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From Coal to Petroleum: Japan's Chemical Industry and MITI's Raw Material Conversion Policy

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Abstract

This study investigates the transition from coal-to petroleum-based production in Japan's chemical industry during the high-growth era by focusing on the Ministry of International Trade and Industry (MITI) raw material conversion policies. Through case studies, this study reexamines the prevailing view of MITI's role in Japan's economic development, highlighting a collaborative policymaking process between the government and industry. The analysis elucidates how acetaldehyde production shifted swiftly to petrochemical methods during the Second Petrochemical Phase Plan (1960–1964) as MITI's policies incorporated earlier proposals from industry. For ammonia, the transition happened through the First and Second Large-Scale Expansion Plans launched in 1965 and 1967, respectively. These policies were formally established by the MITI, but they were implemented in response to requests from industry stakeholders.

Keywords: Industrial Policy, MITI (Ministry of International Trade and Industry), High-Growth Era, Chemical Industry, Energy Transition

INTRODUCTION

This study examines the transition of the chemical industry from coal-based to petroleum-based production during Japan's high-growth period, focusing on the relationship of this transition with the industrial policies implemented by the Ministry of International Trade and Industry (MITI) in the petrochemical sector. By analyzing this transition, this study aims to clarify the roles of both the industry and MITI in the policy-making process.

Japan, which endured severe devastation during World War II, recovered remarkably and achieved rapid economic growth, particularly between 1955 and 1973. During this period, Japan's real GDP grew at an average rate of over 9% per year, significantly increasing the nation's economic power and positioning it on par with major Western countries.[1] This era, commonly referred to as Japan's "high-growth era," has been the focus of much scholarly attention, particularly the factors that contributed to this economic success. Among these, Japan's industrial policy has been one of the most critical drivers of economic development, providing a strategic framework that enabled industries to expand and thrive.[2]

The international interest in Japan's industrial policy gained prominence following a series of studies conducted in the United States. In 1972, the U.S. Department of Commerce published a report highlighting Japan's industrial strategy as a key element of its economic transformation.[3] While its economy was not centrally planned like that of the Soviet Union, the report noted that Japan pursued economic growth through a close and cooperative relationship between private companies and the MITI. This collaboration allowed targeted policy interventions that supported corporate growth, MITI playing a central role in guiding industries through a developmental state model. Building on this perspective, Johnson explored the history of Japan's industrial policy from the pre-war period to the 1970s.[4] His work emphasized how Japan's wartime bureaucrats had implemented policies that were originally designed for wartime purposes but were then adapted and continued into the post-war era. According to Johnson, this policy continuity was instrumental in positioning Japan as a state that prioritized national-level economic strategies aimed at fostering industrial development.

Similarly, Okimoto's research underscored the consistency of MITI policies across industries.[5] He argued that the Ministry's policies, particularly those targeting high-tech industries, were essential for stimulating industrial development. He suggested that these policies created an environment in which industries could flourish, thereby playing a key role in Japan's overall economic success. Although Okimoto focused on specific sectors, his analysis highlighted the broader impact of the MITI leadership on driving Japan's economic growth during the high-growth era. Together, these studies drew attention to MITI's role as a key player in Japan's rapid economic growth.

However, Japanese scholars often present more nuanced views of industrial policies. Many argue that it was not the MITI alone that was responsible for Japan's economic success, but industry associations and companies played a more active role in shaping policy. For example, in a critique of Johnson's research, which emphasized the central role of MITI, Yonekura examined the mold industry, illustrating how industry associations effectively communicated companies' needs to the government.[6] Yonekura's research demonstrated that MITI policies were frequently shaped by the information provided by industry groups, suggesting a reciprocal relationship between government and industry. For instance, in 1956, MITI implemented policies to foster the mold industry, and an industry association was formed to support this implementation. The association successfully communicated companies' needs to the government through advisory councils, which enhanced the effectiveness of policies and highlighted the collaborative nature of policy formation.

Kikkawa's in-depth analysis of the electricity, petroleum refining, and petrochemical industries illustrated that MITI interventions were most pronounced in the sectors facing structural challenges. He highlighted that, while the well-organized electric power industry played a leading role in policymaking, the less-organized petroleum industry accepted increased government regulations. For the petrochemical industry, the large-scale policy introduced in 1967 led to excess capacity due to a misalignment with industry expectations, emphasizing the need for policies aligned with industry behavior to succeed.[7]

Different evaluations of Japan's industrial policy by American and Japanese scholars can be attributed to the nature of the sources used in their studies. For instance, Johnson's reviewed a vast body of previous studies, whereas Okimoto's work, although informed by interviews with MITI officials and corporate leaders, drew heavily on prior research. By contrast, Japanese scholars have utilized a broader range of historical records from organizations and companies to conduct empirical analyses. Therefore, when studying Japan's industrial policy, it is crucial to consider the historical context and all available sources to ensure a comprehensive examination of policy development.

