which is reduced by the punishment for breaking the organization's rules.

$$U = \begin{cases} \pi_1 & \text{if cooperate} \\ \pi_2 - x & \text{if defect} \end{cases}$$

where x is the enforcement cost applied to defectors. Note that this represents a cost to the player not contingent on the behavior of the partner; defecting against a defector is still costly (Miceli & Minkler 2004). If a member breaks the rules, she is punished even if the opponent cheated. Because the organization's reputation extends beyond the individual, it may force her to sacrifice benefit in order to uphold the credibility of the organization. Define an indicator function y to reflect an agent's public affiliation:

$$y^i = \begin{cases} 1 & \text{if player } i \text{ is affiliated with the organization} \\ 0 & \text{if player is not affiliated with the organization} \end{cases}$$

The prisoner's dilemma game assumes typical payoffs in the matrix below, where $c > a > b > d$. Further assuming $2a > c + d$ makes mutual cooperation the jointly optimal outcome. Absent enforcement, the standard solution of mutual defection yields each player b .

	<i>Cooperate</i>	<i>Defect</i>
<i>Cooperate</i>	a, a	d, c
<i>Defect</i>	c, d	b, b

For players affiliated with religion, assume that x , the inflicted cost of enforcement, varies per player but is drawn from a distribution in the interval $[0, \theta]$ with $\theta > 0$, where the managers set θ . The interpretation is that the managers of the religion establish a mythology, a component of which contains supernatural elements in motivating the rules. The variable θ embodies the degree of monitoring by the supernatural, such as a supernatural being or ancestral spirits, as well as the costs of infractions against dogma via damage to spiritual wellbeing held in hostage. Obedience varies per person based on her interpretation of the whole apparatus set by the managers.

For players affiliated with a state, assume that x depends on whether the state catches the violation. This implies external monitoring, which depends on the amount of resources the state dedicates towards supervision. The resources spent on enforcement are sunk; even if no one breaks the law, police are still on the corners and must be paid. The probability of being caught depends on φ , the number of transactions the state can examine, set by managers, with each player having a noisy interpretation of it.

Some tax rate τ is applied to the payoff when members cooperate, supporting the organization's infrastructure and enforcement mechanism imposed on defectors. While assumed exogenous, τ is limited to falling in a range that preserves the payoff ordering above.

The game becomes

	<i>Cooperate</i>	<i>Defect</i>
<i>Cooperate</i>	$\tau(a), \tau(a)$	$d, c - y^i x^i$
<i>Defect</i>	$c - y^i x^i, d$	$b - y^i x^i, b - y^i x^i$

For a certain activity, the players can choose to obey or disobey the organization's protocol. Thus if a player interacts with an affiliated member, the game is no longer a prisoner's dilemma. If designed properly, the x^i serves as *ex post* contract enforcement, while y^i offers an *ex ante* screening device.

Managers of religious or state organization solve the following optimization problems, respectively:

$$\max_{\theta} [a - \tau(a)]p(\theta) - E(\theta)$$

$$\max_{\varphi} [a - \tau(a)]p(\varphi) - E(\varphi)$$

where $\frac{dE}{d\theta} > 0$ and $\frac{dE}{d\varphi} > 0$, and conditions on $p(\cdot)$ are nonlinear based on reproduction rates in the simulation, but generally increasing with enforcement choice variables. Thus managers endogenously set enforcement levels depending on how changes influence marginal revenue and marginal costs, subject to a delay parameter to compensate for lags in population trends.

Agents face three general scenarios. If both players do not belong to an affiliation, the game collapses to the standard prisoner's dilemma. Or an affiliated player may be paired against an unaffiliated. Or both players are affiliated with an organization. In the last two cases, some $y^i = 1$ and the corresponding x^i s matter. Players will only know their own x , meaning they determine with probability p that a random partner will cooperate (Miceli & Minkler, 2004).

If both players are affiliated, for agents to cooperate, $U^C \geq U^D$, or

$$y^i x^i \geq p[c - \tau(a)] + (1 - p)(b - d)$$

resulting in a pooling equilibrium. Players with $y^i x^i < [c - \tau(a)]$ will always defect because the punishment cost is not enough for cooperation to return a higher value. Alternatively, if $y^i x^i \geq (b - d)$, the player will always cooperate. A third group exists for the range of $y^i x^i$ values between these contingent on p . Players here assess the likelihood of cooperation based on the public information of θ or φ , combined with their private valuations of x , and minimax their expected utility.

When only one agent is affiliated, the dominant strategy for the other player is to defect since b is always greater than d and c is always greater than a . The affiliated player will recognize that $p = 0$, and only cooperate if $y^i x^i > b - d$ (Miceli & Minkler, 2004). Again, the organization tries to preserve the reputations of the group above the benefit of the individual by imposing high costs on defection. However, in this case the player is better off by exiting the game and will never play. As a result, affiliated agents only exchange with other affiliated agent, and the unaffiliated only with other unaffiliated. This relates to the earlier discussion about pressures to identify with a group, since members will interact only with other members because of the credibility associated with cooperation.

3.3.2 Simulation

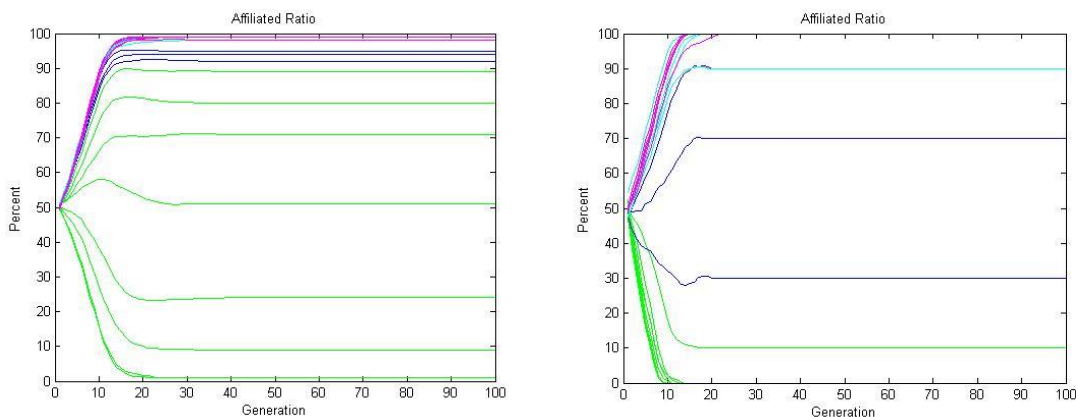
Three different categories of simulations are considered. In the first, only one type of organization exists, either state or religion. The purpose is merely to motivate the threshold necessary to overcome the Hobbesian state of nature. Each has its enforcement mechanism as defined above, where the religion sets some initial θ which trickles down into agent morality, and the state sets some initial φ which reflects the number of externally reviewed transaction. The starting enforcement level incrementally increases between the twenty trials for each state or religion, which affects the initialization of the agent population. Five hundred agents are created, half of which begin in an organization with a randomization of x , the enforcement level. Agents in a religion have a random variable between 0 and θ , while agents in a state have a noisy interpretation of φ , which they use to adjust weighted probabilities of the payoff matrix.

After these initializations, the model iterates the following procedure. Agents randomly assign with each other, and play the game. They are then ranked according to their payoff, and the bottom 10% are removed from the population, while the top 10% reproduce (both edges subject to a little noise in the cutoff) to play the another round with random assignment between surviving players. The population size remains constant but adjusts as the weaker agent types filter out. Between rounds, the managers endogenously optimize the enforcement level by balancing marginal cost and marginal revenue, subject to a slight delay to allow population changes to percolate. Increases in θ or φ lead to percentage equivalent

changes in agents' private x 's. Each of the twenty separate trials are iterated for 100 generations, and the simulation averages 100 runs at each trial level. The initial level of enforcement ranges from low starting levels in green, to low medium levels in blue, to high medium levels in cyan, to high levels in magenta. These characteristics are maintained for all simulation categories.

Thus the agent-based model is evolutionary. The purpose is to see which circumstances best suit different organizational architectures. There are several interesting results from the first simulation run. In *Figure 3.1*, affiliation outperforms remaining unaffiliated rather quickly. Agents who are unaffiliated receive the standard prisoner's dilemma payoff, while those in an organization can achieve the socially optimal outcome once a certain threshold is achieved.

