Frigates: Disequilibrium Learning and Compressed Development

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Before it starts, economic development is hard to visualize, not only because so many different conditions must be fulfilled simultaneously but above all because of the vicious circles: generally the realization these conditions depend in turn on economic development. But this means also that once development has started, the circle is likely to become an upward spiral as all the prerequisites and conditions for development are brought into being.

This approach permits us to focus on a characteristic process of economic development that is fundamental for both analysis and strategy: development depends not so much on finding optimal combinations for given resources and factors of production as on calling forth and enlisting for development purposes resources and abilities that are hidden, scattered, or badly utilized.

Albert O. Hirschman[1]

The modern warship is not only a product, but at the same time a specimen of modern large-scale industry.

Anti-Duhring by Fredrick Engels 1877

Introduction

Proponents of unbalanced growth, notably Albert Hirschman, argued that no developing economy could ever muster all the resources required for simultaneous action, and that the problem for policymakers, was, therefore, how to stagger investments so that the disequilibria created between the supply and demand for various intermediate and final goods touched off self-reinforcing sequences of upstream and downstream investments.

The difficulties with staggering large investments were anticipated in the rational choice criticism of unbalanced growth: Projects big enough to create self-reinforcing disequilibria also afford sufficient opportunities for patronage to breed lobbies of state bureaucrats as well as suppliers of the public sector. Consequently, patron-client networks subordinate development programs to their own self-interest. The consequence of disequilibrium is therefore not continuous, ever more productive disequilibrium, but rather a new balance of political groups that live well by perpetuating the new status quo.

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[1] Hirschman, *The Strategy of Economic Development*, 5.

In this chapter, my point of departure for rethinking industrialization in China is to reassert Hirschman's claim that economic actors can be induced to learn to solve problems by the systematic creation of bottlenecks, and that this learning can become a self-sustaining source of growth as they discover how to recognize opportunities and how to profit from them.[2]

This chapter innovates on Hirschman's thesis of unbalanced growth by theorizing how shocks induce social learning in an archetypal autarky—late Maoist China (ca. 1965-1978).[3] It is in this connection that the experience of Chinese naval shipbuilding and the broader literature on social learning and late industrialization become relevant.[4] As I will show in the rest of this chapter, Chinese shipbuilders have honed a variant of learning through the induction of disequilibria in manufacturing guided missile frigates in a way that illuminates aspects of the general concept that have been underexposed in the older literature on Cold War history and late industrialization. By inventing a gradualist approach to integrate and upgrade batch-specific shipboard systems (i.e., modular design), Chinese shipbuilders inadvertently developed a home-grown mode of just-in-time production at the institutional core of the command economy.

The definition of just-in-time production: Without knowing about the emerging lean production at Toyota, they imagined themselves as active shoppers in the supply chains of shipboard systems, picking key components off the shelves in just the sequence needed to assemble the frigates for which they already had a customer.[5] The closer they came to realizing

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[2] Hirschman, *The Strategy of Economic Development*, 6.

[3] 陈东林, *1966－1976 年中国国民经济概况*. According to Chen, China's international trade in 1969 was 0.72 percent of the global trade.

[4] 陈东林, *1966－1976 年中国国民经济概况*, 148, 293, 340. To my knowledge, commissioned historians in China consistently narrated naval shipbuilding as a major production system of the late Maoist economy. But no scholarly account of the inner workings of Chinese shipbuilding industry existed in English and Chinese literature. This chapter thereby contributes to existing literature in two ways. First, it offers a historical account on the inner workings of naval shipbuilding. Second, it offers a theory to explain institutional changes in this production system.

[5] Chen 陈, "053H 护卫舰研制中的若干技术问题," 111.

this idea, the closer they would be to eliminating the risk of holding inventory (shipboard systems, materials, and half-finished hulls).

How in the world could this happen? Why did shipbuilders change production rules during these turbulent years despite material scarcity? Out of these two empirical questions grew an equally intriguing theoretical challenge: What were the conditions behind this unbalanced growth? This chapter searches for answers to these three questions.

The Argument: Disequilibrium Learning and Uneven Progress of De-Stalinization

I conceptualize the emerging just-in-time production as a vehicle of de-Stalinization of the Chinese production system. This new movement proposed the concept of disequilibrium learning as an alternative to the Stalinist principle of hierarchical monitoring—a defining characteristic of forced defense industrialization of the early People's Republic. This movement thereby began to undermine the institutional basis of the Maoist command economy. The historical actors who spearheaded this movement could not explicitly attack the command economy for its deficiencies yet. Instead, they questioned the Maoist production system as a self-limiting structure. They boldly challenged the Maoist system by adopting its way of speaking, which paradoxically combined canonized modes of expression and arbitrary manipulations of meanings. Till 1965, the discourse of centrally planned defense industrialization centered on reverse-engineering Soviet hardware. In the late 1960s, the promulgated proceedings and the canonized registers were challenged by the practical tasks of naval modernization. Because the orthodox credo was no longer clearly defined and the boundaries of the permissible became blurred, middle-level bureaucrats of the national security state set themselves apart by semantically manipulating the obtrusive rhetoric.

In the 1970s, a group of shipyard engineers in Shanghai sought a path to integrate the customized operations of batch (low-volume) production with the standardized parts of flow (high-volume) production. They placed strong emphasis on synchronizing diverse component supplies from external suppliers while creating built-in redundancy in the finished good for future upgrades. By conceptualizing the hull as a platform for experimentation with gradualist upgrading of shipboard systems, shipyard engineers purposefully design the hull with redundant space and paid detailed attention to the upgradability of the platform (see Table 1 for a crude illustration of technical details). Encouraged by naval officers at the military procurement agencies, this disequilibrium learning at specialty workshops became an asset rather than a handicap. There is a remarkable resemblance between this new mode of production and the "just-in-time" production adopted in Japanese production systems after 1945. In this sense, employees at Hudong Shipyard who worked on military products experienced the Cultural Revolution in a particular way: the Cultural Revolution disrupted central oversight without much affecting the learning processes between designers, producers, and supply bases.

The Historical Narrative

The late Maoist production systems are often presented as either a collection of loosely related Stalinist big-push techniques of mass production or as emanations of class universalism.[6] In this chapter, I want to reinterpret the counterintuitive trajectory of one major defense production system—the shipbuilding of guided-missile frigates.[7] I argue that changes in separate production methods and the broad features of industrial organization follow from a simple idea

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[6] Andreas, *Disenfranchised*; Meyskens, "Experiencing the Cold War at Shanghai's Secret Military Industrial Complex"; Naughton, "The Third Front: Defence Industrialization in the Chinese Interior"; Meyskens, *Mao's Third Front*.

[7] 陈东林, *1966－1976 年中国国民经济概况*, 148， 293， 240;《中华人民共和国国民经济动员史》编写组, *中华人民共和国国民经济动员史(1949-1978)*, 384–85.

of disequilibrium *learning* that has been institutionalized. Hence, the interests of the parts are consistent with the whole.

This idea of disequilibrium learning can be observed by tracing changes in the production methods and procurement rules of the Project 053 guided missile frigates (I will examine three classes: 053K, 053H, 053H1). These projects—the first series of Chinese guided missile frigates—originated as one of the four top-priority platforms procured by the People's Navy. In 1967, it was approved by the Central Military Commission as a highly prioritized weapon system of the Third Five-Year Plan for naval armament ("三五"期间海军重点装备的 4 型舰艇之一).[8] In this case, the constant reduction of in-process and the strain it puts on the whole manufacturing organization is the obvious point of contact between the Maoist defense production systems and the concept of unbalanced growth.

In this case, the reduction of in-process refers to the various ways of utilizing both linear and non-linear feedback to coordinate current materials flows in cross-cutting supply chains (i.e., feedback control in the register of control theory).[9] For example, delay in the supply of radars leads to disruptions to the pre-planned schedule of testing the technical linkages between the missile and the radar, thereby leads to further disruptions in the assembly of the final product (the ship): an undesirable in-process that plagues planned production schedules. As I will explain below, the extraordinarily high level of technical interdependence of shipboards systems became the source of acute coordination problems for actors across the supply and demand domains.

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[8] "主要产品-053K 型护卫舰," 23. The original text: 1967 年 6 月，国家计委、国防工办、国防科委以（67）科三字第 388 号文批复六机部、海司，同意《四型舰艇设计审查及技术协调会议纪要报告》的安排。文中说："四型舰艇是海军的重要装备，对海军现代化建设有重大意义。军委第六十四次常委会在审查国防科学技术'三五'规划时，业已批准。请有关部门立即安排落实。特别是为四型舰艇配套的动力、武备、观通导航设备，更要抓紧进行研制，以便按时按质拿到成果，装备部队"。

[9] Forrester, "Industrial Dynamics," 149–60.

The Project 053 frigates constituted the mainstay of the PRC surface fleet in the late Cold War. In total, two Project 053K frigates (the second was decommissioned in 1986), 14 Project 053H frigates (one was lost in an accident), and 10 Project 053H1 frigates entered the People's Navy's service.[10] Two Project 053H frigates were exported to Egypt between 1982and 1984. By the end of 1989, the People's Navy's surface fleet had 35 frigates. 26 frigates were of the 053H series (This includes Project 053H2 frigates. Project 052H's governance architecture is a further extension of the Project 053H series. In other words, they come along when my narrative is more or less complete).

During the Cultural Revolution, junior engineers at the Hudong Shipyard (沪东造船厂) —a major shipyard at Shanghai—came close to paralyzing themselves in the process of building high-complexity naval vessels. As they attempted to meet pre-planned production schedules, external suppliers were unable to deliver key components such as fire control radars, naval guns, and power plants in a timely manner to the shipyard. Facing this "hold-up" problem, the People's Navy refused to continue the procurement of the incomplete Project 053K frigates.

It is important to note here that this was defense production within a Stalinist system – and undertaken when China had no really significant allies – meant that while naval officers could refuse to continue the procurement of the 053K ships, they didn't have any real alternative to waiting until the same network of designers and suppliers could produce a satisfactory frigate. Therefore, they had to be patient until the new governance architecture was institutionalized and

[10] Chen 陈, "053H 型护卫舰的演变," 107; "主要产品-053H,053H1 型护卫舰," 30. Between 1982 June 30 and 1988 June, 10 Project 053H1 frigates entered service. Project 053H1 received upgrades in shipboard systems. In particular, sonars, main guns and anti-aircraft guns were upgraded. These upgrades utilized products that had been prepared for Project 053K frigates. By the time Project 053H1 frigates entered series production, the reliability of these combat systems had been improved.

bore fruit – something that would not be true with certain other products, or other institutional and historical settings.

While naval officers viewed the incomplete Project 053K frigate as a half-empty glass, a group of engineers at the Hudong Shipyard saw it as a half-full one.[11] By modifying the overall design of Project 053K frigate, these producers challenged the pre-existing hierarchical relations between shipyards, supply bases, and design bureaus. Building on the principle of modular design, they proposed an alternative design for frigates—later designated as the Project 053H frigates.

This emerging just-in-time production placed enormous demands on each manufacturing operation and the logistics system connecting them. Both the producer of final products and suppliers of sub-systems must also be highly flexible, in the sense of being quickly convertible from production of one model to another, if they were to respond to variations in the composition of demand (e.g., modifications to shipboard combat systems). In this manufacturing process, shipyard engineers reevaluated the performance and reliability of each shipboard system supplied by the Original Equipment Manufacturer (OEM) network. This successive removal of inventories created bottlenecks in production that allowed the identification of each shipboard system's weaknesses.[12] In this way, it was analogous to the potentially informative disruption of production caused by, say, the construction of a new steel plant in stories of unbalanced growth.

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[11] Chen 陈, "053H 护卫舰研制中的若干技术问题," 110–11; 周 and 陈, "周振柏-访谈-2025.8.24"; Zhou 周, "护卫舰'摇篮'誉漫天下," 152–53; "主要产品-053H,053H1 型护卫舰," 28–29; Liu 刘, "053H 对海型护卫舰的诞生," 106–7; Chen 陈, "053H 型护卫舰的演变," 107–8.

[12] Chen 陈, "053H 型护卫舰的演变," 107–8.