This study focuses on one particular industrial policy, that is, MITI's raw material conversion policy. This policy played a crucial role in Japan's postwar transition from coal to petroleum as the primary energy source. Often referred to as Japan's "energy revolution," this period marked the country's shift from a reliance on coal to the more affordable and abundant petroleum. This shift was instrumental in enabling Japan's rapid economic growth as the nation centralized the use of inexpensive petroleum to fuel its industrial expansion. This transition laid the foundation for Japan's continued dependence on imported energy, a characteristic that remains central to its economy.

Although considerable research has been conducted on Japan's energy revolution, Kobori's work offers a noteworthy contribution by exploring Japan's energy history from the pre- to the post-war periods and highlighting the roles of both the petroleum and electric power industries in facilitating this transition.[8] He argues that, in addition to the exogenous factor of the international decline in crude oil prices, the endogenous factors of MITI's industrial policies and corporate efforts were crucial in supporting Japan's transition from coal to petroleum, especially as the concerns about future energy shortages grew. However, although Kobori's analysis is broad and covers responses to the energy revolution, it does not focus on the chemical industry. This omission is significant because the chemical industry was profoundly affected by the energy transition and underwent a major shift from coal to petroleum-based production. Moreover, the emergence of new petroleum-derived chemical products has had a far-reaching impact on daily life and consumer behavior in Japan during this high-growth era.

According to Stranges, Japan had already begun researching synthetic fuel conversion from coal to petroleum before the war. Although this effort ultimately failed, its significance cannot be overlooked.[9] Therefore, it is highly likely that these technological failures have contributed to Japan's increasing dependence on imported energy sources. Furthermore, it highlights the importance of examining how Japan continued to rely on imported energy after the war, using the chemical industry as a case study.

This study aims to fill this gap by examining MITI's raw material conversion policy of the MITI with respect to the chemical industry. Specifically, it focused on two key products: ammonia and acetaldehyde. Both were central to the chemical industry's transition from coal to petroleum chemistry and were subject to significant government intervention through MITI's policies. Ammonia and acetaldehyde serve as valuable case studies for understanding how MITI's raw material conversion policy was implemented, as they represent products on which government involvement had a notable influence. This study draws on a range of primary sources, including industry journals from that period and administrative documents from the National Archives of Japan, to provide a comprehensive analysis of policy development and its impact on the chemical industry.

The structure of this paper is as follows. First, it examines the transition of acetaldehyde production from coal-based to petroleum-based chemistry, focusing on MITI's policies and the reasons behind companies' shift to petroleum as a feedstock. Next, it analyzes the transition of ammonia production from coal to petroleum, with emphasis on the development and implementation of MITI's raw material conversion policy. Finally, the concluding section summarizes the roles of both the MITI and chemical industry in promoting Japan's raw material conversion, thus highlighting the cooperative relationship between the government and industry during this transformation period.

THE TRANSITION OF ACETALDEHYDE FEEDSTOCK

Acetaldehyde, a crucial chemical in Japan's postwar industrial development, experienced a notable transformation in its production methodology as the primary feedstock shifted from coal to petroleum. The foundational chemical of coal-based production, commonly referred to as "carbide," is an abbreviation for calcium carbide. Calcium carbide was synthesized by reacting calcium oxide (industrial lime) and coke derived from coal in an electric furnace. When exposed to water, calcium carbide produces acetylene gas, which subsequently serves as feedstock for acetaldehyde in coal-based chemical processes.

In the immediate postwar period, Japan's chemical industry was chiefly concerned with addressing the pressing food shortages, with demand heavily focused on fertilizers such as calcium nitride. However, due to severe shortages of essential raw materials, including coal and electricity, the production of acetylene-derived chemicals, such as those synthesized from carbide, remained inadequate. Then, as Japan's economy recovered, the demand for acetylene-based organic synthesis chemicals, particularly synthetic fibers and resins, began to increase, while the demand for fertilizers subsided. Synthetic fibers such as vinylon, which require acetaldehyde as a precursor, have become increasingly important alongside synthetic resins such as vinyl chloride.[10]

Acetaldehyde played a critical role in Japan's post-war reconstruction and industrial growth, functioning as a precursor for a wide array of chemical products essential for both everyday life and industrial advancement. Notably, acetic acid has emerged as one of the largest consumers of acetaldehyde and acetyl vinyl serves as a key intermediate in the production of polyvinyl alcohol (PVA), which is crucial for manufacturing synthetic fibers such as vinylon. Introduced in the late 1940s as a competitor to cotton, vinylon has become a significant synthetic fiber in Japan's textile industry. Acetaldehyde was also used in the production of octanol, which is primarily employed as a plasticizer in vinyl chloride manufacturing.[11]

ACETALDEHYDE IN PETROCHEMISTRY

Table 1 outlines the major companies in Japan that adopted petrochemical methods for acetaldehyde production during the early years of the country's high-growth period. Mitsui Petrochemical was the first company to commence production using petrochemical processes in 1962, followed by Kyowa Petrochemical in 1963. By 1964, several other major companies, including Tokuyama Petrochemical, Kasei Mizushima, and Chisso Petrochemical, transitioned to petrochemical methods for acetaldehyde production.

