Open Secrecy and Social Capital in Technological Innovation: Managing Collective Secrecy in the Making of the Atomic Bomb

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June/July 2021

Innovation projects often involve the deployment of secrecy as a protectionary measure to prevent knowledge leakage. Research in sociology and anthropology has long emphasized that a core consequence of secrecy is the social structuring of groups of actors, creating boundaries between those in-the-know and those not. In the context of innovation, this translates to a tension between value creation through the social capital benefits of inclusion, and value appropriation through the security benefits of exclusion. I conduct an inductive, historical case study of the "Manhattan Project" to examine the successful management of inclusion-exclusion boundaries in secretive innovation. I find that the emergence of a grey area between knowledge concealing and revealing—open secrecy—fosters an in-between space for organizational members who are partially included into the in-group, yet neither fully included nor fully excluded. I define open secrecy as the intentional revelation of secret-related information between actors. Secret-related information can be of three kinds – information about the act of concealment, meta-information about the secret, and partial information about the secret. I argue that the in-between space fostered by open secrecy preserves the value-creation benefits of inclusion while safeguarding the value-appropriation benefits of exclusion.

One of the great scientific, military, and organizational achievements of the twentieth century was the rapid development of the atomic bomb in the United States during World War II. The journey from the experimental discovery of uranium fission in late 1938 to the tragic deployment of the two bombs on Hiroshima and Nagasaki in 1945 comprised an organizational effort involving over 600,000 people cumulatively, and costing over two billion dollars (Rhodes, 1986; U.S. Department of Energy, 1944). To ensure the success of their endeavor, the administrators of the enterprise (later dubbed the Manhattan Project) brought on board scientists, engineers, and numerous operational staff and blue-collar workers. Several private-sector organizations such as du Pont (manufacturing), Stone & Webster (construction), and Skidmore, Owings & Merrill (architecture) also played key roles in this industrial-scale project (Groves, 1962). Concurrent with the need for such inclusion, however, the context of war demanded that this vast innovative enterprise be carried out in utmost secrecy. Remarkably, this involved excluding most members of the organization from the knowledge of the objectives and details of the project (Groves, 1962; Rhodes, 1986). Many workers realized the true purpose of their work only when they heard President Truman's voice on the radio – announcing that the U.S. had unleashed the "greatest destructive force in history" on Hiroshima (Truman press statement, 1945). The experience of Mary Lowe Michel, a typist at a uranium enrichment plant, indicates the extent to which employees were kept in the dark: "I was very surprised [when I found out]. The night that the news broke that the bomb had been dropped, there was joyous occasions [sic] in the streets, hugging and kissing and dancing and live music and singing that went on for hours and hours. But it bothered me to know that I, in my very small way, had participated in such a thing, and I sat in my dorm room and cried" (Michel interview, 2005). Openness and inclusion on the one hand, and secrecy and exclusion on the other. How did the Manhattan Project successfully balance these contradictory forces in achieving its objectives?

The ability of an organization to protect its knowledge advantage has been of fundamental concern in prior research (Teece, 1986; Liebeskind, 1996; Nahapiet & Ghoshal, 1998; Gallini & Scotchmer, 2002; Ahuja, Lampert, & Tandon, 2008). Secrecy—the intentional concealment of knowledge between actors (Simmel, 1906)—is a pervasive feature of innovation processes (Hall et al., 2014), and the Manhattan Project is hardly alone in deploying secrecy within the organization as an internal "defense mechanism" (Katila, Rosenberger, and Eisenhardt, 2008) against knowledge leakage (Liebeskind, 1997). Similar uses of internal secrecy can be found in diverse contexts, from public-sector contractors working on government projects (e.g. Rich and Janos, 1994 on Lockheed's "skunkworks" programs), to private-sector organizations focusing on research and development (Hall et al., 2014; Thompson, 2017) and new product innovation (e.g. Lashinsky, 2012 on Apple's product development processes). Recent work has shown that innovating organizations generally prefer the use of secrecy over more traditionally-studied protectionary measures such as patenting (Cohen, Nelson, and Walsh, 2000; Hall et al., 2014), and that secrecy is particularly useful for protecting early-stage innovations (Katila, Rosenberger, and Eisenhardt, 2008; Knott and Posen, 2009), "large" innovations that have a significant impact on market share (Anton and Yao, 2004), and complex, process-related innovations (Argyres and Silverman, 2004).

Much of the prior work, however, has taken a primarily utilitarian approach to the study of secretive innovation. This has involved a focus on the costs and benefits of secrecy vis-à-vis other protection measures, unpacking the "economizing calculus" faced by organizations engaged in innovative work (Liebeskind, 1997). In examining this economizing calculus, scholars have analyzed the consequences of secrecy in terms of its legal status and protectionary time-frames (Cheung, 1982; Gallini and Scotchmer, 2002), costs of implementation (Liebeskind, 1997; Cohen, Nelson, and Walsh, 2000), organizational

incentives (Hall et al., 2014), leakage risks and safeguards (Katila, Rosenberger, and Eisenhardt, 2008), and fit with various innovation and industry types (Anton and Yao, 2004; Moser, 2012).

This predominantly economic approach has outweighed a more sociological perspective (Costas and Grey, 2014); one that has long recognized that a fundamental consequence of collective secrecy is the formation of social boundaries between groups of actors (Simmel, 1906; Bellman, 1981; Beidelman, 1993; Jones, 2014). Knowledge sharing is not only of economic value but also of social value (Simmel, 1950), and secrecy involves the inclusion of certain actors into the secret-keeping in-group, to the exclusion of others. Despite early organizational scholarship recognizing the ubiquity of secrecy in organizations (e.g. Argyris, 1957; Dalton, 1959), and its impact on intra-organizational boundaries of inclusion and exclusion (Schein, 1985), the pre-eminence of a utilitarian approach in later research has entailed an under-developed understanding of how organizations manage the social trade-off between inclusion and exclusion that is inherent to the practice of organizational secrecy (Costas and Grey, 2016).

Insight on this front can significantly enhance scholarly understanding of innovation management because the social trade-off between inclusion and exclusion ultimately translates to a functional tension between value creation and value appropriation from innovation outputs. On the one hand, greater inclusion within the organization increases the opportunity, motivation and ability for the exchange and combination of knowledge, ultimately fueling innovation (Kogut and Zander, 1996; Nahapiet and Ghoshal, 1998; Tsai and Ghoshal, 1998; Adler and Kwon, 2002). On the other hand, including multiple members into organizational secrets risks knowledge leakage and compromises the objective of value appropriation (Teece, 1986; Liebeskind, 1997; Hannah, 2005).

To examine the successful management of secretive innovation and its inclusion-exclusion trade-offs in a manner that facilitates both value creation and value appropriation, I conduct an inductive study of the making of the atomic bomb. The Manhattan Project constitutes an unconventional context, picked intentionally to reveal insights about a phenomenon (secretive innovation) that is likely to be more deeply manifest, and hence more clearly visible, in this case than in other, more generalized settings (Pettigrew, 1990; Eisenhardt and Graebner, 2007; Siggelkow, 2007; Bamberger and Pratt, 2010).

SECRECY, INNOVATION, AND SOCIAL CAPITAL

The Role of Secrecy in Innovation

Extant research in diverse fields such as organization studies, economics, and legal scholarship has provided insights into three broad areas—the prevalence, rationale, and management of secrecy in the context of innovation.

In studying the prevalence of secretive innovation, scholars have reported on the persistent importance of secrecy as a protectionary tactic for innovating firms. Early surveys of American firms (Cohen, Nelson, and Walsh, 2000; Levin et al., 1987) have been supplemented by more recent empirical findings and cross-national comparisons (Hall et al., 2014) demonstrating that secrecy is the preferred approach to value appropriation amongst innovating organizations. Hall and colleagues (2013) found that in the UK, for example, only four percent of companies that reported conducting some form of research and building some form of innovation chose to apply for patents. A key contribution of this survey-based line of work has been to empirically establish the ubiquity of informal protectionary measures across organizations and industries, thus providing an impetus for deeper examination of organizational secrecy in the context of innovation.

In studying the rationale for the deployment of secrecy as a protectionary tactic, scholars have analyzed the merits and demerits of the use of secrecy vis-à-vis organizational

objectives. On the beneficial side, secrecy is inexpensive to implement (Cohen, Nelson, and Walsh, 2000), and unlike patenting, it does not involve the release of valuable information to the public domain or an expiry date after which competitors are legally able to appropriate value from the protected information (Gallini, 1992). Secrecy is more amenable than patenting to early stage innovations (Katila, Rosenberger, and Eisenhardt, 2008; Knott and Posen, 2009), innovations that have a high potential market impact (Anton and Yao, 2004), innovations involving complex processual components (Argyres and Silverman, 2004), and innovations that are harder to patent (Gallini and Scotchmer, 2002) or easier to reverse engineer (Moser, 2012). Secrecy can also shelter the focal organization from unwanted scrutiny from external audiences (Cappellaro, Compagni, and Vaara, 2021) and regulators (Funk and Hirschman, 2014). On the negative side, secrecy is vulnerable to employee leakage, and is dependent on employees' felt obligations to maintain confidentiality (Hannah, 2005), as well as on layers of additional safeguards such as non-disclosure agreements and non-compete clauses (Liebeskind, 1997; Katila, Rosenberger, and Eisenhardt, 2008). Further, at the external interface, firms that are highly concerned with knowledge protection tend to engage in narrower external information search and formal collaborations (Laursen and Salter, 2014). Even for those that do search for external knowledge, internal protectionary mechanisms reduce their ability to identify and absorb external knowledge (Wadhwa, Freitas, and Sarkar, 2017), affecting the organization's learning capabilities (Cohen and Levinthal, 1990). Overall, this line of inquiry has provided significant insight into the economic trade-offs involved in the choice between formal and informal modes of knowledge protection. In focusing on these "economizing considerations" (Liebeskind, 1997), however, less attention has been paid to the social consequences of deploying secrecy within an organization.

A third, less populated stream of work has taken up this latter perspective and examined the social processes involved in the ongoing management of secretive innovation

over time. Hannah (2005) studied firms within the high-technology industry to find that the types of secrecy tactics that employees are made subject to influence their sense of obligation to protect sensitive information. Employees that are given access to sensitive information and made subject to strict information handling procedures report a greater sense of obligation to act in accordance with organizational policy than employees who are restricted *in toto* from accessing the organization's secrets. Hannah (2005: 74) suggests that the signaling of trust has a key role to play here – "If a procedure signals to an employee that her employer trusts her, she is likely to respond by increasing her felt obligations to protect trade secrets; if a procedure signals that an employee is not trusted, she is likely to lower her obligations." Oliver and Cole (2019) found that members of secret R&D units nested within larger organizations engage in collective identity work, de-identifying and re-identifying with their parent organization at various stages of the life cycle of secretive innovation. Nelson (2016) conducted a comparative analysis of four inventions across the biotechnology and digital audio industries, and found that inter-organizational sharing behavior amongst researchers is influenced by interpersonal trust, the development stage of the innovation, and the nature in which information is shared (e.g. via formal or informal communication channels). Taken together, these studies begin to point towards the importance of social factors like interpersonal trust, collective identity, and employee motivation in determining the successful management of secretive innovation.

Scholars in sociology and anthropology, meanwhile, have long recognized that collective secrecy is fundamentally a social process, with core implications for the social structuring of people into in and out groups based on processes of knowledge revelation and concealment (Costas and Grey, 2016). Simmel (1906) argued that as secrecy moves from the interpersonal to the collective level, one of the primary social consequences of having groups of actors jointly reveal or conceal information from one another becomes the construction of

exclusionary boundaries between secret keeping in-groups and out-groups (see also Jones, 2014 for similar conclusions from the anthropological literature). In an organizational context, this leads to "a complex configuration of multiple insides and outsides within the organization" (Costas and Grey, 2016: 74). Although prior research has studied the prevalence, rationale, and management of organizational secrecy, we lack an in-depth understanding of the successful management of these inclusion-exclusion boundaries in the pursuit of secretive innovation.

Inclusion-Exclusion and Social Capital in Innovation

The trade-off between the inclusion and exclusion of organizational members translates to a tension between value creation and value appropriation in the context of innovation. Although the deployment of secrecy can help protect sensitive information as well as tacit know-how located within the organization (Kogut and Zander, 1992; Liebeskind, 1996, 1997), secrecy tactics are vulnerable to information leakage from individual employees (Hannah, 2005; Katila, Rosenberger, and Eisenhardt, 2008). Including more employees into organizational secrets thus increases the risk of leakage and harms the potential ability of the organization to appropriate value from innovation outputs (Liebeskind, 1997).

