ABSTRACT

Title of Dissertation:	HISTORICAL EXPLANATION IN STRATEGY RESEARCH: LEARNING BY SCALING IN THE EARLY AMERICAN AUTOMOBILE INDUSTRY
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This dissertation uses the historical explanation to engage in an abductive study of the early American automobile industry (1895-1918). The dissertation suggests that historical explanation is a valuable complement to abductive research. Historical explanation increases the number of hypotheses considered through the temporal perspective it offers and through contextualization. Historical explanation also adjudicates between likely hypotheses to determine the loveliest explanation by evaluating explanatory coherence and consilience. Further, the practical use of the historical explanation is demonstrated by analyzing the challenges that firms faced while attempting to scale manufacturing during the early American automobile industry (1895-1918). The analysis identifies metalworking knowledge as a specific pre-entry capability that mattered and demonstrates that process innovation is critical from a very early industry stage. Thus, this dissertation enhances strategy literature's understanding of why and how scholars should engage with historical explanation.

HISTORICAL EXPLANATION IN STRATEGY RESEARCH: LEARNING BY SCALING IN THE EARLY AMERICAN AUTOMOBILE INDUSTRY

by

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2019

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Dedication

The completion of this dissertation has been the outcome of the sacrifices of many. I want to thank:

- My beloved Amma for inspiring, encouraging and supporting me through her infinite compassion, wisdom, and unconditional love
- My parents, Devan and Indu, who dedicated their entire lives and sacrificed much for the education and well-being of my sister and myself
- My amazing wife, Devika, who always stood by my side, whose emotional support and love gave me the confidence, and whose radiant personality has been the great gift that made this journey joyous
- My lovely sister, Sanjana, whose energy and passion has been the bedrock of our family's joy
- My confidants, Br. Dayamrita Chaitanya and Br. Ramanand, for being the best friends that anyone could ever ask for
- My committee members Rajshree Agarwal, Serguey Braguinsky and David Sicilia for their support and guidance
- My cohort mates Liyue, Hyeun, and Seojin for always being there for me
- My in-laws, Rajendran, Ambika, and Ashwin, for their blessings and prayers
- My mentor, Padma R. Sahib, for her guidance & for assuming the role of my elder sister

and last but not the least,

- My advisors Brent Goldfarb and David Kirsch who patiently supported me through my academic and personal struggles, who gave me the freedom to pursue my ideas, who lifted my spirits on the bad days and pacified my excitement on the good days, who made themselves available to me day and night, and whose friendship I will cherish.

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Chapter 1: Introduction

I argue that historical explanation is a necessary component of abductive research in Strategic Management and use it to engage in an abductive study that explores why some firms are more successful than others during the early stages of the American automobile industry. The historical explanation is necessary because, abductive studies involve comparisons between multiple plausible explanatory hypotheses, and the research methods that Strategy scholars typically use - statistical, qualitative, and experimental - are ill-equipped to compare and identify the best explanation. Using the historical explanation, I argue that, in the early American automobile industry, heterogeneity in the ability to scale manufacturing was the best explanation for differences in firm outcomes and that firms with founding team members who had prior manufacturing experience were the ones that scaled production.

Abductive research involves the observation of an anomaly, the subsequent usage of data to determine plausible hypotheses that may explain the anomaly, and eventually, inferring to the best explanation from the competing hypotheses. I argue that the historical explanation contributes to abductive research by raising the probability that the best explanation is close to the true explanation by increasing the set of hypotheses considered. The wider view that emerges from the temporal perspective and contextualization practiced by historians increases the ability of the historical explanation to discover plausible explanations. The historical explanation also contributes to abductive research by enabling systematic comparative determination of the best – or *loveliest* – explanation among *likely* competing explanations. Historical explanation allows scholars to evaluate how consiliant a hypothesis is with additional contextual details, how coherent a hypothesis is with similar phenomena from different contexts, and whether deeper levels of proposed mechanisms can be explained.

Ensuring the accuracy of the veridicality of testimony requires this to be an abductive study because the research question was conceived from an observed puzzle: American automobile manufacturers were failing during the early stages of the industry even when there was demand for their products. An in-depth reading of the history of the automobile industry revealed that the uncertainties of the early stage must be considered to understand the heterogeneity in firm outcomes and that leaning on history was critical to determine the best explanation for the observed puzzle.

The American automobile industry is an excellent context to study the complexities of early stages for other reasons as well. The industry has been in existence long enough for there to be an agreement on when the various stages of the industry occurred. From a scholarly perspective, there is a substantial understanding of when the industry began and when the initial period of uncertainty ended.

Similarly, the industry has been so important for the American economy that industry records are well-preserved. Many institutions such as the Detroit Public Library, The Benson Ford Research Centre, the Bentley Automotive Collection, etc. have systematically preserved industry records making archival research practical. Moreover, many early entrants in the industry survived long enough to leave documentary records thereby making documentary access easier. The industry is unique in its ability to provide the finer details about the early stages needed to understand the intricacies of this stage at the most fundamental level.

The automobile industry has previously elicited considerable interest from management scholars. In a series of studies, Klepper investigated the competitive advantage that spinoffs and early entrants held, and how spinoff formation arising from strategic disagreements was a core driver of the industry's agglomeration in Detroit (Klepper and Simmons, 1997; Klepper 2002; Klepper, 2007; Klepper, 2009; Klepper, 2015). A series of

papers co-authored by Carroll investigated the performance advantages that diversifying entrants and startups who spend time acquiring sufficient resources before entry had (Carroll et al., 1996), the interaction between organization's technological niches and level of concentration among firms in the market (Dobrev et al., 2002), the effect of age, size, and competition on mortality rates (Hannan et al., 1998; Dobrev et al., 2003), and the challenges of organizational inertia (Dobrev et al., 2003). In another series of papers on the industry, Argyres and co-authors investigated the impact of increasing modularity on a firm's vertical integration choices (Argyres and Bigelow, 2010), the role of knowledge inheritance in integrating value chain activities (Argyres and Mostafa, 2016), the role of pre-entry experience in influencing make or buy decisions (Bigelow and Argyres, 2008) and the role of innovations shocks in strategic repositioning of firms (Argyres et al., 2015).

Even though the automobile industry has been the context for many studies that have had a tremendous impact in the field of Strategic Management, I suggest that prior studies have fallen short on two key aspects. These studies mostly utilized the industry as a source of statistical data and have failed to capture the contextual richness that documentary evidence from the industry offers. Statistical analysis is often limited in capturing the underlying mechanisms that are operating and in appreciating the significance of actors and actions relative to their contexts. In Chapter 2, I argue that utilizing the tools offered by the historical explanation - in the way historians use it - will enable Strategy scholars to explore further mechanisms underlying the outcomes in this historically significant industry. I suggest that the historical explanation is essential not merely because the focal context is over hundred years old. Historical explanation is also necessary because it is better suited to generate competing hypotheses, to evaluate these competing hypotheses, and to infer to the best explanation in an abductive study.

Similarly, prior studies of the automobile industry have underplayed the significance of mechanisms that are relevant during the uncertain early stages of the industry. Focusing on the early stages of the industry, and using the tools offered by the historical explanation to engage with this period, reveals valuable insights into the challenges entrepreneurs faced under extreme uncertainty. In Chapter 3, I use the historical explanation to explore the difficulties associated with scaling in the early American automobile industry. Thus, this dissertation builds on the theoretical findings of prior scholars who have studied the automobile industry to offer a granular understanding of the mechanisms operating during the early industry stages.

The historical explanation was necessary to study the early automobile industry because the variety of underlying mechanisms that firms employed to overcome the uncertainty of this stage cannot be systematically considered through other modes of analysis. The automobile was the most technologically advanced product at the time. Unlike its predecessor technologies like carriages, bicycles, and railway cars, automobiles contained non-modular parts, particularly the engine and the connected transmission system, that were highly interdependent and had to work in tandem for the technology to function. Due to market, technical, and production complexities associated with the newly commercialized automobile technology, uncertainty prevailed during the early stages of the industry resulting in the entry, exit, and growth patterns that correspond to the predictions of the industry evolution literature (Gort & Klepper, 1982; Klepper, 1996). From the birth of the U.S. industry in 1895, the industry witnessed a steady rise with the number of active firms peaking in 1909 with 272 firms, followed by a steady decline in the number of firms operating with an exit rate of over 10% (See Klepper, 2007 for detailed industry patterns).

From the customer's perspective, the concept of a self-propelled vehicle was beyond the imagination or understanding of many. The only aspect of an automobile that was obvious

to a customer from its earlier designs was that it was a horseless carriage. Indeed, during the earlier days, what the purpose of an automobile was, what it should look like, what fuel it should consume, what it's price should be, etc. were all unresolved. Customers did not necessarily understand the technical aspects of an automobile and there were no established standards at the time for the customers to refer to. The variation among car models also indicated that the engineers designing the cars, the experts who had in-depth knowledge of the product, had not reached an agreement on what is a good design and what isn't. Moreover, the purchase of an automobile was a very hefty investment that an average person had to make after careful consideration in the early days. Car prices ranged from under $500 to over $4000. For example, a Ford Model T cost $850 in 1908 while the median household income was approximately $520/year. The fact that the development of the automobile industry came at the heels of the implosion of the bicycle industry towards the end of the 1890s often resulted in the product being looked upon as a fad (Herlihy, 2004). The high exit rate of car companies also did not serve to provide customers the confidence to invest in an automobile either.

Historical exploration of the early automobile industry revealed that many firms suffered because they engaged in the resolution of product uncertainty at the expense of a focus on process uncertainty. Many failed firms attempted to launch a product, learn from customers about their preferences, resolve technical and demand uncertainties, and, only then, focus on the process of manufacturing. This failed strategy is consistent with the product lifecycle literature (Abernathy and Utterback, 1978; Suarez and Utterback, 1995) which suggests that an increase in product innovation rate precedes an increase in process innovation rate. For example, Klepper (1996) suggests that firms initially engaged in product R&D, increased their size, and subsequently invested in process R&D. Historical exploration revealed that this Strategy process innovation was also necessary for the firms to increase in

size. That is, unlike product life cycle literature predictions, in this setting, product and process innovation needed to happen simultaneously; they depended on each other.

Exclusive focus on the resolution of product uncertainty in the early stages often resulted in the firm failing before it had an opportunity to focus on process innovation. In the early automobile industry, production capability was critical because the inability to deliver products on time caused major cash flow issues for the firms. When delivery deadlines were missed, firms were often unable to make outstanding payments to suppliers because the firms received full payment from the customer only at the time of product delivery. Because the automobile was a summer product during the early stages, production delays resulted in firms missing out on the entire season. Moreover, a lack of focus on manufacturing often resulted in quality problems with the products that the firms managed to deliver. Inability to master the manufacturing process often meant that the firm did not survive long enough to implement the technical/customer lessons that firms learned by engaging with the market (Pillai et al., 2019).

I argue that successful firms recognized the interdependencies between product and process innovation from the very beginning. They understood that the automobile not only posed a technical problem but also posed a manufacturing problem. They realized that scale production of automobiles was a difficult process. Further, I suggest that, because the automobile was predominantly a metallic product, only firms with founding team members who had metallic product manufacturing experience were able to recognize that survival did not merely depend on the product-market fit; instead management of the product-market-production fit was critical for survival. Their early focus on production not only improved the efficiency of their existing manufacturing processes, but it also resulted in the introduction of new processes that made manufacturing easier. Moreover, the ability to produce

automobiles resulted in prompt deliveries and customer usage. This enabled the firms to learn valuable lessons on shopper preferences and product usage that they could not have learned otherwise. As a result, manufacturing improvement permitted design changes that made the firms more competitive. Thus, successful firms learned about the interdependencies between product, production processes, and customer expectations.

The historical explanation was necessary to eliminate *likely* alternate hypotheses because the observable statistical data is unable to distinguish between other plausible explanations. An in-depth reading of the history of early firms revealed that even firms whose products were widely regarded to be high quality suffered when they lacked manufacturing capabilities. Similarly, failures were not merely an outcome of poor product-market fit; instead archival records revealed that the firms had difficulties delivering the orders for which they received advances. The historical explanation was also revealed that initial access to capital was often not a limitation for firms with working prototypes because of advance payments from consumers and a high level on interest in the industry from investors, whom the firms accessed as auto shows. Subsequent capital requirements of the firms were often an outcome of re-invested profits that were dependent on manufacturing. Thus, historical explanation provides the granular details needed to engage in a comparative assessment of plausible explanations to determine the *loveliest* explanation.

The rest of the dissertation processes as follows: In chapter 2 I elaborate what abduction is, how historical explanation contributes towards hypotheses generation and inference to the best explanation, and why other methods used in Strategy are insufficient for abductive studies. In Chapter 3, I use the historical explanation to study the early American automobile industry and explore the importance of scaling, and the capabilities needed to scale production. Thus, this dissertation contributes to the field of Strategic Management's

understanding of the importance of historical explanation to abductive research and demonstrates its capacity through a study that furthers our understanding of the early stages of an industry.

Chapter 2: The Contribution of Historical Explanation to Abductive Studies

1. Introduction

Even though Strategy scholars often admit that 'History Matters', there is a limited understanding of how scholars can engage with history to produce knowledge that is generally recognized as contributing to the broader field of Strategic Management. In the absence of this understanding, historical research has been viewed as a chronicle of past events (Danto, 1965), as a source of theorizing using small N case studies (Yates, 2014; Mantere and Ketokivi, 2013), or as a source of data for quantitative analysis (alternately referred to as the history-as-sandbox view). As a result, the unique benefits offered by the historical explanation have been underutilized in Strategy research (Ingram et al., 2012). The purpose of this paper is to argue that historical explanation is a necessary complement to abductive analysis in Strategy research because it enhances the ability to generate and adjudicate between competing hypotheses to determine the loveliest explanation (Pierce, 1905; Lipton, 2003).[1]

Historical explanation in Strategy refers to the use of the temporally situated perspective of the researcher to systematically analyze and interpret records pertaining to actors or actions that cannot be directly observed (Ingram et al., 2012; Bucheli and Wadhwani, 2014). Historical explanation offers empirically defensible theoretical arguments by reconstructing explicit and logically rigorous analytic narratives about aspects of the past that can only be observed imperfectly, using either primary or secondary sources. It is not merely a factual chronicle of past events in a theoretical vacuum. Reductionist analyses that simply use the past as a source of statistical data do not qualify to be a historical explanation either.

[1] Why scholars choose abductive reasoning over other modes of reasoning is beyond the scope of this study.

Historical explanation is inherently abductive with "comprehensive arguments emerg[ing] from the interplay of theoretical ideas and historical evidence (Maclean et al., 2016:614)."

Abduction, a form of explanatory reasoning that generates and justifies hypotheses, can be summarized as follows: "[g]iven evidence E and candidate explanations H_1,H_2…, H_n of E, if H_i explains E better than any of the other hypotheses, infer that H_i is closer to the truth than any of the other hypotheses (Douven, 2017)." Abductive research requires the researcher to engage in contrastive analysis and select among competing, internally coherent hypotheses that fit the observable data. Instead of focusing on why a particular explanation is good, abduction focuses on why the loveliest explanation offers a better potential understanding of the explananda than others (Lipton, 2003).

I suggest that historical explanation contributes to Strategy research by addressing the challenges associated with the generation and evaluation of explanations in abductive studies. The key threats leveled against the generation of hypotheses in abductive research are the bad-lot objection and the argument-from-under-consideration objection (Dellsen, 2018). The first of these threats suggests that the best among available explanations may not be good enough if the generation of explanatory hypotheses is stopped prematurely, leading to unconceived alternatives, and the second advises that abductive inference may lead to wrong conclusions if all the competing hypotheses generated are false (van Fraassen, 1989:142; Wray, 2008; 2011). By engaging in contextualization (as practiced by historians), and by utilizing the wider view offered by the retrospective interpretation of the researcher, historical explanation expands the set of plausible hypotheses considered and, in the process, diminishes these threats.

Further, historical explanation subdues the burden of judgment imposed on abductive studies by offering a systematic, scientifically acceptable methodology to describe the structure of inference, and by uncovering the contextual evidence needed to justify the chosen

explanation. Abduction infers to the best explanation among competing explanations, all of which may be compatible and be able to explain the evidence. Choosing the best requires the researcher to discriminate between competing explanations and make judgments about why one explanation is better than the others. This judgment process may be perceived as a purely subjective process, especially when the options are statistically indistinguishable. Historical explanation enhances the ability to adjudicate between plausible explanations through a structured evaluation of the consilience and coherence of each argument. Historical explanation gauges consilience by identifying additional facts that each hypothesis must explain and by substantiating salient variations under which the proposed mechanisms must remain stable. Similarly, historical explanation evaluates the coherence of each hypothesis by evaluating how parsimonious each hypothesis is with existing knowledge in other contexts, by identifying the assumptions upon which each hypothesis is contingent, and by assessing the ability of the hypothesis to explain the deeper subcomponents of its proposed mechanism. Thus, the historical explanation is a necessary component of abductive studies.

The rest of this essay proceeds as follows: In sections 2 and 3, I define and describe abduction and historical explanation, respectively. In section 4, I describe how historical explanation enhances a scholar's ability to generate hypotheses through the temporal perspective that it offers (section 4.1) and through historical contextualization (section 4.2). Section 5 discusses why statistical, qualitative and experimental methods are on their own insufficient to adjudicate between competent explanations to select the loveliest explanation. In section 6, I identify two criteria that historical explanation uses to adjudicate between competing explanations: consilience (section 6.1) and coherence (section 6.2). Section 7 discusses three illustrative examples from the Strategy literature of abductive studies that use

historical explanation: Braguinsky and Hounshell (2016), Silverman and Ingram (2017), and King and Haveman (2008). I conclude in Section 8.

2. Abduction

Abduction, a term initially coined by Peirce (1905), "is the process of forming explanatory hypotheses… [by] examining a mass of facts and allowing these facts to suggest a theory (CP 8.209)." Pierce defines the logic of abduction as: "The surprising fact, C, is observed; But if A were true, C would be a matter of course; Hence, there is reason to suspect that A is true. (Peirce, 1998:231)." Abduction has since been extended by scholars to incorporate the idea of inference to the best explanation (Harman, 1965; Lipton, 2003). Inference to the best explanation, by adding a third premise to the logic of abduction, permits the conclusion to be true: "The surprising fact, C, is observed; But if A were true, C would be a matter of course; No available competing hypothesis can explain C as well as A does. Hence, A is true (Mackonis, 2013:977)."