This shift resulted in a significant decline in the production of acetaldehyde via traditional coal chemistry methods as petrochemical-based production steadily increased. Figure 1 illustrates the acetaldehyde production ratio using this method, reflecting its contribution to the total production volume. Data from 1964 show that petrochemical processes accounted for 40% of acetaldehyde production. This proportion rose to 70% by 1965, while by 1969, the petrochemical method had entirely supplanted coal-based chemistry, accounting for 100% of the acetaldehyde production.

[Table 1 and Figure 1 here]

INDUSTRIAL POLICY FOR ACETALDEHYDE

MITI has gradually implemented industrial policies aimed at promoting the growth of Japan's petrochemical industry. However, the formal inclusion of feedstock conversion within these policies emerged during the second phase of the petrochemical industry plan.

In July 1955, MITI officially adopted the "Measures for the Promotion of the Petrochemical Industry" through a decision by the ministerial council. This policy, which was designed to foster the domestic production of imported petrochemical products, was known as the First Phase of the Petrochemical Industry Plan. Under this initiative, the production of various petrochemical products began and, by 1958, Japan achieved its domestic ethylene production for the first time.[12]

In December 1959, the MITI issued a policy document titled "On the Policy for the Implementation of the Petrochemical Industry Development Plan," which is widely regarded as marking the beginning of the second phase of the petrochemical industry plan. This second phase introduced several key policy objectives, with feedstock conversion as a significant focus. The primary objectives were as follows:

(1) Enhancing production facilities for items specified in the first-phase plan with the ultimate goal of achieving full import substitution.

(2) Commercializing new petrochemical products by effectively utilizing unused olefins, thereby advancing the development of an integrated petrochemical complex as envisioned in the first-phase plan.

(3) Reducing costs and increasing the supply capacity of basic chemical products by converting feedstock and replacing existing production methods with petrochemical

processes, including those based on natural gas and coke oven gas (COG) chemistry.[13]

MITI recognized the growing interest among chemical companies in transitioning their feedstocks, and the second-phase plan reflected this shift. Masaki Yoshida,[14] a bureaucrat at MITI during the second-phase plan and subsequent key figure in maintaining close industry ties, noted in a September 1959 industry journal that the commercialization efforts of companies following the first-phase plan remained robust. He attributed this activity to several factors: (1) the rationalization of existing petrochemical companies, (2) the transition of existing chemical companies to petrochemical processes, (3) the rationalization of oil refining companies, (4) the commercialization of previously uncommercialized petrochemical products, and (5) the anticipated increase in the production of petrochemical products expected to face future shortages. Regarding factor (2), Yoshida observed that some companies had already adopted petrochemical processes for production even before the implementation of the second-phase plan.[15]

In addition to focusing on feedstock conversion, the second-phase plan also considered the ongoing efforts of companies to utilize unused ethylene fractions. As noted in point (2) above, the second phase aims to "effectively utilize unused olefins," including fractions other than ethylene. Yoshida explained that various companies devised plans to reduce ethylene costs by efficiently utilizing these fractions.[16]

THE BACKGROUND OF ADOPTING THE PETROCHEMICAL METHOD FOR ACETALDEHYDE

Companies adopting petrochemical methods to produce acetaldehyde can be divided into two groups. The first group comprises companies that were already producing acetaldehyde through coal chemistry and subsequently transitioned to petrochemistry. The second group comprises companies that directly engaged in acetaldehyde production via petrochemical methods. The motivations for adopting petrochemical processes differed between the two groups.

For companies previously engaged in acetaldehyde production via coal chemistry, the price disparity between coal and petroleum was the key driver of this transition. Although various historical records provide insights into the production costs of acetaldehyde, a noteworthy analysis comes from Tatsuya Hattori, a member of the planning department of Shin Nihon Chisso, the company with the highest production volume of acetaldehyde via coal chemistry. Hattori examined the economic considerations of carbide, ethylene, and acetaldehyde production in an industry journal.[17]

Table 2 compares the production costs per ton of acetaldehyde produced using the acetylene method in coal chemistry and the Wacker process in petrochemistry.