At the same time, including more members into organizational secrets increases the opportunity, motivation, and ability of members to create value through the exchange and combination of knowledge. One of the unique advantages of organizations is the sense of inclusion provided to its members (Simon, 1991; Kogut and Zander, 1996). This sense of inclusion is both driven by (Schein, 1985), and a driver of (Kogut and Zander, 1992), knowledge sharing within the organization. Building on this foundational work, Ghoshal and colleagues demonstrated how social capital—the appropriable value that inheres in relationships between actors (Coleman, 1988, 1990)—provides a set of mechanisms through which organizations create value (Nahapiet and Ghoshal, 1996; Tsai and Ghoshal, 1998).

From a structural perspective, including members into organizational secrets increases social ties among actors, facilitating the *opportunity* for the exchange and combination of knowledge across disparate parts of the organization (Tsai and Ghoshal, 1998; Tsai, 2001; Tsai, 2002). From a relational perspective, including members into organizational secrets fosters dynamics of trust, reciprocity, and convergent norms and values (Kogut and Zander, 1996; Uzzi, 1997; Nahapiet and Ghoshal, 1998; Sandefur and Laumann, 1998; Adler and Kwon, 2002), facilitating the *motivation* and *ability* of organizational members for the exchange and combination of knowledge. Thus, the same act of inclusion that puts value appropriation at risk increases the potential for value creation in the first place.

To build theory on the successful management of secretive innovation in a manner that facilitates both value creation and value appropriation, I investigated the various tactics of secrecy and openness that shaped inclusion-exclusion boundaries in the Manhattan Project.

METHODOLOGY AND CASE OVERVIEW

The historical nature of this case allows for the dust to settle. This "settled dust" advantage is manifest in four ways. First, secrecy tactics get revealed and de-classified over time – i.e. the facts of the case get uncovered over time. Both the product (what was hidden) and the process (how it was hidden) of secrecy come to light as journalists, historians, and government officials uncover the facts of the case. Second, the lapse of time provides a more objective perspective – i.e. the facts of the case get not only de-classified but also de-mystified. For the Manhattan Project, contemporary narratives in the media lent it an aura of greatness, of larger-than-life figures and of almost mythical secrecy (e.g. New York Times, 1945a, b, c, d; Saturday Evening Post, 1945). Over time, scholars began to dismantle some of the mythical aura surrounding the project. Even writing seventeen years later, General Groves (essentially the chief executive of the Manhattan Project) warned: "Despite the passage of nearly two decades, it is still too early to write a completely objective story of the

development of the first atomic bombs" (Groves, 1962: xvii). Objectivity requires the surfacing of multiple narratives over time. Third, the "closed" nature of the historical case enables the researcher to observe the full picture from beginning to end. It is then possible to evaluate the success of the organization vis-à-vis its objectives (in the present study – the successful management of secretive innovation). Fourth, a historical case allows the researcher to "interpret existing organizational structures…as the result of decisions in past choice opportunities, some of which were made intentionally and others more implicitly" Kieser (1994: 611). Actual decisions and their structural consequences are easier to observe, while the degree of intentionality of actors must often be imputed by the researcher (Cole and Chandler, 2019). My research question privileges decisions, actions, events and their socio-structural consequences over the intentions of individual decision-makers, making for a strong fit between question and method (Edmondson and McManus, 2007).

Data Collection

I pursued an outside-in approach to data collection, starting with independent, comprehensive historical accounts and then moving to first-hand, narrower, specific accounts from key individuals involved in the Manhattan Project. Rhodes' (1986) Pulitzer prize-winning history, arguably the most comprehensive account of the making of the atomic bomb, served as the first point of entry into collecting case evidence. This history provided a source for reconstructing the timeline of the case, along with identifying key actors, events, and outcomes.

Using Rhodes' history as a jumping off point, I identified three individuals who were key to considerations of secrecy and openness in the Manhattan Project – General Leslie R. Groves who ran the project as a whole, Dr. J. Robert Oppenheimer who was the scientific director at the Los Alamos site, and Dr. Leo Szilard who had been involved in efforts around secrecy and openness vis-à-vis nuclear research from an early stage of the work (before

Groves and Oppenheimer got formally involved). Groves and Szilard both have personal accounts of the events published several years after the dropping of the bombs (Groves, 1962; Weart and Szilard, 1978). These accounts contain a mixture of personal recollections as well as reproductions of contemporaneous content such as correspondence and memos. In Oppenheimer's case, his biography (Bird and Sherwin, 2006), collections of his contemporaneous written correspondence (Smith and Weiner, 1980), and the transcript of his 1954 security hearings with the U.S. government (U.S. Atomic Energy Commission, 1954) were the major sources of information.

The Atomic Heritage Foundation's "Voices of the Manhattan Project" was another major source of information, containing oral histories from numerous other, less central figures. The data from less central figures ensured that I was able to understand the experiences of workers across the spectrum and not just the experiences of the few elites at the top of the organization.

Additionally, I used three other types of sources to complement the data from the sources above – official U.S. government histories of the project (e.g. U.S. Atomic Energy Commission, 1944; Smyth, 1945), media articles that provided external perspectives on the case (e.g. Cleveland Press, 1944; New York Times 1945a, b, c, d; Saturday Evening Post, 1945), and documentaries (Else,1981; Sargent, 1989; Rothstein, 2009) that provided overviews of the case history.

Due to this wealth of knowledge, I was able to ensure triangulations across primary and secondary sources, objective and subjective narratives, and contemporary and retrospective accounts of the case (Lipartito, 2015). Ultimately, I drew my findings and analysis from a total of over 3,800 pages of archival data, of which over 2,200 pages constituted first-hand accounts captured in the form of letters, memos, memoirs, oral

histories, speech transcripts, and formal testimony. Table 1 provides a summary of the data sources and their contributions to the case analysis.

Data Analysis and Theorization

I approached the data analysis and theorization process as a sensemaking process, incorporating both categorical and narrative approaches to sensemaking (Weick, 1989; Langley, 1999). The process was iterative at many points (e.g. I would constantly move between coding the events of the case for openness and secrecy, analyzing the chronological sequencing of events, and referencing the organizational literature). However, for presentational clarity, I describe my over-arching process as a five-step sequence.

First, I used Rhodes' history, Groves' personal account, and documentary film footage to develop and corroborate a case history. This involved building a detailed timeline that logged important and relevant geopolitical, scientific, and administrative events. Figure 1 shows a simplified version of the case timeline, with key events highlighted. This timeline is not intended as a summary of the events described in the findings below. Rather, its purpose is to orient the reader to the overall progression of the case, and to provide a useful contextual backdrop to the more detailed episodes described throughout the paper.

Second, given my focal interest in understanding the management of inclusion-exclusion boundaries, I started coding evidence from the case into categories based on their relevance to secrecy (knowledge concealment between actors) and openness (knowledge sharing between actors). One of the benefits of a case study is the ability to incorporate multiple levels of analysis, from individual actions to structural features and governing policies (e.g. Cattani, Ferriani, and Lanza, 2017). I thus created a detailed log spanning events, episodes, administrative policies, and actions of focal actors (see also, Cole and Chandler, 2019) related to openness or secrecy. For example, when I came across evidence of a system of colored ID badges delineating information access rights within Los Alamos, I

coded that as a "secrecy tactic". When I came across evidence of weekly symposia attended by all scientists working at Los Alamos to share research updates, I coded that as an "openness tactic". Note that I employ the word "tactic" here (and throughout the paper) as a catch-all term of convenience, and its use does not necessarily imply intention or explicit design on the part of the individuals involved.

Two developments took place during this stage of coding. One, I began noticing the prevalence of a gray area between secrecy and openness; what I eventually came to define as open secrecy. I added this to my coding scheme, thus creating a third, emergent category. For example, when I came across evidence that members of the Board of Directors at du Pont were told of the existence of the project but not made privy to the purpose of the project, this piece of evidence fell into the third category. Two, I started coding sub-categories within each category of openness, secrecy, and open secrecy. These sub-categories were groupings of the raw evidence within each category that were similar to one another, arrived at through constant comparison techniques (Miles and Huberman, 1994). For example, the use of a formal badge system to govern information access and the joint decisions of some scientists to withhold academic publication both constitute secrecy tactics, but I sub-categorized the former as "mandatory collective concealment" and the latter as "voluntary collective concealment". Figure 3 depicts the categories and sub-categories of tactics that emerged through this coding exercise.

Third, I then analyzed each tactic sub-category with respect to its impact on intra-organizational boundaries of inclusion and exclusion. Table 2 summarizes this analysis. Note that although Table 2 describes the inclusion-exclusion implications of each tactic sub-category separately, an understanding of the social system as a whole requires moving across levels of analysis and keeping multiple configurations in simultaneous view. For example, establishing a weekly colloquium between physicists represents the inclusion of different

groups within the Los Alamos lab, thus removing exclusionary boundaries between scientists. However, the fact that the colloquia are controlled-access events simultaneously reinforces exclusionary boundaries between the physicists and the technicians onsite.

Fourth, I adopted a narrative sensemaking approach focused on the sequencing of the various tactics as they occurred during the case. Case studies provide the ability to study processes unfolding over time, focusing on the interplay between events and decisions (Griffin, 1993). I thus brought the multiple code categories and sub-categories from step two above in conversation with one another by accounting for the temporal unfolding of the events of the case. As a result, I was able to induce system-level patterns showing the emergence and co-occurrence of the various tactics over time (displayed in Figure 4).

Finally, I integrated my findings with the organizational literature to abstract out from the specific case towards the development of a broader theoretical model. This involved, on the one hand, making analytic generalizations from case findings (Yin, 1984), and on the other hand, leveraging established literature to postulate underlying mechanisms and down-stream implications of the findings observed in the case. This analysis is presented in the section on "Open Secrecy and Social Capital in Technological Innovation", and encapsulated in Figure 5. Figure 5 also makes transparent the parts of the argument in this paper that are emergent *directly from* case data, and the parts that are driven by theoretical reasoning *supported by* case data.

Case Overview

The case study covers the period from January 1939 to August 1945. The beginning of this time frame marks the publication of the discovery of uranium fission, which made the ideas of chain reactions and atomic bombs salient to scientists across the world. The end of this time frame marks the deployment of the two atomic bombs and the completion of the objectives of the Manhattan Project. As part of the narrative sensemaking process, I

bracketed the timeline of the case into three phases based on key events. The first phase, labelled "scientific discovery", begins with the discovery of uranium fission. The second phase, labelled "initial government involvement", begins with the formation of the Uranium Committee by President Franklin D. Roosevelt. The third phase begins with the formation of the "Manhattan Engineer District" (MED) headed by General Groves. These are not phases "in the sense of a predictable sequential process but, simply, a way of structuring the description of events" (Langley, 1999: 703). As such, the division between phases is not discrete and there is considerable overlap, with each phase bleeding into the next.

Scientific discovery (1939 – 1940). In December 1938, Otto Hahn and Fritz Strassman (building on their earlier work with Lise Meitner) made a discovery that sent ripples across the scientific world. Working out of Berlin, the scientists successfully identified that one of the products coming out of uranium nuclear bombardment was the much lighter element barium. This upended prior scientific consensus. Where scientists had earlier only identified radioactive decay and transmutation, Hahn and Strassman now recognized the splitting of the atom. Within a few weeks, the news had crossed the Atlantic to reach the United States and scientists across the U.S. started pondering chain reactions, explosive applications, and geopolitics. The reactions of two scientists, both of whom went on to play key roles in the Manhattan Project, exemplify the immediate recognition of the potential military value of the discovery, and the concurrent need for secrecy in innovation efforts. Leo Szilard, who found out about the fission discovery when visiting Princeton, recalled his reaction to the news: "When I heard this, I immediately saw…it should be, of course, possible to sustain a chain reaction" (Weart and Szilard, 1978: 53). From here, Szilard's thoughts moved to geopolitics and secrecy: "I thought that if neutrons are in fact emitted in fission, this fact should be kept secret from the Germans. So I was very eager to contact Joliot and to contact Fermi, the two men who were most likely to think of this

possibility" (Weart and Szilard, 1978: 53). Meanwhile, Enrico Fermi, the Italian physicist who was at Columbia University at the time, set about conducting confirmatory experiments to reproduce the fission results, all the while aware of the disturbing implications of his work. Kevles (1979: 324) documented an episode where Fermi was in conversation with some colleagues, standing by his office window overlooking the Manhattan skyline. At one point during their discussion, Fermi cupped his hands into the shape of a small ball and held it up against the panoramic view in front of him, saying, "a little bomb like that, and it would all disappear."