While Peircean abduction generates possible explanatory hypotheses that are suspected to be true, inference to the best explanation is considered to be a stronger version of abduction that generates an explanatory conclusion that "is true, or at least approximately true (Lipton 2004:3)." Thus, "Peircean abduction is an in-depth account of the process of generating explanatory hypotheses, while [inference to the best explanation] ... is a more encompassing account of the processes both of generating and of evaluating scientific hypotheses (Campos, 2011:420)." For this discussion, I do not make a conceptual distinction between abduction and inference to the best explanation, and, like many past scholars (Barnes

1995; Psillos 2002; Josephson and Josephson 2003), I equate abduction to inference to the best explanation.[2]

In abductive studies, the explanation is before inference instead of inference preceding explanation.[3] Instead of accepting the hypothesis first, and then using it to explain observations, in abductive studies, how well various hypotheses can explain the available evidence is evaluated and then the hypothesis that merits acceptance is determined. Evaluating a hypothesis is not merely an act of relating the hypothesis to the outcome; instead, determining the best requires a comparison between credible alternate explanations. Rather than explaining 'why x', the focus is on contrasting 'why x instead of y', resulting in the elimination of alternatives. The best explanation is the one that is the most informative and has the most potential for improving understanding (Lipton, 2003:60). Indeed, the critical strength of abductive studies is that they overcome the inadequate research process description problems associated with the hypothetico-deductive model by offering a description of how researchers choose the best explanation among alternate explanations (Ketokivi and Mantere, 2010).

Abduction draws a crucial distinction between the likeliest explanation and the loveliest explanation. Lipton (2003) suggests that identifying the best explanation is not merely about likeliness, instead, it is about loveliness: "Likeliness speaks of truth; loveliness of

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[2] Discussions in the philosophy of science have debated the relationship between inference to the best explanation and Bayesianism, "the view that scientific inference involves finding theories that are the most probable in the light of the evidence, where the probabilities for the different theories are to be updated by the rule of 'conditionalization' (Henderson,2014)." van Fraassen argued that inference to the best explanation involves additional explanatory considerations relative to Bayesianism and as a result, inference to the best explanation and Bayesianism have incompatible updating rules (van Fraassen, 1989). However, several scholars have responded by arguing that they are compatible because explanatory considerations serve as constraints that play a role in the assignment of Bayesian probabilities (Okasha, 2000; Lipton, 2004; Weisberg, 2009).

[3] Inference is "a mental process that occurs in the mind of a rational person (Johns, 2008:1)." It is not solely determined by empirical virtues. It is also inherently different from the popular notion of causation which is "a physical process that happens in the world (Johns, 2008:1)."

potential understanding (61)." Likeliness is a matter of probability given the evidence whereas loveliness is derived from explanatory virtues (Lipton, 2003:63). The emergence of new evidence may diminish the likeliness of the explanation but not necessarily the loveliness of the explanation. Lipton (2003) argues that abductive studies strive to infer to the loveliest potential explanation, that is, "the explanation that would, if correct, provide the most understanding, is the explanation that is judged likeliest to be correct (59)." As a result, in abductive studies, explanatory considerations are critical guides to inference; that is, loveliness is a guide to likeliness.

The "best [explanation] is not directly a judgment of truth but instead a summary judgement of accessible explanatory virtues (Josephson and Josephson, 2003:15)." When looking for true theories, "[explanatory] considerations tell us not only what to look for, but also whether we have found it (Lipton, 2003:56)." In abductive studies "reasoning is viewed as a context- dependent process, focused on arriving at what the researcher and the audience judge to be the best explanation for the data in light of the epistemic virtues embraced (Ketokivi and Mantere, 2010:323)." Hence, justification of the inference depends on its power to give a description "that accounts in a natural and unified way both the inferences to the unobserved entities and the processes that characterize scientific research (Lipton, 1991:201)." Explanatory considerations are also evidentially relevant because it makes the probability that a hypothesis can explain an observation more resilient by making certain that the probabilities are less volatile given future information, and because it permits inductive projection to unexamined cases (McCain and Poston, 2014). Moreover, providing understanding through explanatory accounts is one of the fundamental aims of science (McCain, 2015). Thus, inference to the best explanation requires a narrative about why the likelihood of an observable outcome is best inferred from a purported explanation.

Abductive studies are particularly suitable for Strategy research. Non-trivial singular causes that can be readily categorized as necessary or sufficient rarely occur in Strategy research. Each causal factor in Strategy tends to be one among multiple causal factors that are neither necessary nor sufficient for an outcome individually but combine together to form a sufficient or necessary cause (Mackie, 1965:246). As a result, explanations in Strategy often require the process of inferring to the best explanation. However, the significance of abduction for Strategy research appears to be suppressed because, in Strategy research, abductive studies are often misreported as inductive. Studies using an abductive search process to identify relationships are then paired with testimony that misrepresents these relationships as a test of ex-ante theorizing (King et al., 2018:30). Using the principles of abduction to accurately represent the veridicality of testimony, instead of using a misleading hypothesis-testing structure, will serve to enhance the credibility of Strategy research.

3. Historical Explanation

The historical explanation can be described as "empirical research that uses remote sensing [as opposed to direct observation] and a contextualist [as opposed to reductionist] approach to explanation (Ingram et al., 2012:249)." Historical explanation accounts for the specifics of time and space to locate and trace particular mechanisms that generate the outcome of interest. It engages in a theoretically informed exploration of the complex nuances that shape the interplay between actors. When engaging in historical explanation, the empirical evidence and the logical reasoning that construct the narrative are as consequential as the theoretical argument that they inform. Rather than simply presenting the final account, historical explanations report the process of generating the argument in a transparent, succinct, yet scrutinizable manner.

Historical explanation examines the effects to understand the causes (Mantere and Ketokivi, 2013). It "involves comparing multiple explanations of actions and events in the past, typically proceeding by challenging existing or taken-for-granted explanations by offering new ones, rather than a purely inductive process by which explanations emerge from evidence separate from an existing explanation or theory that already claims to account for it (Wadhwani and Decker, 2017:115)." Historical explanation evaluates the position of each relevant causal factor within a sequence, with respect to other factors that make up the sequence, to make an abstraction about why the chosen explanation will repeat and hold up over time. In historical explanation, scholars abbreviate the complete explanation, interpret the available evidence, and make the assertion that certain variables are more important causal agents than others (Roberts, 2010:242).

Scholars use historical explanation "to understand a reality, observed from afar, where the quality of the understanding is judged by whether it convinces others (Ingram et al., 2012:243)." Remote sensing, a defining feature of historical explanation, which generates inferences from residual structures, is critical when direct observation is not possible. Direct observation does not require the subject being observed to have lived long ago; rather, direct observation is a function of access: if contemporary subjects that are the focus of study cannot be accessed directly, the historical approach is invaluable for analysis.

The historical explanation has often been incorrectly portrayed to be restricted to small N inductive analysis that focuses on narratives while employing very rudimentary quantitative tools (Ingram et al., 2012). This misunderstanding of the historical explanation is perhaps an outcome of the influence that Chandler's book Strategy and Structure (1990), in which he conducts a detailed comparison of four firms (du Pont, General Motors, Standard Oil and Sears), has on the field of Management. Historical explanations in Strategy incorporate

elements of qualitative and quantitative analysis that extends beyond case studies of outlier firms or studies that employ simple quantitative tools. Statistical analysis is integral to the historical explanation because basic cause-effect analysis allows the researchers to test whether the proposed mechanisms that arise from 'thick descriptions' can be demonstrated in the form of correlations that occur in the broader population. Similarly, qualitative tools such as textual analysis of archival documents and previously recorded interviews are widely utilized in generating historical explanations. However, even though elements of statistical and qualitative analysis are integral to the historical explanation, neither statistical nor qualitative analysis is on its own a perfect substitute for historical explanation.

Apart from the tools offered by statistical analysis and qualitative analysis that historical explanation borrows, it also utilizes several tools offered by process tracing methods. Hoop tests propose that, for a hypothesis to be true, evidence must be present that identifies a causal connection between the mechanism and the outcome and that identifies the causal factor under consideration as a necessary antecedent for the mechanism (Mahoney, 2012; Ragin, 2008; Goertz, 2006). While failing the test would diminish the standing of the hypothesis, passing the test does not necessarily make it the best explanation. Smoking gun tests examine for evidence that strongly supports a hypothesis, though the absence of the evidence does not diminish the stature of the explanation (Collier, 2011). Similarly, the method of sequence elaboration evaluates the relative importance of particular causal factors within the same mechanism using logic rules that account for temporal ordering, duration, critical junctures, path dependence, and the degree of dependence between states (Mahoney, 2009).

Historical explanation is often viewed as limited by its ability to generalize. It is incorrectly assumed that the historical explanation is ideographic; that is, it engages with a non-recurrent trend related to a unique event happening at a distinct period and hence has

minimal predictive capabilities. Accounting for inter-dependency of variables across time and space does make forecasting human actions difficult. However, the fact that historical explanations acknowledges these difficulties and therefore avoids giving precedence to oversimplification for ease of calculation does not imply that historical explanation is incapable of producing generalizable theories. These qualities make the historical explanation a particularly useful complement to statistical analysis because it is useful to improve the sample to population generalizability argument in cases where the relation between the sample and the population is ill-defined, and when it is unclear how representative the sample is of the population. This lack of clarity is usually an outcome of one of several causes: 1) the starting point is often the sample rather than the population; 2) there is a very obscure understanding of what the target population is supposed to be; and 3) the statistical inference made using random sampling assumption may have limitations because the sampling is seldom truly random (Polit and Beck, 2010). Historical explanations permit causal claims that are contingent, resulting in embedded generalizations that are perhaps more applicable for predictive purposes than categorical, immaculate causations that falsely claim to be universal. For future contexts, historical explanation permits the sharing of the burden of generalization with future scholars because, even though representative sampling from the future is impossible, the contextualization helps determine whether the explanations are applicable to the new and foreign contexts. Moreover, "[w]e know the future only by the past we project onto it. History in this sense is all we have (Gaddis, 2002:3)."

3.1 Bias in historical evidence

Due to the absence of direct observation, and due to the inability to repeat or replicate as one might in a laboratory setting, researchers using the historical explanation need to reconstruct the past using documentary evidence (Callinicos, 1995:65). For historians, such documentary

evidence is often housed in archives which shape perceived reality because of the inherent survival bias which arises from individuals and institutions determining what records to preserve (Schwarzkopf, 2013). It is critical for the researcher to systematically establish the integrity of the evidence because "unlike physical facts [that] exist independent of the observer, social facts depend fundamentally on the agreement between human beings (Murmann, 2012:91)." The location of sources in archives may also have theoretical implications, because archives often use firms and individuals as the central unit of record keeping. This creates complexities for researchers interested in examining other levels of analysis such as specific technologies, phenomena, industries, etc. Thus, it is essential for the historical researcher to describe the process used to generate the data needed to fit representation of past reality.

To account for potential source bias, when selecting a source, the historical researcher needs to establish the validity, credibility, and transparency of sources (Kipping et al., 2014). Often, this step requires the historically-minded scholar to engage in the thought experiment, "What sources have not survived? What's missing? How might the surviving archives bias my interpretation?" Strategy scholars will recognize this as analogous to the "ideal experiment" question. The strategist asks, "What would be the ideal test of my theory?" while the historian asks, "What sources -- existing or lost -- would provide the strongest evidentiary base for my interpretation?" Though proceeding from different starting points, both approaches privilege the mind of the researcher as she frames the inquiry. Establishing validity requires the researcher to not only evaluate the authenticity of the source but also evaluate the reasons for a given record's persistence, while credibility establishes the relative primacy of the source: Was the record generated close in time and space to the events under scrutiny? Transparency refers to the traceability and verifiability of the documentary evidence by *other* researchers. Proprietary sources are often deemed less credible than those available to any would-be

researcher. Strategy scholars seeking to publish in top economics journals will recognize a version of this problem as these journals now require authors to share underlying data sets as part of the publication process. Not all evidentiary traces are equal. Some provide more inferential power than others.

Finally, because no individual source is able to provide a complete account of the facts on its own, historical researchers have to engage in iterative, multi-source triangulation by using divergent accounts to converge on a parsimonious account. The researcher should attempt to interpret the historical record from the perspective of the author and the broader context in which it was produced in order to understand the ascribed meanings (Stutz and Sachs, 2018). Being forthcoming about how a researcher has triangulated across sources and modes of explanation increases credibility. Moreover, it is rarely possible to represent all aspects of the past reality being studied within the realms of a single article. As a result historical explanation aims for a fair representation of the past rather than a complete representation, a representation that must "include all prominent features of the subject, omit no features whose omission would imply something false about the subject; and represent the subject with a fairly uniform degree of detail (McCullagh, 1987:35)."

4.Generation of competing hypotheses

Abductive reasoning must consider suitable, diverse explanations to adopt and test to ensure that the inference generated by abductive research is indeed credible and that the inference avoids the 'anything goes' fallacy (Plutynski, 2011). Historical explanation is a useful complement to abductive studies because historical explanations are inherently driven towards the generation of multiple explanations. Historians necessarily engage in well-founded interpretations to identify multiple causes that converge on a specific outcome (Gaddis, 2002).

This approach focuses on the interdependence between a variety of factors (what social scientists would call *variables*) over time rather than attempting to establish a causal relationship between explicit sets of variables (that is, dependent and independent ones) at a particular moment in time. By contrast, Strategy scholars have focused on producing generalizable nomothetic propositions from systematic observation and experimentation. More recently, Strategy, in keeping with other related social sciences, has moved toward reliance upon narrower sets of observed correlations and explicit use of statistical methods to *identify* specific causal relationships (thus the moniker, the "identification" revolution (Morgan, 2016). As a result, while modes of Strategy research are restricted in their capacity to generate competing hypotheses due to their focus on perfect identification, historians specialize in increasing the number of explanations considered.

In abductive studies, the historical explanation is an iterative process that is triggered by the observance of a phenomenon or an anomaly that warrants an explanation. Historical explanation offers scholars the capacity "for selectivity, simultaneity, and the shifting of scale: they can select from the cacophony of events what they think is really important; they can be in several times and places at once; and they can zoom in and out between macroscopic and microscopic levels of analysis (Gaddis, 2002:22)." That is, the historical explanation gives the researcher the capacity to shift across different levels of analysis, such as individual, firm, group, industry and institutions, to facilitate the generation of multiple plausible explanations. The evolving understanding of the researcher forces him or her to move back and forth between the interpretation of the uncovered evidence and modification of their explanation. Alternate explanations emerge from deep learning of the context that exposes the researcher to theoretical implications proposed by other academics who have studied the same or related contexts and to the context-specific expertise of historians. Thorough study of the historical

context also connects the researcher to the interpretations of journalists from newspapers and trade journals from the period, and to perspectives of individual motivations revealed from documentary records such as diaries, memos, etc. New causal factors that emerge from a changing perspective of the situated researcher will matter for the explanation only if logical contradictions arise or if the new causal factor is more important for the outcome than the existing explanation (Mahoney et al., 2009). At the end of this iterative process, "[e]ven with explicit and logically rigorous accounts, multiple explanations will persist; as they are observationally equivalent, we will not be able to choose among them (Bates et al., 1998:17)."

Apart from generating explanations, historical explanation also ensures that the hypotheses generated are plausible. One of the core challenges scholars have to overcome while making inferences from an abductive study is that "scientists have no reason to suppose that the process by which they generate theories for testing makes it likely that a true theory will be among those generated (Lipton, 2003:152)." The historical explanation, in its attempts to represent past realities, significantly increases the likelihood that a true theory is part of the consideration set. To infer that a systematically executed historical explanation has not considered the truth would require the scholar to believe that significant historical records remain undiscovered or that discovered historical records do not contain the truth. While these are possible, they are highly improbable, and hence increases the confidence one has in the abductive inference that uses historical explanation.

Specifically, two unique features of the historical explanation enhance the researcher's ability to increase the number of plausible explanations considered: temporal perspective and contextualization.

4.1 Temporal Perspective

Strategy scholars assume time to be a clock variable that is used to chronologically arrange events as if through direct observation. It is treated as an ordering device that supports the inference. This approach allows strategy scholars to use computational methods that appear objective while concealing the underlying interpretive work necessary to generate a given temporal ordering (Kirsch et al., 2014). The historical analysis may not be reduced to objective computational methods because it acknowledges that, rather than directly observing the phenomenon, the researcher observes the historical traces of an organization or event or industrial sector that may be subject to selection and distortion (Kipping et al., 2014; Lipartito, 2014). The historical researcher develops interpretations about events and assigns significance to actions and actors based upon her retrospective point of view and preconceptions that she holds in the present (Wadhwani and Bucheli, 2014; Mantere and Ketokivi, 2013). Instead of assuming a fixed temporal ordering of past events, historical analysis requires the researcher to use her judgment to construct a selective yet coherent account of the past that puts forward the historian's interpretation, while simultaneously resolving competing historical accounts (Danto, 1965; White, 1975). Moreover, the researcher who is situated in the evolving present may, indeed should, re-interpret the past or discover new sources that may lead to the creation of new narratives and subsequent revisions of previous explanations (Ricoeur, 2004). Thus, for historians, unlike strategists, temporal orderings require much more than the mere passage of clock time.

Unlike direct observation that is often restricted by the observer's immediate senses, historical explanation, "lifts us above the familiar to let us experience vicariously what we can't experience directly: a wider view (Gaddis, 2002:5)." This wider view not only permits us to see processes that are only visible retrospectively, but also ensures that the search for explanations

is not prematurely closed, that patterns are not overdetermined to ensure artificial coherence, that there is no overemphasis on outliers, and that infatuation with a particular methodology does not alone drive the explanations considered. The expanded horizon reveals aspects that are only addressable in the long run, such as the differences in structures and behavior between organizations in different cultures, confront repetitive phenomena that spuriously claim novelty, identify decisions and possible choice opportunities that lead to current structures, and test theories developed from short-run changes against historical developments to identify conceptual issues (Kieser, 1994; Jones and Khanna, 2006). It promotes a greater understanding of the formation of institutions and their role in shaping cognition and action (Baumol, 1990; Suddaby et al., 2014; Wadhwani, 2011), how action shapes context over time (Welter, 2011; Jones and Wale, 1998), the formation, culture, and communication within teams (Aldrich and Fiol, 1994; Ruef et al., 2003; Lounsbury and Glynn, 2001), and analyses of path dependence and imprinting (Godfrey et al., 2016; Kipping and Lamberg, 2017).

The retrospective viewpoint of the historical explanation allows identification of *contingencies*, that is, outlier actors, phenomena, or events that were either unanticipated or appeared exogenously (Gaddis, 2002:30–31). Contingencies "don't fall within the realm of repeated and therefore familiar experience … [and include] situations where an imperceptible shift at the beginning of a process can produce enormous change at the end of it (Gaddis 2002:29)." They identify critical junctures where certain choices or events lead to long trajectories of change. Contingencies include breakthrough technological shocks that improve outcomes, such as railroad, internet, and agricultural discoveries, and traumatic shocks that result in negative and, often, long term disruption, such as the Great Depression and African slave trade (Kluppel et al., 2018). Contingencies require engagement with history because, at the time, the significance of an event or its status as an outlier is unclear. For that clarity to

emerge, time must pass between the event and the retrospective observation by the researcher. A unique advantage of the historical perspective is that, because the outcomes are known with the passage of time, the historical researcher is able to identify important contingencies. Contingencies are particularly attractive in forming causal arguments because they provide natural experiments with exogenous variations that persist over time. Contingencies also allow researchers to articulate critical turning points and thereby identify alternate paths of development.