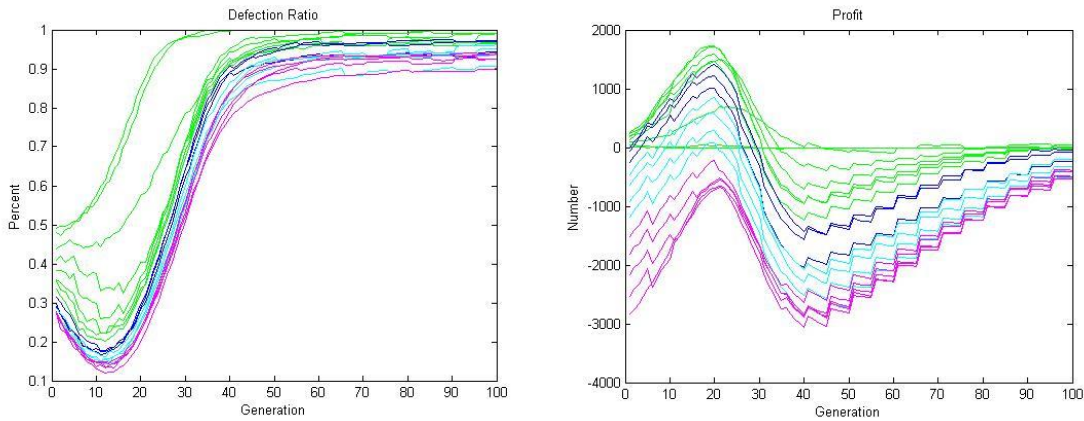
Figure 3.1 The left represents the affiliating rates for a religion, while the right for states.



However, a key difference between the enforcement types surfaces in *Figure 2*, which shows agents' decision behavior throughout the simulation. Religion can scale nicely since there are no associated monitoring costs, only the mythology building. Because each agent self monitors, the organization can easily be invaded by agents drawing a low roll from the distribution. These “sociopaths” receive the benefit of the group’s reputation, but then bear little cost in taking advantage of pious members. The result is that they reproduce very fast, as their payoffs from defection are higher than cooperators and suckers, and eventually push out members whose strategy is cooperation. This simplified framework demonstrates a severe problem with religious type enforcement: it lacks an effective

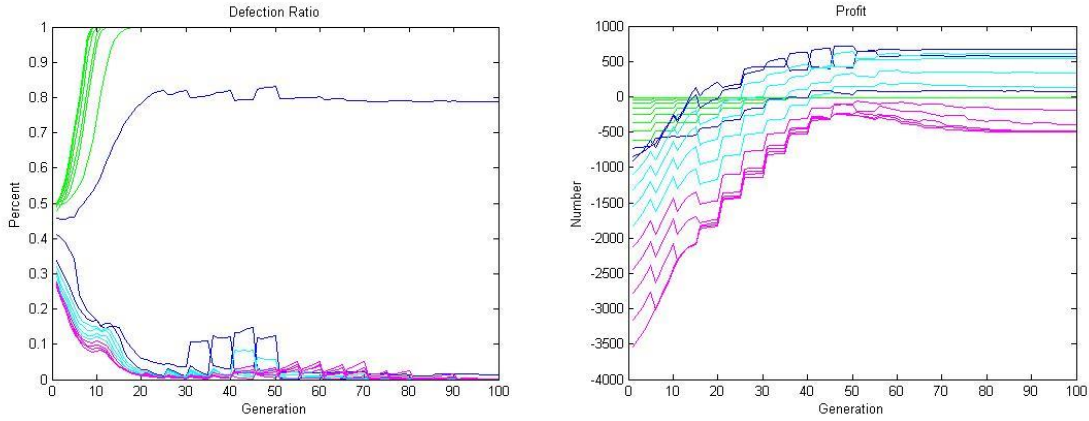
mechanism to filter out bad guys. *Figure 3.2* shows that while, initially, agents affiliate, members cooperate, and managers head towards earning profit, this collapses after several generations.

Figure 3.2 The left panel shows the trend for player actions in a world of only religion. At low levels, everyone defects since remaining unaffiliated is the best strategy. At higher levels, initially, agents begin to cooperate, but they are eventually taken advantage of by sociopaths and pushed out of the population. The right panel shows the profit rate, which initially rises (becomes less negative) as managers can collect from cooperation, but then worsens as sociopaths infiltrate, only to improve in later rounds as managers adjust downward their enforcement costs since they have no effect.



In contrast, the state has a mechanism to filter bad guys. Agents who cheat other agents and are caught lose all of their earnings, and those harmed receive a portion back. So when the ranking occurs, cheaters rank both first (ones who didn't get caught) and last (ones who got caught). If φ is effective enough, it can push out cheaters faster than they can reproduce, and achieve a cooperative society, as shown in *Figure 3.3*. An interesting behavior surfaces in the model: marginal cheaters. These are agents who, at the current setting of φ , play nice, but their subjective interpretation is right on the cusp. So as managers adjust φ downward in response to a well behaved population, suddenly a huge spike in defection occurs as those agents now view cheating as profitable.

Figure 3.3 The left panel shows the trend for player actions in a world of only state. At low levels, everyone defects since remaining unaffiliated is the best strategy. At higher levels, cooperators begin to outperform defectors since the state has a direct mechanism for filtering out cheaters. Spikes occur when the managers lower enforcement, and suddenly face a wave of cheaters who now see defection as profitable. The right panel shows profit levels for managers, which improve as society moves towards full cooperation. High enforcers remain underwater, and the nonmonotonicity relates to the state adjusting φ back up after a spike in defection.



Historically, state and religion have shared efforts in governance. In particular, theocracy, a vertical integration of the state and religion into one vehicle, has dominated how polities organized through the 18th century. While explanations have ranged from culture, to legitimacy, to weak fiscal capacity, simply cost considerations motivate the story here. If the state and religion merge, the maximization problem becomes

$$\max_{\theta, \varphi} [a - \tau(a)]p(\theta, \varphi) - E(\theta) - E(\varphi)$$

Having two distinct enforcement mechanisms allows the managers to select the lowest marginal cost on their respective curves for higher levels of cooperation¹. Managers achieve complete self-monitoring

¹ Adding police to every corner gets prohibitively expensive with less and less returns. Same with adding priests. But selecting a balance of both can reduce rule breaking for less than either alone.

through θ , and have a method to weed out bad guys with φ . Ignoring the loss of control discussed above, which includes revenue sharing considerations, in a homogenous pool of agents of single state and single religion, a theocracy will outperform a state or religion operating alone.

The next simulation holds the same parameterization as the previous, but now with one type of organization with dual enforcement. Because of the nonlinearity of the objective function with only one variable, the simulation holds fixed one type of enforcement at the lowest level, and endogenously adjusts the other, then switches which variable it held fixed. Variation across trials is again in only the starting level of enforcement, incrementally increased across twenty trials. All trials have 100 generations, each of which is simulated 100 separate times. An initial 500 agents are generated, half of which start as affiliated.

Figure 3.4 shows that from any initial starting level, whether low fixed state/variable religion or low fixed religion/variable state, unaffiliated performs worse.

Figure 3.4 The left panel shows convergence for affiliation in a low fixed state enforcement, variable religion enforcement, while the right shows convergence for affiliation in a low fixed religion enforcement, variable state enforcement.

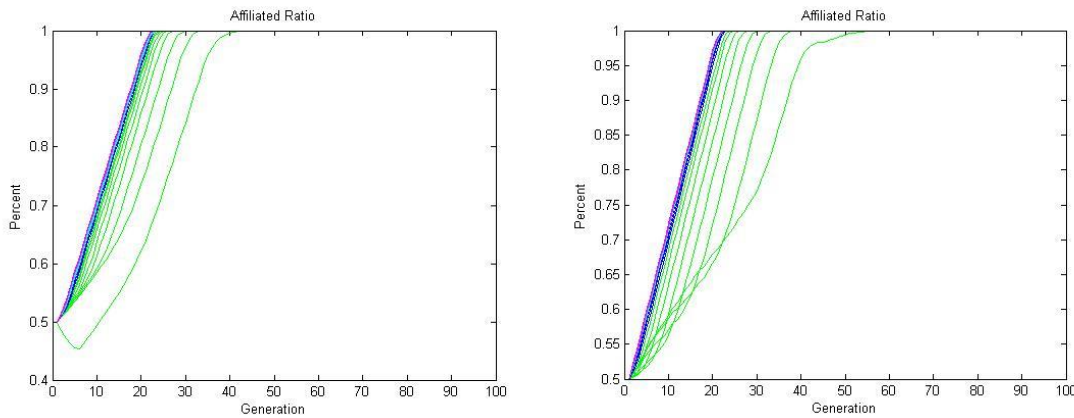


Figure 3.5 shows the defection ratio, where misbehavers stay near zero. The spikes are resulting from the effect discussed above, where decreases in enforcement cause jumps in defection by marginal cheaters who were just barely willing to obey. This leads to a cycle of regulation and deregulation, where

the managers lower enforcement after good behavior only to see bad behavior rise, causing them to raise enforcement only to later cut it again.

Figure 3.5 The left panel shows defection behavior in a low fixed state enforcement, variable religion enforcement, while the right shows defection behavior in a low fixed religion enforcement, variable state enforcement. Spikes occur from the cycle of regulation and deregulation.