In more analytical terms, the Maoist autarky inadvertently created a disequilibrium between supply and demand in the naval shipbuilding sector. In this context of forced isolation from foreign technologies, frontline actors had to make sense of the uncertainty induced by disruptions in supply chains. To resolve this uncertainty, the ensemble of production rules for the Project 053H frigate did not resemble the 'I'll be good to you if you're good to me' type (i.e., a reciprocity-based “gift” economy) at all. Contrary to this type inscribed in the official register of the Cultural Revolution, frontline actors stipulated the kinds of information to be reviewed, set minimum performance standards with reference to that information, and specified precisely how gains in excess of the minimum were to be divided. [13]

These production rules ensured that the information thus revealed was put to productive use first, by assigning responsibility for doing so to those in the best position to learn what was required—typically production managers and engineers at shipyards. Then assurances were provided that no one would be harmed by what was learned and that those adept at applying it would benefit from their efforts. Since the low-volume production of frigates at the shipyard created a continuous flow of information about variations in the performance of supply bases, the production managers at the shipyard were best situated to discover what did not work and what might. The buyers of the People’s Navy rewarded this social learning by providing them with more contracts for successive frigates.

Hence, the unbalanced-growth rules transform what seems from a contractarian point of view like a chain of exchanges into a continuous dialogue of joint possibilities and goals, where

[13] Lin 林, “提出和促成 053H 型护卫舰研制的过程,” 102–5; Liu 刘, “053H 对海型护卫舰的诞生,” 106–7; Zhu 朱, “053H 型导弹护卫舰的形成与发展,” 105–6; Chen 陈, “053H 型护卫舰的演变,” 107–8; Chen 陈, “053H2 型导弹护卫舰武器系统工程研制追忆,” 114–15; Chen 陈, “053H 护卫舰研制中的若干技术问题,” 111; Huang 黄, “053H2 导弹护卫舰研制过程中的两个重要会议,” 112–13.

the parties' historical relations define their mutual expectations. The parties suppose that their understanding of their situation is limited. Therefore, they jointly specify what they believe they understood so as to expose and begin exploring the limits of the understanding.[14] They also have to accept the possibility that their views of themselves, of the world, and the interests arising from both will be changed unexpectedly by those explorations. The production rules in combination with the presumption that the most capable firms would increase their responsibilities and autonomy more rapidly, created an industrial governance structure that encouraged superior performance by rewarding it. In the 1970s, these production rules were confined to the hidden corners of the national security state—Hudong Shipyard and its external supply bases.[15] In the 1980s, these production rules were diffused to every major state-owned shipyard in Dalian, Shanghai and Guangzhou for the civilian export of bulk carriers, oil tankers and container ships.

The Conceptual Argument

This chapter presents a processual account—epistemic drift—to help explain the aforementioned changes in production rules, not as an isolated incident, but rather as a process. This account enables me to pinpoint the generative process from learning to just-in-time production. The shift from the Fordist governance architecture (054K Hierarchy) to the post-Fordist (053H deliberation) is implicitly and necessarily a matter of deconstructing the old in order to create (and legitimate) the new.

To better conceptualize this shift in governance architecture, I propose that changes in industrial governance can be conceptualized with reference to time. This is predicated on a

[14] Herrigel, *Manufacturing Possibilities*.
[15] Chen 陈, "053H 型护卫舰的演变," 107–8.

processual conceptualization of the state.[16] As a regularity that needs to be constantly validated, a state therefore enacts a particular history, which is encoded to the present. Neither the form nor the content of this history is fixed, however, and therein lies in the crux of the argument.

Unvalidation of this history (i.e., abandoning the hierarchy of command-and-control around Project 053K), in this case, is a deliberative project. The seeming stability of the institutional hierarchy rests on the path dependence emerging from feedback loops among different kinds of validation.[17] (e.g., the hierarchy enables a factory to receive funding and deliver the shipboard systems.) Therefore, institutions cannot be shifted at will and require the participation of various social actors: A collective disenchantment with old understandings of the vertically integrated hierarchy enables the actors to develop new understandings of supply chains. As a result, they gradually changed the institutional configuration of the PRC military-industrial complex.

Epistemic drift took place in the slow, steady uncoupling of frontline practices from centrally planned procedures. The operationalization of epistemic drift in this chapter: It is this structural tendency for line units to drift away from *nationally planned rule-based logics* of action toward *locally determined task-based* ones that critically affects changes in production rules. Epistemic drift thereby explains the inadvertent emergence of just-in-time production in China's defense production systems as a manifestation of a broader social dynamic. [18]

What appears to be epistemic drift at the system level often looks like adaptive "sailing" from the frontline perspective of multiple subunits. In other words, epistemic "drift" and

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[16] Abbott, *Time Matters*; Glaeser, "Hermeneutic Institutionalism"; Glaeser, *Political Epistemics* (The University of Chicago Press, 2011).
[17] Glaeser, "Driving Toward Nuclear War."
[18] Sendroiu, "'Probably Tomorrow I'll Become a War Criminal'"; Berk, "State Building through Mediation."

adaptive "sailing" are two sides of the same coin. By theorizing the changes in production rules of guided missile frigates, I emphasize the benefits of approaching such complex events from a processualist perspective—one that emphasizes the importance of looking across levels of analysis and time—not in search of *the cause*, but rather in search of a broader set of conditions that increases the likelihood of such changes occurring.[19]

Roadmap

To place these changes in production rules in context, I will first examine the inner workings of Chinese defense production systems in the 1960s: different shipboard systems fell under the jurisdiction of different industrial ministries.[20] Out of this organizational sore oozed a causal stream that poisoned technical designs, component supply, procurement procedures, and even protocols of quality control. It is the collective impact of this hierarchy that ultimately undermines the shipbuilders' ability to create our organizational level variable—disequilibrium learning.

To get a sense of how important this administrative hierarchy is to the difficulties of creating disequilibrium learning, I will examine the first developmental "phase" of the Project 053 guided missile frigates from 1965 to 1974 (i.e., the first class: Project 053K).[21] Every event along this line traces its origins back to the pervasive influence of top-down planning approved by the hierarchical apex of national security state in 1965. This is a story of how deeply rooted

[19] Glaeser, "An Ontology for the Ethnographic Analysis of Social Processes: Extending the Extended-Case Method"; Abbott, *Processual Sociology*.
[20] Gou 苟, "海军武器（舰炮部分）工业生产建设的回顾"; Zhang 张, "敲开飞航导弹技术的大门-忆'554'技术攻关片段"; Zhou 周, "053 型舰最初阶段电子设备的论证," 99.
[21] Cao 曹, "舰空导弹护卫舰的演变和发展," 95.

hierarchy contributed to the isolation of each shipboard system and how this seclusion ultimately contributed to serious coordination problems along the supply chains.[22]

Out of these coordination problems around Project 053K frigates emerged a re-evaluation of production methods that reshaped technical designs, strategies of component supply, and procurement procedures of the subsequent class of Project 053H frigates from 1974 to 1978—the second developmental "phase" of Project 053 frigates.[23] To get a sense of how important this subsequent just-in-time production is to disequilibrium learning, I will examine the negotiations between shipyard engineers, suppliers, and naval officers for Project 053H frigates between 1973 and 1978. Every event along this line traces its origins back to frontline engineers' strategic uncertainty in managing the supply chains for guided missile frigates. This is a story of how frontline actors' reduction of in-processes—half-finished inventories at the Hudong Shipyard and subcontracting supply bases—contributed to the mutual adjustment between buyers (i.e., naval officers), producers (i.e., shipyard production managers), and suppliers, and how this mutual adjustment ultimately replaced top-down monitoring with decentralized learning for just-in-time production.

Research Design

The institutional and historical condition of this generative process is that the isolated Chinese state struggled to defend itself from the ongoing Cold War rivalry. As a result, elites at the hierarchical apex of the national security state allowed (and indeed made it very likely) this process to play out over a long period, rather than abandoning the project or looking for imports:

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[22] Chen 陈, "053 对空型导弹护卫舰研制片段," 97–98.
[23] Liu 刘, "053H 对海型护卫舰的诞生," 106; Zhu 朱, "053H 型导弹护卫舰的形成与发展," 105–6; Lin 林, "提出和促成 053H 型护卫舰研制的过程," 102–4.

between 1965 and 1980, China did not have a significant ally that was willing to sell guided-missile frigates to the People's Navy at an affordable price (for the Navy) .

However, this structural condition is insufficient to explain how this generative process unfolds. The generative process from disequilibrium learning to just-in-time production is long and complex. As a contributing condition, disequilibrium learning at workshops is relatively remote from central planning at the top echelons of the national security state. As a dependent variable, just-in-time production is conceptually abstract. Thus, lurking in the background of this research design are two methodological challenges.

First, can we trace generative processes on different social scales? As we move further and further away from the "outcome"—the just-in-time production of Project 053H frigates since August 15, 1974—the very notion of causality becomes problematic. In contrast to the experiments of ship hulls for high-speed boats in Chapter 1 and flow production of minesweepers in Chapter 2, "Disequilibrium learning" is more remote from the concrete activities of machine building. Therefore, unlike previous individual (see Chapter 1) and group-level analyses (see Chapter 2), a complete explanation at the organizational level must somehow account for this significant span of causal distance. And given that neither of these things – especially not disequilibrium learning – is concrete enough that a hierarchical superior can simply order subordinates to do it. In other words, how can we establish the causal relation between just-in-time production and disequilibrium learning, given that they are on different social scales?"

Second, what type of evidence is needed? "Disequilibrium learning" is not only more distant in terms of causal proximity, but it is also more abstract conceptually.[24] As events, production managers' struggles to meet pre-planned delivery schedules are relatively concrete occurrences. We can imagine a manager bargaining with the buyer for an extension of the deadline. However, what does "disequilibrium learning" look like? Would you know it if you saw it? How was it institutionalized in the Maoist national security state? What concrete evidence is there that frontline agents spearheaded disequilibrium learning?

Addressing the first problem of tracing generative processes brings me to the epistemic claim of this chapter. If a cause is at play at a given moment in time, I should be able to trace it through actors' behaviors, motivations, and strategies of action.[25] My research protocol narrows the focus to moments of challenge punctuating a long-term temporality under the presumption that these moments provide particularly useful magnifying lenses for analyzing historical actors' motives and understandings.[26]

On how to operationalize this research protocol, the technical archives offer some hints. The archival documents reveal two analytically distinct empirical examples of coordination problems—the control of opportunism and the error-detection and correction regimes.[27] Each of these two examples can be triangulated via expert interviews and archival work.

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[24] Sabel, "Learning by Monitoring: The Institutions of Economic Development."
[25] Ermakoff, *Ruling Oneself Out*. In the field of historical sociology, Ivan Ermakoff developed archival methods to trace generative processes. This dissertation builds on Ivan Ermakoff's methodology.
[26] Glaeser, *Political Epistemics* (The University of Chicago Press, 2011); Zubrzycki, *Beheading the Saint*; Loveman, "The Modern State and the Primitive Accumulation of Symbolic Power"; Steinmetz, *Regulating the Social*. This operationalization originated from historical sociology. It has been implemented in these works.
[27] Sabel, "A Real-Time Revolution in Routines."

First, the suppliers of each key component—such as naval guns, fire control radars, ship hulls, surface-to-air missiles, and diesel engines—were structured as specialized agencies. For the producer—production managers at the Hudong Shipyard—this meant that they had to defend the quality of the final product from defective components. In social scientific terms, this can be conceived as the other classic problem of governance—*the control of opportunism*.

Second, without the production managers' report on information about key components, naval officers—buyers at the military procurement agency—were unaware that increased reliance on off-the-shelf components could drastically reduce in-processes while enhancing reliability. In social scientific terms, this can be conceived as the *error-detection and correction regimes* for sustaining *exchange relations*.

As concrete examples, these two governance problems help us address the two analytical challenges unique to this chapter. First, they help operationalize an abstract concept—disequilibrium learning—by putting some empirical meat on sparse conceptual bones. Second, by virtue of their logically intermediate position for explaining the outcome—the just-in-time production of major combatants—they help bridge the significant causal distance between a remote antecedent—disequilibrium learning—and the outcome.[28] In the following section, I frame each of these three empirical problems of governance as examples of instituted processes to solve coordination problems.

The second challenge is to select evidence for tracing generative processes in the making. The task is to unearth a type of evidence that documents processes from the ground level. If the past is recent, interviews can be sufficient for the task. If the past is too distant, researchers rely

[28] Ermakoff, "Causality and History," 594–96.

on primary historical sources—i.e., sources produced by historical actors—of a behavioral or discursive type. Project 053 frigates offer a rare opportunity to integrate interviews with primary sources.