The historical explanation also reveals continuities, that is, patterns that extend beyond time. Such patterns hold true across a variety of contexts and different periodizations. Continuities "recur with sufficient regularity to make themselves apparent to us. Without such patterns, we'd have no basis for generalizing about the human experience (Gaddis 2002:29)." Because of its ability to provide generalizable relationships, and because these patterns may be reasonably expected to continue, this aspect of history has been salient in the current Strategic management literature. It permits the identification of antecedents that shape behavior and outcomes. It also allows the researcher to explore, conditional on the identified relationship being true, what else should be true.

4.2 Contextualization

Contextualization involves the analysis and interpretation of events and actors in relation to their time and space (Wadhwani, 2016). Contextualization establishes the researcher's assumptions about the relationship between the period in which the researcher is situated and the period under study (Wadhwani and Hansen, 2014). Unlike other methods of analysis that view context as a given condition or as a background, in historical explanation, "contexts are interpreted conditions that place an event or action into a causal or semantic

relationship in time (Wadhwani and Decker, 2017:118)." Contextualization illuminates the "dependency of sufficient causes upon necessary causes, and while context does not directly cause what happens, it can certainly determine consequences (Gaddis, 2002:97)." Contextualization offers the perspective needed to ensure the coherence of explanation and to ensure that readers can assess the claims critically. Contextual knowledge offered by the historical explanation avoids the indiscriminate reduction of contextual complexities into simplified dummy variables, avoids the epistemic fallacy that the known empirical knowledge about the context represents the whole context, and avoids the creation of theory and constructs that are claimed to be eternal and universal despite the interaction with time and changes in context (Hinings and Greenwood, 2002; Weatherbee, 2012; Bhaskar, 2009). Contextualization is not an attempt to replicate the past; instead, it tries to package vicarious experience to fit representations to the past realities that the researcher seeks to explain.

Contextualization in the historical explanation is different from what is often considered to be contextualization in the Strategy literature. Contextualization in a typical Strategy paper is often presented in the form of a chronological list of events that does not in any way attempt to transform these events into the elements of an evolving process (White, 1987:6). The criteria for selecting the events to be represented in the list, the historical significance of the starting and termination times, and the meaning of the events listed are rarely discussed when events are presented in chronological order. Alternatively, contextualization in Strategy often also takes the form of providing details of the events listed in chronological order but fails to achieve narrative closure and simply terminates without any conclusion. Such descriptions are usually used to provide background information from the perspective of the researcher and lack a central plot or a coherent narrative. Instead of merely providing background, chronology, or amassing great details, contextualization in the

historical explanation projects structure onto the facts of the plot, and it is the imposition of structure upon the events that endows them with meaning (White, 1984). Contextualization used by historical explanation "treats explanation and inference as inseparable ... [and] seeks to establish the contextual authenticity of reasoning ... [by] providing the reader with maximal access to the empirical context (Ketokivi and Mantere, 2010:323)." Thus, historians present contextual narratives as the outcome of their analysis, whereas Strategy scholars subordinate contextual narratives to analysis and often deploy anecdotal historical evidence to illustrate a phenomenon, but not as part of the logic of explanation.[4]

Contextualization is established through periodization and narrative reconstruction (Rowlinson et al., 2014). Periodization refers to the organization of events and actions into coherent time periods. Structural changes in the environment, strategic inflection points, periods of crisis, etc. may determine the appropriate time horizons. Periodization has critical implications for the analysis of outcomes because different types of periodization may offer different causal explanations to the researcher. For example, organization of events into short periods (0-10 years) permits the researcher to assign agency to actors, into longer periods (10-100 years) permits formal institutional considerations, and into even longer periods (100-1000 years) permits considerations of informal institutions, customs, traditions, and norms (Williamson, 2000).

[4] The terms context, contextualization, and historical explanation represent different concepts in the Strategy literature. Context refers to the setting that the focal actor is located in but is external to the boundaries of the focal actor, while contextualization is the process of assigning meaning and making sense of the observed data or behavior of the focal actor (Edmondson, 1999; Bunt, 1997; Zahra et al. 2014). Context usually represents data while contextualization couples data to cognition to generate information. Historical explanation utilizes the generated information, that is the meanings ascribed to settings through the process of contextualization, to generate inferences. From an empirical perspective, the context often manifests in the form of control variables, the process of contextualization results in the generation of independent variables, and historical explanations result in narratives. Contextualization is a key tool that historical explanations use, however it is not the only one. Rather than testing theories in context, or generating theories of context that evaluates the effect that contextual factors (e.g. institutions) have on outcomes, historical explanation generates theories from the context (Whetten, 2009).

Narratives are internally consistent, transparent stories that describe changes or dilemmas of choice over time (Zald, 1994). Narrative construction refers to the organization of evidence in a sequence that assigns causes and consequences. Contextualization in the historical explanation employs analytic narratives that "pay close attention to stories, accounts, and context ... [to] extract explicit and formal lines of reasoning which facilitate both exposition and explanation. ... [It] seeks to understand the actor's preferences, their perceptions, their evaluation of alternatives, the information they possess, the expectations they form, the strategies they adopt, and the constraints that limit their actions (Bates et al., 1998:10-11)." This assembly requires the researcher to use her judgment to select relevant actors/events and include particular elements in the plot. Strategy scholars will recognize this process as akin to the challenge of replication in strategic management (Goldfarb and King, 2016).

Contextualization in historical explanation reveals the *structure* and *process* needed by the researchers to construct mechanisms (Gaddis, 2002). *Structure* and *process* differ in their levels of analysis and the tools used for mechanism identification. *Structure* refers to identification of mechanisms through macro level analysis using analytic narratives while *process* refers to mechanism identification through process tracing. Both involve the creation of narratives; however, the *process* goes a level deeper to explore dynamics within the firm to re-construct the decision-making reasons and challenges that are inaccessible at a macro level. The narratives play a more central role in deciphering the mechanisms in the *process* than in *structure*. Historical explanation in the process category permits the researcher to comprehend the variations of human experience and thereby understand how actors thought about their own place during the time to make sense of their context (Wadhwani, 2016). It helps us understand what shaped and constrained the actions of actors and how their evaluative

processes unfolded over time. Because transformative processes are often not static occurrences happening at a particular instant, process permits us to comprehend the effects of the relative timing of events and how that shaped the shared meanings framed by the actors at the time. Comprehending the shared meaning of actors also permits researchers to understand how actors may conform to or flout norms, which not only highlights their agency but also enables us to understand their actions relative to the wider context.

Peirce (1931, 7:220-222) suggests that the explanations to be examined are often instinctive, that is, based on the background knowledge, which gives reasonable belief for them to be probable. Historical explanation engages in contextualized reasoning where, "the empirical context becomes intertwined with the process by which grounds are linked to claims, and the author makes appeals to the context in justifying theoretical conclusions (Ketokivi and Mantere, 2010:324)." It can identify plausible counterfactuals, why they did not materialize, their antecedents, and their consequences that can be contrasted with hypothesized claims to validate causal arguments (Durant and Vaara, 2009; Kipping and Lamberg, 2017). The contextual deep-dives in which the historical explanation engages reveal anomalies, limitations, and boundaries to existing theories while offering instances of exogenous changes for theory testing (Maclean et al., 2016). Because historical explanation does not assume that factors which explain high performance also explain low performance, it is able to offer insights into deviations from average effects, failures, and paths not taken (Kahl et al., 2012). Thus, contextualization not only increases the likelihood of generating the hypothesis that is likeliest to be accurate, but it also offers perspective on how likely the selected hypothesis is true.

5. Weaknesses of other methods in determining the loveliest explanation

Historical explanation is a necessary complement to abduction because the other analytic methods in Strategy – statistical, qualitative, and experimental – are often incapable on their own of adjudicating between statistically likely explanations to determine the loveliest explanation. The econometric analysis, combined with the principles of logic, is often considered to be sufficient to decide on the best explanation. Statistically, factor X is a more important cause of Z than factor Y if measurements show indisputably that: (a) variations in X, and therefore the resulting variations in Z, occur more frequently than variations in Y; (b) change in X causes greater change to Z than does an equal change in Y; or (c) Z occurs relatively more frequently when X occurs and Y does not, than when Y occurs and X does not. However, exclusive reliance on statistical tests for determining the loveliest explanation is extraordinarily difficult because "[b]ehind the apparent precision of quantitative findings lie many potential problems concerning the equivalence of cases, conceptualization and measurement, assumptions about the data, and choices about model specification (Brady et al., 2010:9)." Even popular econometric approaches that use archival data such as using natural experiments, instrument variable approach, event studies, and Granger causality tests have significant practical limitations in determining loveliest explanation (Morck and Yeung, 2011). Statistical models are often "mechanistic and inflexible ... [and] the logic of testing rival explanations is buried in the statistical machinery (Cordray, 1986:17)." Moreover, "[t]he information in any body of [statistical] data is usually too weak to eliminate competing causal explanations of the same phenomenon. There is no mechanical algorithm for producing a set of 'assumption free' facts or causal estimates based on those facts (Heckman, 2000:91)."

A key tool on which statistical analysis often relies to improve the credibility of an explanation is triangulation. Statistical triangulation aims to increase the validity of the results

by using different methods whose biases are offset by each other to produce convergent findings. However, in statistical triangulation, because the focus is often on generating more data with minimal consideration for the epistemological challenges of combining them analytically, it is possible that similar methods have similar flaws which may amplify the effect and hide the error (Moran-Ellis, 2006; Fielding and Fielding, 1986). Moreover, in statistical triangulation, the process of integration is often unclear because it integrates findings at the end (in the methods section) and presents the findings as if they were found simultaneously. Because statistical triangulation is mostly focused on result confirmation there is minimal room for contradictory findings. Thus, statistical triangulation is not a comparative analysis tool used to rank different plausible explanations; rather, it reveals that an explanation is consistent with the data.

Another limitation of statistical analysis that limits its explanatory ability is that it does not "make reference to the objectives, knowledge, reasoning, and decisions of individuals acting in society (Goldthorpe, 2001:3)." Statistical analyses focus on independent variables and prediction while abduction focuses on mechanisms that induce the causal effects and on explanation. Statistical methods used by Strategy scholars frequently assume linear dependency and account for complex causal relations that exist in social systems mainly through interaction variables. They characterize explanations as something that can be statistically inferred directly from empirical regularities without wider considerations for contextual knowledge. Such nomothetic analyses that reduce a complex system to component parts and assign partial contributions to discrete variables are generally incapable of addressing how the relationships between variables are produced. As noted by Byrne (2012), "[i]f we understand the social as composed of complex systems with emergent properties, then the search for general nomothetic mechanisms is pointless... sophisticated description is a necessary precursor of any

attempt at causal explanation (21)." Historical explanations systematically provide the descriptions needed to decompose the various mechanisms underlying the hypotheses, comparing the validity of the interim stages to evaluate the explanatory power of the hypotheses. Thus, discrimination among such observationally equivalent hypotheses may not be possible by mere reductionist statistical falsification.

However, statistical analysis can contribute to the determination of the loveliest explanation when incorporated within the historical explanation. Historical explanation ties "the concept of causation to some process existing in time and space, even if not perhaps directly observable, that actually generates the causal effect of X on Y and, in so doing, produces the statistical relationship that is empirically in evidence (Goldthorpe, 2001:9)." Econometrics is effective in revealing correlations that hold true for the general population, and "[t]hough not proof of causation, correlation is a smoking gun; and history can often supply sufficient circumstantial evidence to convict (Morck and Yeung, 2011:42)."

For experimentation to serve as a mode of determining loveliest explanation, the causes should be manipulable, the treatment assignment and corresponding response must be independent of each other, and one entity's response should not determine the administration of treatments to other entities. Though this may be conceptually possible, from a practical perspective, using experimentation to rank plausible explanations is often impractical in complex social systems. Abduction, which is concerned with explaining observable data, focuses on the cause of effects, whereas experimentation focuses on the effects of causes. Like statistical analysis, experimentation does not explicitly introduce mechanisms or underlying processes that are critical to the determination of explanatory loveliness. Moreover, the determination of the loveliest explanation requires the researcher to go beyond mere time precedence and experimental manipulability of variables.

Similarly, qualitative methods such as ethnography and interviews that involve direct observation are useful to determine the best explanation when they are feasible. However, limited access to subjects restricts their general feasibility, and the researcher has to rely on qualitative tools that are congruent with the historical explanation. Moreover, direct observation is not necessarily better than historical explanation under all circumstances. Both historical explanation and direct observation suffer from sampling bias: the historical explanation is biased by surviving structures while qualitative studies are biased by the records and personnel that can be accessed. The group thinking and common external factors by which subjects under direct observation are influenced may affect the inferences. Qualitative studies are often ill-equipped to verify the validity of these inferences, because the knowledge about long-term outcomes that the retrospective viewpoint offers the historical explanation is not available under direct observation. Thus, for particular kinds of questions, the historical explanation may offer more explanatory power in determining the loveliest explanation than direct observation.

6. How does historical explanation determine the loveliest explanation?

Historical explanation contributes to the determination of the loveliest explanation by differentiating explanations based on their consilience and coherence.

6.1 Consilience

Consilience is an explanatory virtue that represents an explanation's unification capability and invariance. Explanatory unification refers to the ability to explain more of the evidence and more contextual facts than other competing explanations (Thagard, 1978). One proposed hypothesis is considered to be more unified than another if it can explain an additional set of facts that the other hypothesis can not. Conversely, an explanation may also be considered to

be more potent if it reduces the total number of unexplained facts. Explanatory unification is not simply about counting the number of facts that can be explained though; rather it is about the variety and salience of the revealed facts. While theory can be made more unified and made to explain more facts by increasing the number of assumptions, this will offset the coherence of the explanation by reducing its simplicity.

An explanation is more invariant than others when the proposed mechanism for the observed regularity is stable or robust across changes (Woodward, 2000). Changes could be passively observed or be manipulations provoked through an experimental intervention (Russo, 2014). If a mechanism is stable across all changes, such mechanisms become laws. Alternatively, if the mechanism is unstable across all changes, the observation is purely accidental and the mechanism is contrived. Because stability across all changes may be impractical to verify, invariance focuses on changes that are likely to occur in the domain of interest. It explores appropriate attribute changes rather than irrelevant changes (Imbert, 2013). Explanations are often determined to be likely under ceteris paribus conditions, and variance of the ceteris paribus nature of the proposed hypotheses needs to be considered when determining the loveliest explanation. Invariance is a matter of degree, and it is not required that an explanation be invariant across all changes for it to be the loveliest explanation. Indeed, most proposed explanations in Strategy fall in the continuum between laws and accidents. The consilience of theory tends to be dynamic and change across time as additional facts and changing conditions are revealed.

Historical explanations enable evaluation of consilience by specifying facts that are unexplained by the proposed hypothesis, by revealing facts from a variety of relevant aspects of the phenomenon under study, and by using their focus on temporality to examine the dynamic nature of the theory. The historical explanation may also improve consilience by

explaining why diverse plausible hypotheses exist in the first place. Rather than ignoring outliers, neglecting unexplained facts, or overlooking the time element, historical explanations use these factors to enable comparative evaluation. The historical explanation, due to its ability to scale across different time periods and levels of analysis, reveals evidence that may be relevant to a hypothesis but does not necessarily explain it. It scales between microscopic and macroscopic levels of explanations that simultaneously account for different actors, events, and contextual factors within the same period under consideration (Gaddis, 2002). It allows the researcher to ask what else should be true for a given hypothesis to be the best explanation. The researcher can test the deductive implications of the theory under consideration using historical explanation because the outcomes are known and because in-depth contextual knowledge permits tracing of the actual consequences of the theory in past realities. Thus, the historical explanation "serves as a lens through which the apparently independent and disconnected elements of existence are seen as related parts of a whole (Polkinghorn, 1988:36)."

Historical explanations, due to their ability to examine long periods, give the scholar access to stylized facts, defined as discernable empirical regularities between things that exist in the world that are worth explaining (Hirschman, 2016). Stylized facts from other contexts revealed by the historical explanation are relevant to choosing the best explanation. Stylized facts imply that the particular regularity described is more important than other regularities in the world, and a hypothesis' ability to account for such a stylized fact improves its explanatory power. Drawing analogies from the past allows scholars to use wisdom about the past to improve the interpretation of the present situation. Even though which stylized fact a researcher chooses to connect to may depend on her idiosyncratic background and knowledge

bases, the ability of an explanation to account for the stylized fact is nonetheless a demonstrable evaluation criterion for the best explanation.

Historical narratives can enhance the consilience judgment capabilities through triangulation that evaluates the invariability of inference across different types of sources using different methods (Kipping et al., 2014). Triangulation, as practiced by the historical explanation, is not simply about producing similar results. It focuses on different types of documentary sources to reveal different aspects of the phenomenon that are supposed to be consistent with each other (Greene et al., 1989). Historical explanation pays particular attention to whether the integration happens sequentially or simultaneously, whether the different sources utilized and the different findings they reveal can be considered to be equal, and whether the evidence uncovered is independent. Integral to the historical explanation are the sequence of actions taken by the researcher to construct evidence using replicable techniques from verifiable and accessible documentary sources and the sequence of the reasoning process that the researcher engages in to arrive at the inferences. Abductive research is enhanced by this focus on sequence because it permits improved triangulation. In historical methods, because of their ability to observe different viewpoints across different time periods simultaneously, integration of methods happens from the very beginning. Instead of simply using triangulation to improve the validity of the finding by mixing different methods or data sources, historical explanation uses triangulation to explore different aspects of a particular phenomenon to generate a richer understanding of its complexities. Triangulation in the historical explanation generates complementarity for which the hypothesis under consideration must be able to account in order for it to be the best explanation. Triangulation using primary and secondary sources allows the researcher to "place the event in a broader context in a way that a single source may be incapable of … [and] track an event or

development over a long[er] period of time than any single source may be capable of (Wadhwani, 2016:137)." Thus, historical triangulation permits the scholar to know more and increases the scope of realities for which an explanation needs to account, thereby allowing a better determination of the best explanation.