Initial government involvement (1940 – 1942). For the first half of 1939, nuclear innovation efforts were limited to research universities and laboratories across the United States. American governmental efforts towards weaponization did not commence until a letter co-written by Szilard, and signed by Albert Einstein, was communicated to President Franklin D. Roosevelt in October 1939, shortly after the German invasion of Poland. The letter spoke of the recent discovery of uranium fission and warned that "extremely powerful bombs of a new type may thus be constructed" and "Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over." The letter further advised the President: "you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reaction in America" (Einstein and Szilard, 1939). Thus began the military-scientific collaboration towards the development of the atomic bomb.

The Manhattan Engineer District (1942 – 1945). The Manhattan Engineer District[1] (MED) was established in August 1942, with General Groves officially taking over the leadership role by early September (Groves, 1962). Over the next year, Groves organized the scaling up of scientific and industrial efforts. This led to the transfer of bomb development work from various universities (most prominently the Met Lab at the University of Chicago) to three main secret sites across the country (see Figure 2). The site at Oak Ridge, Tennessee handled uranium enrichment. The site at Hanford, Washington handled plutonium production. The site at Los Alamos, New Mexico, famously led by Robert Oppenheimer, handled bomb design, theoretical advancements, and testing.[2]

The Manhattan Project had two main objectives. General Groves recounted: "The basic American military requirements were twofold: to provide our armed forces with a weapon that would end the war and to do it before our enemies could use it against us" (Groves 1962: 11). I codify these as the value creation objective (building the bomb) and the value appropriation objective (not letting the Axis powers imitate American bomb technology). The members of the Manhattan Project achieved these dual objectives in August 1945, when the two atomic bombs were dropped on Japan, with no trace of counter-threat in terms of a similar bomb being possessed by the Axis powers.

FINDINGS

[1] The nickname "Manhattan Project" originally derives from the name "Manhattan Engineer District". Over the years, however, the name Manhattan Project has come to symbolize the entire effort towards making the atomic bomb in the U.S., of which the MED was the major phase. I continue this convention here. "Manhattan Project" thus refers to the bomb effort as a whole (the entirety of this case study), and includes the MED as a specific sub-phase (a major portion of this case study).

[2] Los Alamos can be considered the nerve center of the operation. Badash, Hirschfelder, and Broida (1980: ix) later noted with some levity that "more scientific brainpower was accumulated there than at any time since Isaac Newton dined alone."

My findings suggest that over time, exclusionary tactics of secrecy and inclusionary tactics of openness in the Manhattan Project were supplemented by an emergent set of tactics that I categorize and define as "open secrecy". Open secrecy gave rise to an in-between space occupied by groups that were neither fully included into organizational secrets nor fully excluded, ultimately helping the organization to balance inclusion-exclusion boundaries in pursuit of the dual objectives of value creation and value appropriation. Below, I first describe the secrecy and openness tactics at play before going on to discuss open secrecy, because an understanding of the latter is necessarily situated within an understanding of the former. Additionally, in the interest of brevity, I present a minimal selection of evidence under each tactic. Figure 3 provides a somewhat expanded selection of evidence, which is then further expanded and detailed out in Appendix Tables A1–A3.

Secrecy Tactics

The core secrets in the Manhattan Project comprised the purpose of the project (to build an atomic bomb) and technical details related to the bomb (bomb design, detonation technique, etc.). The belief that Germany was working on an atomic bomb provided the primary impetus behind the push for secrecy in the Manhattan Project (Groves, 1962; Rhodes, 1986). In essence, there was a need for internal secrecy in the service of external secrecy. My findings suggest that there were primarily three types of secrecy tactics employed – voluntary collective concealment, mandatory collective concealment, and physical separation. These served to create exclusionary boundaries between those in-the-know and others.

Voluntary collective concealment. In 1940, scientists on both sides of the Atlantic were busy working on the feasibility of uranium chain reactions. Szilard, in conversation with his colleagues at Columbia University, advocated for self-censorship by the U.S. physicists, withholding publication of their results in journals and conferences (Weart and Szilard, 1978). By default, only those physicists who were working directly with each other were

included in the in-group, and other members of the American research effort became excluded. The American fission researchers were quick to understand the importance of voluntary collective concealment, but were unsure of what to exclude and from whom. In one episode, the Princeton physicist Louis Turner wrote to Szilard as a form of voluntary check on whether to conceal his latest opinion piece (anticipating the use of U-238 as a Plutonium source) for the *Physical Review*:

> Wigner tells me that some of the work on the subject is not being published at present because of its possible military value. I find it a little difficult to figure out the guiding principle…It seems as if it [his opinion piece] was wild enough speculation so that it could do no possible harm, but that is for someone else to say. (Weart and Szilard, 1978: 126–127)

First, there is evidence here of the acceptance of the need for secrecy and exclusion. However, the ad-hoc and self-organized nature of voluntary collective concealment created difficulties, as Turner was unable to "figure out the guiding principle" for exclusion. Szilard's response to Turner's letter provides a rich evocation of the complexities of this tactic:

> You are certainly justified in finding it difficult to figure out the guiding principle which regulates at present what is being kept secret and what is not…It appears important that free discussion of all results and ideas among as many physicists as is practicable should not be inhibited…Perhaps the best solution would be to draw up a list of all trustworthy people who wish to do serious work on uranium and to have free discussion within this group…the Government suggested that the scientists might themselves form some sort of voluntary association and impose upon themselves the restrictions concerning publications which appear to be necessary in order to safeguard the required secrecy. (Weart and Szilard, 1978: 127–128)

Szilard was evidently aware of the simultaneous and contradictory needs for exclusion and inclusion. This prompted further questions regarding the organization of a secret keeping in-group ("voluntary association") that included some scientists ("trustworthy people") while collectively excluding others ("impose upon themselves the restrictions concerning publication"), at a potential risk to value creation ("free discussion of all results and ideas").

As for Turner's paper under consideration, Szilard suggested holding off on publication. This proved to be a futile effort, however, since two Berkeley physicists, Edwin McMillan and Philip Abelson, were independently working on similar ideas and they published a paper later that summer, without the prior knowledge of either Szilard or Turner (McMillan, 1951; Rhodes, 1986). This illustrates the challenge of the informal and self-organized nature of voluntary collective concealment. Inclusion into the secret-keeping in-group remained somewhat ad-hoc, keeping inclusion-exclusion boundaries unclear. There was a clear intent to internally partition the community of scientists into in and out groups. However, there was no clear or agreed-upon definition of what information to conceal (reveal), and which people to exclude (include).

Mandatory collective concealment. As the number of people involved in bomb development efforts grew rapidly, mandatory collective concealment policies became a mainstay of the project. At the commencement of their employment with the MED, every Manhattan Project worker had to sign a form, pledging their silence on the work they were doing (Atomic Heritage Foundation, 2014). A system of colored badges identified the security clearance of every person working on a MED site. Construction workers, machine operators, metal workers and others had red or blue badges, indicating a low-level of clearance. Top-level physicists and military personnel had white badges, indicating the highest level of clearance. Those with white-badges knew that the aim of the project was to develop an atomic bomb, whereas most others did not (Rhodes, 1986; Atomic Heritage

Foundation, 2014). The badge system thus served as a visual artifact of the boundaries between those who were included into organizational secrets and those who were excluded. Further, this partitioning ran both horizontally and vertically (see also Liebeskind, 1997). Vertical mandatory collective concealment entailed white-badged employees keeping secrets from red, blue or green-badged employees. Horizontal mandatory collective concealment entailed keeping secrets within the same level of security clearance. For example, a team of metallurgical workers and a team of machinists may have had the same security clearance, but each group would only be made aware of what they needed to know for their particular job, and everyone was required to not speak to others outside of their immediate work-group about their work (Atomic Heritage Foundation, 2014).

These tactics served to firmly exclude workers from the knowledge shared with organizational members with higher security clearances. At Oak Ridge, for example, almost 5,000 men and women "were trained to run and maintain the calutrons – without knowing why – twenty-four hours a day, seven days a week" (Rhodes, 1986: 491). Mary Anne Bufard, a worker at Oak Ridge, recalled:

> It just didn't make any sense at all. I worked in the laundry at the Monsanto Chemical Company, and counted uniforms. I'll tell you exactly what I did. The uniforms were first washed, then ironed, all new buttons sewed on and passed to me. I'd hold the uniform up to a special instrument and if I heard a clicking noise, I'd throw it back in to be done all over again. That's all I did, all day long. (quoted in Wellerstein, 2012)

Further, this exclusion of groups within the project was not directed solely at front-line, lower-skill workers. Los Alamos housed members of the Special Engineering Detachment (SED), a corpus of army officers with valuable engineering and scientific skills. Even the senior-most officer in charge of this body of over a thousand workers was not made aware of the purpose of the project: "Since he [the SED Head] was not told, as many other

military weren't (nor the machinists, of course), what the purpose of Los Alamos was, he loudly described all of us as draft dodgers who were just escaping Army service and having fun there" (Kistiakowsky, 1980: 57). The fact that the senior-most officer of the SED was unaware of the purpose of the project and displayed a distrustful attitude towards the value of the work being done at Los Alamos provides a clear indication of how out-groups were excluded not only from privileged knowledge, but also from the accompanying sense of purpose and trust that the in-groups were privy to.

Physical separation. During site selection for the MED, Groves relied heavily on picking isolated, remote areas. This had less to do with protecting civilians from radiation spills and more to do with keeping the activities of the Manhattan Project away from prying eyes (Groves, 1962). Even within the Los Alamos site, the area was set up as two nested layers, with a fence within a fence. The outer layer of fencing protected the entirety of the area from unauthorized visitors or wandering locals. The inner layer of fencing further separated out the scientific "Technical Area", containing all the laboratories and physicists' offices, from the residences, communal areas, and various camp amenities, thus "emphasizing that the scientists and their families were walled off where knowledge of their work was concerned not only from the world but even from each other" (Rhodes, 1986: 455). In addition to within-site barriers, the sites were also physically separated from each another. Scientists from one site were not permitted to visit other sites, thus adding a horizontal partitioning between sites to the vertical partitioning within sites.

Physical separation represented a tangible manifestation of inclusion-exclusion boundaries within the organization which made the partitioning between groups abundantly clear (Liebeskind, 1997). For example, when residents at Los Alamos were blocked by military personnel from entering the Technical Area within their own campus, it was clear

that they belonged to an excluded out-group that had not been entrusted with the secrets held by the Tech Area in-group.

Openness Tactics

While secrecy was a feature of the project from early on, openness was likewise a key aspect. The scientists felt that openness was core to the progress of their work and to the proper conduct of science, with Oppenheimer reflecting that "secrecy strikes at the very root of what science is, and what it is for" (Smith and Weiner, 1980: 317). The government officials, meanwhile, recognized that openness was inevitable since the magnitude of the effort required the involvement of multitudes (Groves, 1962). My findings suggest that there were primarily four types of openness tactics employed – voluntary revealing, mandatory revealing, physical colocation, and using external partners. These served to include several people into organizational in-groups, while reinforcing some of the exclusionary boundaries mandated by concurrent secrecy tactics.

Voluntary revealing. "If Congress knew the true history of the atomic energy project, I have no doubt but that it would create a special medal to be given to meddling foreigners for distinguished services" (Weart and Szilard, 1978: 146). Szilard's words here speak to the role that some scientists working in Britain played in aiding and motivating the American efforts early on. In September 1940, a group of British scientists travelled to the U.S. and shared the outcomes of the "MAUD Committee" report, which represented the cutting edge of British research on uranium fission. The scientists thus voluntarily revealed sensitive information in an attempt to bring the Americans in on the bomb development effort (a formal liaison between British and American research efforts was not set up until the end of 1941). When this initial visit proved insufficient to boost American efforts, Mark Oliphant, a member of the MAUD Committee, flew to the U.S. in the summer of 1941 to push harder. He found that the knowledge revealed in the earlier trip had not made it to the American

scientists: "I called on Briggs in Washington, only to find that this inarticulate and unimpressive man had put the reports in his safe and had not shown them to members of his Committee" (Oliphant, 1982). Oliphant then went on to meet with members of the Uranium Committee personally and even flew up to Berkeley to meet with Ernest Lawrence. As a result of this prodding, he managed to focus American attention back onto the prospects of developing an atom bomb.