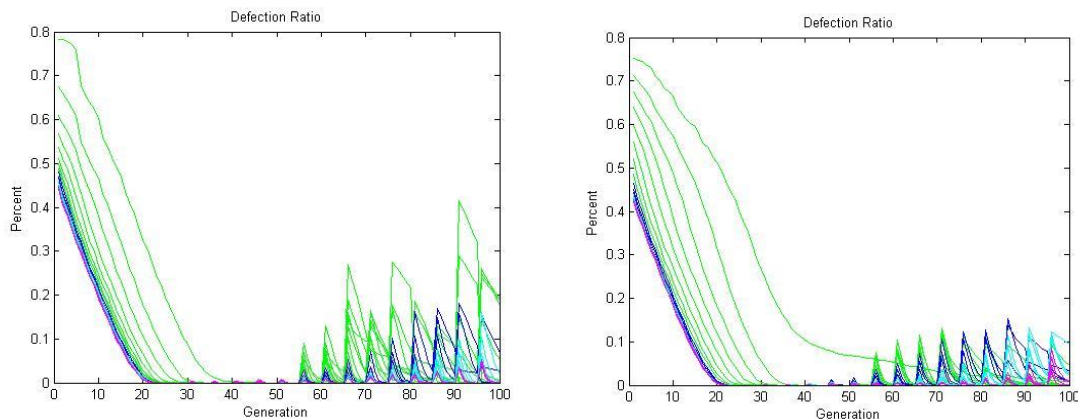
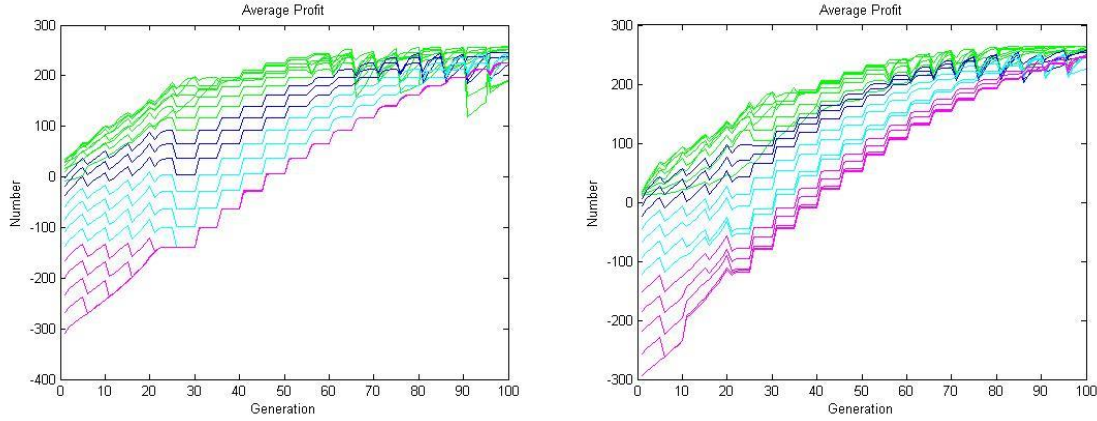


Figure 3.6 continues to demonstrate the success of the dual enforcement, as maximum profitability is achieved from any initial condition. In the previous simulation, if the bad guys replicated fast enough, the organization failed as defection became the optimal strategy. Two equilibria were possible: one where enforcement fell to zero (organizational failure), and one where enforcement remained positive relative to the population dynamics (organizational success in outpacing cheaters). In this simulation, dual enforcement was able to tame the population from any initialization, arriving at the same optimal level of enforcement, subject to slight noise from defection spikes in the deregulation cycle.

Figure 3.6 The left panel shows defection behavior in a low fixed state enforcement, variable religion enforcement, while the right shows defection behavior in a low fixed religion enforcement, variable state enforcement.

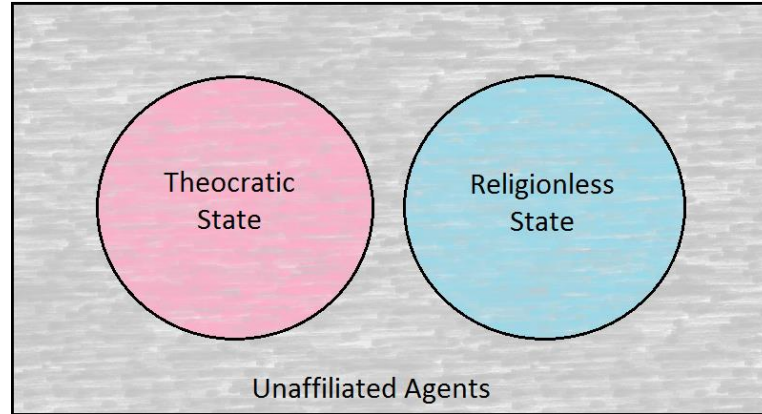


The model demonstrates the success of theocracy for managers, and offers insight on its widespread mode of governance in historical societies. Theocracy, in simple contexts, is cheaper. Nonetheless, state and religion are substantially less integrated in modern times than in the past. The literature offers some explanations. As talked about above, intellectual arguments for the separation of church and state can be seen as a technological change in this model, where the enforcement cost of θ rises significantly relative to φ , a trivial artifact of the model. Arguing for an increase in fiscal capacity relative to religious capacity implies production of religious versus secular goods, which we avoid here. Instead, we leverage the model to examine the performance of theocratic states versus secular states in response to changing conditions in the pool of agents.

The next simulation complicates the space by allowing for multiple governments with multiple agent types. The purpose is to see which type of organization performs better over time as conditions vary: a theocratic state with dual enforcement through θ and φ , or a religionless state capable only of enforcement through φ . These organizations exist in a sandbox of agents, as shown in *Figure 3.7*. An organization attempts to conquer nearby agents if they have excess capacity from operating profitably, even if those agents belong to another organization. Acquiring new agents faces two types of costs. A conquest cost α must be paid if the agent belongs to a different organization, with α diminished for

unaffiliated agents. A conversion cost β must be paid if the agent does not match the organization's religion, and if it does the theocratic state gains β . The religionless state operates neutrally to β .

Figure 3.7 The initialization involves agents existing in a space, some affiliated, some unaffiliated. The states then grow in the culture, where evolutionary forces select the more successful form.



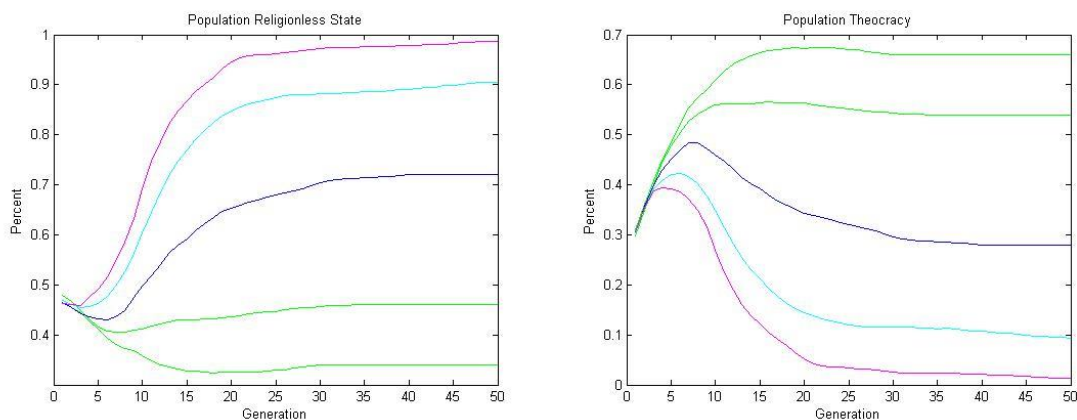
The conversion cost can be considered a transaction cost. The interpretation is that religions that are further apart require more effort in committing to a new infrastructure, while those that are similar still require a cost, but it is smaller. The first version of this simulation involves increasing the transaction cost between runs, in effect increasing the distance between the agents and the theocratic state's religion. Agents are heterogeneous in their affiliation with states and religion. For affiliation with states, agents randomly start unaffiliated, where they have no φ unless conquered, in which case φ is generated, or randomly start affiliated in the religionless state or in the theocracy. For affiliation with religion, agents randomly start as one of three religions, the first effectively being no religion with no θ . Agents in the other two religions draw from each religion's θ setting. If agents are acquired by the religionless state, they keep their religious affiliation; if acquired by the theocratic state, they must convert to its religion, costing β .

The simulation maintained the earlier parameters. Ten trials are run with the only changing parameter being β , the conversion cost increasing across trials. Five hundred heterogeneous agents are randomly generated along affiliation lines, play the game, and are ranked by fitness with a fuzzy 10%

haircut on the bottom and fuzzy 10% reproduction of the top, the same process as previously. The two types of states then collect their revenue, and if they earned a profit that generation, attempt to expand. They rank agents cheapest for them to acquire, and alternate moves updating their list as affiliations change, each turn paying the appropriate α and β costs, and continue as long as they have a surplus. Next they endogenously adjust their enforcement levels, and the next iteration begins.