Historical explanation can further evaluate consilience through hermeneutic interpretation that seeks to "interpret sources in a way that takes into account the contexts in which they were produced (Wadhwani, 2016:138)." This enables the evaluation of inferences from the perspective of the authors of the records. When attempting to identify the best explanation, rather than merely considering the perspective of the researcher, historical explanation accounts for the perspective of the actors at the time. Retrospective sense-making by the researcher is often colored by the theories that are of interest to the researcher and by the researcher's own position in historical time (Kirsch et al., 2014). While other forms of analysis try to get rid of perspective in the name of objectivity, historical explanation takes seriously the perspective of the actors involved. Hermeneutic interpretation acknowledges that "we do not draw on context to make sense of the evidence presented; we see and understand in contexts—physical, historical, cultural, linguistic, moral, experiential, affective—that we venture in as we conjure our interpretations of what is going on (Freeman, 2014:827)." It uses available evidence to assign significance to these perspectives as it tries to develop coherent narratives that represent past realities. As noted by Hacking (2002:46) in his concept of looping, how individuals perceive and classify interacts with that which is being classified and changes it. Hence it is critical to understand how actors perceived events or phenomena to explore how they evolved. Historical explanations accept that evidence does not speak for itself and that to understand the evidence, the viewpoint of its creator needs to be understood because the texts and the authoring process are intertwined (Martin, 1986). This ensures that

the explanation is not anachronistic, that is, explanations from another era are not imposed with disregard for how differently people thought, acted, and organized in the past (Lipartito, 2014:285). Thus, instead of offering an explanation that is independent of perceived realities, historical explanation permits selection of the best explanation that is closest to the truth as perceived by the actors.

6.2 Coherence

Coherence is a theoretical virtue that represents the parsimony, depth, and simplicity of an explanation. The parsimony of an explanation embodies the fit it has with the relevant background knowledge that is assumed to be close to the truth and is therefore taken for granted (Psillos, 2002; 2007). The best explanation is the one that fits in best with our existing explanatory knowledge (Ennis, 1968; Harman, 1968). An explanatory hypothesis is parsimonious if it is logically consistent with relevant background knowledge and if it either explains the background knowledge or the background knowledge explains it (Thagard 1989; Bartelborth 1999; Mackonis, 2013). Explanatory parsimony is higher when a hypothesis displays a preference for familiar mechanisms and concepts used in previously established explanations. The best explanation unifies our understanding of the world "to the extent that it does not posit fundamentally new types of phenomena … [and explains] in terms of or otherwise suitably related to those theories now accepted by scientists (Barnes, 1995:262)." Analogies offered by historical explanations demonstrate parsimony by creating explanatory connections between the phenomenon being studied and the phenomenon for which explanations already exist (Bartelborth, 1999). Though parsimony assumes that existing knowledge is credible, it does not prevent an explanation from contradicting background knowledge; it merely updates knowledge to account for newly discovered theoretical surprises. Parsimony prevents the unwarranted generation of radically new theories because often, "in

solving abduction problems, the demands of originary (or artistic) thinking are proportional to the depth of the abducer's ignorance (Gabbay and Woods, 2005:64)."

Historical explanation is valuable in determining how parsimonious the explanation is with respect to the background knowledge we have about other contexts. Historical explanation evaluates the parsimony of a hypothesis by describing the extent to which hypothesis is transferable and testable in other settings. The loveliest explanation is ultimately an attempt to represent reality, and historical explanation permits the scholar to evaluate whether this representation enables trustworthy and transferrable predictions. Contextualization offered by the historical explanation permits an informed judgment about the abstraction of the findings to proximally similar settings to ensure that the explanations sustain across temporal and spatial dimensions. Contextualization identifies the theoretically relevant characteristics of the focal data that can be compared to determine the relevance of the sample findings in the populations of interest. It permits the higher order abstraction needed to distinguish between details that are unique to the restricted sample and details that are relevant to the broader population. The historical explanation also ensures that findings from other contexts are congruent with the generated explanations. Instead of simply codifying abstract regularities that are independent of intentions or circumstances, historical explanation offers thick descriptions needed to assign significance to an action, to judge the degree of transferability of findings based on the fit between contexts, and to establish connections with existing scientific knowledge (Lincoln and Guba, 1985:124; Geertz 1973:25; Stake, 2010).

In abductive research, "an explanation is more lovely the more fully it describes the mechanism by which a putative cause brings about its effect (Barnes, 1995:257)." The depth of an explanation represents the degree to which it can further explicate its mechanism by

describing why that mechanism should be true. According to Thagard, "a deeper explanation for an explanatory mechanism M1 is a more fundamental mechanism M2 that explains how and why M1 works. M1 consists of parts, and M2 describes parts of those parts whose properties and relations change in ways that generate the changes in the properties and relations of the parts in M1 (Thagard, 2007:38–39)." One can further explore a more fundamental mechanism M3 that explains M2 and continue that process indefinitely. Additional explanations needed to increase the depth of a given explanation may be provided by background knowledge or may further explain background knowledge, thereby further increasing coherence. The depth of an explanation is a dynamic virtue because over time parts of mechanisms will be further explored. Though depth is not necessary to explain observed data, depth provides reasons to prefer one explanation over another. The deeper an explanatory hypothesis is, the better it is.

Historical explanation enables evaluation of depth because it provides thick descriptions that identify the causal mechanism and traces the logic of the processes that generate the outcome. Causal mechanisms, defined as "unobserved entities that – when activated – generate an outcome of interest (Mahoney, 2001:580)" are often beyond the purview of correlational analysis because of their status as unobserved entities, and because they diminish the sufficiency of the causal variable in generating the outcome (Hedstrom and Swedberg, 1998). Historical explanations do not treat causal mechanisms as posited relations that are imagined to exist. Instead, it is possible for the scholar to trace the intermediate steps that connect the cause and the effect to explain why the empirical associations exist. Historical explanation resolves the pairing problem between cause and effect and avoids spurious correlations by offering evidence to identify the mechanism that connects them. The rich contextual knowledge offered by the historical explanation is valuable in evaluating the best

explanation because "discovering causal mechanisms requires taking a close look at actual instances of the phenomenon under investigation …. If investigators lack knowledge of actual instances of the phenomena of interest, they are unlikely to make good decisions about how to conceptualize the mechanisms that generate these phenomena (Mahoney, 2001:591)." Historical explanations allow scholars to examine what happened by using documentary evidence that reveals the various decisions that actors may have made and by offering an interpretation of why they may have chosen those actions. It shows how the mechanisms may change under changing circumstances and explains the conditions under which a mechanism may work.

The simplicity of an explanation is a function of the number and nature of auxiliary assumptions that are needed to be made for a hypothesis to explain the facts (Thagard, 1978). Simpler explanations are considered to be better and assigned a higher probability to be true when unambiguous probability information about competing explanations is absent (Lombrozo, 2007). Simpler explanations require fewer assumptions, fewer initial conditions, and less extra information to explain facts. An explanatory hypothesis is simpler if the assumptions employed by it are a proper subset of the assumptions employed by other explanations. Similarly, when competing hypotheses require the same number of assumptions to explain the initial observation, simplicity may be gauged by exploring the number of additional assumptions needed to explain additional facts or other phenomena (Psillos, 2002).

Simplicity adds a constraint on consilience by restricting its scope because, as Thagard (1978) notes "a simple consilient theory not only must explain a range of facts; it must explain those facts without making a host of assumptions with narrow application (87) …. Consilience and simplicity mitigate against each other, since making a theory more conciliant can render the theory less simple, if extra hypotheses are needed to explain the additional facts (92)."

Alternatively, the consilience constraint prevents oversimplification because that reduces the number of facts that can be explained. Fundamentally, both simplicity and consilience favor explanations that do more with less because consilience seeks to account for a greater number of facts while holding the number of assumptions steady whereas simplicity seeks to explain the same facts while reducing the number of assumptions.

Historical explanation is useful to evaluate simplicity because contextualization reveals not only the circumstances under which the explanation holds but also the scope conditions that limit the generalizability of the theory (Firestone, 1993 Yin, 1989; Tracy, 2010; Lewis et al., 2014). Representing the past reality of what actually happened using evidentiary records permits the scholar to identify the explanation that is closest to the truth with the fewest assumptions. Thus, historical explanations make the captured regularities in human behavior intelligible by citing the initial conditions and by identifying salient aspects upon which the proposed hypothesis is contingent.

7. Exemplar abductive studies that utilize historical explanation

While I have thus far discussed the historical explanation conceptually, in this section, I discuss three exemplary abductive studies that effectively utilize the historical explanation: Braguinsky and Hounshell (2016), Silverman and Ingram (2017), and King and Haveman (2008). Apart from the effective use of the historical explanation for abduction, these studies were specifically chosen for their publication outlet choice and statistical rigor. Studies that utilize historical explanations are often believed to be in the form of books or book chapters. These articles were chosen to overcome that misrepresentation because they were published in leading management journals. Similarly, historical explanations are often believed to be devoid

of statistical analysis. These articles exhibit the power of incorporating advanced statistical analysis into a historical explanation.

In Braguinsky and Hounshell (2016), the authors study the Meiji era Japanese cotton spinning industry to uncover the core driver of its sustained global competitiveness. They argue that the loveliest explanation for the success of the Japanese cotton spinning industry was the presence of superior human capital of a few firms that eventually moved the entire industry into a high growth trajectory. They suggest that the industry's success was an outcome "of several leading private entrants powered by visionary entrepreneurs and guided by the first generation of educated engineers whose technical knowledge stemmed from direct contacts with state-of-the-art sources in England (61)," making important decisions that encompassed all aspects of strategic management. The historical explanation enables identification of the specific strategic choices that mattered and the responsible decision makers. This paper effectively utilizes analytic narratives, statistical analysis, deep historical knowledge, and context-guided theorizing to enhance our understanding of a historically important phenomenon.

In the process of developing the loveliest explanation, Braguinsky and Hounshell (2016) considered multiple likely explanations. The authors demonstrate the consilience of human capital heterogeneity being the loveliest explanation by identifying additional facts that the other likely explanations were unable to justify and by demonstrating the invariance of the human capital explanation. The likely explanations considered were:

a. Early government support for mills, in the form of offering British spinning machinery at subsidized prices and easy loan terms, was the main cause of the success of the Japanese cotton-spinning industry because they produced important demonstration effects and resulted in knowledge diffusion. However, the authors demonstrate that

government-controlled mills could not have been the root cause of industry success because the government-controlled mills used labor-intensive practices that lowered productivity, used inefficient hydro as the source of power instead of the more efficient steam engine, used domestic cotton that was too short for the mills' Western machinery, and were of smaller scale while being scattered in remote locations of the country.

b. Japanese firms, influenced by the Osaka Spinning Company, liberally mimicked each other in choosing minimum efficient mill size and spinning machinery, and that this dissemination of knowledge happened at the industry level through the industry association Boren. The authors argue that this explanation "glosses over the importance of independent strategic choices made by individual firms (52)." Even though "the information and know-how about these best practices and the market infrastructure needed to utilize them were available to all industry participants, including new entrants (61)," only firms with superior human capital chose to make use of them. Specifically, human capital differences determined the strategic choice to adopt "two major innovations that paved the way for explosive industry growth: the introduction of ring spinning frames and the development of new major sources of supply of longer-staple cotton, first from India and then also from the U.S. (53)."

c. Incorporation of firms resulted in superior performance. The authors argue that "even though incorporation appears to be a necessary condition for the revival and growth of former government-sponsored mills, it was not sufficient.... It appears that incorporation helped the process of modernization only if it entailed participation by prominent investors with national profiles (54)." They also suggest that, though the

attributes of the mills may be important in determining investments, owners with superior human capital were indeed the ones that actively sought investor support.

d. Industry growth was driven by innovative new entrants who increased productivity by installing newer machines that were faster, had more spindles per frame, had the capacity to work with different types of cotton, and had the ability to spin a higher quality yarn with finer counts. The authors argue that even though newer entrants were thirteen percent more productive than earlier entrants, "the productivity advantage of new entrants (their higher quality machines) did not translate into better survival, although it did translate into higher rates of being acquired by other firms (58)." Indeed, the acquiring firms were those with superior human capital who understood the importance of strategic management of "the vagaries of the demand, ensuring product quality, and diversifying the product mix", thereby resulting in superior operational efficiency.

The study presents a theoretically parsimonious narrative that utilizes constructs, such as founding team members' pre-entry experience and education, that previous Strategy scholars have studied (Beckman, 2006; Braguinsky, Klepper, and Ohyama, 2012; Carroll et al., 1996; Klepper and Simons, 2000; Mitchell, 1989; 1991). It suggests that, much in line with the predictions of existing Strategy literature, firms founded by innovative teams held long term advantage over non-innovative teams and imitators. The study offers boundary conditions for factors that have been previously identified to be relevant to outcomes by strategy literature. It argues that institutional support is only valuable when it is backed by superior human capital, that tacit technological knowledge acquisition through direct contact needs to be combined with strategic decisions to be effective, and that environmental changes, usually a given, may be outcomes of strategic choices. In the process of recognizing the boundaries, the study has

also uncovered the relative importance of various aspects of the outcome. For example, while arguing for the importance of incorporation, the authors distinguish between necessary and sufficient conditions by elaborating on the importance of prominent investors and the role played by founding teams in attracting them.

The historical narrative presented in the paper also uses thick descriptions to cite multiple analogous phenomena that demonstrate the study's parsimony with alternate contexts. The paper cites "examples of independent strategic choices made by a handful of outliers (47)" that dramatically changed industries. For example, it argues that the phenomenon is analogous to the dominance of the Ford motor company due to their innovative manufacturing paradigm, and the role of Steve Jobs in creating digital music delivery and smartphone industries. The paper also offers analogous situations where there was an unsuccessful transfer of technology due to inability to acquire matching human capital such as the failure of the British government to replicate German dyestuff industry, the failure of Russia to replicate Silicon Valley, and the failure of Ghana's aluminum industry. Similarly, from a simplicity perspective, given the richness offered by the historical explanation, the authors do not need to make additional assumptions to justify their findings. Moreover, the study does not need to introduce additional constructs and offers an explanation within the confines of existing theories.

Further, the authors defend human capital heterogeneity being the loveliest explanation by demonstrating its explanatory depth to reveal fundamental levels of their proposed mechanism. They attribute the poor decision making at government-promoted mills to a non-engineer who was trained in military artillery and had limited experience in cotton spinning. They demonstrate that the successful firms hired qualified college-educated engineers as chief engineers and paid them to acquire manufacturing knowledge in England.

They further explore the reasons for this hiring strategy and trace it back to the efforts by firms to emulate the hiring strategy of the successful Osaka Spinning Co. Thus, the authors select the loveliest explanation from a plausible set of likely hypotheses by using the historical explanation to demonstrate various factors that contribute towards the consilience and coherence of the proposed explanation.

Braguinsky and Hounshell (2016) skillfully address all the criteria proposed in this paper for the evaluation of the loveliest explanation. However, depending on the context and purpose of the study, loveliness may be determined by carefully addressing only some of the proposed criteria. Silverman and Ingram (2017) is an exemplary study that uses the historical explanation solely to focus on the consilience aspect of the loveliest explanation. In Silverman and Ingram (2017), the authors investigate the mechanism that determines the incidence and consequence of asset ownership. Incentive system theory suggests residual claims to a share of the asset's future value as the driving mechanism while property rights theory and transaction cost economics suggest residual control over the use of the asset as the driving mechanism. Distinguishing between these mechanisms has been difficult because the ownership of an asset usually simultaneously offers residual claim and residual control rights. In this study, the authors use the historical Liverpool transatlantic shipping context (1744-1786) to determine which among these likely explanations is the loveliest explanation.

To determine the consilience of the proposed explanation, the authors identify additional contextual facts and changes for which the theories need to account. The authors argue that the Liverpool shipping context is particularly effective in determining loveliness due to three reasons: (1) Although part-ownership of the vessel provided the captain with residual claims to a share of the asset's future value, it did not provide residual control rights over the use of the vessel; (2) The threat of capture of enemy privateering vessels was a hazard that

could not be effectively managed through contractual incentives because, when approached by a privateer, a captain could either surrender the ship, be treated well, and be returned home in accordance with maritime law, or risk his life to fight and escape; and (3) The duration of the trips was so long that they often started before and ended after the outbreak of a war, which served as a shock.

The authors argue that residual claims to a share of the asset's future value is the more consilient driving mechanism if: vessels were significantly more likely to have a captain-owner when they undertake wartime voyages on routes that are particularly susceptible to encounters with privateers, ships with captain-owners were less likely to be captured than those with non-owner captains, and captain-owners were more likely than non-owner captains to forgo maximizing the cargo. The authors engage in analytic narratives and statistical analysis to offer evidence supporting the consilience of residual claims as the driving mechanism instead of residual control. The authors find that vessels have an eleven percent higher likelihood of having a captain-owner for a wartime voyage on routes susceptible to privateers relative to safer routes, that vessels with captain-owners have a ten percent lower likelihood of capture and carry 34 fewer slaves (human cargo) than non-captain-owners. The authors also considered and eliminated four alternate explanations – "residual control rights over the captaincy of the vessel (rather than over the vessel itself), endogenous matching, captain migration across routes during wartime, and a wartime change in bargaining power between shipowners and captains (873)" – to further enhance the consilience of the proposed explanation.

Because the purpose of the paper is to distinguish between two coherent mechanisms already established in the literature in order to determine the loveliest explanation, explanatory consilience takes precedence over coherence with background knowledge. As such, from a

simplicity perspective, the authors do not introduce new constructs or assumptions, and from a depth perspective, the authors rely on existing literature to illustrate the mechanisms. From a parsimony perspective, the authors are unable to claim that one explanation has a better theoretical fit that the other. Thus, Silverman and Ingram (2017), determines the loveliest explanation without having to address all the explanatory qualities discussed in this paper.

While the previously discussed exemplary abductive studies used the historical explanation effectively to determine one lovely explanation, King and Haveman, in an insightful 2008 study, do not choose the loveliest explanation among equally-compelling likely explanations. The benefit of a well-executed historical explanation, like King and Haveman (2008), is that it offers thick descriptions needed for future scholars to form their own judgments. I demonstrate the effectiveness of the framework presented in previous sections by applying it to the thick descriptions that the authors provided to evaluate the likely options and recommend the loveliest explanation.

In King and Haveman (2008), the authors explore the factors that lead to the origins of social movement organizations with a focus on the antislavery organizations that originated between 1790 and 1840. The authors note that the anti-slavery movements were an important context to study because other important movements that transformed politics, such as women's rights and temperance movements, often used the anti-slavery movement as their template. The authors offer two likely explanations for the origins of social organizations: (1) Affiliations with extant social institutions offer resources that lead to the founding of social movements. In the case of anti-slavery movements, church affiliation provided the movements with a mass of believers who can be turned into activists, and with organizing templates that could be adopted. (2) Mass media, particularly print media in the case of anti-slavery movements, influenced founding by providing a channel for the general public to learn

about the existence of social movements and by providing an opportunity for activists to interact with the public by crossing temporal and spatial boundaries.