As a tactic, voluntary revealing is also inherently intertwined with voluntary collective concealment. For example, the U.S. physicists debating whether or not to self-censor their publications had to first share amongst each other the details of their findings. Turner, in his letter to Szilard discussed earlier, attached his article that was intended for publication so that Szilard could take a look and determine whether the content posed a security risk. In order to voluntarily conceal something as a group, the actors have to first voluntarily reveal that information within the group. The corollary to this is seen in the case of the McMillan and Abelson publication discussed earlier – if members do not first voluntarily reveal information within the group, the group does not have the opportunity to decide to collectively conceal that information. As a more individually-driven tactic, voluntary revealing can thus either break down or reinforce exclusionary boundaries between groups, depending on whom the information is revealed to. Oliphant's voluntary revealing led to closer ties between the British and American scientists, whereas the letters between Turner and Szilard served to reinforce exclusionary boundaries.

Mandatory revealing. Mandatory revealing was evident from the early days of the MED. Oppenheimer had approached scientists across the nation to convince them to join the effort at Los Alamos. However, he did not share the full details of the project with them at the time of recruitment (see "revealed concealment" tactic below). Therefore, when the scientists got to Los Alamos, they had to be briefed on information that they had been

excluded from until then. To achieve this, Edward Condon (an administrative head of Los Alamos at that time) created the *Los Alamos Primer*. The document contained sensitive but pertinent information on bomb design ideas, calculations, and detonation options (Condon, 1943). The *Primer* was mandatorily distributed to every white-badge scientist who came on board at Los Alamos. This mandatory revealing served to bring people who had been excluded until then into the secret-keeping in-group. Around the same time, Oppenheimer instituted a policy of weekly colloquia between the scientists at Los Alamos, as a means of ensuring that the scientists were sharing their work with one another on a regular basis (Rhodes, 1986). Once again, these colloquia were to be attended only by white-badged scientists. Mandatory revealing thus brought people into the in-group while maintaining the boundaries created by mandatory collective concealment, with information sharing occurring through formal channels, in line with the need-to-know principle.

Physical colocation. Physical colocation was the other side of the coin, so to speak, of physical separation. Separation ensured that the work of the Manhattan Project was hidden out of sight, while colocation brought the scientists together under one roof so that they could work together more freely. Oppenheimer had specifically suggested the idea of a separate bomb development center to Groves when they met in October 1942, to "permit a freer exchange of ideas and provide for the centralized direction of all work" (Jones, 1985: 82). Prior to the MED, nuclear research was scattered (i.e. there was more physical separation than colocation) across several universities and labs in the country. Oppenheimer later testified to his rationale for demanding physical colocation:

> I became convinced…we needed a central laboratory devoted wholly to this purpose, where people could talk freely with each other, where theoretical ideas and experimental findings could affect each other, where the waste and frustration and

> error of the many compartmentalized experimental studies could be eliminated. (U.S. Atomic Energy Commission, 1954: 12)

Similar to Szilard's letter to Turner, there is evidence here of a recognition that exclusionary boundaries ("many compartmentalized experimental studies") threaten value creation ("waste and frustration and error").

Physical colocation ultimately had a mixed effect on inclusion-exclusion boundaries. On the one hand, colocation removed exclusionary boundaries between scientists working across various labs in the country by bringing them under one roof. At the same time, access rights and security-clearance levels meant that physical colocation still maintained the exclusionary boundaries defined by mandatory collective concealment. The colocation of people working within the Technical Area at Los Alamos, for instance, served not only to expand the in-group of employees in-the-know, it also expanded the out-group of people working on-site but not brought in on the organization's secrets. The simultaneous exercise of secrecy tactics thus constrained the extent to which physical colocation removed exclusionary boundaries.

Using external partners. Some of the most compelling evidence of inclusion in the Manhattan Project comes from the number of external partners that were brought in to contribute to the effort. This created a blurring of inter-group boundaries since some executives of some organizations were brought in on the secretive details of the project whereas others were not. For example, the du Pont chemical company managed all of the plutonium production during the Manhattan Project, playing a role in every stage at Hanford, from site selection to reactor design to construction and operation (Olson, 2020). Their executives were involved in early meetings for information exchange with various stakeholders – military leaders, scientific administrators, and Met Lab researchers:

> During the following week the top officials of du Pont discussed our proposal, and at their request eight of their key employees were permitted to visit the Chicago laboratory, where they went over the status and plans of the project with Compton and his associated, and received all available theoretical and experimental data. (Groves, 1962: 48)

Crawford Greenewalt, a du Pont executive in Chicago who later took over responsibility for plutonium production, became the only non-military or scientific personnel to witness the moment when Fermi and his team achieved the bomb project's (and the world's) first self-sustaining nuclear chain reaction at the University of Chicago (Greenewalt interview, 1965). Groves felt it important to bring in a member of the du Pont executive committee to the site so that ongoing negotiations with the company about their role in handling plutonium production would conclude quicker (Groves, 1962: 54).

The inference that boundaries of exclusion were blurred but not dismantled, however, is evident in the fact that not all external partners were involved to the same extent, and accorded the same degree of inclusion. Relationships with smaller companies were handled in a more arms-length manner. For example, when procuring wood for a planned reactor in Chicago, the Met Lab scientists only told the Sterling Lumber Company how much wood they needed, and that it was needed at "double X priority" for a government project. To the scientists' surprise, the Sterling Lumber Company complied with their request, "no questions asked" (Rhodes, 1986: 429). These smaller partners made important contributions without being made aware of the purpose of the project. On the Hanford site alone, for instance, du Pont employed over 10,000 sub-contractors, conceivably providing everything from construction raw materials to food and catering materials (Groves, 1962: 44).

Open Secrecy Tactics

The analysis of openness and secrecy tactics in the Manhattan Project revealed cases that were not purely related to either concealment or revelation of secret knowledge. My findings suggest that there were three types of open secrecy tactics evident during the making of the atomic bomb – revealed concealment, partial revealing, and permeable physical boundaries. In all three cases, people were neither fully included into the secret-keeping in-group nor excluded to the unaware out-group. Building on these findings, I define open secrecy as – the intentional revelation of secret-related knowledge between actors.[3] Three types of secret-related knowledge can be revealed – knowledge of the act of concealment, meta-information about the secret, or partial information about the secret. I discuss these in conjunction with the discussion on the tactics below.

Revealed concealment. In the winter of 1942–1943, Oppenheimer and a few others travelled around the nation, recruiting scientists from campuses such as Princeton, Columbia, UC Berkeley, and MIT to come work at Los Alamos (U.S. Department of Energy, 2010: 80). In most cases, the scientists were not told of the details of the project until they arrived at Los Alamos (there was always the risk that a potential in-group target decided to decline the invitation). However, to persuade them to join the organization, Oppenheimer and his colleagues informed the prospective recruits that they would be working for a secret military project, and that it was of great importance to ending the war (Rhodes interview, 2018). They

[3] The construct of *open secrecy* developed in this paper is distinct from the colloquial use of the phrase "open secret" as in, "X is an open secret, everyone knows". This conventional usage implies that the contents of secrets are public knowledge (see also Ladegaard, 2020 for a variant of this form of secrecy found in online markets, where the identities of the people involved remain anonymous even while the contents of secrets are known). *Open secrecy*, as conceptualized in this paper, does not involve actual knowledge of the contents of secrets. On the contrary, it implies continued containment of secrets. Although beyond the scope of the present analysis, forms of secrecy wherein the contents are publicly known may be more fruitfully studied through the construct that anthropologists such as Taussig (1999) and organizational scholars such as Costas and Grey (2016) have termed "public secrecy" (see also Zerubavel, 2006).

thus revealed the act of concealment (that there was a secret purpose) and meta-information about the secret (its importance and estimated impact on ending the war), without revealing the secret itself (they would build an atomic bomb at Los Alamos).

John Manley, a physicist Oppenheimer tapped as his main aide for setting up the Los Alamos laboratory, recalls going to places like Princeton and the University of Wisconsin for recruitment. Manley had never been to Los Alamos himself, and was not allowed to tell the potential hires of the location or purpose of the site. However, revealed concealment allowed him to instill in them a sense of the importance of the project without sharing specific details, such that – "either through patriotism or a sense of loyalty or adventure – I don't know what – most of them were agreeable to take a crack at this unknown" (Manley, 1980: 29). Joseph Hirschfelder, recruited to work in the Theoretical Division at Los Alamos, recalled – "the recruiting slogan of the Manhattan Project was 'Help win the war to end all wars', and we all felt that this was true" (Hirschfelder, 1980: 68). Similarly, when bringing on board external partners like du Pont, General Groves informed the company's board members of the secret nature of the project, and that "if we were successful in time, we would shorten the war and thus save tens of thousands of American casualties", without informing them of the purpose or details of the project (Groves, 1962: 49).

Secrecy, defined as the intentional concealment of knowledge, permits a certain degree of flexibility. One, an actor could reveal the act of concealment without revealing the information being concealed. Two, an actor could reveal the act of concealment along with certain meta-information, still without revealing the secret itself. Both these actions were prominent in the Manhattan Project—sharing the fact that there is a secret project, and sharing meta-information about how it is an important military project that will help to end the war and save American lives. This allowed the administrators of the project to bring people on board without giving away sensitive knowledge. Revealed concealment thus had a

unique effect not found in the secrecy and openness tactics discussed thus far. There were those in-the-know (the in-group), those not in-the-know (the out-groups), and those who had been made privy to revealed concealment (the in-between groups).

Revealed concealment was an intentionally and selectively deployed tactic. This is noteworthy since inclusion into organizational secrets takes on greater meaning when coming officially from senior and central figures in the organization (Schein, 1985). To pick a contrasting example, when project leaders hired Dorothy McKibbin to set up the liaison office for people heading to Los Alamos via Santa Fe, New Mexico, they did not bring her into the in-between group. She was simply told, "Would you like to be secretary to my wife? I'm a housing manager for a project that's in Santa Fe", without being given any further information on the project. She later realized that it was a military project but still had no idea that the purpose of the project was to build a bomb[4] (McKibbin interview, 1965). Similarly, a woodworker recruited on the innocent premise of a need for carpenters at "Hanford Engineer Works" (Gardner interview, 1965) might ostensibly have inferred that the huge site was meant for some large secret military project. However, the difference between McKibbin or the Hanford carpenter, and the du Pont executive working at Hanford, was that the du Pont executive was *brought in* to the in-between space of revealed concealment by project administrators whereas McKibbin and carpenter found themselves in the in-between space over time and through guess-work.

[4] In addition to the various concealment tactics in operation, workers also failed to realize the true purpose of the project due to the availability of several rumors providing alternative explanations. At Los Alamos, for instance, these rumors ranged from the belief that they were working on submarine technology, to the suggestion that the campus was a housing facility for pregnant members of the Women's Army Corps (Fermi, 1980: 92).

Partial revealing. Atomic research in the Navy and the Army was compartmentalized at the time through mandatory collective concealment and physical separation. The Berkeley physicist Philip Abelson had been working on uranium enrichment (for submarine propulsion) using the liquid thermal diffusion method at the Naval Research Laboratory. He complained that research progress from the Manhattan Project had been denied to him and that "it is vitally necessary that there be an exchange of technical information" (quoted in Rhodes, 1986: 551). Abelson eventually found out through partial flows of information that the various attempts at uranium enrichment in the Manhattan Project were not proving successful:

> I had enough communication with the people at Columbia to know that they were having trouble. We didn't have too much communication because of secrecy. But without going into detail of what the problem was, I learned that there were difficulties. (Abelson interview, 1966)

Meanwhile, his thermal diffusion method of enrichment had been proven to work. Wanting to help out, Abelson found a way to reciprocate the partial information flows and share this information with Los Alamos:

> I wanted to let Oppenheimer know what we were doing. Someone in the Bureau of Ships knew one of the people…who was going out to Los Alamos. I remember that I met the man in the old Warner Theater here in Washington, up in the balcony – real cloak and dagger stuff. (quoted in Rhodes, 1986: 552)

Abelson's information ultimately reached Oppenheimer. This back and forth of partial revealing was ultimately of great value to the project as they used Abelson's technique as a first step in order to supplement their existing enrichment efforts. Groves later commented that their delay in seeing this option of combining enrichment methods was "one of the things that I regret the most in the whole course of the operation" (USAEC, 1954: 165).