First, I managed to interview the frontline engineer who proposed the original just-in-time approach to design and produce Project 053H frigates in 1974. In August 2025, the (then) junior engineer Zhou Zhenbo (周振柏) participated in my semi-structured interview at Shanghai Jiao Tong University. In the interview, Zhou Zhenbo provided statements with a narrative (diachronic) structure. He recounted his involvement in both Project 053K and Project 053H frigates as the Deputy Director of the Ship Hull Section (船体股副股长) at Hudong Shipyard. Narrative form often discloses much more information about themselves and others than the narrator thinks. To my knowledge, Zhou is the last surviving person who participated in the production and design processes of Project 053 frigates from the very beginning. He was on the payroll of the Hudong Shipyard since November 1967. He was a member of both design teams of Project 053K and Project 053H frigates. According to the memoir of naval engineer-officers who oversaw the procurement of Project 053H frigates, Zhou was the architect behind the just-in-time component supply and modular design.[29] In other words, Zhou spearheaded the

[29] Zheng 郑 and Zhu 朱, "火红的年代-中国海军护卫舰发展回忆," 3; 周 and 陈, "周振柏-访谈-2025.8.24." Naval officers' memoir was dedicated to Rear Admiral Lin Zhen. As a result, their narrative revolved around Lin Zhen's contribution to the Project 053H frigates. These two authors were officers at the military procurement agency. They were responsible for reviewing Zhou Zhenbo's design. Consequently, they did not examine the deliberation inside the Ministry of Machine Building Industry No. 6, but they still acknowledged Zhou's contribution. I conducted additional cross-checks of their statements by examining documents from the Ministry of Machine Building Industry No.6. The original text: 对于护卫舰的总体性能，动力装置和武器装备，林部长亲自组织六机部有关局及沪东造船厂的人员，特别是当时负责设计的周振柏同志一起，在认真负责实事求是的基础上，综合考虑规划。

transformation of governance architectures from the Fordist one (053K) to the post-Fordist one (053H).

I provide checks and corrections to Zhou's statements by probing consistency from technical archives produced by (now deceased) actors along the supply and demand chains—engineers at the Hudong Shipyard, designers at design bureaus, production managers at supply bases, naval officers at military procurement agencies. I compiled a corpus of archival documents that covers all major subunits along the supply chains. This corpus consisted of about 4,000 pages of "lessons learned" documents compiled by the China State Shipbuilding Corporation and the Naval Department of Equipment between 1987 and 1992. These documents were produced for professionals to discover relevant engineering and managerial experiences from historical projects. The intended audience of these documents was, and still is, engineering, managerial, and military professionals with the appropriate security clearance. The aim of these documents is to improve future actions and outcomes. By examining these documents, it is possible to probe the author's position and the context in which the documents were produced. In this way, I also look into how different authors interpreted the same issues.

The First Phase of Frigate Development: Project 053K Frigates and Hierarchy

While empirically compelling, not all shipbuilding projects of major combatants are equally interesting in a conceptual sense. Some military procurement problems are easily explained and hence reveal little. For example, if, after some investigation, it was determined that the supply bases had faulty quality control procedures, or the producers failed to specify the technical parameters of ship hulls, or the buyer insisted on unrealistic demands of speed, or one of the key players at the shipyards was grossly negligent or simply incompetent, or that the rebellious red guards paralyzed the manufacturing process, or that Chiang Kai-shek managed to sabotage the Hudong Shipyard, then this case wouldn't be a puzzle worthy of theoretical attention.

If, however, after investigating the most obvious possibilities, no simple explanation presents itself, then the case becomes more interesting—more frustrating in a practical sense and more intriguing in a conceptual sense. The first class of Chinese guided missile frigates—the Project 053K frigates—is a case in point. In this Project, dozens of coordinating mechanisms,

including regular meetings between suppliers, end-users, and producers, the military's sheltering of the design team from the Cultural Revolution, and briefings from frontline units to ministerial headquarters to forecast progress in cross-cutting supply chains, provided redundant layers of cross-checks and communication. It also received attention from the top echelon of the military hierarchy: it was one of the four most prioritized platforms of the People's Navy in the Third Five-Year Plan ("海军装备科研'三五'计划'").[30] It was formally approved and endorsed by the highest decision-making body of the armed forces—the Central Military Commission—on April 19, 1967.[31] Lastly, by the end of 1970, the political order surrounding defense production at the Hudong Shipyard had become relatively stabilized.[32] Starting from 1969, military production lines at Shanghai shipyards were insulated from the Cultural Revolution. Naval officers were involved in coordinating information flows around the military production lines.[33]

Yet, Project 053K frigates had an exceedingly long development time of 19 years—only one ship reached full operational capability in late 1986. This class consisted of two ships; the second one was decommissioned in 1986 because of corrosion. The length of these processes merits our attention: China began its development of nuclear submarines, destroyers, and frigates in the Third Five-Year Plan when China had no significant international allies. As a result, naval

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[30] "主要产品-053K 型护卫舰," 23–27.

[31] 陈东林, *1966－1976 年中国国民经济概况*, 292. For elite politics at the hierarchical apex of defense industries, see Chen's account.

[32] 《前进中的沪东船厂》编委会, *前进中的沪东船厂-沪东造船厂发展史*, 40–53. The official history of Hudong Shipyard (前进中的沪东船厂) offers a surprisingly detailed account of the Cultural Revolution's impacts on the shipyard. To my knowledge, this is the only official history of major shipyards in Shanghai that offers such a narrative. For readers interested in the history of the Cultural Revolution, Hudong Shipyard presents a somewhat unusual case for examining the political involvement of shipbuilding workers in the Cultural Revolution. This is due to the geographic location of the Hudong Shipyard, which was situated on the west bank of the Huangpu River, making it quite difficult to commute between the Hudong Shipyard and the downtown areas of Shanghai.

[33] 海军司令部, "关于'遥控扫雷具方案'的批复-（69）参院字第 10 号," 77; "主要产品-053K 型护卫舰," 24.

officers didn't have any real alternative to waiting until the same network of designers and suppliers could produce a satisfactory product.

Naval officers regarded this class as an experimental platform plagued by flaws in mechanical and electrical systems. In early 1986, the Project 053K frigate reached full operational capability. In September 1984, the Naval Department of Equipment (海军装备技术部) formally abandoned Project 053K frigates as the platform for further development.[34] The origins of the poor performance of Project 053K frigates cannot be traced to any single component failure.

No single cause was identified. Nothing broke, and no one was to blame. Yet most of the key components—power plants, surface-to-air missiles, fire control systems, and high-caliber guns—were unreliable prototypes till 1986.[35] Hence, everything broke and everyone was to blame. Unlike many other naval shipbuilding projects during the Cultural Revolution (ca. 1966-76), no single player was held accountable. After 15 years of uninterrupted monitoring, engineer-officers at the Naval Department of Equipment terminated further development of Project 053K frigates. No culprit emerged; no smoking gun found. This suggests that the conditions contributing to the exceedingly long development time, sub-optimal performance, and poor reliability of the Project 053K frigates were extremely complex or not fully understood, or both. Why?

This section recasts the industrial history of Project 053K guided missile frigates by examining the three conceptual dimensions of the production rules —the control of opportunism,

[34] Cao 曹, "舰空导弹护卫舰的演变和发展," 95–96.
[35] Zhou 周, "053K 舰第二期工程研制片段," 100–101.

the choice of goals, and error-detection and correction regimes. I start by following Charles Perrow's *Normal Accidents* and take a decidedly system-oriented approach to the developmental problems of the Project 053K frigates.[36] My interpretation develops a story of how deeply rooted administrative *hierarchy* contributed to the isolation of each key component, and how this seclusion ultimately contributed to serious coordination problems along the supply chains.[37] Taken together, I argue that the turbulent development of Project 053K frigates occurred from the unanticipated interaction of non-failing sub-units.

I found three coordination failures in Project 053K frigates. On the supply side, the designers' inability to monitor prototyping processes at the supply bases is explained as a failure to coordinate by standardization. This fact can be interpreted as an empirical instance of the control of opportunism. On the demand side, the fact that the naval engineer-officers were unable to develop an alternative design based on off-the-shelf components is explained as a failure to coordinate by plan. This fact can be interpreted as an empirical instance of the choice of goals. Finally, a military procurement policy that blocked the possibility for producers and buyers to negotiate and change pre-planned performance requirements hindered attempts to coordinate by mutual adjustment. This fact can be interpreted as an empirical instance of the error-detection and correction regime that regulates the interactions between suppliers and buyers.

Background: Technical Interdependence and Administrative Seclusion

Notwithstanding the geopolitical pressures from ongoing, hot conflicts in Southeast Asia, Soviet and American national security states continued to project an image of cutting-edge modernity in the 1960s. These two superpowers' computerized fire control systems, search

[36] Perrow, *Normal Accidents*.
[37] Chen 陈, "053 对空型导弹护卫舰研制片段," 98.

radars, inertial guidance systems, and guided missiles—the archetypal implications of cybernetics—were perceived by PRC naval officers as the benchmark of their naval modernization efforts.[38] According to Zhou Changxuan (周昌宣) at the Design Bureau 701, designers selected the American Charles F. Adams class destroyers and the Soviet Project 41 destroyer as benchmarks for the development of major combatants in 1965.[39] In late 1965, the People's Navy formally proposed to procure guided missile frigates from domestic producers.[40]

In comparison to the combatants produced in the 1950s, the defining feature of the Project 053K frigates is the drastic increase in the technical complexity of their shipboard systems.[41] The initial design placed a strong emphasis on guided missiles and computerized fire control.[42] Accordingly, most of the shipboard combat systems—such as stabilized 100-millimetre automatic guns, 37-millimetre automatic guns, surface search radars, air search radars, fire-control radars, stabilized gyrocompasses (平台罗经), and three-dimensional air search radar—

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[38] Gerovitch, *From Newspeak to Cyberspeak*, 173–79; Zhang 张, "敲开飞航导弹技术的大门-忆'554'技术攻关片段."Gerovitch's narrative offers an in-depth account of Soviet cybernetics by situating it in the geo-military context of the early Cold War. Gerovith also examined the rhetoric of Soviet defense scientists. To my knowledge, there is no similar study of the Maoist national security state's interests in cybernetics' military applications.

[39] Zhou 周, "053 型舰最初阶段电子设备的论证," 98–99; Zhou 周, "我国舰用情报中心研制任务的由来," 59–60.

[40] 中国造船编辑部, 心系海疆庆祝方文均同志九十寿诞专辑, 104. To my knowledge, Chinese defense researchers at design bureaus involved in naval shipbuilding began to use electronic computers in 1964. In addition to guided missiles and fire control systems, electronic computers were used by naval architects to solve computing problems in hydrodynamic experiments. Fang Wenjun was the naval architect who worked as the deputy director of naval ship model basin—Design Bureau No. 702.

[41] Zhou 周, "勇克船体建造关"; Ma 马, "65 舰动力装置设计"; Wang 王, "65 舰空调系统设计"; Shao 邵, "65 型护卫舰船体结构设计"; Pan 潘, "65 型护卫舰上交流电制的采用"; Yu 俞, "65 型护卫舰设计的成功之路"; Yu 俞, *65 型护卫舰设计方案的形成*. The first frigate program of domestic design and production—Project 65 frigates— was implemented in the early 1960s. It featured the innovate use of domestically produced steel, specialized welding techniques, alternating current, and an air-condition system. These were innovations in the hull, electrical, and mechanical system. The combat system was quite primitive since the weapons were reverse-engineered Soviet ones of WWII specifications. See Chapter 2's brief examination on the Project 65 frigates.

[42] 编纂委员会, 上海航天志, 86–107. The technical history of HQ-61 surface-to-air missile (红旗六十一号导弹武器系统) can be found there. It is important to note that the HQ-61 system was under the jurisdiction of the Ministry of Machine Building Industry No. 7. For the shipbuilding ministry (Ministry of Machine Building Industry No.6), it was an external supply network.

had to be prototyped at specialized design bureaus.[43] The Hudong Shipyard had to prototype the powerplant as well. Consequently, the Hudong Shipyard—the producer at the Ministry of Machine Building Industry No. 6—received key components from external suppliers.[44] As I will explain below, this coupling of technical interdependence and administrative seclusion created a set of coordination problems for both producers and buyers: hierarchical structures of the command economy further complicated the "hold-up" problems.