However, the authors are presented with a conundrum in determining the loveliest explanation. It is unclear if mass media was a cause, consequence or companion to the growth of antislavery organizations. This is because mass media benefitted from the efforts of social movement organizations as the movements provided content for the media and often started their own newspapers and magazines. Similarly, social institutions provided a foundation for the development of both mass media and social movements. As such, in the context of anti-slavery movements, to determine the loveliest explanation, the authors had to determine, "Did media have any non-endogenous influence on antebellum social movements? And to what extent did churches have direct effects on antebellum social movements, net of their indirect effects through church-supported media? (497)."

The authors utilize historical evidence to discuss why both explanations may be equally likely as well as the challenges in attributing causality. Using the number of post offices as an instrument, and by exploring theological differences among different churches to classify them as this-worldly churches (focused on improving the human condition) and other-worldly churches (focused on soul's relation to the divine), the authors can disentangle causality. The authors find that "temporal and spatial variation in the development of magazines is strongly associated with temporal and spatial variation in the founding of antislavery societies (520)", that is, mass media causally influenced the founding of anti-slavery social movements. Similarly, the authors also find that, while this-worldly churches supported the social movement, other-worldly churches undermined it. Thus, the authors find two compelling explanations.

I suggest that, even though both explanations appear to be equally consilient, mass media is a more coherent explanation because it uses fewer assumptions, has greater potential for depth improvement, and is more parsimonious with modern entrepreneurial contexts.

The authors argue that extant churches influenced the formation of social organizations by providing movements a mass of believers who could be turned into activists and by providing organizational templates and structures that could be adopted. However, these mechanisms are assumed – the authors are unable to verify either that the membership of churches overlapped with the membership of newly formed social organizations or that organizational templates were indeed adopted. While the authors offer an example of the agency system that was pioneered by the churches being adopted by one organization, widespread adoption or effectiveness of this organizational template is an assumption.[5]

The authors argue that mass media influences the formation of social organizations by offering a medium of interaction for the activists and the public. The information presented by the authors about the presence of publications dedicated to antislavery movements, repeated articles in the general publications on anti-slavery movements, and letters to the editor about such movements from the general public demonstrates the use of media as a channel for the interaction between activists and the public. For example, the authors note, "Newspapers and magazines—not just periodicals published by antislavery societies but also the many non-affiliated, general-interest periodicals—carried announcements about meetings, offered updates on legal initiatives, printed fiery letters to the editor, and published emotion-laden essays, poetry, and fiction describing the horrors of slavery (499)." The authors present more tangible evidence of this mechanism that does not necessitate the need for assumptions. As a result, mass media is a simpler explanation than the church's influence.

[5] The agency system was one where the individuals travelled across the country to spread a message.

The depth of the church explanation is harder to increase from the perspective of a Strategy scholar because the mechanism depends on theological beliefs. On the contrary, the depth of the media explanation can be increased by exploring the incentives for media organizations to promote anti-slavery messaging, the heterogeneity of their actions, and the antecedents to the founding of anti-slavery publications. Similarly, though both explanations are presented to be equally parsimonious with existing literature, I suggest that mass media is a more parsimonious explanation in an organizational context. Existing knowledge about entrepreneurial strategies in other contexts give precedence to the role of mass media opportunities over theological endorsements. Thus, I suggest that the rich information provided in King and Haveman (2008) can be applied against the proposed evaluation framework to determine that mass media is the loveliest explanation.

8. Conclusion

The purpose of this essay is to suggest that historical explanation is a necessary complement to abductive research. Abduction is a two-step process that involves the generation of multiple plausible hypotheses from observed data and the adjudication between these likely explanations to determine the loveliest explanation. During the hypothesis-generation stage, historical explanation supports abduction by diminishing the risks of generating inferences from an insufficient set of plausible explanations. Historical explanation increases the number of plausible explanations considered by utilizing the wider retrospective viewpoint offered by its temporal perspective and by analyzing the narratives that emerge from the historical contextualization process.

Historical explanation is necessary to adjudicate between competent explanations to generate the loveliest explanation. Loveliness is an outcome of a hypothesis's explanatory

virtue and its ability offer potential understanding. The traditional statistical, qualitative, and experimental analyses used by Strategy scholars are on their own ill-equipped to engage in the comparative analysis needed to determine the loveliest explanation. However, when combined with the historical explanation, the loveliest explanation can be determined by evaluating the consilience and coherence of explanations. I argue that an explanation has greater consilience than other candidates if it can explain more facts that the historical evidence has uncovered, and if its mechanisms are invariant across a greater number of salient changes revealed by the historical evidence. Similarly I also suggest that, a hypothesis has greater coherence than other plausible explanations if the proposed mechanism is more parsimonious with existing knowledge from other comparable contexts revealed by the historical explanation, if the historical explanation reveals greater depth by explaining the sub-processes that constitute the proposed mechanism, and if historical explanation identifies fewer assumptions upon which the hypothesis is contingent. Further, I discuss three exemplary papers published in leading Strategy journals, Braguinsky and Hounshell (2016), Silverman and Ingram (2017), and King and Haveman (2008), to demonstrate how the proposed evaluation framework can be effectively implemented.

This paper presents a number of questions that demand consideration in future studies: When should a scholar choose to generate inferences from an abductive process instead of inductive or deductive? How are historical explanations useful in non-abductive studies? Does the concept of explanatory loveliness have implications for inductive, deductive, and replication studies?

This paper strives to upend the notion that historical explanation is restricted to small N case studies with rudimentary arithmetic. Rather than framing historical explanation to be a method of last resort to be used when all else fails, I identify at least one situation where

history is a necessary component of the research process. To further demonstrate the merits of using historical explanation in abductive research, in the next chapter, I use the historical explanation to explore the challenges firms encountered in the early American automobile industry and the capabilities needed to overcome them.

Chapter 3: Learning to Scale or Scaling to Learn? An Empirical Exploration of Production Scaling in the Early American Automobile Industry

1. Introduction

This study suggests that the founding team's prior operational experience in a factory that manufactured metal products was critical for firm performance during the early stages of the American automobile industry (1895-1918). An in-depth exploration of the context revealed that knowledge of metalworking mattered because it enabled firms to manage the particularly difficult problem of production scaling. Due to similarities between the two manufacturing processes, metal factory experience provided founders with the capabilities needed to overcome production bottlenecks at automobile factories. This experience allowed the firms to gain production efficiencies through skilled factory tooling and streamlined production processes. I demonstrate statistically that firms that had founding-team metal-factory experience, on average, survived longer and increased their production capacity annually. I use historical narratives to discover the existence of the phenomenon, multivariate statistics to subsequently verify that it is indeed relevant to the broader population, and finally, records from the industry archives to triangulate the underlying mechanism. Thus, my findings suggest that bottlenecks to growth, if they do indeed exist, may be context specific and that the capabilities needed to overcome those bottlenecks may also be context specific.

I make the following contributions to the literature: (1) I contribute to the pre-entry experience literature by identifying 'knowledge about how to scale' both as a distinct capability that firms inherit, and as a necessary component of successful entrepreneurial teams in the early automobile industry (Eisenhardt and Schoonhoven, 1990; Klepper and Simons, 2000; Delmar and Shane, 2006; Beckman et al. 2007; Ganco and Agarwal, 2009; Klotz *et al.*, 2014).

My finding also suggests that the value of any specific pre-entry experience is context specific because certain inherited capabilities are more useful than others in certain contexts. (2) I contribute to the product life cycle literature by proposing that, in contrast to previous predictions, process innovations may be critical from a very early stage of the industry (Suarez and Utterback, 1995; Murmann and Frenken, 2006; Klepper, 1996; Cohen and Klepper, 1996). Product life cycle literature suggests that firm success depends initially on product innovation and subsequently on process innovation. However, my findings suggest that process innovations influence the design and viability of product innovations from a very early industry stage. Similarly, product life cycle literature also suggests that a firm's market share determines its R&D investments in process technologies. However, my findings suggest that process innovations are critical to gaining market share from a very early stage of the industry.

This is an abductive study that utilizes the historical explanation to initially generate the likely explanations, and subsequently to determine the loveliest explanation from among them. To justify scaling capability as the loveliest explanation, I use the tools offered by the historical explanation to uncover the complex nature of the scaling problem, the specific functional experience needed to overcome the posed challenge, and the range of actions the experience enabled the firm to undertake. By situating actors in their context and tracing the decision-making processes inside the firms, I use archival records to identify the manufacturing challenges firms faced, the specific skills that were inherited from a metal factory, why metal factory experience enabled production capability in the automobile industry, and the mechanisms through which metal factory experience translated to production capabilities. Thus, I demonstrate the unique insights that strategic management can gain through the use of historical explanation in an abductive study.

I proceed as follows: I describe the literature's view on the challenges that firms face while attempting to scale in section 2. I add specificity to the discussion in section 3 by describing the challenges that firms in the early automobile industry had to overcome while trying to scale production. In section 4 I describe why metal factory experience was relevant to the early industry stage auto firms. I describe the data used for multivariate analysis in section 5, present the statistical findings in section 6, and consider alternate explanations in section 7. In section 8 the implications of these findings for the pre-entry capabilities and product lifecycle literature are discussed. In section 9, I describe the critical role contextual richness plays in revealing the insights presented in the paper and propose future directions. In section 10 I discuss the findings and in section 11, conclude.

2. Scaling

The antecedents and consequences of scaling have received limited attention from management scholars. Scaling refers to the process through which firms modify their existing routines to synchronize their internal organization of work with their escalated production goals (Nelson and Winter, 1982; De Santola and Gulati, 2017). While a variety of factors such as design and engineering excellence, marketing capabilities, or financial management skills could explain the observed heterogeneity of performance in the early automobile industry, contemporaneous industry records including books, letters, company records, newspaper articles, and trade magazines consistently reveal scaling as a critical and challenging problem. I focus on the specific challenges associated with scaling, the capabilities needed to overcome these impediments, and the resulting performance advantage.

Firms create competitive advantage by achieving production scale economies (Klepper, 1996). Scale allows firms to generate efficiencies through the effective utilization of

equipment, employee specialization, experiential learning, quicker payback on investment, and reduction of overhead costs per unit (Dobrev and Carroll, 2003). It permits greater access to complementary technologies and resources such as finance and marketing capabilities (Cohen, 1995; Dussauge et al., 2004). It permits greater and more diverse experimentation to facilitate more complex problem solving (Macher and Boerner, 2006). Scale also creates a barrier to competition. As noted by Knudsen, Levinthal, and Winter (2014; 1581), "even in the absence of economies of scale, an established firm operating at significant scale benefits from an advantage over potential and actual entrants ... [because, scale] shields off a small set of firms from the competitive force of continuing entry, even when new firms enter with a potentially superior cost value, or business model." However, the resource-based view suggests that scale is a firm-specific asset with heterogeneous slopes in the size-efficiency relationship rather than a shared asset that acts as a barrier to entry to protect all incumbents. (Madok, 1999).

However, scaling is a challenging process. Scaling requires significant changes to the firm's strategic commitment such that the ineffectiveness of these changes will prove costly for the firm. Scaling requires an expanded scope of activities. Merely engaging on the same set of activities, but with more personnel, limits the firm's scaling capacity. Rather than replicating or extending an existing set of routines, scaling requires disruptive changes that result in the development of new routines and removal of existing routines (Nelson and Winter, 1982: 119; Mishina et al., 2004). Scaling requires firms to make the tradeoff between duplicating previously successful template versus encouraging local variation, better ways of thinking, experimentation, and customization (Sutton and Rao, 2014). Firms need to modify their internal organizational design by transitioning from an informal/fluid structure to one with clearly formalized functional roles that allow firms to divide complex tasks and manage the complexities and interdependencies of scaling (DeSantola and Gulati, 2017).

Scaling imposes significant adjustment frictions on the firm which makes it difficult for them to engage in the restructuring that is needed to meet the demand or productivity shocks (Pozzi and Schivardi, 2016). Firms often find it difficult to maintain operational efficiency while developing relevant knowledge in the new capacity, resulting in a transition period with heightened costs and efficiency losses (Winter and Szulanski, 2001; Knudsen et al., 2014). While scaling, firms often face adjustment costs arising from "error-prone transmission, or replication, of firm-specific knowledge, amplified by organizational interdependencies and organizational diseconomies of scale adjustment (Knudsen et al., 2014: 1571)." Moreover, the capabilities that make a firm successful may not be scale-free, i.e., the value of the capabilities may be reduced due to the magnitude of firm operations over which they are applied (Levinthal and Wu, 2010). There are also limits to how much firms can scale within a specific period (Penrose, 1959) and the returns to scale need not be continually increasing.

3. Scaling in the early American automobile industry

The automobile industry in the United States was born in 1895 and faced a turbulent early phase till the emergence of the all steel closed body dominant design in 1923 (For a brief history and industry patterns see Klepper, 2007). The rapid growth of the auto industry mirrored the economic realities of the time. During this period the US population almost doubled from 63.5 million in 1890 to 107 million in 1920, and the US national income almost tripled from 23 billion on 1890 to 65 billion in 1917 (Friday 1918; US Census, 1960). The rapid development of a vast domestic market that had an ever-increasing appetite for improving living standards implied that manufacturers of the latest attractive technological advancements like the automobile could scale, but had to do so quickly.

The organizational factors which affected scaling were critical from the early stages of the automobile industry.[6] Unlike the popular belief that scaling became indispensable only after the emergence of Ford's moving assembly line in 1914 and the subsequent production success of the Model T, historical records suggest that scaling was critical from the onset of this industry. Olds Motor Works captured the market through its mass-produced Curvedash as early as 1901 (Flink, 1990). Historian George May noted that even "by 1903, automobile concerns on both sides of the Atlantic had been faced with the necessity of altering and streamlining their manufacturing techniques in order to achieve large-scale production (1975: 137)."

Prominent Detroit banker Eugene Lewis, writing shortly after World War II, observed that the "making of cars and component units were all new with few precedents to follow (1947: 189)." Scale production of the automobile was perhaps the most challenging endeavor undertaken by the industrial society at the time. Previously mass-produced technologies, the Springfield Armoury Musket with ~45 parts (Woodbury, 1960) and the Singer Sewing Machine with ~300 parts (Brandon, 1977), were significantly simpler products than the automobile with ~5000 parts (McCalley, 1994).[7] Moreover, automobile manufacturing required a fundamental shift in the attitudes of the individuals. As noted by the president of the Newark Gear cutting Machine co., "[i]n the general industrial field, machinery is designed relatively heavy—up to the point of clumsiness. Considering the automobile as a machine, it

[6] I gathered information about the industry from the archives housed at the leading American automotive history collections such as the Benson Ford Research Centre, the National Automotive History Collection at the Detroit Public Library, the Western Reserve Historical Society, and the Bentley Library. I used newspapers, letters, gazette publications, phone directories, firm records, automotive histories, autobiographies, social directories, and trade magazines to explore the context.

[7] Refers to the number of parts in Ford Model T, often considered to be one of the simplest vehicles from the era.

is designed relatively light—down to the breaking point—and yet is surprisingly efficient and lasting. (Eberhardt, 1921)."

From a very early stage, technical and design innovation was a necessary but not sufficient condition for firm success because they could be easily imitated, licensed or purchased (Klepper and Simons, 1997). Production scaling gave firms in the automobile industry "an advantage in R&D because of the larger output over which they can apply the results … (with the advantage) particularly pronounced for process relative to product R&D (Cohen and Klepper, 1996: 241)." From a demand perspective, efficient production processes gave consumers confidence in the quality of the firm. In her study of early automobile advertising, Pamela Laird notes that to reassure buyers and build confidence, automobile manufacturers, especially middle-class automobile manufacturers, included facts and figures about how quantity production reduced costs (Laird, 1996). Manufacturing was so integral to the identities of firms that they even advertised about their production prowess. For example, Chalmers Motor Car Co., in 1912 claimed, "We build our motors, transmissions, axles, self-starter, steering gear, and other im-portant parts. We cut our own gears; heat- treat our steels. We even have our own foundry… No motor car factory is more completely equipped with new machinery (Chalmers, 1912)."

Unpredictability associated with unspecified customer preferences made scaling particularly challenging in the early automobile industry. This uncertainty often prevented firms from making either long-term commitments toward any particular strategic direction or product specific investments during the early stages of this industry. When scaling needs did become evident, firms needed to scale quickly to satisfy the demand. During this stage, entrepreneurs often faced with what Gans et al. (2016), have called the paradox of entrepreneurship in their theory of entrepreneurial strategy. Entrepreneurs had N versions of

the product that appeared equally viable. However, whether they can scale a version or whether the scaled version of a product would be successful was uncertain. To overcome this uncertainty, they had to experiment and make strategic commitments towards scaling each version. However, making the strategic commitment towards one version often precluded them from pursuing others due to their limited resources.

Scaling was an iterative process rather than a one-time commitment. Firms needed to stage and efficiently manage their scaling to match predicted demand while ensuring that resources are available to make further updates to the strategy. Since entrepreneurs often overestimated the potential of their ideas (Cassar, 2010), they engaged in over investment rather than staging their scaling process. As noted by Benjamin Briscoe in 1908, firms had to "risk ploughing most of its profits back into improved plant and equipment...and manufacturing gamblers 'plunged' unduly large amounts of capital in light of existing technological uncertainties (Flink, 1970:309)." When early-stage manufacturing firms failed to manage the scaling process efficiently, it resulted in excess capacity, surplus raw materials, and costly long-term fixed contracts. How much resources to spend on building capacity at each stage, and its timing, were complex decisions. Moreover, innovations create technical imbalances between interdependent components, machines, and processes (Rosenberg, 1969). Due to the complexity of the automobile technology and its manufacturing process, resolution of these imbalances required sequencing through multiple iterations.

Firms that successfully scaled had to make substantial organizational architecture changes and orient their entire organization towards building and selling vehicles to large populations. In such firms, top management teams, whose attention has been suggested to have implications for firm actions (Cho and Hambrick, 2006), paid careful attention to the scaling capabilities. For example, surviving meeting minutes from Studebaker's 1915

committee meetings indicate that the management team members "were consciously thinking about productivity improvements in their auto plants, [such as] implementing progressive assembly and otherwise minimizing employees' excuses for wandering around the plant, attempting to plan plant workloads farther in advance, and introducing conveyor belts (Raff,1991:727)." The automobile does not merely present a design problem, but also a manufacturing problem. As noted by early automobile industry pioneer Walter Flanders, "[t]he engineering problem thus becomes one of operation sequence, support for the work, tool design, and — in some cases—design of the work itself (1921: 532)." Early manufacturers simultaneously engaged in process innovation and product innovation because efficient designs were essential to high-quality manufacturing. As noted in the Mechanical Engineering journal, "the difficulty of maintaining accuracy increases in geometric ratio with each added accurate dimension on the same piece (Chester, 1921)." For example, the article continues to state that, the 'percent estimated increase in the ratio of cost per operation' was expected to rise from 30% for 2 dimensions to 500% for 6 dimensions on one piece (Chester, 1921).