The episode above illustrates how, in addition to revealing the act of concealment or meta-information related to the secret, actors can reveal partial information without giving away the secret itself[5]. In the Manhattan Project, there were several areas of knowledge, such as isotope separation or plutonium production, that were important but insufficient for a potential competitor to use to imitate bomb development. Consider, for example, the physicist Hirschfelder's recollection of being consulted at an early stage of the project through partial revealing and how it was insufficient knowledge for him to uncover the project's secret objective:

> [Tolman]…discussed with me the general requirements for the Los Alamos gun without telling me what it would be used for. I recognized the similarity of this gun with a super-secret device which the British were developing to penetrate the fifteen feet of concrete which protected German submarine pens; thus, I did not make the connection between Tolman and the atomic energy project. (Hirschfelder, 1980: 72)

Permeable physical boundaries. The strict physical boundaries within and between Manhattan Project sites were occasionally permeated by project members moving in between them. As a case in point, Feynman and one of his Los Alamos colleagues, the future Nobel laureate Emilio Segrè, were trying to remotely fix a problem at Oak Ridge. Engineers at Oak

[5] Partial revealing is largely consonant with Nelson's (2016) finding of "strategic withholding" amongst research scientists. However, I use the term partial revealing and avoid co-opting Nelson's terminology for semantic reasons that have a bearing upon the conceptual thrust of the term. First, with secrecy as the backdrop, revealing becomes the action undertaken, and "withholding" is the status quo maintained in the absence of action. The tactic described here, that contributes to open secrecy, is related to revealing rather than withholding as an action, and research in related domains suggests caution in assuming that the two behaviors are a straightforward inverse of one another (Sherf, Parke, and Isaakyan, 2021). Second, this action is not always "strategic" and can be opportunistic or even hopeful. Abelson's sharing of Naval research with Los Alamos was a hopeful move that did not involve a clear understanding of whether the knowledge would be helpful to Los Alamos. Third, although it is implicit in Nelson's (2016) concept of strategic withholding, the fact that only partial information is being shared in this tactic merits explicit expression in the terminology.

Ridge were struggling to ascertain the quantity of U-235 in their output solutions. Physical separation and mandatory collective concealment between Los Alamos and Oak Ridge meant that the Los Alamos scientists could only send out written instructions to Oak Ridge (subject to approval by the military mail censors). This approach failed to solve the problem. Finally, Segrè "said that the only possible way to get it right is to go down there, to see what they're doing" (Feynman, 1975). When the Los Alamos physicists petitioned the Army to permit a visit to Oak Ridge:

> The Army people said no, it is our policy to keep all the information in Los Alamos in one place, and that the people in Oak Ridge would not know anything about what it [the U-235] was to be used for. They just knew what they were trying to do. I mean the higher people knew they were separating uranium, but they didn't know how powerful the bomb was, or exactly how it worked or anything. And the people underneath didn't know at all what they were doing. (Feynman, 1975).

Insistent, Segrè pushed back against the Army policy until they made an exception. Physical separation was thus supplemented by permeable physical boundaries. Ultimately, when Segrè visited Oak Ridge to solve the problem of U-235 ascertainment, he made a separate serendipitous discovery related to unsafe handling procedures of chemical solutions, thus helping to avoid a major accident. Feynman later stressed ominously, "the plant would never work. It would have blown up. I swear it would have. If nobody had paid attention" (Feynman, 1975). Thanks to the fortunate visit of Segrè across compartmentalized lines, Los Alamos and Oak Ridge started officially working across group boundaries, rendering their physical boundaries permeable on a selective basis (cf. Lisfhitz-Assaf, 2018 on the perforation of knowledge boundaries).

Evolution and Interaction of Tactics Over Time

Open secrecy in the Manhattan Project emerged over time, and continued to coexist with secrecy and openness tactics (see Figure 4). During the early phase of scientific discovery, the traditional norms of publication and debate in the scientific community were prominent. Although scientists like Leo Szilard were debating the importance of secrecy, there was little intentional concealment of information in 1939. In fact, over the course of the year, around one hundred scientific papers were published on the topic of uranium fission (Badash, Hirschfelder, and Broida, 1980: xii). By the middle phase of initial government involvement, secrecy tactics such as voluntary and mandatory collective concealment came into play. The voluntary withholding of publications was succeeded by a formal ban on publications. By the time the MED came into being, secrecy and openness tactics such as mandatory collective concealment–mandatory revealing and physical separation–physical colocation became widespread and open secrecy tactics such as revealed concealment and permeable physical boundaries began to emerge. The emergent tactics did not replace but rather complemented existing tactics. Tying these patterns together with the analysis on inclusion-exclusion boundary impacts (summarized in Table 2), it is evident that the system as a whole moved from one of minimal inter-group divisions (during the scientific discovery phase) to one with increasingly clear partitioning between groups (during the initial government involvement phase) to one with a combination of clearly included and excluded groups as well as several in-between groups. For example, the permeation of physical boundaries (blurring of inclusion-exclusion boundaries) took place between closed-off secret sites (keeping clear exclusionary boundaries between groups) that themselves housed thousands of people in one area (creating inclusionary boundaries between groups).

OPEN SECRECY AND SOCIAL CAPITAL IN TECHNOLOGICAL INNOVATION

The findings presented thus far suggest that intentional as well as emergent tactics of revealed concealment, partial revealing, and permeable physical boundaries allow for an

organizational gray space of open secrecy to emerge over time. This fosters several in-between groups, of members who are neither fully included into the secrets of the organization, nor fully excluded. Drawing on social capital theory, I posit that this ability, to bring members into a space in-between full inclusion and exclusion, helps the organization to simultaneously glean some of the value creation benefits of inclusion while preserving the value appropriation benefits of exclusion. Figure 5 encapsulates my arguments below.

Open Secrecy and Value Appropriation

Members of the in-between groups fostered by open secrecy are not privy to the strategic secrets of the organization. For example, du Pont managers working at a Hanford plant during the Manhattan Project would have been told that they were working on a larger, nationwide secret military project (revealed concealment) and that the objective of their plant was to produce Plutonium (partial revealing), without being given any further knowledge of the application of plutonium for chain reactions, bomb design or military plans. The organization's strategic secrets, involving—"knowing that" (e.g. knowing the physics of plutonium chain reactions) and "knowing how" (e.g. knowing how a plutonium core can be fit into a bomb)—thus remain secure (Ryle, 1949, Kogut and Zander, 1992, 1996), preventing critical leakages and enabling value appropriation from innovation outputs.

Open secrecy tactics preserve the value appropriation objective because the knowledge constituting an innovation is typically complex, multidimensional, and situated in practice (Polanyi, 1967; Kogut and Zander, 1992; Orlikowski, 2002). As such, the concealment and revelation of information are not acts that occur along a single spectrum. For example, workers exposed to revealed concealment during the Manhattan Project were not some X% more aware of the project's objective of building an atomic-bomb compared to out-group members. Rather, they were simultaneously aware (of the existence of a secret) and unaware (of the secret itself). Rilinger's (2019) notion of "complex secrets" further

highlights that knowledge is not only multidimensional but also multiconfigurational. Complex secrets are only compromised when multiple pieces of knowledge are revealed along with their corresponding configuration. This makes complex secrets more difficult to uncover and allows greater leeway for open secrecy tactics to operate. In addition to being complex, multidimensional, and multiconfigurational, information can also be polysemous – the same information can have different meanings based on situation and context (Donnellon, Gray, and Bougon, 1986; Bechky, 2003; Kellogg, Orlikowski, and Yates, 2006). For example, the du Pont engineers aware of plutonium could still assume the output of their work was meant for some other use; one popular rumor was that they were creating energy for submarine propulsion (Rhodes, 1986). To the extent that an organization's secrets constitute complex secrets involving multidimensional, multiconfigurational, and situated knowledge, there is room for open secrecy to operate without compromising the objective of value appropriation.

Open Secrecy and Value Creation

Members of the in-between groups fostered by open secrecy are relatively more included towards the in-group than the purely out-group members, which implies that the in-between groups have greater opportunity, motivation and ability to contribute to the successful exchange and combination of knowledge across the organization (Nahapiet and Ghoshal, 1998; Adler and Kwon, 2002), ultimately fueling value creation (Moran and Ghoshal, 1996).

Opportunity for the exchange and combination of knowledge. Opportunity, in this model, refers to the latent potential for the flow of useful knowledge. This potential inheres in the patterns and qualities of social ties within the organization (Adler and Kwon, 2002; Burt, 2005). Open secrecy brings people within the organization who may otherwise have been relegated to an out-group in contact with more members or parts of the organization. Bringing members into this in-between space gives rise to "emergent patterns of

accessibility" that allow for intentional as well as accidental exchanges of knowledge (Nahapiet and Ghoshal, 1998: 249). At the same time, this increased access afforded to members of in-between groups is a controlled form of access, since they are still not brought in on core organizational secrets. This controlled inclusion forms the mechanism through which open secrecy tactics create greater opportunity for the exchange and combination of knowledge within the organization.

To illustrate this point, consider Emilio Segrè's insistence on accessing Oak Ridge in the preceding case analysis. Travelling across compartmentalized lines in order to solve one problem, Segrè serendipitously noticed another, more consequential problem that could have posed trouble for the organization if it had gone unnoticed. The open secrecy tactic of permeable physical boundaries, in this example, created greater opportunity for the transfer of useful knowledge from Segrè (an in-group member) to the workers at Oak Ridge (who then became members of the in-between space created by open secrecy). Had the physical separation between organizational units remained firm instead, the opportunity for such serendipity would have been reduced, harming value creation efforts (Roberts, 1989). The use of open secrecy within the organization thus helps create opportunity structures that contain the potential for fruitful knowledge exchange.

Motivation to engage in the exchange and combination of knowledge. The mere existence of opportunity is insufficient to spur the voluntary exchange of useful knowledge (Nahapiet and Ghoshal, 1998). The actors involved need to be motivated to participate in social exchange. Open secrecy fosters this motivation by bringing the in-between group members in on the knowledge that there is a larger, concealed purpose behind their work. The ability to link one's own tasks to a larger organizational purpose facilitates motivated action towards that purpose (Carton, 2018). Unlike the NASA employees studied by Carton (2018), those in the in-between groups of the Manhattan Project did not know the ultimate aspiration

of the organization. However, it follows logically that knowing that there is *some* larger purpose will still provide opportunities for workers to reconstrue their work as the pursuit of *some* higher objectives and aspirations (Carton, 2018), thus fueling more motivation than not knowing at all.

In the preceding case analysis, Feynman's insistence on partially revealing nuclear physics details to plant workers at Oak Ridge illustrates this point: "in my opinion, it's impossible for them to follow or to obey a bunch of rules that they don't understand, unless they understand how it [nuclear physics] works" (Feynman, 1975). The use of open secrecy to bring organizational members in to an in-between space between inclusion and exclusion thus fuels greater motivation for the exchange and combination of knowledge between organizational members.

Ability to engage in the exchange and combination of knowledge. The existence of opportunity structures and motivated actors is of limited use if the parties to the exchange do not have the ability to successfully anticipate and realize value from the exchange and combination of knowledge.

Members of the in-between groups fostered by open secrecy are able to form expectations about the value of their knowledge without having full knowledge of other parts of the organization. Actors can "anticipate that interaction, exchange, and combination will prove worthwhile, even if they remain uncertain of what will be produced or how" (Nahapiet and Ghoshal, 1998: 249). In the preceding case analysis, the behavior of Philip Abelson, who shared Navy research results with Los Alamos, illustrates this point. The fact that Abelson knew that Los Alamos existed, and that they were working on uranium enrichment as well, enabled his anticipation that his research results may be of value to the Los Alamos scientists. An actor exposed to open secrecy is thus more able to anticipate potentially valuable knowledge exchange compared to one who is relegated to the excluded out-group.