[Table 2 here]

The cost of producing acetaldehyde using the acetylene method (coal chemistry) and the Wacker process (petrochemistry) can be divided into three main categories. The first category, "raw materials," includes acetylene, ethylene, and oxygen. Owing to the substantially lower cost of petroleum compared to coal, the Wacker process proved more economical in terms of raw materials. The second category, "utilities," covers electricity, steam, and water. Because the acetylene method requires large quantities of steam, the Wacker process was also proven to be more cost-effective. The third category, "other," includes labor, maintenance, construction interest, manufacturing expenses, by-product credits, and royalties. The costs related to facility construction and patent fees render the acetylene method more advantageous.

Although the cost difference in "raw materials" was significant, even when considering "utilities" and "other" costs, the acetylene method was not dramatically cheaper. These factors likely contributed to the transition of many companies toward the Wacker process for acetaldehyde production.

For companies already producing acetaldehyde via coal chemistry and those entering the market via petrochemistry, a common motivation for adopting the petrochemical method was the promising nature of acetaldehyde as a derivative that consumes ethylene.

The consumption of ethylene by a derivative varies by product, and a conversion factor was used to approximate the amount of ethylene consumed. The conversion factor indicates the amount of ethylene required to produce the derivative. Among the major ethylene-based derivatives, the conversion factor for high-density polyethylene and low-density polyethylene is approximately 1.1, meaning that the production of one unit of polyethylene consumes 1.1 units of ethylene. Some derivatives, such as the styrene monomer, have a low conversion factor of 0.34. In comparison, acetaldehyde has a conversion factor of 1.2, making it a derivative that consumes a large amount of ethylene.

[Figure 2 here]

According to Figure 2, ethylene consumption for low-density polyethylene was overwhelmingly high, followed by acetaldehyde, high-density polyethylene, ethylene oxide, and styrene monomers, in descending order. Low-density polyethylene was a widely used derivative produced by several companies. Although specific data on acetaldehyde production from 1962 to 1963 were unavailable, by 1965, the ethylene consumption of acetaldehyde was second only to low-density polyethylene. Therefore, from the perspective of ethylene consumption, acetaldehyde is a highly promising derivative. Because of the price difference between coal and petroleum, as well as ethylene consumption, many companies have begun producing acetaldehyde using petrochemical methods.

Owing to the combination of lower petroleum prices and high ethylene consumption, many companies have adopted petrochemical methods for acetaldehyde production.

THE TRANSITION OF AMMONIA FEEDSTOCK

This section explores the policies surrounding the shift in raw materials for ammonia production. Before discussing this transition, it is important to outline its role in coal chemistry. Ammonia is synthesized from nitrogen and hydrogen gases, while hydrogen is typically derived from coal. In coal-based chemical production, ammonia, along with tar-derived products, represents one of the primary categories of chemical output.[18]

Ammonia can be classified into two main categories. The first is its use in fertilizers, where it plays a critical role in the production of compounds such as ammonium sulfate and urea. The second category is industrial use, where ammonia serves as a precursor in the manufacture of synthetic fibers and resins such as nylon and acrylonitrile.

Japan’s fertilizer industry experienced s swift recovery during the postwar period, largely because of strong government intervention and protection. Following Japan’s defeat in World War II, severe food shortages led to widespread public demonstrations. As such, the government identified the chemical fertilizer industry as vital to national recovery, alongside key industries such as electric power and coal. To stimulate the production of chemical fertilizers, the government extended significant support, including low-interest loans and priority access to essential materials, such as steel. By 1949, this support allowed Japan’s chemical industry to recover to prewar production levels.[19]

AMMONIA IN PETROCHEMISTRY

By 1950, the global recovery of the fertilizer industry had reached a stable phase, leading to heightened international competition. As a result, Japan's fertilizer industry has faced increasing pressure to rationalize and maintain its competitiveness. In the early 1950s, Japanese fertilizer manufacturers exported chemical fertilizers at prices lower than those in the domestic market. This became a political issue in late 1952, when Japanese companies exported fertilizers to India at unprofitable prices, provoking a backlash from domestic agricultural stakeholders. Fertilizers were in short supply within Japan but were sold abroad at lower prices, leading to a surge in domestic prices. In response, the Japanese government enacted legislation aimed at stabilizing fertilizer prices.[20]

To increase rationalization, Japanese fertilizer manufacturers have begun shifting the raw materials for ammonia production from solid sources, such as coal and coke, to fluid sources, such as petroleum and naphtha. This transition was driven by the need to reduce costs and enhance production efficiency.