The Control of Opportunism in the Eyes of Producers: Failure to Coordinate by Standardization

Starting from 1965, the industrial governance of Project 053K frigates has been based on the principal-agent model. In this model, the choice of projects is assumed to be unproblematic. Principals are simply assumed to be endowed with the capacity to identify the projects best for agents. The task of governance is to motivate the agent's faithful implementation of the project, punishing the agent for opportunistic, self-regarding use of gaps or imprecision in the principal's plan, and rewarding the agent for using discretion to correct mistakes in the plan to achieve its goal.

In more narrative terms, this means that Design Bureau No. 701 is the superior agency responsible for drafting the "master plan"—the overall design of the frigates—according to the buyer's demand. Design Bureau No. 701 is also the principal that monitored supply bases, shipyards, and other design bureaus for prototyping key components. According to this production rule, Design Bureau 701 was also responsible for removing the defects or deficiencies in the final product. If the Design Bureau No. 701 failed to remove such defects, the engineer-

[43] "主要产品-053K 型护卫舰," 24; "343 型舰用双 100/130 炮炮瞄雷达," 30; Zhang 张, "我国第一代舰载主炮跟踪校射雷达的研制," 106–7.
[44] Gou 苟, "海军武器（舰炮部分）工业生产建设的回顾," 61–62.

officer at the Naval Department of Equipment (i.e., the buyer) could escalate this issue by reporting to the superior agency of Design Bureau 701—the headquarters of the Defense Scientific Research Institute No. 7. This coordination mechanism (i.e., penalty default) was central to the error-detection and correction regime of the Project 053K frigates.

Prior to 1975, the Defense Scientific Research Institute No. 7—a military unit at the time—operated under a command-and-control structure of the Ministry of Defense. In this institutional setting, command authority was dictated by hierarchical relations. Design Bureaus specializing in designing key components were subordinate to Design Bureau No. 701.[45] Yet, at the root of Project 053K's developmental process was the principal's (designers at Design Bureau No. 701) inability to identify projects best suited for the agents—design bureaus for prototyping key components. Designers at Design Bureau No.701 had a well-conceived design for the ship hull. However, both designers at Design Bureau No.701 (principal) and engineers of supply bases (agents) lacked prior engineering experience with surface-to-air missiles and medium-speed diesel engines for frigates.[46] No pre-existing standards for key components existed. Consequently, designers at Design Bureau No.701 found difficulties in selecting goals and monitoring the development of the shipboard system.

The lack of industrial standards amplified inefficiencies in the cross-cutting supply chains. For example, engineers of the shipboard launchers of surface-to-air missiles (i.e.,

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[45] 编纂委员会, 上海航天志; Fang 方, "我国首制舰空导弹发射装置的诞生及其发展概况的回顾"; "主要产品-7231 舰空导弹发射装置"; Chen 陈, "053 对空型导弹护卫舰研制片段"; Shen 沈, "053 小型火炮导弹护卫舰方案设计工作回顾." In techno-military jargons, the principal—Design Bureau No. 701—is referred to as General Supervising Unit of Ship(舰总体), the agent— Shanghai Bureau of Aerospace (上海航天局)—is referred to as the General Supervising Unit of the missile system (导弹总体). And Design Bureau No.713 reports to Shanghai Bureau of Aerospace and Design Bureau No. 701: 总体决定系统系统决定设备。

[46] Shen 沈, "053 小型火炮导弹护卫舰方案设计工作回顾," 96–97; Chen 陈, "053 对空型导弹护卫舰研制片段," 98.

"agents" at Design Bureau No. 713) relied on technical parameters outlined by the designers at Design Bureau 701. Since industrial standards did not exist, the "principal" at Design Bureau 701 developed and readjusted the technical parameters through a trial-and-error process. This resulted in unforeseeable uncertainty for the engineers of the launchers. [47]

In social scientific terms, this episode between the Design Bureau No. 713—the agent—and the Design Bureau No. 701—the principal—epitomized a classic conceptual problem of economic development: "the dilemma of economic development is that learning undermines the stability of relations normally required for monitoring".[48] Instructions for the execution of novel projects are by definition so complex and ambiguous that "agents can interpret them as authority to pursue their own ends, not those of their supervisors, and the redirection of effort may be undetectable to the higher-ups."[49] From within a bureaucratic organization (the Defense Scientific Research Institute No. 7), the agent's learning disrupts the regularity of pre-existing rules and thus gives rise to a paralyzing fear of the breakdown of monitorability.

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[47] "主要产品-7231 舰空导弹发射装置," 54–58; Fang 方, "我国首制舰空导弹发射装置的诞生及其发展概况的回顾," 125–26. Fang Juntian (方君天) was the engineer at Design Bureau No. 713. He and his colleagues designed the launcher. See Fang's original text on the technical details of this trial-and-error process: 1966 年 6 月，我所接到七院关于准备在中型火炮导弹护卫舰上配备舰空导弹的通知，并要求对其发射装置研究设计。… 1968 年 2 月，有七机部主持召开的论证会上，根据战术上的需要，确定导弹发射装置为三联装，上蹲式，高低方向瞄准，备弹 18 枚的战术技术要求。据此，我们进行了方案论证和设计。… 1969 年 2 月，由 李敬堂、我和王心德三同志带队去上海沪东造船厂进行三结合设计，由于舰总体提出舰的稳性不够，要求发射装置必须减轻重量，联装数由三联装改为双联装，备弹由 18 枚减少到 12 枚。为此我们又修改了方案。我们边设计边供图，克服了重重困难，终于在 1970 年 7 月完成了全部图纸。In Design Bureau No. 713's unpublished historical review, engineers expressed frustration to the designers at Design Bureau No. 701, see original text: 正当设计工作进行到 1969 年 10 月时，七〇一所提出：舰排水量有限，发射装置要减少原定重量，三联装改成双联装，备单由不少于 18 枚改为 12 枚。… 致使七一三所历时一年半的设计工作基本前功尽弃，重新进行方案设计。可见，总体论证不但不可少，而且必须充分。

[48] Sabel, "Learning by Monitoring: The Institutions of Economic Development," 137.

[49] Sabel, "Learning by Monitoring: The Institutions of Economic Development," 137.

Consequently, designers at the Design Bureau 701 diligently drafted the overall design to fulfill buyers' demands.[50] Naval engineer-officers—buyers who monitored the production and design processes—found no evidence that any of the designers were negligent. Designers at Design Bureau 701 *prioritized monitoring over learning.* However, in the administrative context of hierarchy, these designers were unable to learn the difficulties associated with prototyping shipboard systems in a timely manner. Due to the hierarchical relationships between designers and suppliers, *monitoring* progress in prototyping the shipboard system came at the expense of *learning.*

The Choice of Goals in the Eyes of Naval Officers: Failure to Coordinate by Plan

In this section, I will explain why naval engineer-officers did not propose a modified design for the Project 053K.

To begin with, regular meetings between end-users, designers, and shipyard engineers were held at the very beginning of the design process for Project 053K frigates. In fact, naval officers from the East Fleet and designers at Design Bureau No. 701 were both present in the Hudong Shipyard. This "combined" design team (三结合设计组) was formally established in October 1969. On March 10, 1970, the People's Navy and the Ministry of Machine Building Industry No. 6 co-approved the technical-and-tactical requirements (战术技术任务书). This means that the buyer and producer jointly finalized the customized specifications for this procurement contract.

In plain language, this design team was the best-organized and most experienced group in the historical context of the Cultural Revolution. This design team consisted of approximately

[50] Zhou 周, "053 型舰最初阶段电子设备的论证," 99.

seventy professionals: seven naval officers from the East Sea Fleet, 25 designers from the Design Bureau No. 701, and the remainder were engineers at the Hudong Shipyard. About 32 members of this group (including designers from design bureaus) were in military uniform. This group was well-organized because the major players were qualified professionals who respectively represented the interests of actors across the supply and demand domains. This group was experienced because the designers from Design Bureau No. 701 had conducted well-conceived basic research to refine the ship hull since early 1967. Lastly, this group was politically insulated from the Cultural Revolution because approximately half of the members were commissioned officers who were entrusted with a top-priority assignment of the Five-Year Plan.

For practical activities of designing the frigates, this group ensured that end-users could incorporate their feedback into the early-stage design. Accordingly, they jointly specified the overall design with on-site assistance from production managers at the Hudong Shipyard. Then, the Hudong Shipyard production managers immediately began organizing the construction of the ship hull around the pre-planned specifications. This ad hoc group only existed at the early stage of design because the members then returned to their respective organizations to develop the sub-systems. In more narrative terms, this design process was structured around *sequential coordination* along the supply chains. End-users, designers, and producers were all present to disaggregate the engineering task at *the early stage* of design.

The problem with this seemingly well-oiled mechanism of *coordination by plan* is that naval engineer-officers struggled to integrate information about the actual, concurrent processes in the supply chains. While on-site posts of military representatives monitored each design bureau, shipyard, and supply base, each of these military units focused on monitoring local problems with the specific key component. In other words, these embedded units paid relatively

little attention to problems of compatibility between components. For example, military representatives played an active role in removing defects from the newly prototyped 18V390 diesel engines—the power plants in the early 1980s. (In 1975, the 18V390 diesel engines failed to pass quality control testing.) This division of tasks reflects a general characteristic of the socialist bureaucracy: lower levels were supposed to fulfill only a limited, clearly circumscribed task. Accordingly, engineer-officers never had a chance to adjust their imaginations of the final product according to the capabilities of the OEM network. Hence, no fundamental re-evaluation of the overall manufacturing process was undertaken, even when substantially consequential disruptions unfolded in the supply chains of shipboard combat systems. When faced with an unfortunate turn of events in cross-cutting supply chains, critical responsibilities were too diffused to trigger decisive action.

On June 24th, 1971, the hull of the first Project 057K frigate was launched. But none of the four shipboard combat systems—the automatic anti-aircraft guns, the stabilized high-caliber guns, the surface-to-air missiles, and the fire-control system—were ready to be installed.[51] Yet the Hudong Shipyard lacked institutionalized solutions to the "hold-up" problems regarding key components. All of these shipboard systems received state certifications—the centerpiece of quality control procedures for series production—in the early 1980s. Production managers experienced this lack of institutionalized solutions as a pervasive sense of loss.

Error-Detection and Correction Regimes: Failure to Coordinate by Mutual Adjustment

This section moves further away from the machine-building processes. It shifts up one level of analysis from producers of intermediate products to the interaction between supply and

[51] Zhou 周, "053K 舰第二期工程研制片段," 100.

demand for the final product. I will explain organizational failure—the nonexistence of mutual adjustment between buyers and producers—in the case of Project 053K frigates. This is puzzling because the same set of actors exhibited agile mutual adjustment in instances involving high-speed gunboats and mine-countermeasure vessels. Why?

I argue that naval officers at the procurement agency were unable to know the consequences of adjusting pre-planned performance for warfighting in the case of Project 053K frigates. This power/knowledge failure critically affected buyers' ability to intervene and learn. Group inaction is evident in their understanding of the procurement procedures.

Unlike the projects of high-speed boats (see Chapter 1), naval officers had no firsthand experience with the new shipboard combat systems under development. In terms of machine building, a large portion of the shipboard systems on high-speed boats were supplied through the licensed production of Soviet components at domestic supply bases. Neither of these two conditions was present in Project 053K frigates. [52]

Unlike the projects of mine-countermeasures vessels (Chapter 2), the Project 053K frigate's specifications were *not* based on accumulated operational experience. The People's Navy had no surface-to-air missile systems in its inventory in the 1960s. As I have mentioned

[52] Huang 黄, "037 艇前四艘建造情况的回忆"; Shi 施, "037 产品第二艘艇建造情况的回忆"; Tang 唐, "037 首制艇的建造与参加海战"; Luo 罗, "01 首制舰建造和试航片段"; Chen 陈, "01 改装后的导弹发射试验"; Hou 侯, "建造我国第一艘 037 反潜护卫艇的回顾"; Lin 林, "结合国情研制和发展 037 型反潜护卫艇"; Ying 应, "排除主机故障，为 037 首制艇正名"; Wu 吴, "037 型反潜护卫艇的设计和生产." Hudong shipyard organized the licensed production of four Soviet-designed Project 6601 (Soviet code: Project 50) frigates in the 1950s. All components—including structural steel, power plant, and shipboard combat system—were supplied by Soviet supply bases via rail transport. Naval combatants designed and produced in the early 1960s relied on both imported and reverse-engineered Soviet parts. For example, the first batch of Project 037 corvettes relied on a hybrid of imported and reverse-engineered components, while the hull form was a scaled-up one from the Project 62 high-speed gunboats examined in Chapter. Project 053K's strategy of component supply is radically different from these minor combatants.

above, the specifications were the outcome of intelligence gathering on contemporary Soviet and American destroyers.