The knowledge sharer's ability to anticipate value needs to be complemented by the knowledge receiver's ability to realize that value. Adler and Kwon (2002: 26) locate this capability in the individual-level "competencies and resources at the nodes of the network", while Nahapiet and Ghoshal (1998) locate this in the collective abilities of the organization as a whole. In both cases, the presence of diverse, relevant expertise across the organization increases the ability to realize value from the exchange and combination of knowledge (Cohen and Levinthal, 1990). Open secrecy tactics facilitate this state of affairs through the selective borrowing of expertise. In the preceding case analysis, open secrecy tactics like partial revealing and permeable physical boundaries facilitated the borrowing of relevant knowledge resources, evident in the examples of du Pont scientists brought in during the early stages of the project to help with calculations regarding the scaling up of uranium isotope separation from laboratory quantities to industrial quantities (Groves, 1962).[6]

DISCUSSION

This archival study examined the successful management of secretive innovation and its concurrent inclusion-exclusion trade-offs in a manner that facilitates both value creation and value appropriation. My findings suggest that processes of revealed concealment, partial revealing, and permeable physical boundaries facilitate open secrecy, viz. the intentional revelation of the act of concealment, meta-information related to secrets, or partial

[6] Finally, it is worth re-emphasizing that the increased opportunity, motivation, and ability fostered by open secrecy is a property of the gray space (of in-between groups) as a whole, rather than of individual open secrecy tactics. I have not conceptually isolated the contribution of each open secrecy tactic to the dimensions of opportunity, motivation, and ability because, as noted earlier, the various tactics are interrelated and co-occurrent in the social system, and it is their interplay that gives rise to the in-between space between inclusion and exclusion. The social capital dimensions of opportunity, motivation, and ability are also themselves interrelated and co-occurrent (cf. Tsai and Ghoshal, 1998), rendering the isolation of relationships between each open secrecy tactic and each component of the social capital framework neither parsimonious nor meaningful.

information related to secrets. These processes may be either intentionally designed or emergent through the behaviors of individuals within the organization. Exposure to open secrecy brings organizational members into a space in between inclusion and exclusion vis-à-vis organizational secrets. This in-between space fosters value creation by increasing the opportunity, motivation, and ability for the exchange and combination of knowledge across actors. Meanwhile, the multidimensional, multiconfigurational and situated nature of strategic secrets ensures that information security and the value appropriation objective are preserved. This study challenges and extends our existing views on knowledge sharing, the link between knowledge flows and organizational structure, and the role of secrecy in innovation.

Knowledge Sharing and Concealment

Classic work on knowledge flows within and across organizations emphasized the need to account for types of knowledge and their transferability (Nelson and Winter, 1982; Nonaka and Takeuchi, 1995). For example, explicit knowledge can be transferred (or stolen) through documents or products, whereas the transfer of tacit knowledge is more likely to rely on the movement of knowledge-holders across boundaries (Liebeskind, 1997). Recent scholarship, meanwhile, has begun building a more complex picture of knowledge sharing and concealment by focusing on the social processes involved, thereby uncovering a variety of knowledge sharing (Bechky, 2003; Kellogg, Orlikowski, and Yates, 2006) and concealment (Nelson, 2016; Rilinger, 2019; Cappellaro, Compagni, and Vaara, 2021) practices. Developments in information and communication technology have also opened up new avenues for balancing knowledge sharing and concealment, for instance, by allowing online actors to keep their identities concealed while sharing their knowledge publicly (Ladegaard, 2020).

An understanding of open secrecy extends this literature by highlighting the role of meta-knowledge – i.e. knowing *of* something rather than knowing it. This form of meta-knowledge allows for the operation of a "third space" outside a simple spectrum of knowing and not knowing (Janssens and Steyaert, 1999; Putnam, Fairhurst and Banghart, 2016). For example, as discussed earlier, workers exposed to revealed concealment are not some X% more aware of the content of organizational secrets than out-group members. They are simultaneously aware and unaware (Nelson, 2016). Accounting for the role of meta-knowledge promises to be a fruitful avenue for future scholarship.

Knowledge Flows and Organizational Structuring

This study makes two main contributions from an analytical standpoint—shifting the locus of analysis of knowledge concealment from the external interface of the organization to its internal structure, and underscoring the link between knowledge flows and inclusion-exclusion boundaries. Much of the extant work on the strategic sharing and concealment of organizational knowledge has been concerned with the interface between the organization and external stakeholders such as professional colleagues (Nelson, 2016), innovation partners (Laursen and Salter, 2014), competitors (Alexy, George, and Salter, 2013), regulators (Funk and Hirschman, 2014), and investigators (Cappellaro, Compagni, and Vaara, 2021). Focusing on the internal interface moves the conversation toward the important question of organizational structure and the shaping of inclusion-exclusion boundaries. By illuminating complexities in processes of knowledge sharing and concealment this study thus sheds light on complexities in organizational structuring.

This study challenges the conventional view that the structural consequence of collective secrecy is the drawing of (complex, but) distinct boundaries between those in-the-know and those not in-the-know (Simmel, 1906; Costas and Grey, 2016). While upholding the basic idea that collective secrecy entails the construction of inclusion-exclusion

boundaries, this study demonstrates that there is a rich, in-between space of possibility wherein actors can be both somewhat included and somewhat excluded. Although this study stops short of theorizing about the nature of the in-between space itself, future research may benefit from a deeper examination of this space created by open secrecy.

For instance, the preceding analysis suggests that this space in between inclusion and exclusion represents a difference in kind rather than a difference in degree (see the preceding discussion on the "third space" of meta-knowledge). I have suggested elsewhere that this organizational third space might constitute a "liminal space" (Borpujari, 2021). Further work may benefit from exploring this suggestion, delving deeper into the experience of being a member of such an in-between group, and unpacking, for instance, whether the experience of in-betweenness is not only a relational one (between inclusion and exclusion), but also an existential one with important identity dynamics at play (Ibarra and Obodaru, 2016; Söderlund and Borg, 2018).

Further research is also needed to investigate the idea of structural liminality within an organization. Large portions of the work on liminality in organizational contexts has focused on liminality as a transition process rather than an enduring structural feature (Söderlund and Borg, 2018), drawing on original anthropological work on liminal experiences during ritual transitions (Van Gennep, 1909; Turner, 1967). The transitional approach to liminality also resonates with prior work on inclusion-exclusion boundaries in organizations. Schein (1985) emphasized the "inclusionary movement from outsider to insider" for organizational members as they gradually "become privy to some of the more secret assumptions of the group" (Schein, 1985: 99). In contrast, this study challenges the idea of a stage-wise "inclusionary movement" in the context of secretive innovation by showing how, through ongoing intentional as well as emergent tactics of knowledge sharing

and concealment, organizational members can create and re-create (Giddens, 1984) a liminality that is both fragile (at a given moment in time) and lasting (over time).

Secrecy in the Innovation Process

This study begins to question the assumption that secrecy is de facto harmful for the value creation objective. The theoretical model developed here demonstrates how open secrecy can, at the very least, mitigate some of the inhibitory effects of closed secrecy for value creation within the organization. Further, viewing the concept of open secrecy in light of the extant literature also suggests that open secrecy can be beneficial to value creation (over and above the mitigatory benefit mentioned above). First, actors included into a secret undertaking are likely to place value in their group membership by virtue of inclusion, regardless of the content of the secret (Simmel, 1906; Goffman, 1959). This notion of a beneficial aura of secrecy for in-group members would extend to in-between group members since knowledge of the actual content of the secrets is irrelevant to the aura of secrecy. Second, the existence of an in-between space in the organization can also invite exploration and experimentation by employees, allowing them to act on hunches and try out alternative courses of action (Howard-Grenville et al., 2011). Third, having members in the in-between space potentially allows greater structural range for the incubation of novel ideas. Research on the generation and adoption of ideas suggests that more novel ideas come from the periphery rather than the core of a network (Cattani, Ferriani, and Lanza, 2017). In completely secretive innovation, peripheral members would not even be aware of the existence of a secret within the core group. Under open secrecy however, some portions of the network periphery are brought into a middle layer between the core and the periphery. This middle layer's knowledge that there *is* something going on, and some further meta-information about the secrets of the core group could allow greater ability for the generation of novel ideas.

Finally, the arguments developed in this paper call for further research examining the roles of secrecy, open secrecy, and inclusion-exclusion boundaries at various stages along the innovation process. For instance, Perry-Smith and Mannucci (2017) identify four broad stages of the idea journey – generation, elaboration, championing, and implementation. Analyzed through this framework, the motivational benefits of open secrecy may be more useful in the generation of ideas while the structural implications of open secrecy may be more useful in the elaboration and championing stage. In the implementation stage, the benefits of open secrecy may be outweighed by the downsides.

Boundary Conditions and Generalizability

A historical case study, perhaps more so than other forms of qualitative research that involve contemporaneous data collection, aims not to arrive at perfectly reproducible results but to generate theoretical insights that contribute to a scholarly repertoire of "tentative theories and concepts with which to address always-novel conditions" (Pratt, Kaplan, and Whittington, 2020: 5). Against this epistemological backdrop, there are two main limitations that inform the boundary conditions for the theoretical model developed here – the extreme-case nature of the study, and the single-case nature of the study.

The extreme setting of World War II entailed a high degree of patriotism and urgency to contribute towards the cause. As such, a key boundary condition for the findings in this paper is that organizational members accept the need for secrecy. In the Manhattan Project, this boundary condition was met due to the agreement by most involved of the need to prevent leakage of information to the Germans, and the high levels of patriotism brought about by the war (Groves, 1962; Rhodes, 1986). This contributed to people adopting an attitude of acceptance towards the secrets that the organization chose to withhold from them. The successful containment of the core secret thus required a two-way collusion of "don't tell" and "don't ask". To some extent, this patriotic setting may be generalizable to cases of

strong organizational identification. Members who identify strongly with their organizations or its leaders would be more likely to accept and work through internal secrecy and its challenges. Irrespective of what drives the acceptance, however, it is the acceptance itself that forms the more proximal boundary condition for the model developed in this study.

The single-case nature of this study poses a key question – to what extent was the Manhattan Project an "organization"? It was clearly not a typical organization. The organization was set up with a very specific objective, meant to be achieved within a fixed time frame, and most of the workers involved were cut off from their normal lives and physically relocated. As such, this case more closely resembles a temporary system, i.e. – "a set of diversely skilled people working together on a complex task over a limited period of time" (Goodman and Goodman, 1976: 494). At the same time, as evident in the analyses above, this temporary system lasted over several years, and displayed more formal structure, hierarchy, and administrative control than prototypical temporary organizations (Meyerson, Weick, and Kramer, 1996). The fixed time-frame of the project, as well as a view of the project as a "temporary total institution" (Bechky, 2006), is of particular relevance here since it likely influences the first boundary condition of the extent to which members of the organizational out-groups as well as the in-between groups continue to accept the need for secrecy.

The fixed time-frame of a temporary system is also key because organizational objectives can change over time. After the Axis powers were defeated, the U.S. government became much more concerned with keeping bomb secrets from the Soviets. Eventually, Klaus Fuchs, a British scientist who had been living and working at Los Alamos, gave away

many bomb secrets to the Soviets[7]. Would the Manhattan Project as an organization have been considered a success had its goals included the safe-keeping of secrets from *any* external organizations *into perpetuity*? Ultimately, it is not possible to infer from the current case whether open secrecy would be similarly effective in instances of continuous, non-project-based innovation, despite the fact that it proved effective over the half-decade time-frame of the bomb project. As such, this study is most directly generalizable to similar temporary systems. In recent years however, there has been a steady rise in project-based organizations, and project-based work within organizations (Cattani et al., 2011), indicating that theories related to temporary systems and project work are of increasing significance in today's world (Bechky, 2006).

Conclusion

The conclusions from this study can be best summarized by borrowing a metaphor from Michael Polanyi, who compared the task of scientific innovation to the image of dispersed groups of people working on a common, giant jigsaw puzzle. Inclusion is critical to successful outcomes: "The only way the assistants can effectively cooperate and surpass by far what any single one of them could do, is to let them work on putting the puzzle together *in sight of the others*, so that every time a piece of it is fitted in…all the others will immediately watch out for the next step that becomes possible in consequence" (Polanyi, 1962: 55, emphasis added).

[7] The case of Klaus Fuchs, however, highlights the limitations of secrecy itself, more so than those of open secrecy. Oppenheimer later testified that even "if Fuchs had been infinitely compartmentalized, what was inside his compartment would have done the damage" (U.S. Atomic Energy Commission, 1954: 220). Fuchs was not a member of the in-between groups but rather, squarely an in-group member.

Organizational secrecy, in this metaphor, implies that all parts of the puzzle are blocked off from view except for the pieces that a given group has to work with. This setup would only work under the stringent constraint that the administrators know in advance what the overall puzzle looks like, are able to break it down into self-contained compartments, and delegate the right parts to the right groups. Few organizational problems are that straightforward or involve that much administrative prescience. At the same time, giving full access to everyone to view the puzzle in real-time threatens value appropriation as outsiders may find it easier to view and copy the solution.

Open secrecy provides an important solution in this case, with room for enhancing value creation while maintaining security. Revealed concealment would mean that the rest of the puzzle is still darkened, but the employees now know that they are working on part of an important, larger, secret puzzle. Permeable physical boundaries and partial revealing between groups would mean that parts of the puzzle become selectively visible to some members. Through these tactics, there will be greater opportunity, motivation and ability for the exchange and combination of knowledge within the organization. Experts working on one end of the puzzle could provide insights on another, and serendipitous discoveries (discovering that a given piece of the puzzle actually fits elsewhere) become more likely. The full view of the puzzle is still not available to these workers.