[Figure 3 here]

Figure 3 illustrates the production share of ammonia by each production method as a proportion of the total production volume. In 1958, petrochemical methods accounted for approximately 10% of the total ammonia production in Japan. However, by 1962, this figure had increased by 50%. Between 1962 and 1965, the production ratio of petrochemical methods remained relatively stable, at approximately 50%. In 1965, the MITI introduced the first large-scale policy to strategically promote a shift in the raw materials for ammonia production. By that year, the petrochemical method accounted for just over 50% of total production; however, by 1968, this figure had increased to nearly 70%. In 1968, the MITI implemented a second large-scale policy and, by 1973, approximately 90% of ammonia production was based on petrochemical methods.

DEVELOPMENT OF THE FIRST LARGE-SCALE AMMONIA PRODUCTION POLICY

In the early 1960s, Western companies led the way in scaling-up ammonia production facilities, prompting Japan to follow suit to enhance international competitiveness. For approximately 50 years, Kellogg, an American company specializing in the construction of oil refining and petrochemical facilities, has refined the technology necessary to achieve large-scale production, while minimizing construction costs. Natural gas was the primary feedstock for ammonia production in the United States, whereas naphtha was predominantly used in Europe. The British firm Imperial Chemical Industries successfully developed a process for the catalytic reforming of naphtha. This global shift toward scaling up production facilities was driven not only by the increasing demand for fertilizers and industrial applications but also by technological advancements from companies such as Kellogg and Imperial Chemical Industries, which made large-scale production feasible.[21]

In March 1965, the MITI set the large-scale expansion of ammonia production facilities as a strategic policy goal. In an administrative document released in the same month, the MITI referenced these new technological developments, which enabled large-scale production, and established the principle that “new expansions should, from the perspective of strengthening international competitiveness, be at a scale of at least 500 tons per day (T/D) per production line.”[22]

However, this policy was not initiated solely by the MITI. The same administrative document noted that 17 ammonia production companies submitted requests to the MITI to express their desire for administrative guidance. Each company, with the signature of its president, prepared a preliminary proposal that was later compiled into MITI’s administrative document. For instance, regarding the proposed production standards, the ammonia industry’s proposal stated that “it is desirable to set the production scale at a standard of 500 tons per day per production line.” This suggests that 500 tons per day was based on industry preferences.[23]

Subsequently, the ammonia industry requested approval for facilities with a production capacity of approximately 300 tons per day, contingent on the availability of raw materials and the condition of their facilities. Although this suggestion was not adopted in MITI’s final administrative document, several companies were later approved for production capacities of approximately 300 tons per day.

Table 3 lists the facilities approved under the First Large-Scale Expansion Policy. While most companies opted to use naphtha as raw material, Kasei Mizushima was an exception, as it began producing ammonia with a daily capacity of 250 tons using off-gas, a by-product of ethylene production. As previously mentioned, this choice reflects industry preferences. Nissan began production at a capacity of 430 tons. According to the company's historical records, one reason for this was the "internal agreement within the Ammonium Association," an industry group, which MITI respected.[24]

[Table 3 here]

The First Large-Scale Expansion Policy led to diversification of the types of petroleum-based raw materials used in ammonia production. Prior to this expansion, petroleum feedstock was limited to heavy oil and crude oil. By 1960, heavy oil accounted for 15.5% of the total production capacity; however, its use did not spread widely because of the lower cost of crude oil. Beppu Chemical began using crude oil in 1958, which accounted for approximately 40% of its total production capacity by 1965. However, owing to the high costs of production facilities, the use of naphtha and off-gas became the focus of the First Large-Scale Expansion Policy.[25]

DEVELOPMENT OF THE SECOND LARGE-SCALE EXPANSION POLICY

In January 1968, the MITI set a second large-scale expansion of ammonia production facilities as a strategic policy objective. In an administrative document issued that month, MITI highlighted the increasing capital investments in Western countries and emphasized that, to strengthen Japan's international competitiveness, production lines should, in principle, have a capacity of at least 1,000 tons per day (T/D). This marked a significant increase compared with the previous standard of 500 tons per day established during the first expansion phase.[26]

The document acknowledged that large-scale expansion would give rise to several challenges, including “the procurement of large amounts of capital for facilities, the financial burdens associated with decommissioning older equipment, and the smooth handling of surplus personnel.” To address these issues, MITI stressed the importance of “securing financial resources and providing tax incentives" to support companies through the expansion process.”[27]

The administrative document included provisions for exceptional cases. It stated that “in special cases where the use of particularly low-cost raw materials becomes feasible, the minimum production capacity will be set at 750 tons per day, and such cases will be considered separately.”[28] This clause reflected MITI’s recognition of the growing number of companies adopting off-gas as a raw material for ammonia production.