In the cases of high-speed boats and mine-countermeasures vessels, mutual adjustments between end-users, buyers, and designers were facilitated by combat experience gained from the Taiwan Strait and Vietnam. Naval officers were experienced operators of most shipboard systems, ranging from ammunition hoists to degaussing gears. Hence, the naval officers were willing to negotiate with producers for changes in performance standards *because* they knew the consequences of such negotiation.

Naval officers faced insurmountable difficulties at implementing this logic of knowledge-making to the Project 053K frigate. Their upholding of pre-planned specifications resulted from their *inability* to foresee the operational consequences of adjusting performance standards. The implication here is that being unable to say with confidence that any particular deviation from the original specifications would still give them a frigate that would work for combat purposes, they instead became rigid, unwilling to risk authorizing any deviation from the original specifications. Accordingly, this kind of thinking became thoroughly indexical, characterizing work all the way up to the Central Military Commission. The ultimate analytical referent was exactly: nowhere. [53]

This new balance was the inadvertent outcome of the Maoist administrative hierarchy. This empirical observation is particularly intriguing when compared with Hirschman's conceptualization of unbalanced growth. From a conceptual perspective, firms pursuing growth

[53] 马泉山, *新中国工业经济史, 1966-1978*, 230. This "local" problem of knowledge-making within the national security state was indeed a malaise of the socialist system. For the national political economy, commissioned historian Ma Quanshan offered a narrative on the central government's understanding of wage-labor policy that is compatible with this chapter's theorization of the PRC state's knowledge-making efforts.

strategies together faced different incentives and were more likely to succeed than firms in isolation. If all users of an intermediate product invest simultaneously, the producer of that good can invest in a larger-scale and presumably more efficient plant than otherwise, benefiting all customers. These are nonpecuniary externalities.[54]

This historical account directs our attention to a political irony: The Maoist hierarchy for top-down monitoring inadvertently led to the seclusion of key players along the supply and demand chains. The monolithic intentionality to stagger a big-push industrialization resulted in *inaction* among key players. In other words, the Project 053K frigate case reveals how the state's efforts at knowledge making ultimately undermined its chances for successful accumulation of its own power.

The Maoist national security state became powerless to stop a yawning chasm between official understandings and lived realities. Over time, the effectiveness of coordination mechanisms eroded, and self-corrective policies became impossible to institutionalize, even among the most loyal, resourceful, and best-trained officers. This cognitive crisis manifested itself not in open defiance to the Maoist order of things, but in a paralyzing disorientation that unmanned what should have been the state's vanguards of defense industrialization. The consequence of disequilibrium in this case was therefore not continuing, ever more productive disequilibrium, but rather a new balance of social groups. Self-reinforcing sequences of upstream and downstream investments failed to occur. Hence, this historical reconstruction helps us understand why the People's Navy struggled to make sense of the turbulent development of

[54] Hirschman, "The Political Economy of Import-Substituting Industrialization in Latin America"; Hirschman, *The Strategy of Economic Development*.

Project 053K frigates in spite of its desire to do so. Political knowledge that was cut off from renewal through experience and critical procedures became circular reasoning.

Table 1 A Crude Summary on Changes in Specifications[55]

	053K	**053H**	**053H1**
Standard Displacement	1674 tons	1457 tons	1565 tons
Length	103.5 meter	104 meters	103.22 meters
Beam	10.8 meter	10.8 meter	10.8 meters
Draft	3.20 meter	2.98 meter	3.05 meter
Powerplant	2×18E390VA Diesels (2×8820 KW)	2×12E390VA Diesels (2×5292 kW)	2×12E390VA Diesels (2×5580 kW)
Speed (top speed at standard displacement)	28 knots	26 knots	25.5 knots
Crew	198 (30 officers)	198	200
Armament	2 × twin HQ-61B Surface to Air Missiles 2 × Type 712-I twin 100 mm guns (automatic) 4 × Type 715-I twin 37mm AA guns (automatic) 2 × Type 65, 5-tube ASW Rocket Launchers (1.2 km range) depth charge (DC) rack	6 × SY-1 Surface-to-Surface Missiles 2 × 100 mm gun (hand operated) 6 × twin 37 mm AA guns (hand operated) 2 × Type 65 5-tube ASW Rocket Launchers 4 × Type 64 5-tube A/S mortar launchers depth charge (DC) rack	6 × SY-1 Surface-to-Surface Missiles 2 × Type-712 twin 100 mm gun 4 × Type-715 twin 37mm AA guns (automatic) 2 × Type 65 5-tube ASW RL 4 × Type 64 5-tube A/S mortar launchers depth charge (DC) rack

[55] “主要产品-053K 型护卫舰”; “主要产品-053H,053H1 型护卫舰.”

The Second Phase of Frigate Development: Project 053H Frigates and A Silent Revolution in Routines

The Project 053K frigates—the first developmental phase of guided missile frigates—revealed three separate pieces of the obstacles to sustaining disequilibrium learning within the command economy: individuals erred; groups floundered; and organizations failed. However, an effective intervention to initiate and sustain self-reinforcing sequences of upstream and downstream investments did occur inside the late Maoist command economy. This intervention originated from the firm-level decisions of frontline engineers. The more frontline engineers maintained, restocked, and cut setup times, and jointly operated clusters of machines, the more autonomous they became. Eventually, they had a say in decisions regarding the allocation of capital for their use.

This section presents a cross-level tracing of the generative process to account for the occurrence of disequilibrium learning between 1973 and 1978. In doing so, this section offers a historical reconstruction of the Project 053H frigates—the second developmental phase. In this project, the inadvertent emergence of "just-in-time" production in the Chinese shipbuilding

industry, and by extension the flexibility of shipbuilders to accommodate changes in supply and demand domains, emerged from lessons learned from building the Project 053K frigates.

An informally organized but highly motivated group of junior engineers and production managers at the Hudong Shipyard spearheaded these changes in production rules. They were frontline actors who directly participated in building the first Project 053K frigate. In this process, they accumulated knowledge about deficiencies of the externally supplied key components. They then attempted to remove these deficiencies by proposing a modified design.

This modular design—later designated as the Project 053H frigates—centered on on-site *experimentation with* off-the-shelf components. By learning about changes in performance of off-the-shelf components, this modified design enabled frontline actors to substitute unreliable parts with reliable ones on a rolling basis. Consequently, each batch of Project 053H frigates received *batch-specific* upgrades of *standardized* parts. In this way, the distinction between batch production—customization for economies of variety and mass production—standardization for economies of scale is eliminated. In other words, this modified design revolved around a home-grown form of just-in-time component supply. What appears to be epistemic drift at the system level often looks like adaptive "sailing" from the frontline perspective of multiple subunits.[56]

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[56] Chen 陈, "053H 护卫舰研制中的若干技术问题," 110–12. Chen Shiying (陈世英) was the direct supervisor for Zhou Zhenbo at Hudong Shipayrd. Chen was the director of Military Ship Hull Section (军品船体股长) while Zhou was the deputy director. Chen's unpublished "learned lesson" document confirmed the accuracy of Zhou's statements in my interview. In addition, Chen's unpublished account offers a description of the machine-building activities: 这型护卫舰设备选型的指导思想是立足现实，不 高指标，当时面临的是主机选型问题。经过我厂柴油机设计人员及舰艇及舰艇总体设计人员的协调论证，否定了 43/82 主机，而采用 12 缸 390 中速主机。由于 18 缸 390 柴油机那时尚未过关，因此 12 缸 390 机功率指标推荐降低至 5145 千瓦，而采用这型机的好处是可以利用我厂已有的科研成果，同时克服 18 缸 390 中速柴油机研制中存在的问题，提高零部件寿命，且曲轴毛坯在上海地区亦能就近解决，能保证生产进度。其他设备的选用，重点是导弹武器。由于对空导弹出不来，转而选用对海导弹。

For Zhou and his colleagues, the building of the "superior" Soviet-type system of hierarchical monitoring—as an aspirational model central to the Project 053K frigates—was postponed to an *indefinite* future in which they would have acquired the necessary capacity across all the necessary construction processes. This emic notion of an indefinite future was the outcome of two contingent factors: (1) ceaseless changes in demands for enhancing reliability of components and (2) the producers' struggle with building backward linkages with supply bases for high-value, high complexity products (e.g., air search radars and combat information center) from 1961 to 1978. Accordingly, shipbuilders understood the mastery of the necessary capacity across all construction processes as a *moving* target. [57]

Moreover, this indefinite future was inadvertently disrupted by another expansive present that emerged from the geopolitics of the late 1970s: Sino-American rapprochement (ca. 1971-1978) and China's economic cooperation with the capitalist West enabled Chinese shipbuilders to shift their production from military vessels for import substitution to civilian cargo ships for export. When Zhou and his colleagues paid visits to Japanese shipyard in the early 1980s, they came to realize that what they were doing was not just the best they could do under difficult circumstances, but actually better than the Soviet system that they had originally seen as an aspirational model. (This will be the focus of chapter 5)

<u>The Control of Opportunism: Social Learning in the Eyes of Frontline Engineers</u>

[57] Zhou 周, "我国舰用情报中心研制任务的由来," 59–60; Zhou 周, "053 型舰最初阶段电子设备的论证," 98–99; Lin 林, "提出和促成 053H 型护卫舰研制的过程," 102–5; Zhu 朱, "053H 型导弹护卫舰的形成与发展," 105–6; Liu 刘, "053H 对海型护卫舰的诞生," 106–7; Zhou 周, "第一代舰舰导弹装备水面战斗舰艇的历程," 109–10; Chen 陈, "从 07 雷击舰改装上游导弹到 051 型驱逐舰海鹰导弹武器系统定型," 179–82; Chen 陈, "051 型驱逐舰战术技术论证," 73–76; Ma 马, "研制 051 导弹驱逐舰的经验与教训," 76–77; Zheng 郑 and Zhu 朱, "海军装备建设的重要里程碑-忆 051 型驱逐舰的成长和发展," 80–82.

Production managers at Hudong Shipyard between 1974 and 1978 developed a new understanding of the problem of controlling the opportunistic exploitation of discretion. In the 1950s, Hudong Shipyard production managers spearheaded the adoption of Soviet-inspired production control for series production. They pioneered the flow production of Soviet-designed frigates in the 1950s.[58] They also played key roles in reverse engineering and flow production of Soviet-designed missile boats in the 1960s. [59]

It was the painful experience with the Project 053K frigate and the Sea Battle of 1974 that began to concentrate production managers' attention back on the shopfloor, as they realized that the elimination of in-processes and the extent to which efficiency could be increased were directly related to fulfillment of production quotas.

The production engineers' experiment with a modified design—later designated as the Project 053H—took place in this context. For this design, Zhou Zhenbo (周振柏) envisioned the creation of a just-in-time strategy that would encompass the entire production process and would reduce total production time. In more analytical terms, Zhou Zhenbon no longer imagined the shipyard managers' on-site adjustments as simply a means of eliminating waste in *individual* production processes. In mid-1974, Zhou's design was completed. It was a serious re-evaluation of the entire manufacturing process.[60]

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[58] Jiang 姜, "'6601'护卫舰在'沪东'制造成功," 35–39; Luo 罗, "01 首制舰建造和试航片段"; Li 李, "琐忆 6601 型护卫舰的转让制造"; Yu 俞, "在 01 型护卫舰转让制造中结合国情解决技术问题的事例"; "主要产品-6601 型护卫舰." Jiang's memoir narrated the technical and managerial activities around the adoption of Soviet flow production. This includes welding, sectional building methods, inventory management, production control, and planning.

[59] 《前进中的沪东船厂》编委会, *前进中的沪东船厂-沪东造船厂发展史*, 37-38， 47-51; Luo 罗, "一个舰艇建造师的不了情," 97–100; Ye 叶, "发愤图强 自力更生 '6621'首制艇试制回忆," 51–55; Hou 侯, "签订《二四协定》前后的回忆," 87. The Chinese code is Project 6621. It refers to the Soviet Project 205 missile boat.