Figure 3.8 displays the simulation results. The states quickly eat up agents who are unaffiliated, as these are cheapest to acquire. At low levels of β , the theocratic state outperforms the religionless state. The interpretation here is that religion is a very useful tool for the political authorities, who are capable of weaving their mythology into foreign religions, which then fortifies their claims to divinity and allows them to more cheaply enforce institutions. However, as religious distance increases, it becomes more difficult for the theocracy to convince new agents of the leaders' celestial backing. When the differential between religions is high, a theocracy fails, as forcing religious conversion on new agents becomes more expensive than the cost savings. The religionless state outperforms by avoiding conversion costs.

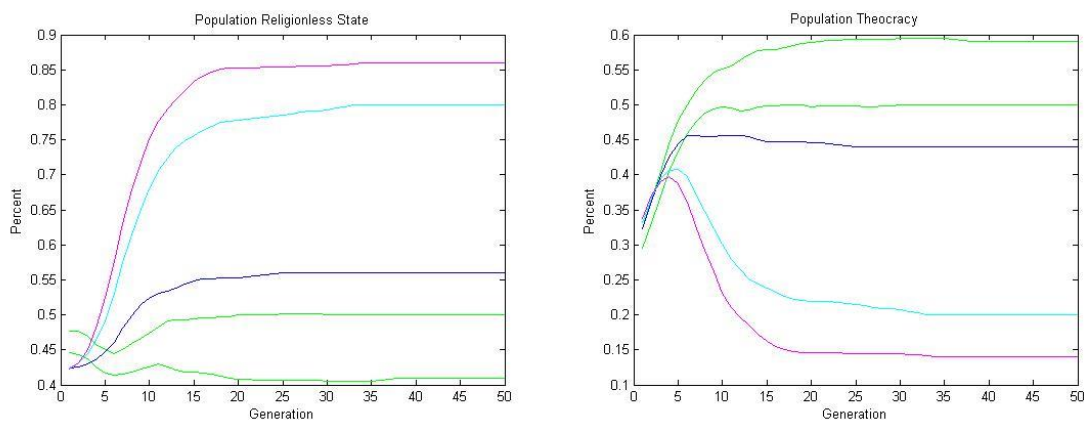
Figure 3.8 When transaction costs are low, a theocracy leverages the advantages discussed above. But as they increase, the religionless state outperforms.



The next simulation is an extension. Agent heterogeneity is augmented by increasing the number of religions for each trial. Ten trials are run with the only changing parameter being the number of religions agents can randomly begin as, the first type again being no religion. A linear sequential distance then represents the transaction costs between religions, with the theocratic state religion anchored at the

far corner. By increasing the number of religions, the probability that an agent does not match the state religion increases, resulting in conversion costs. *Figure 3.9* shows a similar dissolution of the theocracy's success, which monotonically declines as the number of religions increases. The states again consume unaffiliated agents first, then begin to exchange back and forth. At low religious diversity, the theocracy performs well, but the religionless state outperforms at higher numbers.

Figure 3.9 The number of religions increases between trials. When there are only a few religions, the theocracy outperforms a religionless state, but underperforms as the number of religions increases



The model demonstrates conditions where state and religion are most effective as dual organizing entities and when they fail. The model shows that changing agent characteristics can lead to changes in the effectiveness of a joint throne and altar system. In particular, transaction costs associated with the distances between religions in the space, as well as the number of religions agents can choose from, unwind the vertical integration of church and state from strictly an optimization perspective.

3.4 Empirics

The model stresses the importance of the state religion's distance from agents' religion to the success of a theocracy. As that distance increases, the success of the state religion declines. To test this, we used data from the "Historical Politics Data," (HPD) containing annual information on the territories occupied by today's nation states since the year 1000 (Cosgel, 2016). This information includes origin and religion of

political rulers, main and secondary religions of the population, and a dummy variable if political authorities supported a state religion. To identify significant religious groups in recent centuries, HDP used the estimates of population shares provided by Brown and James (2015), which in some cases goes back to 1700s. For earlier periods, HPD used historical sources to identify the main religion and to determine whether a significant second religion existed. In cases of conflicting information about a particular variable, HPD looked for consistency by giving priority to sources with comprehensive coverage, such as Encyclopedia Britannica, the “Country Studies” collection of the Library of Congress, and the book series “Cambridge Histories Online.” Rather than restrict the dataset to territories of certain size, duration, or type, HPD included all territories for which complete information was available.

To proxy for the transaction cost for conversion, we developed a metric based on the aerial distance between a religion’s founding location or relevant capital city, called TC . Accordingly, religions like Judaism and Christianity would be considered closer than either is to Hinduism, implying less transaction costs for agent conversion. The proxy captures much of the natural similarities we would intuit because of the effect proximity has on information diffusion. The closer the territories of different religions, the more they will overlap, influence one another, and share components, thus the closer will be their mythologies. This allows for less friction in converting agents since more elements of the narrative are consistent.

Finally, we tracked the number of regime changes or capacity collapses polities have had as we trace modern territories back through time to come up with a mean duration of stability, called L . This variable is intended to represent success or longevity of a nation. The nature of the model is evolutionary, indicating scenarios best suited for different types of polities over time. This longevity variable serves as the dependent variable, signaling the model’s prediction on conditions which lead to the success of nation types.

The regression combines these data with other sources on historical or geographic characteristics of a country. The dependent variable is the religious distance between the ruler’s religion and the population. In addition to key variables of interest, we included other variables in our baseline analysis to

control for their influence, such as standard geographical variables measuring the average precipitation, temperature, and elevation, and historical variables regarding the duration of settlement, timing of Neolithic transition, and presence of communist or colonial regimes. These controls are indicated by the vector X . We also included dummy variables to control for systematic differences between (UN) regions and recent centuries.

The regression takes the form

$$L_t = \beta_0 + \beta_1 TC_t + \beta_i X_{i,t} + u_t$$

and *Table 3.1*² shows the results of the baseline OLS analysis of influences on the longevity of states. The table includes several combinations of the key variables with control variables to check for the consistency of our results to alternative specifications. Not reported in the table for space constraints are the regional controls (dummy variables for the 22 UN regions), included in all equations to control for the well-known systematic regional differences in the development of states.

² I wish to acknowledge and thank Metin Cosgel for providing the data and results of this regression.

Table 3.1 Key result indicate the significance of the transaction cost variable, where an increase in the religious distance leads to a .5% decrease in the polity's longevity, with a goodness of fit around 14%.

VARIABLES	(1) Duration (mean)	(2) Duration (mean)	(3) Duration (mean)	(4) Duration (mean)	(5) Duration (mean)	(6) Duration (mean)	(7) Duration (mean)
Religious distance	-0.0550*** (0.00551)		-0.0746*** (0.0106)	-0.0589*** (0.0128)	-0.0536*** (0.0138)	-0.0451*** (0.0132)	-0.0500*** (0.0135)
Religious distance - Squared			4.15e-06** (1.94e-06)	1.45e-05*** (2.34e-06)	1.11e-05*** (2.80e-06)	9.43e-06*** (2.65e-06)	9.82e-06*** (2.85e-06)
Africa * Religious distance				-0.0646*** (0.0151)	-0.0620*** (0.0147)	-0.0650*** (0.0141)	-0.0618*** (0.0143)
Asia * Religious distance				-0.0203 (0.0125)	-0.00527 (0.0125)	-0.00769 (0.0123)	-0.00337 (0.0121)
Oceania * Religious distance				-0.133*** (0.0172)	-0.128*** (0.0202)	-0.117*** (0.0202)	-0.120*** (0.0201)
W_Hemisphere * Religious distance				-0.101*** (0.0135)	-0.0736*** (0.0142)	-0.0610*** (0.0150)	-0.0626*** (0.0152)
Africa	193.8*** (20.69)	171.7*** (19.13)	196.1*** (21.06)	223.0*** (28.36)	236.0*** (42.62)	74.95* (38.25)	132.3*** (49.27)
Asia	49.88*** (14.94)	43.73*** (14.32)	52.48*** (15.26)	36.94** (16.79)	64.41** (28.01)	19.61 (17.46)	60.73** (28.46)
W_Hemisphere	356.4*** (22.96)	331.8*** (23.02)	353.3*** (23.14)	385.9*** (26.80)	436.5*** (78.59)	317.9*** (33.28)	443.0*** (74.29)
Oceania	404.3*** (28.79)	364.8*** (28.74)	394.4*** (29.76)	461.0*** (39.72)	587.6*** (84.45)	465.2*** (81.84)	565.5*** (88.63)
Total land area					-3.74e-06* (2.03e-06)		-4.29e-06* (2.41e-06)
Percentage of arable land					-0.844 (0.735)		-0.304 (0.768)
Land suitability for agriculture					41.01 (46.23)		25.54 (52.80)
Mean elevation					3.229 (30.38)		-20.72 (32.56)
Temperature					-3.274** (1.382)		-3.573* (1.843)
Precipitation					0.703*** (0.198)		0.368* (0.213)
Migratory distance from East Africa					-7.720* (4.505)		-6.044 (4.552)
Terrain roughness					-94.85 (97.35)		1.612 (109.8)
Religious distance (log)		-22.30*** (2.337)					
Log [Neolithic transition timing (ancestry adjusted)]						-96.97*** (27.39)	-73.63** (37.22)
Years since settlement						7.583** (3.116)	8.114** (3.720)
Constant	151.0*** (8.582)	174.4*** (10.25)	154.8*** (8.994)	142.8*** (9.776)	179.9*** (34.45)	960.4*** (239.8)	800.6** (328.0)
Observations	1,568	1,568	1,568	1,568	1,197	1,124	1,111
R-squared	0.135	0.134	0.136	0.152	0.136	0.134	0.137
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1							

The results of the systematic empirical analysis over historical polities support the model with significance at the 99% level. This implies that as the transaction costs increase between agents and the state religion, the success of the polity declines, sowing conditions for the collapse of theocracy based on

agent compositional changes. The benefit through cheapened enforcement is offset by the frictions associated with religions further apart.