In the Manhattan Project, the puzzle went from being openly visible (during the early phase of scientific discovery) to being increasingly darkened (during the second phase of initial government involvement) to being layered with varying shades of grey for different groups of people (during the third phase of the MED). Open secrecy, through its ability to foster a space in between inclusion and exclusion, and the consequent effects on organizational social capital, likely played an important role in solving the puzzle of the atomic bomb before anyone else could.

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TABLES AND FIGURES

Table 1. Summary of archival data sources and their usage.

Type of Source	Sources Used	Contribution to Data Analysis
First-hand, Contemporary	Extensive personal correspondence and memos: • Groves, Leslie • Oppenheimer, Robert • Szilard, Leo	Evidence on the day-to-day lives, experiences and perspectives of key project members. Narrative sensemaking around key episodes and inter-personal interactions giving rise to the various tactics found in the case. Triangulation of findings from first-hand, retrospective, and second-hand, retrospective sources.
First-hand, Retrospective	Personal memoirs and recollections: • Bradbury, Norris (1980) • Brode, Bernice (1980) • Dudley, John (1980) • Fermi, Laura (1954) • Feynman, Richard (1975) • Gardner, Phil (1965) • Greenewalt, Crawford (1965) • Groves, Leslie (1962) • Hirschfelder, Joseph (1980) • Kiernan, Denise (2013) • Kistiakowsky, George (1980) • Manley, John (1980) • McKibbin, Dorothy (1965) • McMillan, Edwin (1980) • McMillan, Elsie (1980) • Michel, Mary Lowe (2005) • Oppenheimer, Robert (1965) • Szilard, Leo (1978) Government proceedings and testimony: • Oppenheimer security hearing with the U.S. Atomic Energy Commission (1954)	Understanding the entirety of the case, including key events, timelines, and actors. Evidence on the day-to-day lives, experiences and perspectives of project members. Categorical sensemaking around tactics of secrecy, openness, and open secrecy. Narrative sensemaking around key episodes and inter-personal interactions giving rise to the various tactics found in the case. Quantitative data on the scale of the project, and the operations of the various sites within it. Triangulation of findings from second-hand, retrospective sources, as well as between first-hand accounts of various actors.

Second-hand, Contemporary	Official government accounts: • Manhattan District History commissioned by Groves • Smyth Report • Truman press release Media articles: • New York Times • Saturday Evening Post	Understanding the entirety of the case, including key events, timelines, and actors. Perspective on contemporary civilian views on the project. Quantitative data on the scale of the project, and the operations of the various sites within it.
Second-hand, Retrospective	Civilian histories and biographies: • American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer (2005) • Day One (1989) • Secret History of the Atom Bomb (2009) • The Day After Trinity (1981) • The Making of the Atomic Bomb (1986) Official government histories: • The Manhattan Project: Making the Atomic Bomb (2010)	Understanding the entirety of the case, including key events, timelines, and actors. Familiarization with the wider social context of the events of the case. Categorical sensemaking around tactics of secrecy, openness, and open secrecy. Narrative sensemaking around key episodes and inter-personal interactions giving rise to the various tactics found in the case. Quantitative data on the scale of the project, and the operations of the various sites within it. Triangulation of findings from first-hand contemporary and retrospective accounts.

Table 2. Impact of the tactics on inclusion-exclusion boundaries.

Tactic Category	Tactic	Impact on inclusion-exclusion boundaries	Selected case evidence*
Secrecy	Voluntary collective concealment	• Excludes members from organizational secrets, creating boundaries between included and excluded groups within the organization. • Lack of clarity on which groups are included or excluded due to self-organized nature of the tactic.	• Szilard, Fermi and Pegram decide not to publish Fermi's research, effectively concealing his work from fellow U.S. researchers. • Turner writes to Szilard, confused about the guiding principles of concealment.
	Mandatory collective concealment	• Excludes members from organizational secrets, creating clear boundaries between included and excluded groups within the organization. • Multiple inclusion-exclusion boundaries, based on need-to-know principle. Vertical concealment entails keeping secrets between different levels of security clearance, and horizontal concealment entails keeping secrets between groups at the same level of security clearance. • Good clarity on which groups are included or excluded due to use of formally mandated policies and top-down administration of the tactic.	• Badge system at Los Alamos makes the inclusion-exclusion of members within the same campus abundantly clear. • 5,000 people at Oak Ridge run the calutrons for uranium separation without being told why they are doing so. • Plant workers are not allowed to unionize to prevent information exchanges and integration.
	Physical separation	• Physically excludes members from secret-keeping in-groups, creating tangible boundaries between included and excluded groups within the organization. • Horizontal physical partitioning of groups (e.g. restricted access across sites) as well as vertical	• Los Alamos campus contains a fence-within-a-fence structure. Organizational out-group members living on the same campus cannot access the Technical Area. • Dr. Glenn Seaborg, working at the University of Chicago,

Tactic Category	Tactic	Impact on inclusion-exclusion boundaries	Selected case evidence*
		physical partitioning of groups (e.g. scientists vs. technicians within the same site). • Strong clarity on which groups are included or excluded based on formal allocation of access rights to physical spaces.	is not allowed to enter the Los Alamos site.
Openness	Voluntary revealing	• Includes members into organizational secrets, while reinforcing exclusionary boundaries based on voluntary collective concealment. • Lack of clarity on which groups are included or excluded due to self-organized nature of the tactic.	• Mark Oliphant makes personal trips around the U.S. to share updates from British nuclear research. Individually-driven nature means that he reaches out to people he knows (e.g. Ernest Lawrence) instead of relying on formal channels of communication.
	Mandatory revealing	• Maintains the partitioning of secret-keeping in-groups from others, as revealing takes place through formal channels, in line with the need-to-know principle. • Multiple inclusion-exclusion boundaries, based on concurrent mandatory collective concealment policies. • Good clarity on which groups to include or exclude due to use of formally mandated policies and top-down administration of the tactic.	• Edward Condon drafts the *Los Alamos Primer*, used to share information with incoming scientists at Los Alamos. • Weekly colloquia set up among white-badged scientists at Los Alamos.
	Physical colocation	• Includes members into organizational secrets, but is constrained by super-ordinate boundaries created by physical separation. • Strong clarity on which groups are included and which are excluded based	• Oppenheimer argues for a central laboratory for nuclear research and bomb design, leading to the establishment of Los Alamos. Scientists working disparately across university

Tactic Category	Tactic	Impact on inclusion-exclusion boundaries	Selected case evidence*
		on formal distribution of access rights to collocated spaces.	campuses are brought together under one roof.
	Using external partners	• Includes groups into organizational secrets. However, the concurrent use of open secrecy tactics such as revealed concealment or partial revealing leads to a blurring of boundaries between secret-keeping in-groups and others. • Lack of clarity on which groups are included or excluded since different partners are included to differing degrees, including some brought in to the in-between space of open secrecy.	• Groves brings in Stone & Webster, du Pont, and other firms for project support. Not all external partners are brought in to the same degree. • Some executives / staff of du Pont are brought in on project details while others are not.
Open Secrecy	Revealed concealment	• Creates a gray space where groups are both partially included (somewhat in on the secret) and partially excluded (not fully in on the secret). At the same time, these in-between groups are neither fully included (not brought into the secret keeping in-group) nor fully excluded (not relegated to the unaware out-group). • Clarity on which groups are included, excluded or in between since the tactic is formally sanctioned.	• Recruitment involves telling the scientists that they will be working on a secret project of great importance to the war, but not revealing the purpose or details of the project. • Groves reaches out to du Pont executives, who in turn petition their Board of Directors, without revealing the secret purpose of the project. • Air force crew involved in the final bombing missions are not told of the nature or implications of the bomb they are carrying.
	Partial revealing	• Creates a gray space where groups are both partially included (somewhat in on the secret) and partially excluded (not fully in on the	• Philip Abelson shares pertinent information with Oppenheimer, across

Tactic Category	Tactic	Impact on inclusion-exclusion boundaries	Selected case evidence*
		secret). At the same time, these in-between groups are neither fully included (not brought into the secret keeping in-group) nor fully excluded (not relegated to the unaware out-group). • Lack of clarity on which groups are included, excluded or in-between due to mix of formal and ad-hoc, individually-driven nature of the tactic.	compartmentalized lines. • Feynman informs Oak Ridge staff about the basics of atomic physics and uranium enrichment. • Tolman consults Hirschfelder about gun design.
	Permeable physical boundaries	• Creates a gray space where groups are both partially included (somewhat in on the secret) and partially excluded (not fully in on the secret). At the same time, these in-between groups are neither fully included (not brought into the secret keeping in-group) nor fully excluded (not relegated to the unaware out-group). • Clarity on which groups are included, excluded, or in-between due to controlled nature of permeation.	• Oppenheimer brings in several consultants to Los Alamos – Rabi, Bohr, Von Neuman. • Feynman and Segrè obtain permission to travel to Oak Ridge. This leads to important improvements to operational safety at the uranium enrichment plants.

*Detailed in Appendix Tables A1–A3.

Figure 1. Chronology of key events in the making of the atomic bomb.