Table 4 lists the facilities constructed under the Second Large-Scale Expansion Policy. Under the First Large-Scale Expansion Policy, most companies opted to use naphtha as raw material. However, in the Second Large-Scale Expansion, the diversity of raw materials increased. Three companies continued to use naphtha, whereas the other three shifted to off-gas as their primary feedstock. This shift indicates that, as ammonia production using petroleum progressed, the range of petroleum-based raw materials became more varied.

[Table 4 here]

This policy, similar to the first, was not developed independently by the MITI. According to an administrative document related to the Second Large-Scale Expansion Policy in November 1967, the ammonia industry formally requested administrative guidance from the MITI. In fact, in November of that year, companies affiliated with the Japan Ammonium Industry Association submitted a document to the MITI, signed by their respective presidents, titled "Request for Guidance on the Implementation of Ammonia Facility Expansion."[29]

The ammonia industry has been exploring strategies to enhance its international competitiveness and has emphasized the urgent need to construct large-scale facilities with a daily capacity of 750 tons or more. To achieve this goal, the industry argued that it was necessary for the government to provide long-term loans for the construction of new facilities, the decommissioning of outdated facilities, and the initiation of new related projects. Furthermore, the industry has requested special tax measures to support both new large-scale facilities and decommissioned plants.[30]

Consequently, although the policy set a baseline of 1000 tons per day, higher than the 750 tons per day requested by the ammonia industry, the standard for large-scale production was originally proposed by the industry itself. Additionally, the tax incentives sought by the industry were implemented to reflect their influence on the final policy decisions.

CONCLUSIONS

In this study, I elucidate the relationship between the MITI and the chemical industry by analyzing the development of raw material conversion policies during Japan's period of high economic growth, focusing on acetaldehyde and ammonia as case studies.

First, regarding the raw material conversion of acetaldehyde, two key factors underpinned the industry's shift to petrochemical production: (1) the potential to significantly reduce production costs and (2) the importance of acetaldehyde as a valuable derivative for ethylene consumption. It can be concluded that the second-phase plan was established in response to these two driving factors.

Next, concerning raw material conversion for ammonia, both the first and second large-scale expansion plans were initiated by the MITI for achieving raw material conversion and lowering production costs through large-scale production. In terms of specific policy details, during the first large-scale expansion, the MITI adopted the expansion scale proposed by industry. During the second large-scale expansion, while the MITI set a production scale higher than the industry had requested, it also met the industry's demand for financial support, illustrating the collaborative nature of the policy development process.

A common feature of the raw material conversion policies for both acetaldehyde and ammonia was MITI's attentiveness to industry preferences. Conversely, the industry leveraged

MITI’s policies to facilitate its growth. This perspective contrasts with the conventional view that the MITI nurtured the industry unilaterally. Furthermore, raw material conversion policies were formulated by considering broader societal conditions at the time rather than simply reflecting MITI’s objectives. Therefore, both policies were enacted through a cooperative relationship between the MITI and industry.

The progression of raw material conversion in Japan’s chemical industry was not solely directed by the MITI but was achieved through concerted efforts between the MITI and industry. This partnership led to the introduction of petrochemical products to the Japanese market, fostering the emergence of a consumer society akin to that of other industrialized nations.

It is important to note that the industrial policy is not confined to raw material conversion. A comprehensive analysis of various industrial policies across different sectors would further illuminate the dynamics between the MITI and industry, which remains a subject for future research. A detailed analysis of the dialogue between the MITI and various industries regarding industrial policy in other sectors will also be a subject for future research.

Tables

Table 1. Companies Producing Acetaldehyde Using Petrochemical Methods in the Early Years of the High-Growth Period (tons)

Companies	Location	1962	1963	1964	1965
Chisso Petrochemical	Chiba	-	-	31500	36000
Kyowa Petrochemical	Mie	-	61500	61500	61500
Tokuyama Petrochemical	Yamaguchi	-	-	60000	60000
Mitsui Petrochemical	Yamaguchi	24000	24000	24000	24000
Kasei Mizushima	Okayama	-	-	45000	60000
Total		24000	85500	222000	241500

Source: Juukagaku Kogyo Tsuushinsha.[31]

Table 2. Production Cost per Ton of Acetaldehyde by Different Production Methods (Yen)

Production Method	Acetylene Method	Wacker Process
Raw Materials	45540	27800
Utilities	6400	2910
Others	3340	10610
Total	55280	41320

Source: Nikkan Kogyo Shimbunsha.[32]

Table 3. List of Facilities Approved under the First Large-Scale Expansion Policy

Company	Daily Production Capacity	Raw Materials
Kasei Mizushima	250	Off-gas
Toyo Koatsu Kogyo (Mitsui)	500	Butane
Sumitomo Chemical	750	Naphtha
UBE Corporation	600	Naphtha
Showa Denko	500	Naphtha
Nissan Chemical	430	Naphtha
Total	3030	