3.5 Discussion and Conclusion

Institutions constrain the behavior of individuals, but in doing so, they structure how individuals expect other people to behave (North, et al, 2009). Individuals are more likely to obey if they believe others will obey as well, and are willing to incur costs on themselves to achieve the gains from that coordination. Those costs echo the organization's managers' mechanism of enforcement. The common thought here returns to Weber: that the threat of violence through history has dominated how societies cooperate, and the boundaries of that credible threat in turn carve the boundaries of organizations. Enforcement shapes civilization.

But physical violence is only one form. Religions have secured more members and lasted longer than any state. And they have achieved this by wielding a different type of violence. Clerics hold a monopoly over the legitimate use of spiritual violence. In holding this monopoly, the clerics as managers achieve a form of credible coordination, oftentimes where contractual obligations do not require third party monitoring. An omniscient overseer, rewards or curses in an afterlife, guilt and morality: we can view these as cleverly constructed tools for enforcement of institutions.

While states and religions both generically serve as organizations, they manifest in unique ways, one leveraging the natural the other the supernatural. This has led to a type of alliance that has been the prevailing the design of societies throughout history. The story here is that states and religions merge because vertical integration allows the joint organization to select the lowest marginal cost of each form of enforcement. As the effect of policemen diminishes, managers increase the number of priests to convince agents not to break the rules. Third-party enforcement combined with an internalized system of enforcement achieves obedience more cheaply.

If theocracy is advantageous, why has this form of government diminished over time? Our account does not require a weakening of belief systems, implying a technological change in enforcement.

Religious fanatics can be as zealous as ever. Instead, the decline of theocracy comes from agent compositional changes. The transaction costs for converting members has risen as agents possess religious affiliations that are further apart, and more religions exist for agents to choose from, as societies have become more mixed over time. A state religion is useful in enforcement only if it can make credible threats, which requires the population to match its dogma. The costs associated with aligning agents can exceed the benefits of dual enforcement.

The model showed this with a simple prisoners' dilemma game representing the Hobbesian state of nature. Organizations that can make defection costly can achieve the socially optimal outcome. But this requires credible threats. The state dedicates resources to examining a certain number of transactions, punishing those it catches, and the religion dedicates resources to building a mythology, personally convincing agents not to break the rules. An agent-based simulation traced the behavior across a number of conditions. The state by itself faces a crisis of regulation and deregulation, while the religion itself can be invaded by sociopaths. But together, they performed substantially better. However, when competing against a religionless state, the theocracy only outperformed when conversion transaction costs were low, indicated by religious distance and number of religions. Regression analysis over a historical data set matched the model's predictions.

Modifying state theory created a narrative of cooperation based on enforcement. But the model can be extended to consider a number of other scenarios by adding in elements from the two sided markets literature, which focuses on platform compatibility and agent pricing. In the simple model here, compatibility was considered evolutionarily against other organizational forms, but this could be broadened to examine aspects of control. Nash bargaining over control rights for revenue when organizations combine would introduce a new dynamic into the model. It could also explore the strategy of mergers to create credible threats on current nonmembers (e.g., a religion may merge with a state to use the state's apparatus to enforce its institutions on nonmembers; hexing a person not of its religion motivates no behavioral change). Strategic compatibility could be extended even further to integrate features of coalition theory. Furthermore, asymmetric pricing could easily propose why different agents

faced different tax rates in historical societies (e.g., the Ottomans taxed Jews different than members of other religions). Focusing on interaction among agents and managers enhances classical models of political economy.

4 Uncertainty in Markets vs Firms

4.1 Introduction

The work of theories of the firm aims at explaining whether a transaction locates within or across firms and why. Firm boundaries are an economizing process balancing market transaction costs and internal governance costs. Ultimately, information and knowledge determine organizational design as they challenge both markets and firms (Holstrom and Roberts, 1998). Decision problems, unlike chess, are not deterministic; they involve decision making under uncertainty. Handling uncertainty becomes one of the most important factors in governance (March and Simon, 1958; Thompson, 1967; Pfeffer and Salancik, 1978).

Although theories of the firm are often an abstraction, the property rights approach gives a tangible measure of boundaries: a firm is the set of assets under common ownership (Grossman and Hart, 1986). Taking this definition seriously, we can measure firm size in different sectors through public company data and examine how those boundaries change overtime. Controlling for certain factors, the 30 year period since 1985 reveals that firm boundaries are correlated with the business cycle, where the visible hand of management shrinks during recessions. I argue that this is consistent with the IO literature through how markets and governance handle uncertainty.

From the Schumpeterian (1939) perspective, innovation and technology drive both economic growth and the business cycle. These changes move the economy from its equilibrium, initiating a process of adjustment. This adaption breeds uncertainty about how the future equilibrium will influence “new consumers’ goods, the new methods of production or transportation, the new markets, the new forms of industrial organization” (Schumpeter, 1939). Creative destruction is a disruptive force of economic change which markets and firms must discern with blurred vision.

Uncertainty associated with this adjustment process has two effects examined in this paper: to firm specific capabilities, and to the cost of the market mechanism. These firm and market side effects shape the limits of organizations, and are explored empirically using U.S. public corporation data from the SEC. I proxy for firm capabilities through the balance sheet line item goodwill, an intangible asset

capturing the value of a company's brand, customer base, employee relations, or patents and proprietary technology. I proxy for the cost of using the market mechanism by developing an index of the ratio between firm value and its ownership claims from acquisition data across several macro sectors. I regress these proxies on detrended, inflation adjusted sector averages of firm size. The time series regression analysis validates these stories of the theory of the firm.

4.2 Uncertainty

The multidimensionality of uncertainty has led economists to hold different views on its affects to organization. But a careful reading of their interpretations can lead to a consistent viewpoint. For Knight (1933), uncertainty occurs when there is “no valid basis of any kind for classifying instances.” As he claims that judgement is non contractible, uncertainty is the source of opportunity for the entrepreneur, and leads to a process of cephalization.

However, Knight is agnostic on the connection between judgment and uncertainty. He skips over the processing of uncertainty, which would give the entrepreneur the opportunity over the market. Penrose (1959), then, aligns with him on the role of imperfect information as a condition for firms, but elaborates on firm heterogeneity through this examination. For Penrose (1959), uncertainty is “the entrepreneur's confidence in his estimates or expectations.” She describes it as an important determinant in the growth of the firm, and that firm resources and capabilities affect its ability to handle uncertainty. Coping with uncertainty affects a firm's ability to plan, collect information, and execute. She argues that “when more resources become available, more information can be obtained, more uncertainty eliminated, and more expansion planned” (Penrose, 1959). Thus extending Knight through Penrose, firm size increases through its ability to reduce uncertainty.

Uncertainty in transaction cost economics creates a market failure, which increases transaction costs. Uncertainty, then, can be mitigated by moving the transaction into the firm. For Coase (1937), uncertainty results from challenges to a firm's ability to plan or forecast, and that it would be improbable for a firm to exist without it. To Williamson (1985), three major themes motivate the scope of the firm:

frequency, uncertainty, and asset specificity in transactions. He argues that internal governance increases in each.

There seems to be a distinction between the type of transactional uncertainty examined by Williamson and Coase, and the type of volatility uncertainty considered here. In fact, Williamson (1975) argues that in response to volatility, firms should avoid ownership as internal governance might be inappropriate after the new environmental shift. Similarly, Coase (1937) notes that “a firm ... emerge[s] in those cases where a very short-term contract would be unsatisfactory.” But recessions serve as precisely the time when short term contracts best buffer against the volatility of change. Forecasting becomes costly. Firms mitigate the uncertainty through short term contracts until they gain a better view of the landscape. Both capabilities and transaction cost economics become consistent in their approach to firm size and market uncertainty, in that unpredictability reduces internal governance.