4. Significance of pre-entry metal factory experience

Transitioning from prototype construction to scale production of the automobile required an intimate understanding of how a factory operated. Specifically, it required an in-depth understanding of iron and copper manufacturing, knowledge about the use of precision tools, and the management of challenges associated with a large workforce. While the automotive technology was new, the processes used to manufacture the technology was initially an extension of what other metal-use heavy industries were using. For workers, "the shift from carriage or machine shops to auto shops involved little noticeable changes (Peterson, 1987: 105)." Founding team members who were involved in the daily factory operations of mining

firms, foundries, tool and die makers, manufacturers of boats, railway carriages, engines, firearms, sewing-machines, roller skates, kerosene lamps, machine tools such as lathes and drill presses, phonographs, bicycles and other metal consumables gained unique production management knowledge that were valuable in the early automobile industry.

Rosenberg's (1963) theory of technological convergence, suggests that in the early 1900's metalworking employed similar skills, techniques, and facilities for production of a wide range of products.[8] Due to this technological convergence, solutions to technological problems developed in other industries where metalworking skills mattered, could be rapidly transmitted into the automobile industry. On the manufacturing of automobiles, Rosenberg notes,

> "The problems of large-scale automobile production involved the extension to a new product of skills and machines not fundamentally different from those which had already been developed for such products as bicycles and sewing machines. Underlying the discontinuity of product innovation, then, were significant continuities with respect to productive processes. The transition to automobile production for the American economy after 1900 was therefore relatively easy, because the basic skills and knowledge required to produce the automobile did not themselves have to be 'produced' but merely transferred from existing uses to new ones (1963: 437)."

Historians note that the most important factors that contributed to mass production were advances in the production of metals, development of machine tools, usage of precision instruments, and efficient methods of generating power (Williamson, 1967: 679). Metal factory employment provided founders experience with all these aspects that we so critical to the scaling of manufacturing. Thus, I suggest that metal factory employment serves as a proxy to measure the tacit manufacturing capabilities that early industry stage automobile firms needed to scale.

[8] Describing technological convergence Rosenberg (1963) states, "[P]rocesses and problems became common to the production of a wide range of disparate commodities that industries which were apparently unrelated from the point of view of the nature and uses of the final product became very closely related (technologically convergent) on a technological basis-for example, firearms, sewing machines, and bicycles. (:423)"

Founders with metal factory experience were better equipped to manage the complex task of making an automobile due to the similarities between automobile plants and metal product manufacturing. Much like other metal factories, auto manufacturing in the early stages had four basic steps: foundry work, machining, body making, and final assembly (Rubenstein, 2001; 121). Foundry workers, using their expertise in the preparation and wielding of molten metal, produced the castings designed by the engineering staff. These castings were then used to fabricate the individual parts. Machinists used metal-cutting tools to grind, drill, and buff rough castings and forgings into precision parts. Different parts were subsequently assembled into components such as an engine. Eventually, the various parts and components were assembled to produce the motor vehicle (Meyer, 1981; 11). These steps used a variety of tools such as milling machines, lathes, screw machines, surface grinders, drill presses, boring machines, spindle drills, horizontal millers tooth cutters, metal sheet presses, soldering irons, gas furnace and pneumatic hammers that were similar to metal product manufacturing.

Substantial re-design of models, which, as suggested by Pillai et al., (2018), happened annually from a very early stage, imposed expensive re-tooling requirements on the firms. The pace of technological change was so fast in the industry that "the rapid advance in engineering, design and mechanics rendered models a year old obsolete (Doolittle, 1916: 416)." As noted by industry observers at the time, "standard [manufacturing] practice predicates [the need for] machine tools, jigs, dies and templates to carry out manufacturing and a minor change or two in specifications wrecks the whole idea (Doolittle, 1916: 228)." For example, in 1911, General Motors wanted to adopt "a bevel- gear type differential of a new design which would replace the gear company's goods in Buick, Cadillac, Olds, Oakland, and probably other cars as well. To produce the new gear meant retooling at an expense of at least a half-million dollars (Pound, 1934: 485)." Similarly, before launching their new car in 1914, The Dodge Brothers

Company had to spend half a million dollars retooling their factory (Hyde, 1996). Thus, the factory transitions resulting from the model changes warranted expertise that was predominantly gained through re-tooling experience from metal factories.

Metal factory experience gave founders knowledge about operational challenges associated with scaling and how to overcome them. It allowed them to gain efficiencies through improved processes and tools. For example, Walter Flanders, who had previously worked for multiple metal tool manufacturing factories (Glasscock, 1937; 118), was able to increase the production at the Ford factory in 1906 from twenty to one hundred and fifty cars a day merely by rearranging the existing equipment. Through improved tools designed by their manager who had previous tool-and-die experience, Cadillac was able to reduce the time required for a process by one-tenth in 1905 (*Detroit News*, June 17, 1923), and Ford was able to reduce the amount of time it took to make a fly-wheel from 18 minutes to 1 minute (McNeill, 2002). Edward Budd at Hupmobile, who had previously worked for Symara Iron Works, was able to reduce the time it took to paint vehicles from weeks to just one day (Nieuwenhuis and Wells, 2007). He achieved this by replacing flammable materials with newly designed metal components and subsequently baking on the enamel and various coatings of paint and varnish (Palmer, 1913). The adoption of Vanadium Steel after a two-year development process, which provided three times the tensile strength at much-reduced weights, was crucial to designing and manufacturing durable vehicles at a higher rate (Ford, 1927). To improve efficiency through improved accuracy, rather than guessing temperatures from the color of the metal surface, firms with metal factory expertise introduced pyrometers to give precise readings of treating temperatures (Gartman, 1986: 64). Thus, metal factory experience allowed firms to scale production by engaging in the advanced metallurgy needed

to design new types of ingredients that reduced processing times, and by engaging in re-tooling /process improvements.

Metal factory experience of founders provided firms critical access to routines. While scaling requires modification of existing routines, in early-stage industries where there may be a limited number of routines under existence, which routines to follow is often unclear. Even though routines from other industries could be imported to the auto industry, its fit and its ability to contribute towards scaling were unclear in the absence of functional expertise that metal factory experience provided. Since scaling required management of growing geographical footprint, a growing number of employees/consumers/investors, physical assets, an increased amount of financial transactions etc., early-stage firms struggled when effective routines were absent. Often, only when they attempted to scale did many firms realize that transitioning from *batch* production, to *scale* production, at the brisk rate demanded by the industry at the time was not a trivial process.

Examining the type of jobs that happened inside the automobile factory gives an indication of the significance of metal factory experience. For example, towards the end of the observation period, in 1917, a "count of occupations and trades at the Ford Motor Co. found machine hands to be by far the largest groups, comprising 32% of those employed. The next single largest category, about 10%, comprises assemblers (Peterson, 1987: 37)." Considering that towards the end of the observation period the automobile firms were complex organizations with a variety of different task requirements, one may assume that the percentage of machine labor within each firm was even higher during the earlier phases of the industry.

4.1 Tools

One of the most critical knowledge that metal factory experience provided founders is that of machine tools that were indispensable to manufacturing. As noted by the Society of Mechanical Engineers, since automobile manufacturing required continuous production, "it demands and employs every last possibility in cutting qualities of steel, power and accuracy in machines; and particularly in skill in the design of fixtures, tool outfits, and methods of machining (Flanders, 1921: 532)." The auto industry did not merely restrict itself to the use of existing tools; rather it experimented and was even the source of major innovations in the machine tool industry. For example, the President of Toledo Machine Shop Company noted that, "[t]he development of power presses, together with that of dies and special tools, has been so marked in the last twelve years, principally because of the demand for intricate stampings for the automobile trade, that it is believed a far greater advance has been made than at any other period in the history of the business (Hinde, 1921: 530)." Between 1903 and 1912, the automobile industry made a series of innovations in the machine tools it used such as the introduction of jigs and fixtures, compound machines, revolving fixtures, ganging of work, semi-automatic tools and finally, automatic tools (Gartman, 1933: 67). Relevant knowledge about the design and operation that metal factory experience provided was a necessary ingredient for firms to keep pace with such brisk changes.

Grinding tools provide an illustrative example of the significance of tools in the industry and the need for metal factory experience to effectively use them. Grinding tools removes unwanted metallic extensions to the thousandths of inches. Unlike other single-point (e.g., lathe, boring machine) or double-point (e.g., drill press) tools, the grinding machine used thousands of points simultaneously and continuously to smoothen surfaces and attain precision while making parts. It was particularly useful in automobile construction because the

alloys that auto industry used to produce strong, lightweight parts "presented difficult problems if machined before heat treatment and insoluble difficulties when hardened, unless techniques of grinding were employed (Woodbury, 1959; 121)."

Though this tool was incredibly useful, only the firms with prior metal factory experience recognized the need and effectiveness of this tool. As noted by the Scientific American, "[g]rinding is the most accurate operation in machining metal. Accuracy is economy - though not all makers seem to appreciate that fact. (January 16, 1909: 55)." Historians note that,

> "The cylinders of few moderate-priced cars are not finished by grinding, boring and reaming only being employed. Bored and reamed cylinders are not true as the pistons and rings, when assembled in the cylinders bear on minute metal ridges only. Approximately one- half the bearing surface cannot be utilized until 0.002 to 0.005-inch of the surface has been worn away and the space thus left between the piston rings and the cylinder walls permits the passage of gas and oil. Such cylinder blocks resulted in engine trouble after it has been used for a few months (Jacobs, 1922: 198)."

Firms with prior metal factory experience recognized the benefits offered by this tool and enabled efficient manufacturing of a variety of parts such as the following: (1) The construction of crankshaft, a critical component of the engine that converts the linear up and down motion of the pistons to rotational movement useful for wheel propulsion, required over five hours of processing (Colvin and Stanley, 1908). Usage grinding tools explicitly designed for crankshafts, the E.R. Thomas Motor Car Co. who had prior experience using grinding machines in bicycle manufacturing, reduced the processing time to fifteen minutes in 1905 - a practice eventually adopted by the entire industry (Woodbury, 1959). (2) Camshaft, a critical component of the engine that controls air and fuel inlet valves into the combustion chamber at specific times, were made using a long, time-consuming, and inaccurate method in which each component was manufactured separately. Firms that adopted grinding machines were able to manufacture the camshafts more precisely from a single piece of hardened alloy.

(3) Pistons rubbing against inaccurate engine cylinders resulted in metal fragments entering the lubrication system. However, it was of the utmost importance that the cylinder bores stood square with the bottom of the cylinder block (Jacobs, 1922). Grinding machines smoothened these surfaces accurately that permitted better engine operation. Thus, the efficient use of tools not only allowed higher quality production that translated to demand, they also reduced the time to produce and thereby enabled scaling.

5. Data

My sample consists of American firms that commercially sold automobiles from 1895-1918.[9] The data collected resides inpaper archives at the leading automotive history collections such as the Benson Ford Research Centre, the National Automotive History Museum, the Western Reserve Historical Society, and the Bentley Library. Due to the magnitude of the data collection effort, the analysis uses information about firms based in Michigan (148 firms), New York (110 firms), Ohio (99 firms), Illinois (91 firms), Indiana (79 firms), and Massachusetts (58 firms). These states were the leading locations of auto producers during the early stage that extended until the emergence of the dominant design and together they represent 585 firms or 70% of the industry.

Using the Standard Catalogue of American Cars, I identified all firms that attempted production and their entry/exit dates, the city of operation, spinoff status, and parent name. Firms who produced experimental prototypes that never commenced production are not part of the dataset. I used gazette publications, phone directories, firm records, automotive

[9] Following the U.S. entry into World War I, the War Industries Board put resource consumption restrictions on the industry starting 1919 (Motor Travel, 1918). Due to fundamental changes that happened in the industry because of these restrictions, such as cancellation of auto shows and firms delaying the release of new models, the observation period ends at 1918.

histories, autobiographies, social directories, and trade magazine announcements to identify the founding team members, and their experience before industry entry. To distinguish firms based on the operational expertise of the founders, I have also collected pre-entry work experience and subsequent auto industry work roles of founding team members based on their job titles. For example, the data allows me to distinguish between a wealthy hobbyist startup and a startup initiated by machinists who had experience manufacturing, or between investor led spinoff and a factory manager lead spinoff. An individual is assumed to have been involved in the operations of a metal factory if he served as the CEO, Vice President, or General Manager of a firm that produces metallic products. Individuals who served as board member, treasurer, secretary, chief designer, or in any other capacity that was unable to influence the production process directly were not considered to have metal factory experience.

Further, to measure scaling capacity, I used production quantity figures from the Raff-Trajtenberg (1997) dataset.[10] This dataset contains production information for all firms that entered the New York auto show between 1901 and 1918. The New York auto show, organized by the Automobile Club of America, was the marquee event where the public witnessed what the industry had to offer and the premier launch pad for new models (Flink, 1988: 25; Smith, 1968: 49). Annual production information during the observation period was obtained for 456 firms out of 585 firms in the dataset.

[10] As described in Goldfarb, Zavyalova and Pillai (2018), the Raff-Trajtenberg dataset "is based upon numbers reported in the Standard Catalogue and other sources for leading firms. While production numbers for leading firms are well known (Smith, 1968), the information for smaller firms is spotty. Sometimes only the total quantity the firm ever produced is known, but how those quantities are distributed across years is not. At other times, even this number is not known with certainty. In the former case, we assumed a distribution with a single production quantity peak and distributed the known total across the years of known activity. In the latter case, the same technique was applied, but to a "guesstimated" number based on the qualitative description in the Standard Catalogue. While we acknowledge that this implies a lack of precision, to our knowledge, this is the most comprehensive database of production quantities from the period (:2352)."

I identify firms with metal factory expertise in founding teams and statistically test their survival and scaling advantage. The dependent variable *Failure* is used to test the survival advantage using the Cox hazard model in Models 1-5. Each row in the dataset analyzing Models 1-5 represents a single year that the firm was active. *Failure* is a dummy variable that is set to 1 the year before firm failure. In Model 6 the dependent variable, *Average Annual Change in Production,* which represents the scaling capability of the firm, is measured by first calculating the annual change in production (Production in year t MINUS Production in year t-1) and then averaging it across the life of the firm during the observation period. Each row in the dataset used for Model 6 represents a single firm.[11] Negative *Average Annual Change in Production* implies that on average the firm shrank. Since the automobile industry has historically been funded by pre-orders (Flink, 1970), a negative change in production suggests either that the firms' production capability withered away or that it experienced reduced demand. During a period in which the initial demand was mostly the outcome of a good quality prototype, a reduction in previously existing demand implies that the firms were unable to do justice to the prototype in the manufacturing process. Thus, I suggest that Negative *Average Annual Change in Production* is representative of diminished scaling capabilities.

The results account for the following control variables that have been suggested to influence the outcomes in this industry by prior literature (Klepper, 2007): *Detroit* representing a firm's presence in Detroit, *Spinoff* representing whether at least one founding team member worked for another auto manufacturer prior to entry, and *Firm's Parent Top Ten Manufacturer* representing whether the parent firm was among the top ten producers the year before spinoff

[11] Due to the extremely unusual and historic production success that Ford Motor Co. experienced during the period, it was not included in Model 6. However the results are robust to its inclusion.

birth. To control for entry timing, I group the firms into three cohorts: *Cohort 1*(entry before 1905), *Cohort 2* (entry from 1905 to 1909), and *Cohort 3* (entry from 1910 to 1918).

6. Results

6.1 Descriptive statistics

In Table 1, which presents the descriptive statistics for the 2416 Firm-Year dataset used for analysis in Models 1-5, the key outcome variable is *Failure*. Similarly, in Table 2, which describes the 456-firm dataset used for analysis in Model 6, the key outcome variable is *Avg. Annual Change in Production*. As predicted by prior literature, not only are *Detroit* (correlation coefficient = -0.04), *Spinoff* (-0.07), and *Firm's Parent Top Ten Manufacturer* (-0.09) negatively correlated with failure (i.e. positively correlated to survival), but earlier entrants (*Cohort 1*: -0.1) also have a higher probability of survival than later entrants (*Cohort 2*: 0.04 and *Cohort 3*: 0.07). Similarly, *Detroit* (-0.17), *Spinoff* (-0.18), *Firm's Parent Top Ten Manufacturer* (-0.25), and *Cohort 1* (0.03) displays an increased ability to scale. The high mean value of *Cohort 1* in Table 1 indicates the higher entry during the earlier period and a higher probability of survival

It should be noted that *Cohort 3* entrants (0.01) are also capable of scaling and that *Cohort 1* entrants do not appear to have an advantage over them. I suggest that during the 1910-1918 period the ability to scale was the most focused capability in the industry due to the success of the Model T. As a result, the correlation is an outcome of the fact that firms that were capable of scaling were more likely to enter during this period. Relative to other explanatory variables, *Metal Factory Experience* is more correlated to survival (-0.18) and scaling capabilities (0.30). Of the 585 firms in the dataset used to analyze Models 1-5, 112 were spinoffs, 139 firms had founders with metal factory experience, and 61 firms were spinoffs with metal factory experience. Off the 456 firms with production information that is used to

analyze Model 6, 86 firms were spinoffs, 96 firms had founders with metal factory experience, and 43 firms were spinoffs with metal factory experience.

6.2 Survival analysis

Models 1-5 in Table 3 presents the results of the Cox Hazard models (Stata function: stcox) with *Failure* as the dependent variable. In this model, if the 95% confidence interval is below 1, that independent variable contributes to a higher probability of survival (or lower failure hazard). Model 1-4 replicates the findings from Klepper (2007). Model 1 suggests that relative to later entrants (Cohorts 2 and 3), earlier entrants (Cohort 1) have a higher probability of survival. Model 2 suggests that relative to firms located elsewhere, those based in *Detroit* had lower failure hazards (95% CI: [0.56,0.95]). Model 3 suggests that being a *Spinoff* (95% CI: [0.48, 0.81]) is a better predictor of survival. Model 4 suggests that when parent performance is considered, the survival advantage of *Detroit* (95% CI: [0.69, 1.20]) and *Spinoffs* diminish (95% CI: [0.56, 1.02]). It also suggests that spinoffs from better performing parents had a higher probability of survival (95% CI: [0.32, 0.90]). Model 5, suggests that controlling for all the other variables, *Metal Factory Experience* resulted in lower hazards of failure for the firm (95% CI: [0.44, 0.74]). It also suggests that the predictive power of *Detroit, Spinoffs, Parent Top Ten Manufacturer* significantly diminished when metal factory experience is considered.