Source: Nihon Ryuan Kogyo Kai and Nihon Ryuan Kogyo Shi Henshu Iinkai.[33]

Table 4. List of Facilities Approved Under the Second Large-Scale Expansion Plan

Company	Daily Production Capacity	Raw Materials
Mitsui kouatsu kagaku	1000	Butane
Mitsubishi kasei	1000	Naphtha
Nihon kasei	1000	Naphtha
Asahi kasei	800	Off-gas
Kashima Ammonia	950	Off-gas
		LPG
Nihon Ammonia	1550	Off-gas
		LPG
Ube Ammonia	1250	Naphtha
Total	7550	

Source: Nihon Ryuan Kogyo Kyokai.[34]

FIGURES WITH CAPTIONS

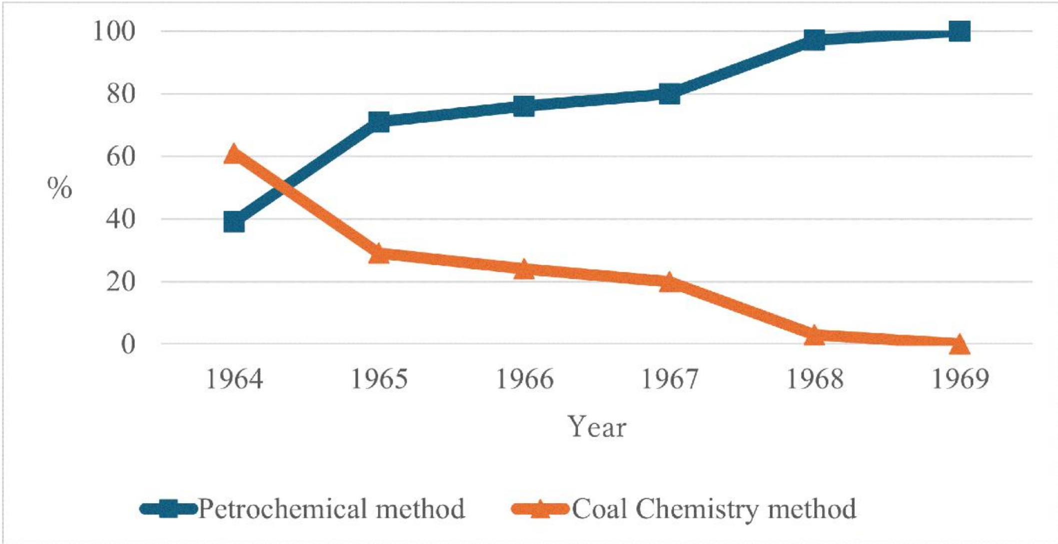

Figure 1. Transition from Coal Chemistry to Petrochemical methods in Acetaldehyde Production (%). Source: Sekiyukagaku Kogyo Kyokai.[35] Data before 1964 could not be confirmed.