[60] 张亦隆, "中国海军护卫舰史（中）"; "主要产品-053H,053H1 型护卫舰"; Chen 陈, "053H 护卫舰研制中的若干技术问题," 111; 周 and 陈, "周振柏-访谈-2025.8.24." Zhou's just-in-time strategy was consequential for the

Zhou's systematic reevaluation can be observed at three different levels.

First, Zhou re-purposed the ship hull of the Project 053K frigates as the platform for further development, thereby utilizing the existing capacity, special-purpose machines (e.g., jigs 胎架), and materials that had been assembled for the Project 053K frigates to jump-start the 053H project.[61] In this way, the Hudong Shipyard could repurpose the idle capacity while circumventing the paralyzed supply chains for the Project 053K frigates. As I will explicate below, naval engineer-officers welcomed this move and interpreted it as a valuable contribution to the naval modernization effort.

Second, Zhou addressed bottlenecks in supply chains by substituting unreliable prototypes with off-the-shelf, standardized components. Zhou Zhenbo reevaluated the present capabilities of subcontracting supply networks of the Hudong Shipyard: external production facilities that supplied weapons, electronics, and generators to other military production lines of the Hudong Shipyard. Then he and his colleagues listed a "downgraded" list of existing sonars, radars, surface-to-surface and naval guns from the inventories of external suppliers.[62] Most of these shipboard systems were "transplanted" from smaller missile boats and submarine chasers.

People's Navy's fleet modernization. By 1980 December 12, the People's Navy received all 14 Project 053H frigates. As a result, the People's Navy had 22 major combatants equipped with surface-to-surface missiles in 1980. This also implies that the PRC national security state acquired the home-grown capacity to sustain series production of guided missile frigates. Zhou Zhenbo's statements on procedures and technical details are cross-checked with documents authored by Chen Shiying (Zhou's colleague at the same unit). See Chen's original text: [1974 年 3 月] 回厂后，我们又仔细研究了论证方案，提出了"一型两用"的想法，即利用已有 053K 舰型，排水量比原论证方案大，需增加到 1400 吨，但带来的好处是一套胎架，场地可为二型舰轮番生产用，并可利用其部分图纸资料，从而可缩短设计周期。我和厂生产组杨志源向上海市革会工交组造船组汇报了，此种想法得到了各级领导的支持。最后确定 053H 的研制任务。我们于 1974 年 8 月开始了 053H 舰的扩大初步设计各项工作，创立了工厂设计护卫舰的先例。

[61] Shen 沈, "053 小型火炮导弹护卫舰方案设计工作回顾," 97.

[62] Editorial Committee, "沪东造船厂（主要研制单位简史）," 125; Liu 刘, "053H 对海型护卫舰的诞生," 106–7; Chen 陈, "053H 护卫舰研制中的若干技术问题," 110–11; 周 and 陈, "周振柏-访谈-2025.8.24." Zhou Zhenbo;s account at my interview has been triangulated with sources by other actors who directly involved in this inventory management.

This can be interpreted as a cost-effective way to "pacify" the suppliers of the Project 053K frigates while jump-starting high-volume throughputs.

Painfully aware of the turbulent construction of Project 053K frigates, Zhou recognized the necessity of the smooth delivery of components for assembly once the construction of ship hulls had been initiated. To facilitate the smooth delivery of components, he incorporated combat systems from pre-existing minor combatants as much as possible. The fire-control radar and surface-to-surface radars were transplanted from Hudong Shipyard's pre-existing assembly line of missile boats. The 37-millimeter twin-barrel naval guns were a pre-existing, hand-operated version supplied from reputable supply bases.[63] In other words, though Zhou Zhenbo could not eliminate the dependence on external OEM networks for combat systems, he managed to enhance efficiency and reliability by expanding the use of off-the-shelf parts. Moreover, Zhou and his colleagues was willing to "upgrade" these ones once the Project 053K components became available and reliable.

Third, Zhou prioritized reliability by readjusting the standards of performance. Zhou's design strategy revolved around reaching the minimum standards of performance at maximized reliability. According to Zhou, the standard of minimum performance of the frigate was

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[63] Zhou 周, "第一代舰舰导弹装备水面战斗舰艇的历程," 109–10. The Project 053H frigates were equipped with reverse-engineered Soviet surface-to-surface missiles (Soviet designation: P-15; Chinese designation: 上游 1 号、SY-1). It is important to note that this missile system was based on an off-the-shelf component (7724 型双联装舰舰导弹发射装置) as well. In the late 1960s, these SY-1 missiles entered series production in China. Aerospace Engineers at the Ministry of Machine Building Indusry No. 7 prototyped the shipboard missile system at a special design bureau in Shanghai. See original text from Zhou Bolin's unpublished memoir (周柏林-上海航天局第八设计部高级工程师): 60 年代末，SY-1 舰舰导弹已在我国批量生产。该型导弹性能稳定、命中精度高、战斗部威力大。与导弹配套的舰上设备如导弹共计雷达、射击指挥仪、水平仪等也配套生产。SY-1 导弹原先装备于 6621 型和 6624 型等导弹快艇。导弹武器系统的艇上设备有导弹攻击雷达、射击指挥仪、固定式导弹发射架,水平仪、角速度传感器、射前检查仪和电源等。… 1974 年起，我国小批量研制 053H 型导弹护卫舰，用来更新在第二次世界大战时留下的性能相当落后的旧、杂护卫舰。该型舰上装有两座双联装回转式 SY-1 导弹发射装置。导弹武器系统的方案基本上是以 01 型护卫舰的导弹武器系统为基础。

conditioned by the shipboard surface-to-surface missiles. To launch the missiles, the frigate needed to reach the speed of 25 knots.[64] Zhou's design passed this standard by relying on a modified prototype of diesel engines (the 12V390 engines). In comparison to the ones for Project 053K frigates (the 18V390 engine), this modified design of diesel engines circumvented defects by reducing the maximum continuous rate.[65] Naval officers accepted Zhou's readjustments since the new design could launch surface-to-surface missiles: a major upgrade to the combat capabilities of the frigates.

Redefining Exchange Relations

To illuminate Zhou's just-in-time system from a final perspective, I want to call attention to the choice of goals. The system works because the participants are induced to enhance their performance by constantly redefining themselves how that is to be done. In the case of Project 053H frigates, the clear distinction between "principals" who make initial plans and "agents" who are expected to revise or remake those plans in the course of "executing" them no longer exists. Zhou and other managers of the Hudong Shipyard—the frontline actors—proposed the modular design of frigates directly to the buyers. Choice of goals and the broad projects embodying them are as much the product as the starting point of organizational activity.

Zhou revised the pre-existing bureaucratic identities of shipyard engineers in two interrelated ways. First, Zhou managed to draft the overall design task that had been strictly

[64] Chen 陈, "053H 护卫舰研制中的若干技术问题," 111; 周 and 陈, "周振柏-访谈-2025.8.24."

[65] "VE390 系列中速柴油机," 41–44. 12. 18V390 refers to 18 cylinders; the maximum continuous rate is 7938kW.12V390 refers to 12 cylinders; the maximum continuous rate is 5292kW. The 18V390 diesel engine was refined in the 1980s. In the early 1980s, the military representatives embedded into Hudong Shipyard and engineers at Hudong Shipyard collaborated to remove the deficiencies of 18V390 diesels. The improved version of 18E390VA was installed on the Project 053H2 frigates. By 1989, two Project 053H2 frigates entered service. The development of the Project 053H series continued into the 1990s. A complete technical history of the Project 053H series—Project 053H (14 ships), Project 053H1 (10 ships), Project 053H1G (6 ships), Project 053H2, Project 053H2G (3 ships), and Project 053H3—will explode the intention of this dissertation chapter.

reserved for Design Bureau No. 701. Instead of reproducing the principal-agent structure between the design bureau and the shipyard, Zhou subsumed the design bureau's *monitoring* role into the shopfloor *learning* effort at the Hudong Shipyard. Second, Zhou's design was a deliberate solution to the ongoing naval modernization effort. Instead of waiting for the military procurement agency's contract, Zhou *proposed* a solution (i.e, the modified design) to the procurement agency. By elaborating and extending these rules of design and production, Zhou radically defined the identities of every major actor along the supply chains. In other words, Zhou's innovation worked outside the parameters set by the existing procurement policy of the Plan. [66]

It is worth noting that Zhou and his colleagues were skilled in political articulation. Zhou and his superiors reconciled their proposed just-in-time production and the ideological discourse of planned industrialization by casting this design team as a faithful purveyor of information that could not travel through official channels. In June 1973, they submitted the proposal of an alternative approach to frigate production as a "People's Letter" (人民来信) to the ministerial

[66] 周 and 陈, "周振柏-访谈-2025.8.24"; Chen 陈, "053H 护卫舰研制中的若干技术问题," 111. For readers interested in the subversion of the command economy's established procedures, it is worth noting that Zhou and his colleagues' practical activities could be easily misinterpreted as rule-following behavior. They proposed several different design concepts (设计方案) based on their understanding of technical parameters. On a superficial level, this partially derives from a standard operating procedure of the Soviet-type system. The buyer first proposes the request to the designers at the corresponding design bureau. *By request of the buyer*, the designer usually submits several design concepts to the buyer for review. The buyer then evaluates and revises the design. Zhou and his colleagues' activities deviate from this procedure in two ways. First, they directly propose the design concepts to the buyer instead of waiting for the buyer's demand. Second. They—frontline engineer at specialty workshops—replaced the role of the specialized design bureau. See original text from Chen Shiying's account: 设计航速不低于 25 节，当时考虑了排水量为 1100 吨左右与 1300 吨左右这两种方案，主要区别是一座导弹发射架还是两座导弹发射架，以及是双 57 炮还是双 100 炮。此项建议于 1973 年 6 月由厂领导向六机部科技局、生产局做了口头汇报。1974 年 3 月上旬六机部科技局通知沪东造船厂派人去北京落实 1973 年建议之事。我和朱贤煜带原作两个方案图去京。同年 3 月 11 日六机部军管会副主任林真谈了他对搞简易护卫舰的几点考虑，提出以造代修的想法，交代了主炮的来源，解决了我厂源提建议的不足之处。并要求我们对主机问题再论证一下。我们二人和六机部刘恩弟同志对建议性护卫舰的武备、主机、总体、造价等方面作了论证，特别是主机选型作了三机型五个方案的比较分析（U300,12E390,37Д）最后形成了一份论证报告。

headquarters and the Central Military Commission. While making the empirical observation of bottlenecks along the supply chains as their analytical referent, they avoided anything that could be read as undermining mobilization and resolution. As I will explain below, naval officers accepted this reconciliation as a meaningful contribution to national defense.[67]

The record of the back and forth indicates that naval officers rejected one part of the Hudong letter: they could not afford to jump-start the development of another design of a different hull form. However, they endorsed the idea of utilizing existing inventory. In accordance with naval officers' "conditional" acceptance, Zhou proposed to use the Project 053K hull as the platform for the just-in-time strategy of component supply. In addition, Zhou's colleagues prepared a different design with a new hull form as a contingency plan. [68]

The effect of Zhou's elaboration and extension of the just-in-time rules and related practices was to create a relation between subcontracting suppliers and the large-firm customer (the Hudong Shipyard) strictly analogous to the one between the large firm and the in-house group of engineers for producing diesel engines. The presumption that agreements with subcontractors will be extended through renegotiation, assuming acceptable performance, is equivalent to the shipyard engineers' employment security.

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[67] 周 and 陈, "周振柏-访谈-2025.8.24."