The Kaplan Meier survival curves (Stata function: sts graph) presented in figure 1 indicates that, while 29% (=39 firms that survived /134 firms in the risk set) of the firms with metal factory experience survived for at least 10 years, only 7% (=31/451) of the firms without metal working knowledge survived the same period. Because the status of the firm as a spinoff may be the leading alternative explanation for survival, figure 2 presents the Kaplan Meier curves that further breaks down the firms by their spinoff status. The risk table presented in

figure 2 suggests that while 35% (=26/74) of the non-spinoff firms with metal factory experience (labeled as *metal =1 / spinoff =0*) survived 10 years, only 8% of spinoff firms without metal factory experience survived (*metal =0 / spinoff =1*). Thus, the Cox Hazard models and the Kaplan Meier survival curves suggest that prior experience at metal factories was a better predictor of survival than the alternative explanations proposed by prior literature.

6.3 Effect on annual production capacity

Due to the modal nature of the production data, i.e. the significant heterogeneity in the number of vehicles produced by firms with some producing less than 100 annually and some producing thousands annually, a quantile regression is used to estimate effects (Stata function: qreg). This type of regression is more robust to the effects of outliers. With a binary predictor, the coefficient of a quantile regression is the difference in medians between groups coded 0 and 1. Model 6 suggests that, relative to the median firm without metal factory experience, the median firm with metal factory experience increased their production annually by an additional 71 vehicles. Since the other possible binary explanatory variables include 0 in their 95% confidence intervals, the difference in the median between groups of 0 and 1 are indistinguishable, i.e., other firm attributes have not offered a production advantage when metal factory experience is considered. Thus, metal factory experience has a positive and significant impact on the scaling capabilities of firms.

7. Likely explanations considered

I acknowledge that scaling may not be the only capability that matters. However, any such alternate explanation needs to align with the uncovered historical evidence. For example, to argue that failure was caused by weak final demand, an alternative explanation would need to account for the strong overall demand that characterized the early automobile market. General

accounts suggest that the hype surrounding automobiles was so enormous that most firms with a functioning automobile were able to gain initial orders. At the onset of the industry, automobile manufacturers demanded advance cash deposits of up to twenty percent from the dealers with the remainder paid entirely in cash upon delivery (Flink, 1970; 294). As noted by Roy Chapin, one of the founders of the Hudson Motor Car Company, "[d]ealers' deposits often paid half the sum necessary to bring out a full year's production (Seltzer, 1928:21)." At the same time, auto manufacturers paid their suppliers only after the manufacturer completed the production and delivered the vehicle. This arrangement of cash advances and delayed supplier payments allowed the early entrants to remain solvent despite having only minimal initial cash investments (Goldfarb et al., 2012). Thus, in its earlier stages, the industry was mostly funded by customers and suppliers. The existence of the company at least for a year indicated that they had initial orders; the ability to full fill those orders, however, was heterogeneous.

It is possible that better quality ideas could be the ones that performed well and attracted the relevant expertise. For example, firms that wanted to engage in high volume production may have sought specific types of talent. However, if production expertise was a critical capability, we should also see limited discussions in archival sources about the importance of other capabilities, greater percentage of survivors to have production expertise in their founding teams by the end of the observation period, and a greater ability for firms with production expertise to increase their capacities annually. I offer evidence supporting these outcomes through my historical and statistical analysis.[12]

[12] If production expertise was critical, I should also observe increased mobility among production experts due to market demand for this rare competency, higher probability of mobility for production experts from failed firms relative to other employees in the same firm, and a higher probability of failing firms with production capabilities being acquired instead of going bankrupt. I am in the process of empirically verifying

Perhaps not every firm wanted to scale. Firms that focused on customization, often the risk-averse firms that produced technology which solely strived to serve known consumer requirements, never engaged in mass production either because the burden of satisfying ever-changing customer demands prevented them from making the long-term investments needed to scale production, or because they preferred exclusivity. However, given the tremendous growth of the industry, firms remained exclusive even with a marginal increase in production. Any firm choosing to produce a fixed number of cars throughout their life is an outlier in this industry. Even firms attempting to focus on limited, high-status consumers should demonstrate a marginal annual growth in production capacity. An absence of such growth (as measured in Model 6), indicates an inability to scale rather than choice. Moreover, history suggests that many firms, such as Lozier Motor Car Co., that started by serving elite markets, were forced to continue to do so because they failed in their attempts to mass produce a lower-priced vehicle (Davis, 1988).

Achieving scale may also have negative consequences. Scale may result in diseconomies, i.e., "when information about a firm's capabilities is dispersed among the individuals in the firm, production is inefficient ... when people in a hierarchy exploit the bargaining power that their private information gives them (McAfee and McMillan, 1995: 400)." Scaling often requires codification and sharing of tacit knowledge within firms; however, codification may erode the competitive advantage since codification makes it easier for rival firms to acquire or imitate the knowledge (Lado and Zhang, 1998; Tsai, 2001; Rivkin 2001; Coff et al., 2006). The influx of new talent needed to achieve scale may threaten

these predictions from the data I already collected using statistical evidence and qualitative evidence from historical records.

organizational culture (Harrison and Carroll, 2006). However, the historical evidence does not indicate the existence of adverse consequences of scaling in this context.

8. Implications for theories of industry emergence

An in-depth exploration of the context has revealed that the ability to manage production scaling was a specific capability that founders inherited from their pre-entry experience operating a factory that depended upon knowledge of metalworking. The analysis suggests that this experience provided founders the ability to overcome production bottlenecks through efficient use of tools and streamlined processes. I use historical narratives to offer qualitative evidence of causality and demonstrate the practical use of historical methods at the boundary of traditional inference in the absence of a dispositive statistical test of causality. I use multivariate statistics to test that predictions hold true for the general population by demonstrating the survival advantage and the annual production advantage that metal factory experience conferred on firms. This observed impediment to growth and its solution, though embedded in the context, holds valuable lessons for the field of strategy literature.

While a number of theories have strived to explain firm outcomes during the early stages of an industry, my findings have implications, predominantly, for two theories: (a) the pre-entry experience literature that uses the evolutionary economics perspective and the new venture teams perspective. (Helfat and Lieberman, 2002; Klepper, 2002; Bayus and Agarwal, 2007; Beckman et al., 2007; Klotz et al., 2014); and (b) the product life cycle theory that uses the dominant design perspective and the R&D capacity perspective (Abernathy and Utterback, 1978; Suarez and Utterback, 1995; Christensen et al., 1998; Klepper, 1996; Cohen and Klepper, 1996; Murmann and Frenken, 2006; Suarez et al., 2015). Even though my findings are

necessarily less generalizable because it is based on a single industry study, the study uncovers propositions that may be tested in other contexts.

8.1 Pre-entry experience

Proposition 1: The value of founding team pre-entry experience depends on the specific capability that is inherited by the firm and the contextual relevance of that capability.

The relevance of metal factory experience in overcoming scaling issues is a context embedded finding that is not applicable to most other industrial contexts. However, the finding suggests that early industry stage firms face unique challenges to growth that may be specific to the context in which they operate in. It also suggests that the capabilities that firms need to overcome such a challenge may also be context specific. Not all pre-entry experiences are equally valuable; some endow capabilities that are more important than others (Chen and Thompson, 2015). As a result, for the literature to have predictive validity, it is critical to have a renewed focus on identifying specific, firm-level, pre-entry capabilities that matter, why this particular capability gives firms performance advantages, whether employees exploit their pre-entry knowledge, and which specific pre-entry functional experience permits learning and inheritance of these capabilities.

The literature on pre-entry experience from the evolutionary economics perspective has revealed its sustained impact on the choices and the performance of a firm (Evans and Leighton 1989; Brüderl et al., 1992; Gimeno et al., 1997; Sleeper 1998; Klepper and Simons 2000; Delmar and Shane 2006; Franco and Filson 2006; Ganco and Agarwal, 2009).[13]

[13] The rich literature on pre-entry experience suggests that firms inherit a variety of skills from their founders that subsequently affects their performance. Firms inherit human resource and employment blueprints (Baron and Hannan, 2002, 2005), technological and market knowhow (Agarwal et al., 2004), and non-technical knowledge related to regulatory strategy and marketing (Chatterji, 2009) from the prior experience of its founding team members. Pre-entry experience allows firms to overcome the liability of newness by providing access to capital (Gompers et al., 2006), and by signaling trustworthiness (Eisenhardt and Schoonhoven,

However, in a variety of contexts, studies have offered "conflicting empirical evidence regarding the main effect of pre-entry experience on performance (Ganco and Agarwal, 2009: 229)." Evolutionary economics studies have pointed to performance advantage of startups, diversifying entrants, and a convergence between them (for a detailed review, see Ganco and Agarwal, 2009). Diversifying entrants may have access to more resources and better integrative capabilities across firm boundaries; but often fail due to their structural inertia (Carroll et al., 1996; Klepper and Simons, 2000; Helfat and Campo-Rembado, 2016; Moeen, 2017). In contrast, startups may have fluid or organic structures and core competencies that better fit their competitive environment, but they may not be adept at the renewal and reconfiguration needed to transition to incumbency (Helfat and Raubitschek, 2000; Chen et al., 2012). The comparison of various measures of performance may further convolute the effect of pre-entry experience. For example, the finding that start-ups introduce product innovations at a higher rate than diversifying entrants but nonetheless also fail at a higher rate (Khessina, 2002; Carroll and Khessina, 2005) makes it difficult to decipher what the ideal strategy is.

Similarly, the new venture teams (NVT) literature, has also revealed the impact of founding team's prior experience on firm-level outcomes (Eisenhardt and Schoonhoven, 1990; Beckman 2006; Beckman et al., 2007; Chowdhury, 2005; Klotz et al., 2014).[14] Prior research has explored the impact of the founding team's characteristics on short-term outcomes and the effect of imprinting on long-term consequences. However, the new venture team literature "know[s] quite little about how and when NVTs influence[s] the [firm] performance (Klotz et

1996), reputation (Burton et al., 2002), legitimacy (Stuart et al., 1999), and technological relevance (Podolny and Stuart, 1995). It also allows businesses to overcome growth impediments (Chen et al., 2012) by providing companies the capacity to reposition and adapt (Eggers, 2014), by influencing the firm's ability to identify market opportunities (Gruber et al., 2013), and by increasing the likelihood of diversification (Wu, 2013). It facilitates survival even when companies lose early stage technology competition (Furr et al., 2018).

[14] The new venture teams' literature has characterized prior experience using factors such as company affiliation (Beckman, 2006), educational prestige (Lester et al., 2006), success (Nelson, 2003), and employment background (Amason et al., 2006).

al., 2014: 229)." This is due to its lack of focus on collecting primary data needed to understand team-level mediating and moderating mechanisms (For a detailed review, see Klotz et al., 2014). Moreover, these studies often offer uncertain predictions on the founding team composition. For example, the pre-entry experience could be more or less beneficial to firms depending on the characteristics of the founding team (Zheng et al., 2016). While diverse founding teams have access to a broader set of information that they use to enhance performance through explorative behavior (Beckman, 2006), homogeneous teams excel in execution speed and engage in exploitative behavior (Baum and Wally, 2003; Kor, 2003; Fern et al., 2012). Founding team characteristics such as alignment of functional experience with competitive strategy (McGee et al., 1995; Shrader and Siegel, 2007) and educational diversity (Foo et al., 2006; Amason et al., 2006) has also been suggested to have contradictory performance outcomes. Pre-entry activities could even have detrimental effects in dissimilar contexts since they create strong biases and overconfidence rooted in inadequate information (Mulotte et al., 2013).

Recognizing specific capabilities that matter may not only resolve some of the contradictions and partial explanations offered by the theories explaining performance in early industries, but also offer practical advice to entrepreneurs. For example, I suggest that the contradictory evidence offered in the pre-entry capabilities literature is due to a lack of focus on specific capabilities, and how their relevance changes as the industry evolve. Studies that identify specific pre-entry skills that matter, such as management skills (Dencker et al., 2009), engine manufacturing (Thompson, 2001), and financial management (Brinckmann et al., 2011), are rare. The literature uses prior employment to represent the presence of relevant skills. However, even though each employment opportunity provides individuals with a variety of skills, the literature rarely identifies which skills are relevant or how that skill translates to a

specific action that the firm engages in. Because the specific skills needed to succeed may be gained either from firms in the same industry or others, these skills could be spread across both startups and diversifying entrants.

From a new venture team perspective, identification of specific capabilities may help partially resolve the diversity vs. homogeneity debate. Having similar education or overlapping experience in a firm does not necessarily mean that the individuals possess the same skills. Focusing on specific capabilities rather than making assertions on capabilities based on team priors may better explain the performance difference between teams. It may also help the literature progress towards understanding why certain types of teams may be more useful than others at certain stages of the firm/industry, and understanding how specific team processes influence firm performance.

8.2 Product life cycle

Proposition 2: Process innovations, due to their influence on the firm's product choices and market size, are critical to the firm performance from the early stages of an industry.

Process innovation has been described as the "grubby and pedestrian side of the innovation process (Rosenberg, 1982)," as the "most primitive form of innovation (Tushman and Rosenkopf, 1992: 313)," and as "a second-order innovative activity, a rather dull and unchallenging cousin of the more glamorous product innovation (Reichstein and Salter, 2006: 653)." However, this study reveals that process innovation may be critical much earlier and may have a greater impact on the early stages of an industry than previously thought.

In the dominant design perspective of the product life cycle literature, firm success depends initially on their ability to uncover the dominant product design and subsequently on their ability to incorporate the dominant process design (For a detailed review, see Murmann

and Frenken, 2006). This model treats early industry stage product experimentation to be a stochastic process driven purely by exogenous technological factors. In this model, after the market converges to a single dominant design through a process of competitive elimination of products, firms shift from product to process innovation resulting in price competition. The literature characterizes process innovations as being merely consequential during that the mature stage price competition.

However, the early automobile industry suggests that production processes influenced product design choices. Firms that were adept at managing the scaling problem strived to design products in a manner that improved production efficiency. Production process innovations were critical for the organization because it biased the scope of the product innovations. Because 'how to produce' was a strong determinant of 'what to produce', firms were not merely competing on non-stochastic technology choices during the early stages of the industry. After all, "[d]ominant design is not a product, but a way of doing things which is manifested in a product (Lee et al., 1995: 6)." In this context, technical capabilities were necessary, yet insufficient for firm performance. By taking a selection perspective where survival is predicated on technology choice and timing of entry, the dominant design literature may have undermined the importance of process innovation.

Thus, even though the dominant design literature has described competitive advantage to be the "result of the fortunate combination of technological, economic and organizational factors (Suarez and Utterback, 1995; 416)," it has predominantly focused on the technological aspects. The technology focus of this literature fails to acknowledge that "[f]irms rarely fail because of an inability to master a new field of technology, but because they do not succeed in matching the firm's systems of coordination and control to the nature of the available technological opportunities (Pavitt, 1998: 433)." Moreover, the finding that process

innovation is important even during a period of intense product innovation conforms to studies that have described the process and product innovations to be complementary (Martinez-Ros, 2000; Damanpour et al., 2001; Reichstein and Salter, 2006).

In the R&D capacity perspective of product life cycle theory, firms create competitive advantage by achieving production scale economies. Venture costs depend solely on process R&D, and the firm's process R&D investments are proportional to its size. As a result, average unit costs and marginal profits vary based on the market share. As existing firms grow, the minimum viable scale also increases thereby making it harder for new firm entry. In this model, a standard product exists from the outset and the consumer choice depends solely on the market share. However, the importance of process innovations in overcoming scaling challenges encountered during the early automobile industry suggests that process innovations are essential to achieving market share. The assumption that market share precedes process innovation does not hold true in at least this context. Moreover, this model's assumption that a standard product exists from the outset undermines the key role process innovations play in determining the product.

9. Value of contextual richness in studies of industry emergence

The automobile industry is one of the most studied contexts in the field of strategy, with numerous scholars making many valuable findings. This study is able to generate unique novel insights despite the existence of a rich literature on the same industry because it engaged in an in-depth exploration of the industrial context. Recognition of the impediments to growth and the specific capability that firms needed to overcome this impediment require an intimate understanding of the underlying mechanisms that can only be gained from contextual knowledge. However, this study does not intend to criticize prior studies on the automobile industry. This study has been aided immensely by the valuable insights prior automobile

industry studies have offered. My study is able to extend work in this in part due to advances in digitization at the major automobile industry archives that provided access to records that were often unavailable to prior scholars.

Theories in strategy accurately derive many generalizable results that explain early-stage firm performance. However, they are often constrained in their ability to advise entrepreneurs on specific capabilities entrepreneurs need to have or specific actions they need to take. These theories often struggle to capture the difficult decisions entrepreneurs need to make when faced with the unpredictable demand fluctuations and the discontinuous technological changes that characterize early-stage industries. Indeed, during this stage, this uncertainty is often a higher threat to survival than either environmental complexity or munificence (Anderson and Tushman, 2001).

An outcome of these theories' lack of specificity is that, even though the lessons from these theories are valuable, the theories' ability to advise entrepreneurs may often be severely limited. For example, technology management literature's focus on an industry level ex-post analysis of factors that may have influenced the dominant design has come at the cost of exploring specific actions that firms may take ex-ante to influence the dominant design. This limits the theory's ability to offer entrepreneurs timely advice on when to enter, or what technology to pursue. Similarly, while it is evident that pre-entry capabilities matter, the theory faces limitations when offering insights to individuals on which capability they should focus on, when, and why. From a new venture team perspective, it struggles to conclusively advise entrepreneurs what the team characteristic should be, at what stage are some characteristics more important, and what effects are driven by the team as a unit or by individual members.

Thus, these theories are confronted with the 'postulate of commensurate complexity' whereby they are unable to simultaneously achieve generalizability, accuracy, and simplicity

(Thorngate, 1976). Indeed, they mostly trade the realism of context for generalizability to the population and measurement precision (Scandura and Williams, 2000). In practice, this often means that the studies focus on findings that can be applied to multiple industry contexts rather than embedded generalizations that are only applicable to a unique environment. However, partial analyses of complex phenomena render partial explanations that may be mutually inconsistent resulting in excessive truth claims and extreme assumptions for the sake of generalizability. This has diminished not only the impact of theory on practice but also the impact of business education on business outcomes of students (Leavitt, 1989; Hambrick, 1994; Mintzberg and Gosling, 2002; Donaldson, 2002; Pfeffer and Fong, 2002). At its worst, the partial explanations and ambiguous theories could even have adverse effects on good management practices (Ghoshal, 2005) – a concern amplified by the finding that 29% of the published results are non-replicable (Goldfarb and King, 2016).

Development of richer theories that incorporate the complexity of context, rather than simple reductionist prescriptions which consider premises as an underlying assumption, may serve to offer more valuable insights for practitioners. As noted by Oxley et al. (2010), "the single most important change the field should make to improve quality is to increase the level of specialization in strategy research (:378)." This requires scholars to invest in gaining in-depth contextual knowledge rather than merely engaging in a single industry study. Such rich contextual knowledge not only reveals how and why transformational changes occur, but also how often and how many actors undergo such changes. Deep knowledge about the environment also establishes the context in which to evaluate various revealed relations and helps scholars gauge the strength of the relations.