4.3 Markets and Firms

Since Coase (1937) asked why can transactions be efficiently managed inside a firm, the literature blossomed with rich answers. The scope of this paper limits attention to only two, transaction cost economics and the capabilities theory of the firm, which are the subject of the empirical analysis below.

Coase’s (1937) answer to the existence and scope of the firm was related to the costs of transacting in the market. There is a cost to using the price mechanism, and when these costs are high enough, it becomes less costly to coordinate through commands of internal governance. These organizations can outperform the arm’s length transactions of the market.

We can examine the costs of using the market by considering the price firms are willing to pay for another company in an acquisition. Such a purchase implies that the acquirer chose neither to transact with the firm nor build the structure from scratch, both of which are market activities. This premium paid above the price of its physical assets instantiates the cost of using the price mechanism. When this ratio is high, firms are willing to pay a lot to acquire other firms because the transaction costs in the market are

high, as increasing the scope of internal organization is less expensive than using the market. And when the ratio is low, firms are more profitable with contract arrangements through the market.

This ratio, called in the paper the Q ratio, is similar to Tobin's Q in that it compares market and book values. But there are a few key differences. First is the derivation. Tobin's Q relies on market capitalization as a valuation of the firm against difficult to calculate replacement cost of its assets. Stock valuation of a company is a very different valuation than outright purchase, used here. Stock investors have different criteria in valuing slices of ownership, often making multiple trades in a day in a very volatile market. An acquisition for complete ownership by management seldom takes less than years to complete after extensive analysis of private information. Thus the price arrived at is different.

Furthermore, the intention of Tobin's Q aims at deciding internal or external investment. Instead, the ratio here proxies for the price mechanism through examining changes in the premiums on acquisitions. Lastly, the long run equilibrium market value of Tobin's Q must equal the replacement cost of its assets (Bharadwaj, et al, 1999). Such unity need not hold here. While Tobin's Q can be viewed as a type of intangible firm valuation, acquisition prices seem better suited to price firms, leading to the unique application for the ratio developed here as a transaction cost proxy.

In the capabilities theory of the firm, idiosyncratic and firm specific resources, knowledge, technology, and organization influence the growth and performance of the firm (Penrose, 1959; Barney, 1991; Mahoney and Pandian, 1992). Such capabilities can offer a sustained competitive advantage in growth and scope. We can proxy for this knowledge capital through goodwill, an intangible balance sheet asset recorded during an acquisition. Goodwill captures many of the firm specific skills the capabilities theory represents: organizational structure, customer relations, patents, technologies, production design, etc. Ultimately, changes in aggregated goodwill will reflect changes in the sector's capabilities.

The analysis, then, will focus on quantifying how changes in the proxy for the price mechanism through the Q Ratio and changes in the proxy for the capabilities of the firm through goodwill affect firm size across the examined period. These ultimately reflect the ability of the market and the firm to process uncertainty related to the environment. When it increases, transactions move to short terms contracts on

the market to buffer uncertainty, and when it decreases, management's ability to forecast and plan improves to locate transactions within the firm.

4.4 Data and Stylized Facts

Data on acquisitions and company financials was acquired through Reuter's Thomson One Banker database. The comprehensive reference links to SEC Edgar databases and others to include company balance sheet and profit and loss information, market value data, as well as merger and acquisition data for all public companies ranging back through 1985. The context of the data is appropriate because the many firms are not restricted to local markets, and the collection and verification by a regulatory agency ensures quality.

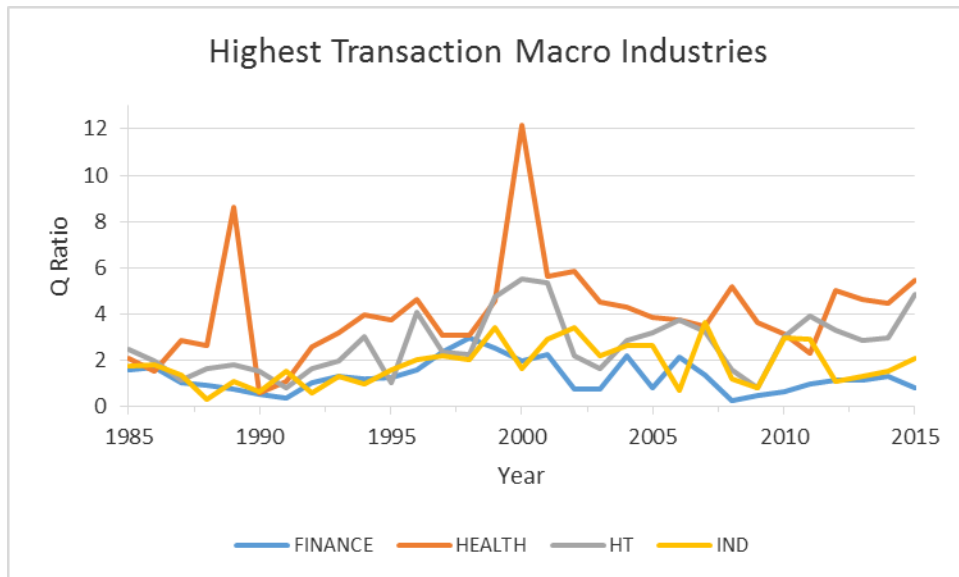
To construct the Q ratio, I compiled all public acquisitions since 1985 through 2015 in all macro industry groups in the USA, totaling over 10,000 observations for approximately \$8.3 trillion dollars' worth of transactions. *Table 4.1* (dollars in millions) details the data by macro industry. The average premium paid for a company acquisition over its book value was more than 100%, driven largely by Healthcare and High Tech industries. Alternatively, for financial companies, the premium was lowest at approximately 25%. As I argue this as a proxy for the cost of using the market, financial companies tend to have the most liquid assets, and thus should experience least transaction costs, while healthcare is one of the most patent heavy industries, implying high transaction costs for exchange.

Table 4.1

Macro Industry	Value of Transaction	Count	Q Ratio
CPS	\$ 269,588	710	2.96
ENERGY	1,151,482	759	2.10
FINANCE	1,549,023	2,362	1.24
GOVAGY	394	4	3.51
HEALTH	1,251,970	1,045	4.48
HT	955,177	1,925	2.98
IND	445,615	963	1.62
MATERLS	374,721	536	2.11
MEDIA	817,646	502	2.22
REALEST	254,587	248	2.03
RETAIL	171,428	345	1.90
STAPLES	280,311	381	2.36
TELECOM	752,127	417	2.08
Grand Total	\$ 8,274,067	10,197	2.06

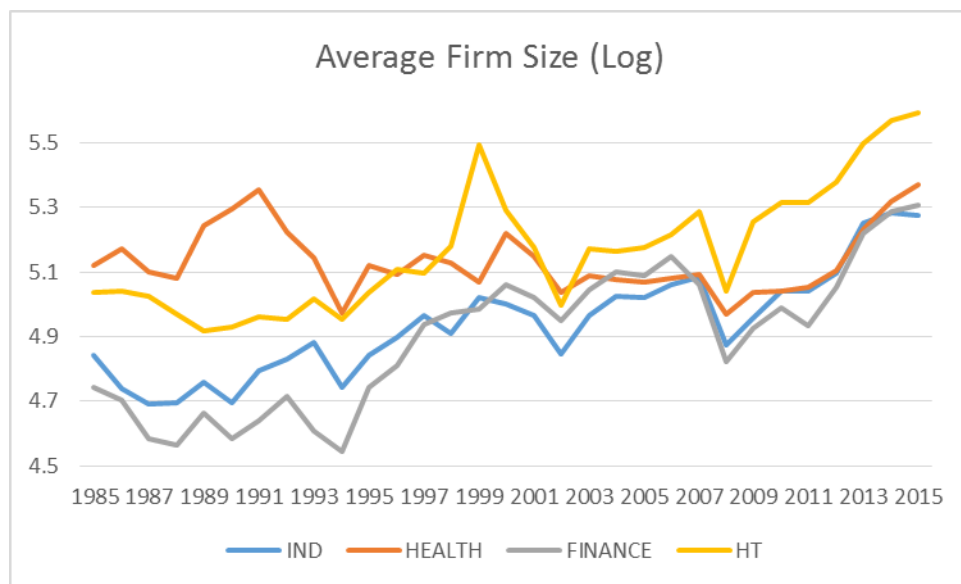
Figure 4.1 graphs the Q ratio for the industries with the most transactions, which will form the major units of analyses for this paper. The curves trace the business cycle as they crash in recessions, implying the market becomes the reliable means of coordination during the downturns of the business cycle, to be commented on further in the discussion section. Healthcare tends to be extremely volatile, where in 2000, 61 acquisitions averaged a premium of approximately 12 times asset book values.