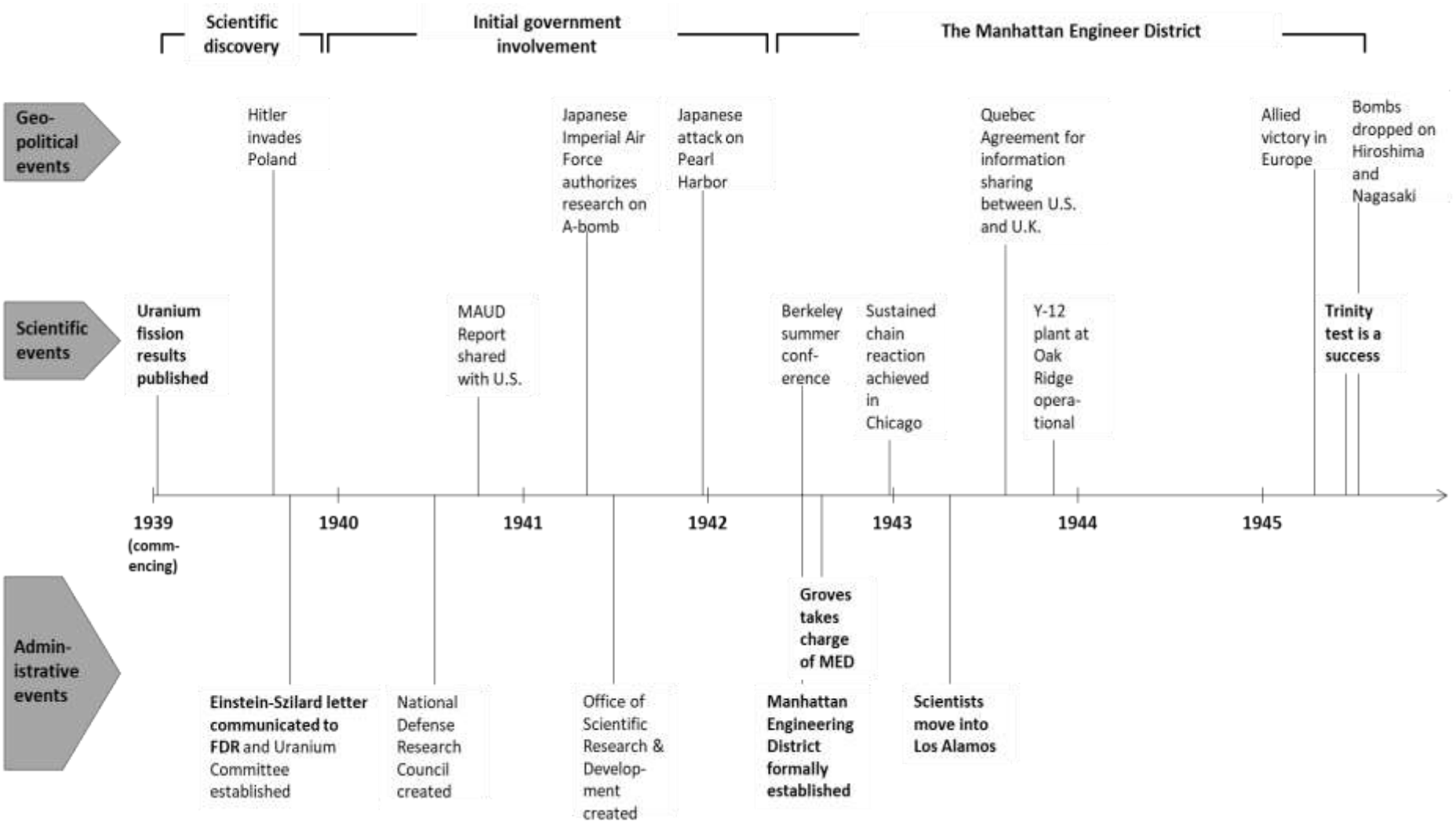
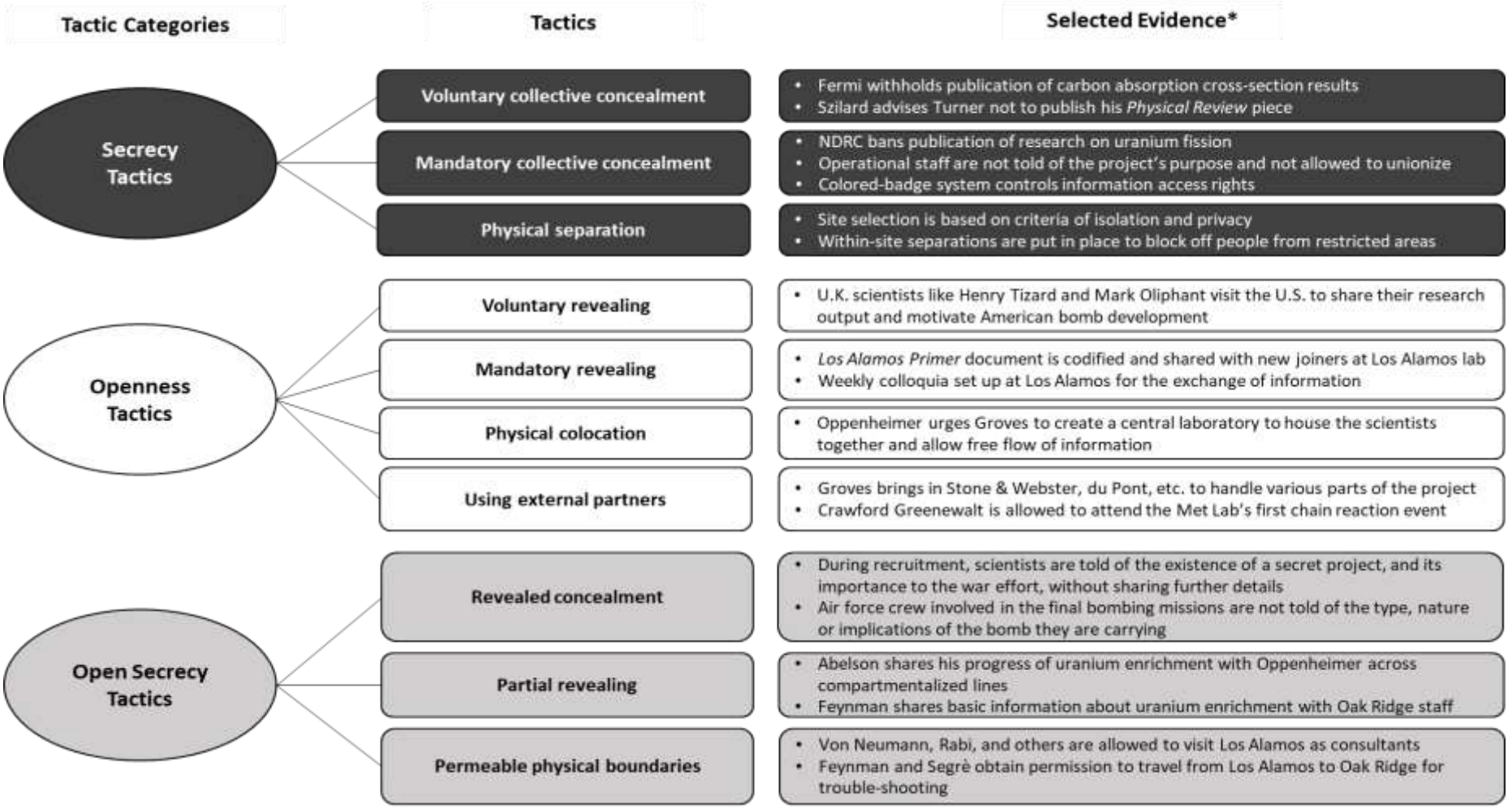


Figure 2. Details of the 3 primary secret sites of the Manhattan Engineer District.

Figure 3. Tactics related to secrecy, openness, and open secrecy.



*Further evidence is detailed in Appendix Tables A1–A3.

Figure 4. Evolution of tactics over time.

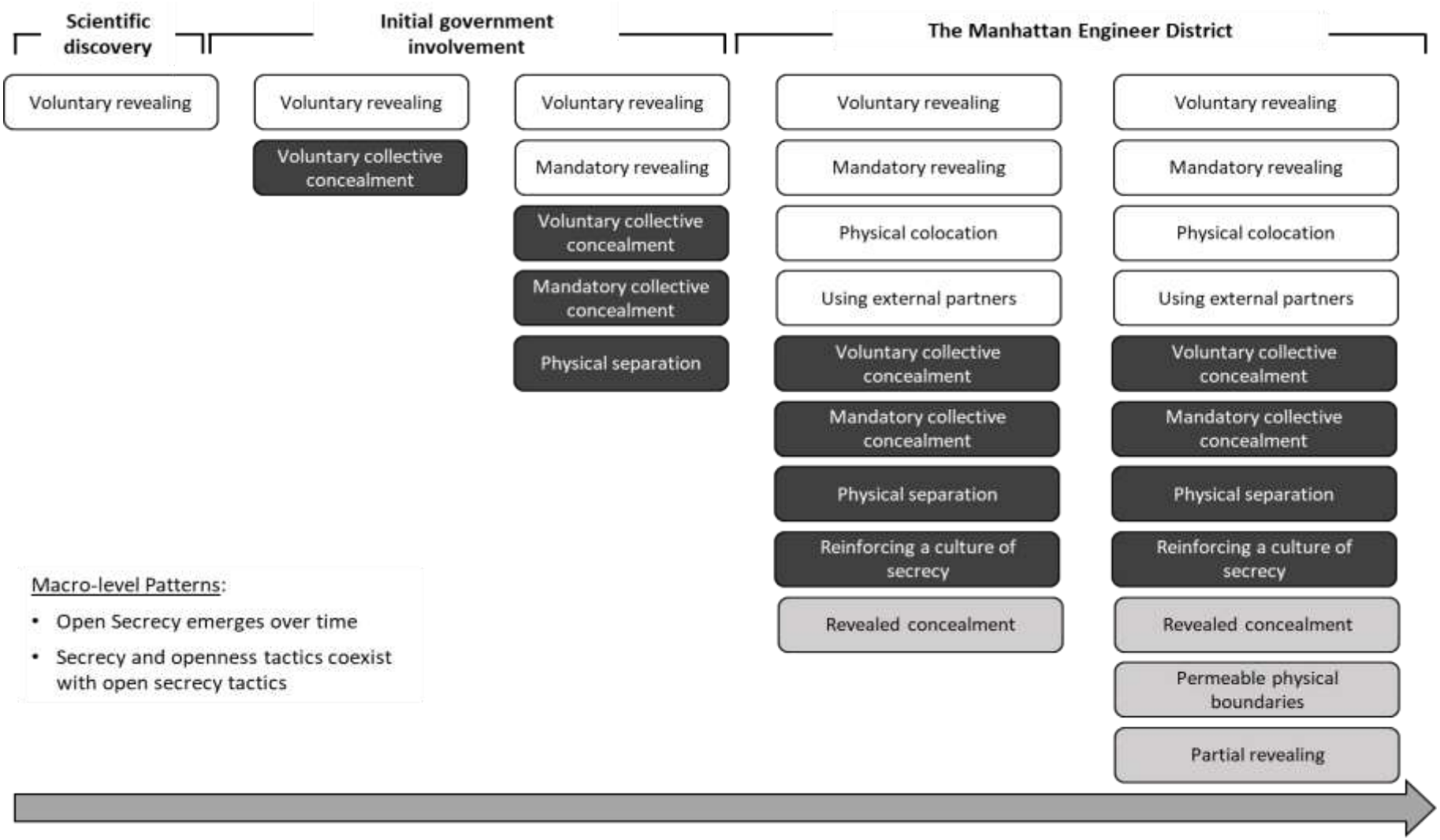
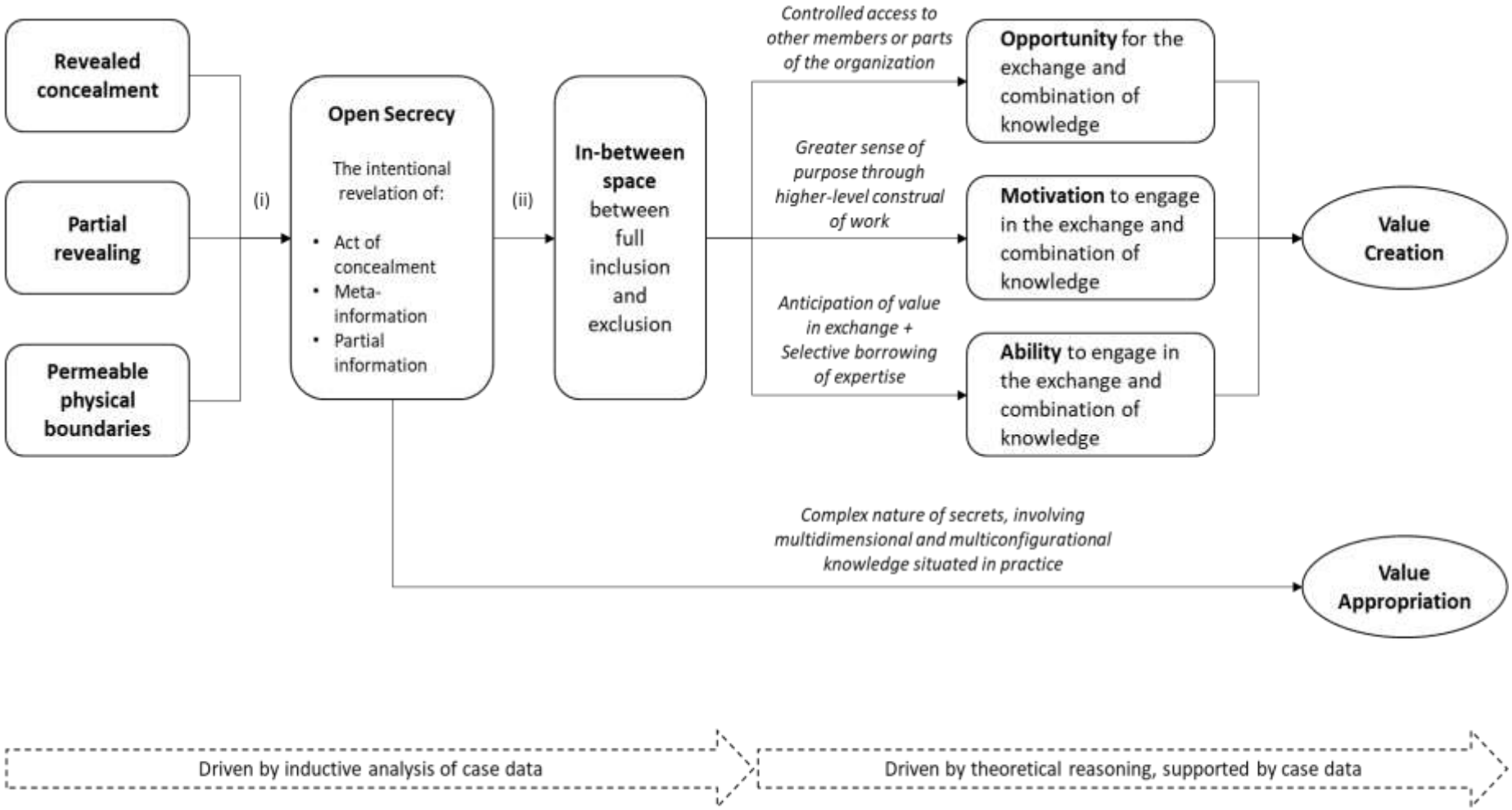


Figure 5. Theoretical model: Open secrecy and social capital.



(i) Detailed in Figure 3, and Appendix tables A1 – A3
(ii) Detailed in Table 2