Further, I also propose the use of historical methods as a tool to engage in an in-depth exploration of a context. identify specific capabilities that matter and to identify how they

translate to firm actions. Historical methods can be described as "empirical research that uses remote sensing [as opposed to direct observation] and a contextualist [as opposed to reductionist] approach to explanation (Ingram et al., 2012: 249)." It refers to the use of systematic practices in analyzing and interpreting historical artifacts, documents, and images. Historical research often begins with historically significant phenomena rather than theoretically framed questions. (Lipartito, 2014). Instead of offering universal generalizations deciphered from dependent and independent variables relevant at a particular moment in time, historical reasoning provides embedded generalizations and theoretical claims within narratives by recognizing the interdependencies and evolving direction of causality between variables over time (Gaddis, 2002). Historical methods orient towards theory building rather than hypothesis testing, towards usage of small samples that are often limited by access rather than random sampling, and towards exploring phenomena to uncover unexpected results rather than measuring marginal effects or outcomes (Yates, 2014). Thus, historical inference views actions and actors as temporally situated and is bound by the limits of the context.

Moreover, the historical inference is well suited for the analysis of the operation of pre-entry capabilities in early-stage industries. It can be utilized as a source of exogenous variation that allows better causal inference, and as a source of legacies that enhances analyses of path dependence (Ingram et al., 2012). History can be particularly useful for this literature because it excels in areas where existing research methods have encountered difficulties. Because historical methods can take outliers seriously, historical inference often uncovers mechanisms at work during early industry stages that do not fit existing theoretical models (Bates, 1998; Hansen & Libecap, 2004; Silverman & Ingram, 2017). Historical methods allows application and development of theory to reveal the operation of transformative social processes, explains the form and origins of significant contemporary phenomena,

disambiguates among competing explanations, and thus contributes towards the study of the emergence of new industries (Forbes and Kirsch, 2011; Maclean et al., 2016).

10. Discussion

In this study, I suggest that firms whose founding team members had prior operational experience in a factory that produced metallic products were able to overcome production bottlenecks and thereby achieve scale. I restrict my focus to one crucial challenge that entrepreneurs faced in a single industry at a particular stage. I engage in a broad reading of the archives of the industry using historical methods to reveal the underlying characteristics of the challenge and the specific role metal factory experience played in enabling firms to overcome them. Thus, the findings are necessarily less general and embedded in the context of the study. However, I strive to offer a richer understanding of the challenge and the value of a specific experience.

This study focuses exclusively on the early stages of the industry. Prior industry emergence studies have often either grouped together earlier and later stages of an industry or focused exclusively on mature stages of an industry, thereby limiting our understanding of the mechanisms that are unique to the early stage. Due to the availability of fewer records from the earliest stages of an industry, archival sources used for these studies are not neutral with respect to outcomes. Researchers encounter information that has been retrospectively reordered to emphasize what is understood to be important *post hoc and may, therefore, miss important paths-not-taken and their implications for the industry as it did emerge* (Kirsch et al., 2014; Lipartito, 2014).[15] The combination of multi-stage grouping and retrospective sensemaking

[15] For example, in studies of automobile industry emergence, the 1899 US Census Bureau report which states that the number of gasoline cars sold trailed both steam and electric has been cited often to support a wide range of claims and counterclaims (Kirsch et al., 2014). However, the retrospective bias of these studies prevented them from noting that, in 1899, when the automobile industry was at its infancy, the census bureau

may result in misestimation or underestimation of the significance of certain early stage phenomena. By utilizing comprehensive knowledge of the early stage industry context, this study is able to offer insights that are minimally influences by the biases of the mature stage outcomes.

Few studies have identified specific pre-entry capabilities that matter and the specific actions they influence. This study contributes to this literature by identifying a specific pre-entry capability that contributed to performance advantage. I suggest that 'What experience matters?' is a relevant question that should be asked in other contexts. The capabilities needed to overcome bottlenecks to growth are expected to vary across contexts since the nature of the bottlenecks are also expected to vary. The literature on pre-entry capabilities needs to offer more specificity by identifying what knowledge is valuable, why, in what context, and from where firms inherit this knowledge. This knowledge could be particularly powerful for managers in contemporary contexts. Thus, the process of scaling needs to be studied at this level of specificity in *other* contexts to uncover the range of potential underlying mechanisms that limit and enable growth.

It should be noted that other studies have explored the importance of pre-entry capabilities in the automobile industry. Klepper (2007) suggests that spinoffs have lower hazards of exit than other startups due to the industry-specific knowledge they inherit, and that a parent firm's performance was a predictor of spinoff performance. Argyres and Mostafa (2016) suggest that, in the automobile industry, the strategic choice to vertically integrate key value chain activities enhanced survival duration and that the integration choices of the parent predicted those of the spinouts. Carroll et al. (1996) argue that diversifying entrants, and

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grouped together firms that sold vehicles and those that sold transportation services (Kirsch and Mom, 2002). As a result, scholars may have overestimated the significance of electric and steam vehicles to fit their respective theoretical narratives.

startups that spend time acquiring sufficient resources before entry had lower initial mortality rates. Supporting the longevity advantage offered by pre-entry capabilities, Hannan et al. (1998) suggest that even as firms aged, the mortality rates of diversifying entrants and spinoffs remained unaffected. Bigelow and Argyres (2008) suggest that pre-entry experience significantly affected make-buy choices in the automobile industry. Yet, these studies have not identified specific pre-entry capabilities/resources that firms inherit or how they translate to firm actions and how those firm actions result in a performance advantage. My study does, however, align with the results of Thompson (2001), who, in his study of the shipbuilding industry from 1824-1914, suggests that entrants with prior vessel construction or engine manufacturing experience survived longer than firms with unrelated foundry experience.

This study challenges key predictions of the product life cycle framework. Unlike the prediction that the firm's product innovations and market size precedes process innovations, this study suggests that process innovations are critical for firms from the early stages of an industry due to their influence of product innovations and market size. This study joins others, who in a variety of industry contexts, have challenged other predictions of the product life cycle theory. Studies on publicly traded US firms (McGahan and Silverman 2001), and industry-specific studies on the amateur camera (Windrum 2005), turboprop engine (Bonaccorsi and Giuri 2000), microelectronics (Filson 2001), personal computers (Filson 2002), and mobile phones (Giachetti and Marchi 2010) have suggested deviance from the predictions of the product life cycle framework. Future research can explore how and why process innovations are adopted, designed, and executed at the various stages of an industry, and how this may affect the evolutionary trajectory of industries.

The revealed significance of metal factory experience adds a further dimension to the rich management literature that has investigated how capable managers and the adoption of

managerial practices have a profound effect on the productivity of plants. The capabilities of strategic decision makers responsible for operating a factory have a lasting effect on the plant's ability to achieve scale, and subsequently, profits. As early as 1887, on the first volume of *Quarterly Journal of Economics*, describing the significance of efficient production, Francis Walker wrote: "surplus, in the case of any employer, represents that which he can produce over and above what an employer of the lowest industrial grade can produce with equal amounts of labor and capital. In other words, this surplus is of his own creation (274)." Innovative management practices have been associated with plant productivity (Ichniowski et al.,1997). Analyzing a sample of 1500 publicly traded US firms, Bertrand and Schoar (2003) found that there are significant manager fixed effects on performance. Examining the limited liability firms from Denmark, Bennedsen et al. (2007) discover that professional managers outperform managers with familial ties. In their field experiment with Indian textile plants, Bloom et al. (2013) show that the adoption of management practices raised productivity. Using survey results from German manufacturing plants, Bender et al. (2018) find that firms with better managers had a superior stock of employees. Braguinsky and Hounshell (2016) found that superior managerial talent of a single firm allowed it to make strategic decisions about technology that not only made it highly productive but also put the industry on a high growth trajectory. However, unlike this study, this literature has not examined the mechanisms for reaching scale economies under the uncertainties and constraints imposed on firms during an industry's earliest stages.

This study suffers from a number of potential limitations. (1) It assumes that resources and routines accessed by individuals in their prior experience can be successfully transferred and replicated in new contexts. However, some firm capabilities may be less decomposable and portable (Baldwin and Clark, 2002). (2) Except in the case of prior experience within the

automobile industry, this study does not consider the success of the prior firms in its analysis. It is possible that more successful prior employers had better knowledge to impart on its employees. As a result, we may expect heterogeneity in outcomes based on the quality of prior non-automobile industry employer of the founder. (3) The study does not consider hiring capabilities that may mediate the influence of founder's experience on firm outcomes. For example, during the early 1900's, hiring an effective foreman and having access to skilled labor may have had an impact on the execution capabilities of the founder. (4) The paper does not explore the role of inherited assets; it only considers inherited knowledge. Founders' ability to re-purpose assets such as tools, factory facilities, and employees from their prior businesses may reduce initial firm costs and thereby have an impact on firm outcomes. (5) While the study offers qualitative evidence that suggests the importance of process innovations, it does not measure process innovations. The study theorizes about the role of process innovations without statistically testing it. Ongoing data codification efforts are expected to offer quantitative and historical evidence that addresses these limitations.

11. Conclusion

This paper analyzes a specific stage of an industry that was of great economic importance using quantitative and historical methods to offer findings that may be tested in other contexts. This study suggests that the capabilities inherited from some pre-entry experiences are more important than others for firms to overcome growth bottlenecks. It also suggests that process innovations, due to their influence on product innovations and on scaling capabilities, may be critical from a very early stage of an industry. Thus, the study suggests that, if bottlenecks to growth exists in early stage industries, the capabilities needed to overcome those bottlenecks are context specific.

Further, the study also demonstrates that the historical explanation is an effective tool that scholars can use to infer to the best explanation in an abductive study. The quest for generalizability and statistical causality of relations in the Strategy literature has often led to inconsistent, ambiguous findings that are devoid of knowledge about the unique interdependencies that characterize each context. In contrast, this study demonstrates that historical explanation offers a more meaningful understanding of what the likely explanations are, and a systematic, scientifically rigorous method to determine the loveliest explanation from among them.

12. Tables and figures

Table 1: Chapter 3 variable correlations - all the firms in the sample

		Mean	1	2	3	4	5	6	7
1	Failure	0.20	1						
2	Metal Factory Experience	0.36	-0.18	1					
3	Spinoff	0.21	-0.07	0.28	1				
4	Detroit	0.17	-0.04	0.19	0.38	1			
5	Firm's Parent Top Ten Manufacturer	0.10	-0.09	0.27	0.63	0.42	1		
6	Cohort 1 (Entry before 1905)	0.40	-0.10	0.12	-0.21	-0.16	-0.12	1	
7	Cohort 2 (Entry from 1905 to 1909)	0.35	0.04	-0.05	0.11	0.05	0.08	-0.62	1
8	Cohort 3 (Entry from 1910 to 1918)	0.20	0.07	-0.08	0.12	0.12	0.04	-0.45	-0.42
N(Firm-Year) = 2416; # of Firms = 585; For all variables Min =0 and Max =1									

Table 2: Chapter 3 variable correlations – firms with known manufacturing data within the sample

		Mean	1	2	3	4	5	6	7
1	Avg. Annual Change in Production	118	1						
2	Metal Factory Experience	0.21	0.30	1					
3	Spinoff	0.19	0.18	0.37	1				
4	Detroit	0.16	0.17	0.19	0.28	1			
5	Firm's Parent Top Ten Manufacturer	0.07	0.25	0.31	0.56	0.19	1		
6	Cohort 1 (Entry before 1905)	0.26	0.03	0.04	-0.15	-0.10	-0.10	1	
7	Cohort 2 (Entry from 1905 to 1909)	0.39	-0.04	0.01	0.02	-0.02	0.04	-0.5	1
8	Cohort 3 (Entry from 1910 to 1918)	0.35	0.01	-0.04	0.12	0.11	0.05	-0.44	-0.58
N = 456 (# of Firms); For variable 1 Min = -3000 and Max = 5916; For variables 1-7 Min =0 and Max =1									

Table 3: Chapter 3 analysis results

	Model 1 – Cox DV: Failure	Model 2 – Cox DV: Failure	Model 3 - Cox DV: Failure	Model 4 - Cox DV: Failure	Model 5 - Cox DV: Failure	Model 6 – Quantile Reg. (0.5 percentile) DV: Avg. Ann. Prod. Chg.
Cohort 2 (Entry from 1905 to 1909)	1.31 [1.05, 1.64]	1.34 [1.07, 1.68]	1.42 [1.13, 1.78]	1.42 [1.14, 1.78]	1.33 [1.06, 1.67]	-1 [-26, 24]
Cohort 3 (Entry from 1910 to 1918)	1.43 [1.12, 1.83]	1.50 [1.10, 1.68]	1.60 [1.24, 2.05]	1.58 [1.23, 2.04]	1.50 [1.16, 1.92]	-1.1 [-25,25]
Detroit		0.73 [0.56, 0.95]	0.85 [0.64, 1.12]	0.92 [0.69, 1.20]	0.92 [0.70, 1.22]	0 [-29,29]
Spinoff			0.62 [0.48, 0.81]	0.75 [0.56, 1.02]	0.85 [0.64, 1.15]	4 [-28,36]
Firm's parent top 10 manufacturer				0.54 [0.32, 0.90]	0.64 [0.38, 1.08]	14 [-13, 41]
Metal factory experience					0.57 [0.44, 0.74]	71 [23, 118]
N (Firm-Year)	2416 (Firm-Years)	2416 (Firm-Years)	2416 (Firm-Years)	2416 (Firm-Years)	2416 (Firm-Years)	456 Firms
95% CI in	# of Firms = 585; # of Failures = 483					

Figure 1: Kaplan-Meier survival estimates (metal working only)

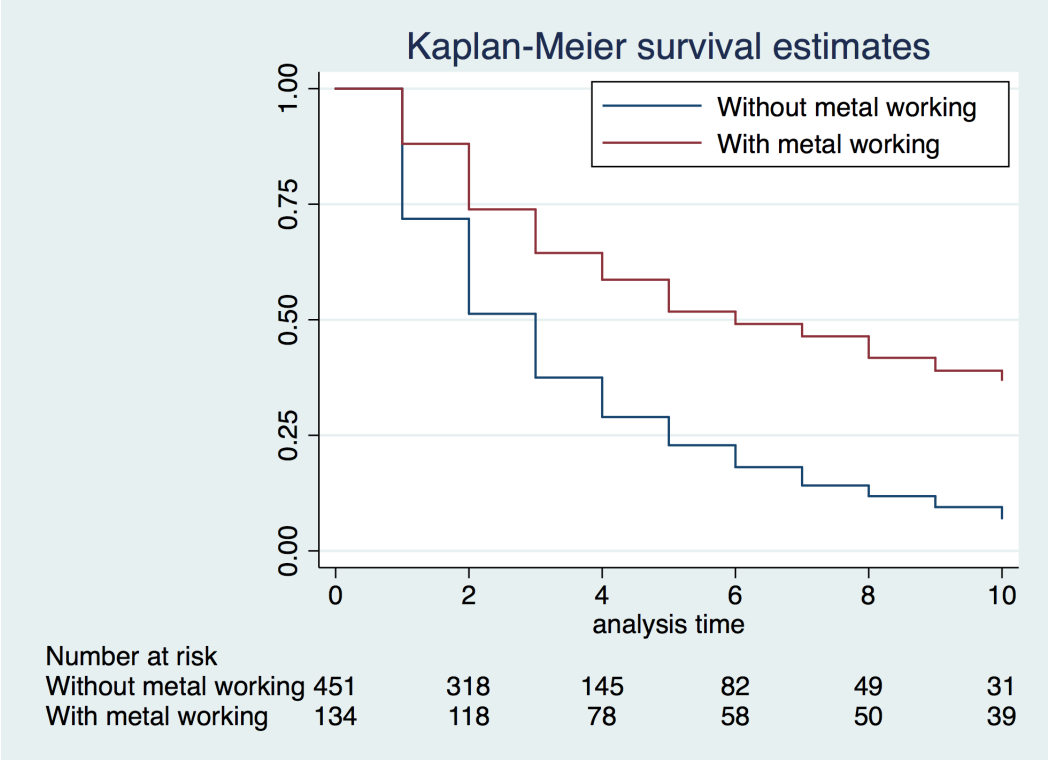
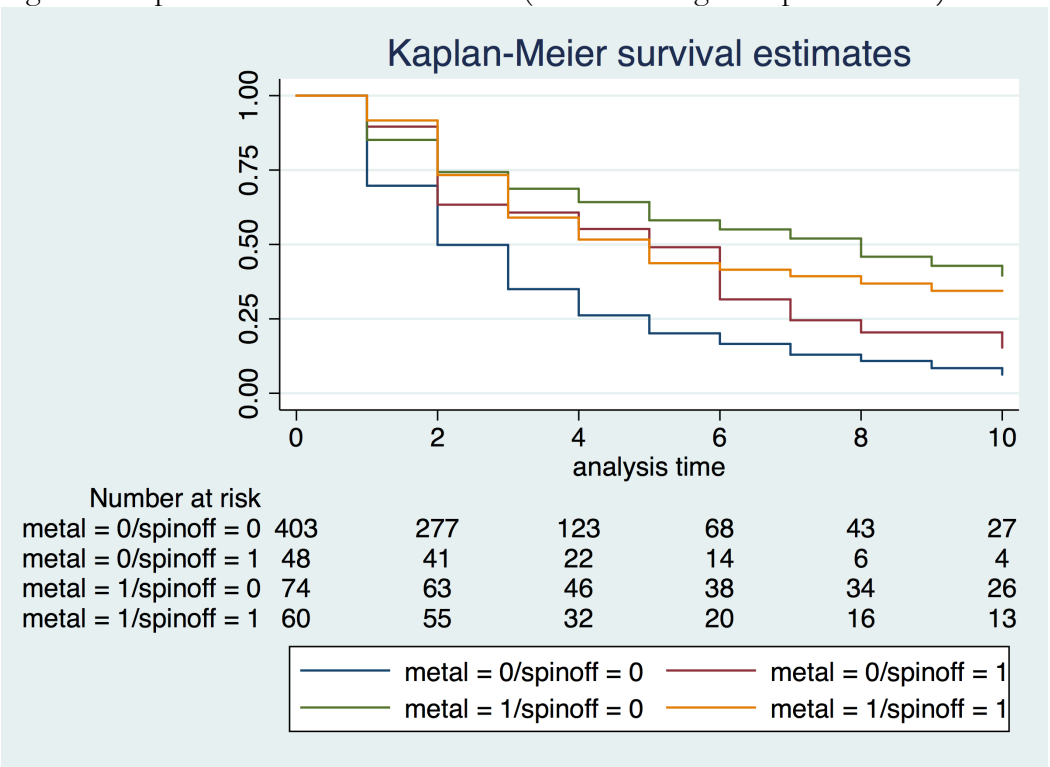


Figure 2: Kaplan-Meier survival estimates (metal working and spinoff status)



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