Figure 4.1



Public company data was also pulled through the Thomson One Banker database for each of the macro industries. The criteria was for all domestic material companies with over \$100 thousand in assets starting in 1985, with that threshold adjusted for inflation each year. Over 75 thousand observations were obtained across the 30 year period across all sectors examined. *Figure 4.2* shows the logarithm of the average firm size based on market capitalization of all firms over \$100K in assets each year (adjusted for inflation).

Figure 4.2



4.5 Model and Results

There is a connection between the market proxy, capabilities proxy, and firm size through uncertainty. I argue that the market and firm are substitute methods of processing uncertainty, which when driven by the Schumpeterian business cycle, shifts the boundaries of the firm. For these variables, I obtained firm sizes by averaging total market capitalization of all material firms, deflating with PPI numbers, then taking the logarithm to remove exponential trends and stabilize the variance. The same was done for the balance sheet items for intangible assets, and the market cost was determined by the Q ratio discussed above for each sector. Note that only the top sectors based on number of acquisitions were examined due to sample size shortages.

However, as these data are time series, the dependent variable is highly correlated with the dependent variable from the previous period. The issue is that this often implies serial correlation among the errors. The Box-Ljung test demonstrates autoregression of the data with significance for one lag, and the Durbin-Watson statistic indicates correlation among errors. Arguing for weak dependence would be spurious.

Transforming the regression provides a solution. Examining the effect of the first difference with the same tests reveals that the residuals become uncorrelated and not statistically different than zero. Therefore, the process appears integrated of order one, where after the first difference, the series does indeed become weakly dependent. Furthermore, the series is stationary as no trend exists, validated by the constant term being not statistically significant and its confidence interval running through zero. Assuming linearity, then, and with weak dependence, no perfect collinearity, zero conditional mean, absence of homoscedasticity, OLS is BLUE and the usual standard error metrics are asymptotically valid (Granger and Newbold, 1974).

The dependent variable in the regression becomes a measure of the first difference in average firm size per sector per year, while the independent variables are the transformed Q ratio and average intangibles assets per sector per year, or

$$Firm\ Size = \beta_0 + \beta_1 Intang + \beta_2 Ratio + u$$

Endogeneity between the independent and dependent variable is inappropriate: firm size is based off year end values, while intangible asset numbers and the ratio run throughout the year, thus the arrow of time protects against reverse causality. Measurement error should be mitigated by the fact that the data are audited numbers. Confounding variables pose potential problems, however, the analysis is trying to explain part of the variation in firm size with these variables holding strong in variations on the form of the regression.

The regression results determine that the independent variables are both significant at the 1% level and positive, as shown in *Table 4.2*. This confirms the hypothesis that as the market cost proxy increases, firm size increases, as transaction cost economics would suggest. Similarly, as average

intangibles increase, signaling increased capabilities, firm size again increases. The R^2 is strong explaining approximately a quarter of the variation.

Table 4.2 Regression results demonstrate significance at the 1% level for the independent variables.

Dependent Variable: Firm Size							
6 Largest Sectors				4 Largest Sectors			
	Coeff	95% Conf Interval			Coeff	95% Conf Interval	
Intang	0.0627*** (0.0051)	0.0099	0.0303	Intang	0.0559*** (0.0057)	0.0336	0.0781
Ratio	0.0201*** (0.0098)	0.0432	0.0822	Ratio	0.0166*** (0.0112)	0.0053	0.0279
Constant	0.0007 (.0079)	-0.0148	0.0162	Constant	0.0037 (.0097)	-0.0156	0.0229
No of obs	176			No of obs	116		
Adj R^2	0.25			Adj R^2	0.22		

4.6 Discussion and Conclusion

The results show the effect of the cost of the price mechanism and capabilities on firm size. I argue that these results are driven by a Schumpeterian version of economic change in that downturns in the business cycle reduce both the costs of using the market and the value of an organization's capabilities because of the change in processing uncertainty.

Schumpeter's (1939) view of the business cycle is one driven by the entrepreneur, that the cyclical nature reflects an adjustment to innovation. These changes cause a number of effects, including increasing the amount of uncertainty in the economic environment through new production methods, technological adoption, and price changes. Management faces a trade off in their capabilities and the level of uncertainty (Penrose, 1959). As their ability to process information and plan diminishes, capabilities are diminished as well. This in turn reduces firm size. Management copes with uncertainty by reducing the risk of ownership through short term contracts.

Furthermore, the Schumpeterian cycle leads to changes in "combinations of the factors of production," be it new technologies or materials or organization (Schumpeter, 1939). This affects the

value of the capabilities that firm's efforts have developed. Smith's (1776) view of the firm was of a manufacturer's efficiency associated with a more intense division of labor. Essentially, different firms have different costs for the same productive activity (Richardson, 1972). These capabilities reflect the knowledge base of the firm connected to its specialization, specific to a certain environment. As the economic environment changes to render obsolete the competitive advantage of their firm specific knowledge and skills, or causes their methods to become dissimilar or less productive, the value of capabilities dilutes. The firm shrinks until it replaces the assemblage with new knowledge, reflecting the trend seen in the changes to firm size.

Recessions are generally associated with intensified competition between firms (Bloom, 2014). This, combined with firms attempting to mitigate uncertainty through short term contracts, leads to a lower cost of the price mechanism. Planning cannot transform rapid changes in the particular time and place that take place in the adjustment phase (Hayek, 1945). Uncertainty through volatility, then, pushes transactions onto the marketplace.

The architecture of the economic system rests on substituting organization between markets and the firm. This, in turn, rests on the ability of each to process information and knowledge. The economic system is volatile, where innovation and change can reposition the equilibrium to an uncertain location. The "islands of conscious power" can outperform the market through unique capabilities in processing uncertainty with accurate plans and forecasts (Robertson, 1923). When forecasting is interrupted, the "unconscious cooperation" deals better with the dispersed and changing knowledge through market contracts (Robertson, 1923). Downward trends in the business cycle maximize such uncertainty.

5 Works Cited

- Alchian, A. (1950). 'Uncertainty, evolution and economic theory', *Journal of Political Economy* 58 (3): 211-221.
- Alchian, A., Demsetz, H. (1972). 'Production, information costs, and economic organization.' *American Economic Review* 62(5): 777-795.
- Ashby, W.R. (1960). *Design for a Brain: The Origin of Adaptive Behaviour*. Second Edition, John Wiley and Sons: New York, NY
- Auerswald, P. (2008). 'Entrepreneurship in the theory of the firm,' *Small Business Economics* 30, 111-126.
- Auerswald, P., Kauffman, S., Lobo, J., Shell, K. (2000). 'The production recipes approach to modeling technological innovation: an application to learning by doing.' *Journal of Economic Dynamics & Control* 24 (3), 389-450.
- Barney, J. B. (1991). 'Firm resources and sustained competitive advantage.' *Journal of Management*, 17, 1, 99-120.
- Barro, R.J. and R.M. McCleary (2005). 'Which countries have state religions?' *The Quarterly Journal of Economics*, 120(4): 1331-1370.
- Bharadwaj, A.S., Bharadwaj, S.G., and Konsynski, B.R. (1999). 'Information technology effects on firm performance as measured by Tobin's q.' *Management Science* (45:7): 1008-1024.
- Bloom, N. (2014). 'Fluctuations in uncertainty.' *Journal of Economic Perspectives* 28(2): 153-76.
- Boiset, M. and Sanchez, R. (2010). 'Organization as a nexus of rules: emergence in the evolution of systems and exchange.' *Management Revue: The International Review of Management Studies*, 21(4): 378-405.
- Brusoni S., Marengo L., Prencipe A., Valente, M. (2007). 'The value and costs of modularity: A problem-solving perspective.' *European Management Review*. 4, 121-132.
- Caminati, M. (2006). 'Knowledge growth, complexity and the returns to R&D.' *Journal of Evolutionary Economics* 16, 207-229.