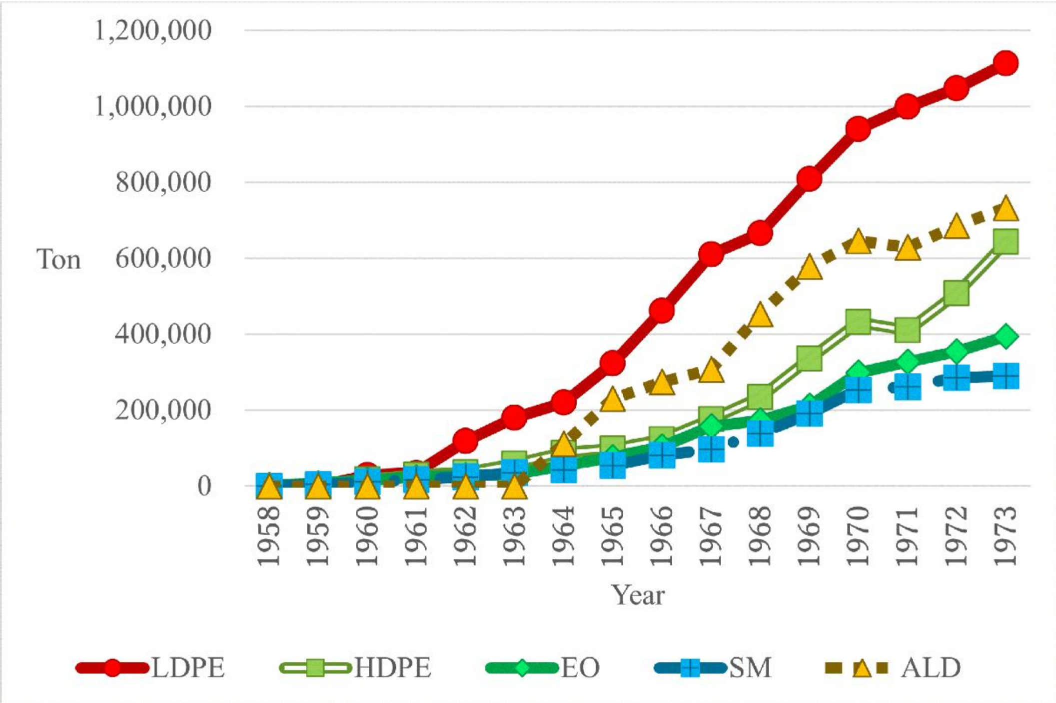

Figure 2. Ethylene Consumption of Major Ethylene-Based Derivatives (Tons). Source: MITI and Juukagaku Kogyo Tsuushinsha and Keiataro Nagai.[36] LDPE: low-density polyethylene; HDPE: high-density polyethylene; EO: ethylene oxide SM: styrene monomer; ALD: acetaldehyde. Data for Data for the other products—LDPE, HDPE, EO, and SM—were also used in Nagai (2020).

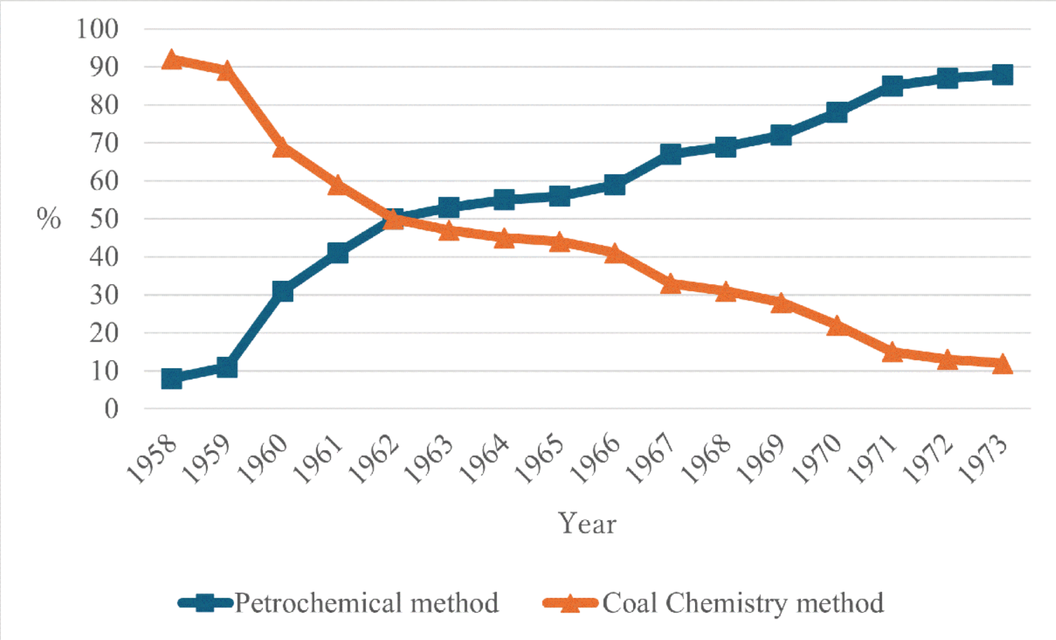

Figure 3. Transition from Coal Chemistry to Petrochemical methods in Ammonia Production ((%). Source: Sekiyukagaku Kogyo Kyokai and Tsusho Sangyo Chosakai (Japan Industrial Association).[37]

NOTES

[1] Kiyoshi Hamano, Shigehiko Ioku, Muneyoshi Nakamura, Makoto Kishida, Masakazu Nagae, and Toshiaki Ushijima, *Nihon Keizai-shi 1600-2015: Gendai Rekishi kara no Yomitori* (*Japanese Economic History 1600-2015: Contemporary Readings from History*) (Keio University Press, 2017), 269.

[2] For example, the importance of industrial policy during Japan's high-growth era is highlighted in several works on Japanese economic and business history, including textbooks

such as Hamano et al., 292–5, and works such as Minoru Sawai and Masayuki Tanimoto, *Nihon Keizai-shi: Kinsei kara Gendai made* (*Japanese Economic History: From Early Modern to Contemporary*) (Yuhikaku, 2016), 383–8; and Matao Miyamoto, Takeshi Abe, Masaru Udagawa, Minoru Sawai, and Takeo Kikkawa, *Nihon Keiei-shi: Edo kara Reiwa e, Dentō to Kakushin no Keifu*, 3rd ed. (*Japanese Business History: From Edo to Reiwa, A Genealogy of Tradition and Innovation*) (Yuhikaku, 2023), 301–8.

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