[68] Zhou 周, "护卫舰'摇篮'誉漫天下," 152. This political articulation was well-received by policymakers at the naval command. Deputy commander-in-chief of the People's Navy Zhou Xihan enthusiastically acknowledged the design team's contribution. Zhou's statements in unpublished memoir are consistent with thoese of Chen Shiying, Lin Zhen, and Zhu Jizhou. See Zhou Zhenbo's original text: 于 1973 年六月以人民来信上报中央军委和六机部军管会，根据当时我们的工艺与设备和海军装备的现状，改造老、旧、杂护卫舰更新的设想与想法，并搞了两个方案，一个方案从船的线型开始，搞一个全新的护卫舰，采用六种主机型号；另一个方案是我搞的，利用 053 成功的船体线型，采用 12V390 柴油机，全舰武备配置两个方案基本一样。报告上去之后，上面很快旧同意我所做的设计方案。并 1974 年 8 月 15 日在北京和平宾馆由海军副司令周希汉主持，各舰队管装备司令、海装、六机部、沪东船厂等单位参加，周副司令宣布利用 053 平台，采用 12V390 柴油机为动力，其他设备采用国内过关成熟的产品，在设计中留有改装和加装的余地等建造全新护卫舰。当时我和沈维安介绍了总体方案和动力装置，周副司令对方案给予高度评价，在会上确定并建造了一批护卫舰。

This bottom-up approach to eliminating the distinctions between craft production and mass production bore a striking resemblance to the just-in-time methods in the Japanese production systems. Similar to the goals of the Japanese production systems, the goal at the Hudong Shipyard was to transform mass production methods through the reduction of in-processes, the elimination of waste, and the creation of value for buyers. Therefore, disequilibrium learning—a critical condition for transforming the Chinese shipbuilding industry from mass production to just-in-time production—could be found in the manufacturing processes of assembling power plants, combat systems, and ship hulls.[69]

Zhou explained that modifying the Project 053K frigate's design was a reaction to the disturbing news of the Sea Battle of the Paracel Islands. The painful memory of World War II motivated Zhou to major in naval architecture at Huazhong Institute of Technology (华中工学院).[70] Upon graduation, he received an appointment as a junior engineer—deputy director of the

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[69] 周 and 陈, "周振柏-访谈-2025.8.24"; Lin 林, "提出和促成 053H 型护卫舰研制的过程," 106. In my interview, I explicitly asked Zhou about his role in the design and production of Project 053H frigate. Zhou's statements are consistent with those of other key players. For example, see Lin Zhen's original text: 053H 型总体方案、扩大初步设计都是沪东厂搞的，在舰的造型，主机选型，主要配套设备等方面也是由他们提出并经各方同意的。除第一艘舰用的 580 多吨钢材由部物资局落实之外，后续舰的备料及主、辅机、器材配套的订货大部分都是由沪东造船厂落实的，部物资局给以必要支援，特别是 12V 主机的研制，时间很紧，要克服各种困难。

[70] 刘道生回忆录, 295–96. Zhou Zhenbo's college education was enabled by the Maoist national security state's institutional response to the Sino-Soviet split. In 1960, the People's Navy worked with the Ministry of Education to expand undergraduate programs for defense technology at civilian research universities. As of 2025, these universities still formed the institutional core of research organizations for defense technology. See Vice Admiral Liu Daosheng's memoir. Vice Admiral Liu received higher military education in the Soviet Union. Till the Cultural Revolution, Liu was the deputy commander-in-chief of the People's Navy. He oversaw the education and training of commissioned officers. The original text from Vice Admiral Liu's memoir: 在海军的倡议下，由教育部党组和国防科委党组牵头，经中共中央、国务院批准，在 1960 年 7 月召开了一次有关地方高等学校和国家部委及军兵种参加，专门研究在地方高等学校设置国防专业，培养国防专业技术人才的会议。会议主要研究有关导弹原子能、造船及其配套专业的布点规划问题。… 会后我们又同教育部和有关院校逐个落实，制定了在上海交通大学，大连工学院，华中工学院，华南工学院等 13 所高等学校设置有关舰船机电及配套专业和有关海军方面的专业（专门化）的规划。这也为造船工业、生产和科学研究系统，在东北、华东、华南、华中经济大区，以大连、上海、武汉、广东为中心，实现教学、科研与生产三结合基地的形成，创造了良好的条件，打下了一定的基础。

Section of Ship Hulls of Hudong Shipyard (船体副股长). While building the Project 053K frigate, he was deeply disturbed by the news that the South Sea Fleet lacked major combatants in the Sea Battle of the Paracel Islands in January 1974 (西沙海战). In Zhou's self-understanding, socialism successfully cast itself as a living bulwark against imperialist aggression. Zhou's emotive understanding of imperialist aggression gained heightened importance in part because South Vietnam's American-made destroyer escorts were bigger and more heavily armed than the South Sea Fleet's Project 6610 minesweepers and Project 6604 submarine chasers (see Chapter 2 for the minesweeper program).[71]

Error-Detection and Correction Regimes: Mutual Adjustment and the "Binding Agent"

To turn the new design of Project 053H frigates and the just-in-time production methods into actual weapon systems, one critical piece of institutional change is still missing: This group of engineers and managers at the Hudong Shipyard has to secure investment from the military procurement agency for their heterodox experiment with the production system. At the very least, they must determine how much autonomy to assume in this regard and how to cooperate with outsiders—such as outside suppliers of parts and naval officers at the military procurement agency—in securing whatever services and goods the group does not provide itself.

In early 1973, the director of Hudong Shipyard and the frontline engineers proposed the early stage design (later codified as Project 053H) to Lin Zhen—the former deputy chief of staff

[71] 中国人民解放军历史资料丛书编审委员会, 海军·综述大事记, 165–76; Wei 魏, "西沙自卫反击战"; 王, 最忆是西沙; 林 and 王, "西沙海战中的 85 炮." The South Sea Fleet's operational records on this sea battle remain unavailable for publishable academic research. Nevertheless, the operational history of this sea battle can be reconstructed from these sources. For the analytical purpose of this dissertation, I only focused on the shipboard combat systems and shipbuilding of the naval vessels involved in this sea battle. Two of these sources were authored by on-site surface warfare officers who were responsible for navigation and the main gun. The other two were authored by senior officers and commissioned historians at the naval headquarters.

of the People's Navy who was embedded into the Core Party Committee of the Ministry of Mchine Building Industry No. 6 (六机部党的核心小组成员). Prior to this role, Lin Zhen had orchestrated the competitive development of high-speed gunboats in the 1960s (see Chapter 1). Facing a multitude of political and technological obstacles, Lin pursued other members of the Party Committee of the Ministry of Machine Building Industry No.6 to collectively make the risky decision to endorse the proposed 053H in 1973.[72] In the political context of the ongoing Cultural Revolution, Lin and his comrades could be accused of sabotage because Project 053H was not an authorized project of the Five-Year Plan.[73]

In other words, Lin Zhen orchestrated a discursive challenge to an existing military procurement policy of the Plan. According to the Five-Year Plan, the People's Navy had requested the construction of Project 053K frigates and the repair of its antiquated frigate fleet, which consisted of World War II destroyer escorts. Instead of repairing these destroyer escorts as specified in pre-existing procurement policy, Lin and his comrades proposed to substitute these ships with the Project 053H frigates on a one-to-one basis.

Lin Zhen explained his reevaluation of the naval procurement policy in an unpublished document of "lesson learned" in detail:

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[72] 周 and 陈, "周振柏-访谈-2025.8.24." In my interview, Zhou remembered Lin Zhen as a pragmatist leader (办实事的领导). Zhou was impressed by Lin Zhen's agile response to his proposal. After submitting the people's letter, Lin met Zhou in person to discuss the alternative design and the just-in-time production methods. Convinced by Zhou's proposal, Lin soon started this persuasion within several weeks.

[73] Zheng 郑 and Zhu 朱, "火红的年代-中国海军护卫舰发展回忆," 4–5; Lin 林, "提出和促成 053H 型护卫舰研制的过程," 104. Lin Zhen personally promoted Zhou's alternative design both in the deliberation at the shipbuilding ministry's headquarters and the communication with the People's Navy's party committee. Rear Admiral Lin Zhen's original text:从和沪东造船厂研究方案时起，我就把部的有关局，如生产局，科研局，物资局等领导和有关同志找到一起研究讨论和着手做有关的准备工作，使"以造待修"的方针逐步得到理解和支持。… 就这样，通过自下而上的半个多月反复做工作，党的核心小组终于在 1974 年 5 月中旬同意以六机部党组的名义向海军发文，并附上了以我个人署名写的建议和方案全文。到此，第一步关键的"出台"环节就算走通了。

> Prior to 1974, the Navy repeatedly requested to repair the vintage (老，杂，旧) fleet of frigates. It was tough for the Ministry of Machine Building Industry No.6 to accomplish this task. [First,] these frigates were vintage ones of radically differing specifications (又老又杂). Their ship hulls had serious corrosion. The power plants were of different specifications (主机都是杂牌的). So, it was challenging to renovate them. Even if the renovation were completed, the top speed would still be reduced to about 12 knots. [The original performance was about 16 to 18 knots.] Second, this was a problem of time and cost. The renovation (大修) for one vintage frigate took about two years. Each frigate cost at least three million Yuan. [According to producers, the estimated cost was about five to six million Yuan.[74]] It was very likely to exceed this number. The total cost was tens of millions of Yuan (数千万元). The production time of the new frigate [based on Zhou Zhenbo's modular design] was about a year. The price per ship was between 10 to 15 million Yuan. These were new ships of superior performance. So, whether the vintage frigates were worth repairing shall be questioned. Also, although the Jiangnan Shpyard still had several repair docks for this task of renovation, it would take five to six years to complete the renovation of the existing fleet of vintage frigates. This would adversely affect the Jiangnan Shipyard's capacity to build other products. Lastly, these vintage frigates would need to be repaired again soon after this renovation. Therefore, we decided to formulate a [procurement] policy of substituting repair with production (以造代修).[75]

This order for refurbishing WWII frigates was a long-standing request that demanded the impossible: the insurmountable challenge was to find spare parts for the vintage shipboard systems. In 1965, admirals speculated that they could substitute these frigates with the (now derailed) Project 053K. In this context Lin Zhen offered a distinctive solution to circumvent this deadlock to the higher-ups: by licensing a changed approach to producing new ones, the top elites would get a functional stop-gap measure. Moreover, this stop-gap measure had the potential to become a more cost-effective alternative to the Stalinist mode of industrialization.

It is worth noting that Lin possessed considerable rhetorical skills. Lin's communication relied on hints, half-words, and reticent expressions. Endorsing modular design and just-in-time

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[74] Liu 刘, "053H 对海型护卫舰的诞生," 106.

[75] Lin 林, "提出和促成 053H 型护卫舰研制的过程," 102. According to naval engineer-officer Zhou Fuming (周福明) who oversaw the procurement of Project 053H series, the procurement price of the 14 Project 053H frigates was about 10 million Yuan per ship. This price is a result of the policy of substituting repair with production: Project 053H frigates relied on transplanting some of the combat and navigation systems from vintage frigates. The subsequent Project 053H1 frigates received upgrades in shipboard systems. The procurement price of Project 053H1 was about 20 million Yuan per ship.

production for naval shipbuilding was not simply a matter of technical curiosity; it was, in essence, a political statement. By problematizing the existing procurement policy via the utilitarian, consequentialist register of socialism, naval engineer-officers implicitly undermined the Maoist ideological discourse on technology.

Historians who specialize in the history of the Soviet Union and the People's Republic of China have both productively deployed Foucauldian categories to analyze power relations and subject formation in historical existing socialisms. [76] My approach differs from the Foucauldian approach in important ways. For the study of late Maoist subjectivities, Li Yujie has productively explored one variant of radical subjectivity by examining the Dazhai model (大寨模式). This chapter complements Li's empirical findings in her dissertation: The totalizing discourse of the late Maoist state is escapable. If the actors subversively deploy canonized modes of expression, they can create and enhance their autonomy to a certain scope and extent.

While naval engineer-officers circumvented the centrally planned procedures of top-down control, they refrained from openly defying the Maoist order of things. Unorthodox Lin's position may seem, but his style of argument was quite orthodox: he was trying to prove that just-in-time production was fully compatible with the austerity of planned industrialization. Lin justified the analysis of a state of being by semantically situating it within an encompassing picture of social life in its temporal progression. As a true master of dialectical materialism, Lin skillfully deployed Stalinist newspeak techniques to undermine the Stalinist principal-agent hierarchy. In more analytical terms, this was a subversive use of the ideological discourse on defense technology.

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[76] Halfin, *Terror in My Soul*; Kotkin, *Magnetic Mountain*; Li, "Wheels and Sweat." The hermeneutic sociology of this dissertation contributes to the existing study of socialist subjectivity in history.