- Chandler, A. (1977). *The Visible Hand*. Cambridge, MA; Belknap Press.
- Coase, R. (1937). 'The nature of the firm', *Economica*, 4(16): 386–405.
- Cosgel, M. and T. Miceli (2009). 'State and religion.' *Journal of Comparative Economics* 37(3), 402–416.
- Cosgel, M. (2016). 'Historical polities data.' University of Connecticut Working paper.
- Diderot, D (1992). *Diderot: Political Writings*. Translated by JH Mason and R Wokler. Cambridge, England: Cambridge University Press.
- Ethiraj, S.K., Levinthal, D. (2004). 'Modularity and innovation in complex systems.' *Management Science* 50,159-173.
- Ethiraj, S.K., Levinthal, D., Roy, R.R. (2008). 'The dual role of modularity: Innovation and imitation.' *Management Science*, 54(5): 939-955.
- Fagiolo, G., Marengo, L., Valente, M. (2005). 'Population learning in a model with random payoff landscapes and endogenous networks,' *Computational Economics* 24(4), 383-408.
- Finke, R. and L.R. Iannaccone (1993). 'Supply-side explanations for religious change,' *The Annals of the American Academy of Political and Social Sciences*, May, 27-39.
- Finke, R. and R. Stark (1992). *The Churching of America 1776-1990*. New Brunswick NJ, Rutgers University Press.
- Foss, N. (1996). 'Capabilities and the theory of the firm.' DRUID Working Paper, No. 96-8. Copenhagen: Danish Research Unit for Industrial Dynamics.
- Frenken, K. (2006). *Innovation, Evolution and Complexity Theory*. Edward Elgar, Northampton.
- Ganco, M., Hoetker, G. (2009). 'NK modeling methodology in the strategy literature: Bounded search on a rugged landscape,' in Donald D. Bergh, David J. Ketchen (ed.) *Research Methodology in Strategy and Management (Research Methodology in Strategy and Management, Volume 5)* Emerald Group Publishing Limited, pp.237 – 268.
- Gavetti, G., Levinthal, D.A., Rivkin, J.W. (2005). 'Strategy-making in novel and complexity: The power of analogy.' *Strategic Management Journal* 26, 691-712.

- Glassman, R. (1973). 'Persistence and loose coupling in living systems.' *Behavioral Science*, 18(2): 83-92.
- Granger, Clive and P. Newbold (1974). 'Spurious regressions in econometrics.' *Journal of Econometrics*, 1974, vol. 2, issue 2, pages 111-120.
- Gregory, B.S. (2012). *The Unintended Reformation*. Belknap Press of Harvard University Press, Cambridge MA.
- Greif, A. (2006). *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade*. Cambridge, England: Cambridge University Press.
- Grossman, S.J., and Hart, O.D. (1986). 'The costs and benefits of ownership: a theory of vertical integration,' *Journal of Political Economy*, 94: 691-719.
- Hayek, F. (1945). 'The use of knowledge in society.' *American Economic Review*, 35(4): 519-30.
- Hobbes, T. and Gaskin, J.C.A. (1998). *Leviathan*. Oxford: Oxford University Press.
- Hodgson, G.M. and Knudsen, T. (2010). 'Generative replication and the evolution of complexity' *Journal of Economic Behavior and Organization*, 75(1): 12-24.
- Holstrom, B. and J. Roberts (1998). 'The boundaries of the firm revisited.' *The Journal of Economic Perspectives*, 12(4): 73-94.c
- Iannaccone, L.R. (1991). 'The consequences of religious market structures: Adam Smith and the economics of religion.' *Rationality and Society*, III, April, 156-177.
- Johnson, ND and M Koyama (2013). 'Legal Centralization and the Birth of the Secular State.' *Journal of Comparative Economics*, Elsevier, vol. 41(4), pages 959-978.
- Kauffman, S., Lobo, J., Macready, W.G. (2000). 'Optimal search on a technology landscape.' *Journal of Economic Behavior & Organization* 43 (2), 141-166.
- Kauffman, S.A., (1993). *The Origins of Order. Self-organization and Selection in Evolution*. Oxford University Press, New York & Oxford.
- Kauffman, S.A., Macready, W.J. (1995). 'Technological evolution and adaptive organizations.' *Complexity* 1, 26-43.

- Knight, F. (1933). *Risk, Uncertainty, and Profit*. New York: Houghton Mifflin.
- Langlois, R.N. (1988). 'Economic change and the boundaries of the firm.' *Journal of Institutional and Theoretical Economics* 144(4): 635-657.
- Langlois, R.N. (1992). 'Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries.' *Research Policy* 21(4): 297-313.
- Langlois, R.N. (2003). 'The vanishing hand: the changing dynamics of industrial capitalism.' *Industrial and Corporate Change* 12(2): 351-385.
- Levinthal, D.A. (1997). 'Adaptation on rugged landscapes.' *Management Science* 43 (7), 934-950.
- Levinthal, D.A., Warglien, M. (1999). 'Landscape design: designing for local action in complex worlds.' *Organization Science* 10 (3), 342-357.
- MacCulloch, D. (2003). *Reformation, Europe's House Divided 1490-1700*. Allen Lane, London.
- Mahoney, J. T. and J. R. Pandian (1992). 'The resource-based view within the conversation of strategic management.' *Strategic Management Journal*, 13, 363-380.
- March, J. and H. Simon (1958): *Organizations*. New York: Wiley.
- Marengo, L., Dosi, G. (2005). 'Division of labor, organizational coordination and market mechanisms in collective problem-solving.' *Journal of Economic Behavior & Organization*, 58 (2), 303-326.
- McGuire, MC and M Olson (1996). 'The economics of autocracy and majority rule: The invisible hand and the use of force,' *Journal of Economic Literature*, Vol. 34, March, 72-96.
- Miceli, T. and A. Minkler (2004). 'Lying, integrity, and cooperation.' *Review of Social Economy*, 62(1).
- Nelson, R. and S. Winter (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.
- North, D. & J. Wallis & B. Weingast (2009). *Violence and Social Orders: A Conceptual Framework for Interpreting Recorded Human History*. Cambridge, England: Cambridge University Press.
- Penrose, Edith T. (1959). *The Theory of the Growth of the Firm*. Oxford: Oxford University Press.
- Pfeffer, J. and G. Salancik. (1978): *The External Control of Organizations*. New York: Harper & Row.
- Putterman, L. (1996). *The Economic Nature of the Firm*. Cambridge: Cambridge University Press.

- Press, K., (2007). 'Divide and conquer? The role of governance for the adaptability of Industrial Districts.' *Advances in Complex Systems* 10, 73-92.
- Richardson, George B. (1972): 'The organisation of industry.' *Economic Journal* 82: 883-896.c
- Rivkin, J.W. (2000). 'Imitation of complex strategies.' *Management Science* 46 (6), 824-844
- Rivkin, J.W. (2001). 'Reproducing knowledge: Replication without imitation at moderate complexity.' *Organization Science* 12 (3), 274-293.
- Rivkin, J.W., Siggelkow, N. (2006). 'Organizing to strategize in the face of interdependencies: Preventing premature lock-in.' *Long Range Planning* 39, 591-614.
- Robertson, D.H. (1923). *Control of Industry*. London: Nisbet and Co.
- Schumpeter, J.A. (1934). *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.
- Schumpeter, J.A. (1934). *Capitalism, Socialism, and Democracy*. Cambridge, MA; Harvard University Press.
- Schumpeter, J.A. (1935). 'The analysis of economic change.' *The Review of Economics and Statistics* 17(4): 2-10.
- Schumpeter, J.A. (1939). *Business cycles: a theoretical, historical, and statistical analysis of the capitalist process*. Mansfield Centre, Connecticut: Martino Pub
- Simon, H.A. (1962). 'The architecture of complexity', *Proceedings of the American Philosophical Society*, 106: 467-482.
- Simon, H.A., (2002). 'Near decomposability and the speed of evolution.' *Industrial and Corporate Change* 11(3), 587-599.
- Skarbek, D (2014). *The Social Order of the Underworld: How Prison Gangs Govern the American Penal System*. Oxford, England: Oxford University Press.
- Smith, A. (1976 [1776]). *An Enquiry into the Nature and Causes of the Wealth of Nations*. Glasgow and Clarendon Press: Oxford.

- Solow, D., Vairaktarakis, G., Piderit, S.K., Tsai, M. (2002). 'Managerial insights into the effects of interactions on replacing members of a team.' *Management Science* 48(8), 1060-1073.
- Strumsky, D., Lobo, J. (2003). 'If it isn't broken, don't fix it: Extremal search on a technology landscape,' Santa Fe Institute Working Paper 03-02-003.
- Thompson, J. (1967). *Organizations in Action*. New York: McGraw-Hill
- Tilly, C. (1985). 'War making and state making as organized crime.' In *Bringing the State Back in*. 169-187. Cambridge, England: Cambridge University Press.
- Veblen, T.B. (1898). 'Why is economics not an evolutionary science?' *Quarterly Journal of Economics*, 12(3): 373– 97.
- Weber, M. (2015). *Rationalism and Modern Society*. Translated and edited by T Waters and D Waters. Palgrave Books.
- Weick, K.E. (1979), *The Social Psychology of Organizing*, Reading, MA: Addison-Wesley.
- Weinberger, E. (1996), 'NP-completeness of Kauffman's NK model, a tuneably rugged fitness landscape.' Santa Fe Institute Working Paper, 96-02-003.
- Williamson, O.E. (1975), *Markets and Hierarchies*, New York: Free Press.
- Williamson, O. E. (1985): *The Economic Institutions of Capitalism*. New York: Free Press.
- Wintrobe, R. (1998). *The Political Economy of Dictatorship*. Cambridge, England: Cambridge University Press.
- Zagorin, P. (2003). *How the Idea of Religious Toleration Came to the West*. Princeton University Press, Princeton, New Jersey.