In terms of organizational sociology, Lin's re-evaluation of military procurement policy centered on mutual adjustment. In this document, Lin not only critically discussed the limits of the existing procurement policy but also examined the proposed just-in-time production and Zhou's modified design.[77] In this way, Lin and his comrades make systematic use of junior engineers' causal knowledge that the pre-existing hierarchy had preempted. They tacitly joined Zhou's knowledge-making effort by changing initial assumptions in a bottom-up fashion. Enabled by the Stalinist newspeak rhetoric of "overtake and surpass," Lin concluded that Zhou's performance standards for the new design were acceptable by comparing it (with the top speed of 26 knots) with contemporary diesel-powered frigates of capitalist navies.

Then, naval engineer-officers facilitated just-in-time production in three important ways: first, they supplied the high-caliber naval guns by providing the Hudong Shipyard with thirty Soviet-made guns (100-millimeter hand-operated ones bought in the 1950s) from the Navy's inventory. This was the only key component that the Hudong Shipyard engineers had failed to secure from the OEM network. Second, they incorporated feedback from end-users by modifying the plan of armaments. For example, they replaced two twin-barreled 25-millimeter automatic guns with two 37-millimeter ones. Third, they finalized the customized specifications by reviewing Zhou Zhenbo's design. This customized specification—the tactical-and-technical-requirements (战术技术任务书)—set the minimum performance standards for the emerging just-in-time production.[78] Hence, naval-engineer officers encouraged the firms to subject themselves to rules that created informative disequilibria in their operations.

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[77] Lin 林, "提出和促成 053H 型护卫舰研制的过程," 104.

[78] Zhu 朱, "053H 型导弹护卫舰的形成与发展," 105–6; Lin 林, "提出和促成 053H 型护卫舰研制的过程," 102–5.

The key point is the extent to which a specific understanding of just-in-time production and ways of looking at intermediate goods became commonplace, even among those who staffed the hierarchical apex of the Maoist national security state. In September 1974, the Headquarters of the People's Navy approved the proposed Project 053 production and its just-in-time production. The naval authorities then submitted this proposal to the Central Military Commission. Soon, the deputy director of the General Department of Rear Services Feng Yongshun (总后副部长兼装备计划部长冯永顺; also served as the director of the Department of Equipment Planning) held a conference in Beijing to discuss the proposal of Project 053H frigates. On behalf of the Central Military Commission, Feng endorsed the proposal. On October 22, the Central Military Commission formally approved the new procurement policy. From November 6 to 10, naval engineer-officers and engineers of Hudong Shipyard gathered at Shanghai Yanan Hotel (上海延安饭店) to approve the preliminary technical design of Project 053H.[79]

Hence, in 1974, the regime of mutual adjustment was instituted at all echelons of the national security state, ranging from ministerial headquarters in Beijing to specialized workshops at Shanghai shipyards.[80] Lower levels' knowledge formation began to incorporate renewal through experience and thorough-going critical procedures. Actors along the supply chains of

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[79] Lin 林, "提出和促成 053H 型护卫舰研制的过程," 104; Zheng 郑 and Zhu 朱, "火红的年代-中国海军护卫舰发展回忆," 4. Deputy Commander-in-Chief of the People's Navy Liu Daosheng was also present in the conference. Naval engineer-officers from the Naval Department of Equipment participated this conference too.

[80] 中国人民解放军历史资料丛书编审委员会, 海军·综述大事记, 152–53. The classified official history of the People's Navy viewed the procurement program for the guided missile frigate as a significant achievement in naval modernization during the Cultural Revolution. But it does not explain the formation of the procurement policy. It also does not mention the Project 053K frigates. The original text: 新型导弹护卫舰的自行研制工作起步稍晚[相对于 051 型驱逐舰],始于 1968 年。从部队执行战备任务的角度看，新型导弹护卫舰比驱逐舰更为需要。装备部门建议采取过渡的方法，即先利用旧舰的各种设备，建造对海型导弹护卫舰，这样就可以很快交付部队使用。第一艘导弹护卫舰于 1957 年 2 月开工建造，6 月 28 日下水，12 月编入序列。1976 年粉碎"四人帮"后，开始成批建造。

guided missile frigates, with varying degrees of efficacy, energetically deployed just-in-time production rules analogous to the Japanese ones. The production of Project 053H frigates revolved around a variant of just-in-time production without commitment to workplace democracy, but not without substance or consequence.[81] By this sentence, I do not mean a normative evaluation of the Maoist state's unfulfilled commitment to workplace democracy. Rather, I want to highlight that the People's Navy firmly supported the expansion *of autonomy* for frontline actors because the People's Navy benefited from such activities in terms of naval modernization. In other words, naval officers endorsed *the expansion of autonomy* because of their evolving conception of self-interest. This implies that the utilitarian, consequentialist aspect of socialist ideology can be mobilized to support radically different institutional arrangements around workplace democracy.

The key point is that Zhou Zhenbo's just-in-time strategy—officially known as "small footstep jogging (小步快跑)"—became an analytical referent in all subsequent naval shipbuilding programs of major combatants till this day (as of 2025).[82] In other words, the knowledge-making effort that revolved around renewal through experience and thorough critical procedures was instituted at the PRC national security state. [83]

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[81] Chen 陈, "053H 护卫舰研制中的若干技术问题," 110–12; Zheng 郑 and Zhu 朱, "火红的年代-中国海军护卫舰发展回忆," 5; 周 and 陈, "周振柏-访谈-2025.8.24.". See the naval officers' original text: 053H、H1、H1G 和 H2 型几十艘千吨级护卫舰成为七年年代到九十年代的日常执勤的主要兵力，也是任务最繁重的舰种。… 由于"小步"改进，便于海军部队组织、指挥训练 、干部培养、后勤保障、维修技术等逐渐相应跟上,形成战斗力。由于"快跑"不断线，便于国家工业部门在积极研制新装备同时稳定配套协作关系， 不断提高质量和可靠性。

[82] Chen 陈, "053H2 型导弹护卫舰武器系统工程研制追忆," 114. Home-grown computerized fire-control—combat information center (CIC) was installed on Project 053H2 frigates. The procurement order was issued on April 4, 1982.The first batch of two Project 053H2 frigates' production began in October 1984 and entered service on December 2, 1987. Project 053H2 was a development program based on the Project 053H platform.

[83] 稽 Ji, "国营第四一一〇厂有关改进雷达产品的生产改进情况," 94. The home-grown variant of just-in-time production was embraced by key players along the supply chains of naval shipbuilding. The lead engineer of Factory No. 4110 Ji Chushen (稽储申) mentioned that the strategy of "small-step jogging" was widely distributed to

Conclusion

Let me quickly summarize this dissertation's main historical lesson about the Maoist national security state so far: In Maoist China, institutions of defense production and those of military procurement were flip-sides of the same state-building project, hoping to realize sovereignty materially. The one aspired to create weapon systems comparable to those of the imperialist enemies; the other aspired to stamp out defects in military hardware. Because the party-state cast socialism as a living bulwark against imperialist aggression, both were seen as essential to the institutional reproduction of socialism. And both for that very reason grew in size, effort, and budget through all the many crises socialism went through from its inception.[84] If the administrative budget had no room to build hospitals, there was always room to increase capital investment in defense production.[85] Thus, defense industries were officially designated as the driving force of planned industrialization for the Fourth Five-Year Plan in 1970.[86] The PRC's command economy ultimately instituted the contour of a Stalinist war economy.

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supply bases in the 1980s. See Ji's original text: 根据海装领导指示精神，海军装备要"小步快跑",即生产工厂科技人员要不停地利用成熟新技术，加装、改装海军老装备，以提高老装备的战技性能，延长装备服役期和品生命期。

[84] 《前进中的沪东船厂》编委会, *前进中的沪东船厂-沪东造船厂发展史*, 39, 43, 46; Jiang 姜, "'6601'护卫舰在'沪东'制造成功," 35. In March 1952, Hudong shipyard had about 200 employees. In 1965, Hudong Shipyard had 7893 employees. By 1968, Hudong Shipyard had 10222 employee. It is important to note that the Hudong Shipyard also received investment for its capital equipment for civilian sea-going bulk carriers. In 1969, Hudong Shipyard received two major investments for renovating the facilities for diesel production and creating two building berths.

[85] 马泉山, *新中国工业经济史, 1966-1978*, 237.

[86] 陈东林, *1966－1976 年中国国民经济概况*, 334, 338–45; 马泉山, *新中国工业经济史, 1966-1978*, 90–92, 270. Ma Quanshan offers a diagnosis to the self-destructive dynamic within this Stalinist war economy by examining the Third Front: unless the war breakout, otherwise the Third Front created a gigantic surplus in machine building capacity with limited supply of energy and raw materials. The original text: 到 70 年代末，"三线"地区主要机械工业产品累计新增生产能力，已大致相当于 1965 年机械工业的全国产量。而这一时期，"三线"原材料工业和能源工业的投资则显得不足，同庞大的机械加工制造能力不相适应。这种工业结构，除非发生战争或战争迫在眉睫，即缺乏稳定的广大的市场基础，同地区经济也不容易融合，许多工厂必须为此支付办全能工厂、办职工文化教育福利事业的额外成本，使他在未来的生存发展中处于明显的不利地位。

Moreover, the Maoist national security state's knowledge about naval shipbuilding throws an interesting light on the ways in which the state more generally produces knowledge about itself and the economy. Existing debates about the state's role in promoting economic development are deadlocked by a particular understanding of information problems. It is unclear how the state could acquire knowledge of the economy superior to that of the firms, and more obscure how the state could avoid becoming the captive protector of the very economic groups whose transformation it aims to encourage. These two concerns are connected in a particularly daunting way: in redirecting the economy, the state must rely on information not directly available to the parties of economic exchanges. Otherwise, the participants could redirect themselves.

But such information is politically tainted: Its generation and transmission depend on the participation of social groups as likely to use the chance to influence authorities to shelter themselves from competition as to use this occasion to improve their reaction to it. Under these circumstances, nothing less than the *deus ex machina* of the "strong" state—a prescient guiding agency independently moving the levers of government—is required to make public action a motor for rather than an obstacle to growth.[87]

In this chapter, I argue that this conceptual deadlock can be overcome by rethinking the kind of knowledge production required for effective state intervention, thereby restricting the types of relations that can exist between the state and firms. Although these aforementioned criticism informed by rational-choice theories are not groundless, they overstate the obstacles to effective intervention. I show how conceptual innovations on the disequilibrium-learning idea

[87] Kohli, *State-Directed Development*. Though of course the guiding agency itself could also prioritize its own interests.

furnish alternatives to the standard understanding of these points; how these alternatives capture the workings of Chinese state-led industrialization better than the "Weberian" developmental state view; and how, finally, this counterinterpretation reveals similarities in a wide range of apparently disparate but successful efforts at promoting industrialization. Naval modernization, as the archetype of the Maoist state's forced defense industrialization, serves as a central example.[88]

This chapter attempts to explain the different ways in which actors of the Maoist state—from elite policymakers to frontline engineers—interpreted the meaning of forced industrialization through the lenses of their own local contexts and participated in a multilayered politics of knowledge production in their workplaces, eventually paving the way toward transforming a particular Cold War world.

My point is a simple one: namely, that Chinese production systems were unavoidably involved in processes not specific to China, from the emergence of just-in-time production to the advent of unbalanced growth. At the institutional core of the Maoist national security state, the Soviet-inspired principle of top-down monitoring gave way to a far more vigorous production rule committed to a vague, ambitious, war-conditioned vision of disequilibrium learning. Over the turbulent years of late Maoism, that vision acquired institutional forms which had some important resemblances to, and many important differences from, both capitalist projects of lean production, such as Japan, and other Leninist projects of mass production, such as the Soviet Union.

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[88] Li, "Birth of the Phoenix." Li Yujie's article offers in-depth archival research on changes in a major production system for civilian consumers—the bicycle industry in Shanghai. For readers who are interested in the civilian sector of Maoist planned industrialization. Li's article reconstructs production methods, political circumstances, and organizational changes.

Hence, disequilibrium learning within Chinese production systems was enabled by the processual formation of space for local innovation—delegating authority for decision-making to local units and frontline actors—rather than through formal power-sharing at the hierarchical apex.[89] The upshot is that structural impediments can best—and perhaps only—be identified and surmounted in the course of a reform process that generates concrete solutions, rather than in anticipation of it.[90]

[89] Ghosh, "The Significance of Small Things."
[90] Sabel and Zeitlin, *Experimentalist Governance*, 181.