Discussion Paper Series A No.459

Trade and Industrial Organization: Japanese Ammonium Sulphate Industry in the Interwar Period

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October 2004

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[1] This paper has benefited immensely from constant encouragement and valuable comments from Proffessors J. Teranishi, K. Odaka , Y. Kiyokawa and O. Saito at the early stages of its preparation. Any sins of omission or commission that still remain are absolutely mine.

TRADE AND INDUSTRIAL ORGANIZATION: JAPANESE AMMONIUM SULPHATE INDUSTRY IN THE INTERWAR PERIOD*

Abstract

Trade is considered an effective antidote to the exercise of domestic market power. This paper, through an analysis of the structure, conduct and performance of the Japanese ammonium sulphate industry during the interwar period shows that trade is not always a sufficient condition for domestic markets to become competitive. In industries exhibiting substantial economies of scale, availability and diffusion of technology, existence of surplus international capacity and the ability of domestic producers to deter imports can impede instantaneous adjustment of international supply to imbalances in demand and supply thereby allowing domestic producers to exercise their market power.

* This paper has benefited immensely from comments by Professors J. Teranishi, K. Odaka, Y. Kiyokawa and O. Saito of Hitotsubashi University. The usual caveat stands.

INTRODUCTION

This paper aims at analysing the impact of international trade on structure, conduct and performance of the Japanese ammonium sulphate industry during the interwar period. The heavy and chemical industrialization of Japan during this period brought with it high fixed-cost technology amenable to scale economies. Entry into these new industries required substantial initial investment and technological capability that was in short supply in Japan in the prewar period. Such fixed cost industries tend to become monopolies or oligopolies and are in a position to extract economic rents by engaging in non-competitive behaviour. The conventional theory has it that free and unfettered international trade is a sufficient condition to render the domestic market competitive even when a single or a few competitors dominate the domestic market. In the presence of free international trade, domestic producer(s) cannot effectualise their monopolistic or oligopolistic power. It was in this vein that Haberler, (1959) underlined the role of free international trade as the most potent anti-monopoly measure to ensure free competition.

Growth and development of the Japanese ammonium sulphate industry during the interwar period provides an ideal and interesting case to evaluate the effect of international trade on domestic market structure, conduct and performance. Developing very rapidly during World War I, the industry was dominated by two firms that practically

supplied the whole of the domestic output through the 1920s. It was only in late twenties that new Japanese firms entered the industry and the market became potentially more competitive. Thus, domestic production of ammonium sulphate in Japan was highly concentrated until the 1920s. During the interwar period, the industry did not have any protection from international competition in the form of tariffs or quotas. This makes it a prime candidate for studying the behaviour of a potentially oligopolistic industry in the presence of international trade. An added advantage of the ammonium sulphate industry is that it produces a more or less homogenous product allowing us to avoid complications introduced by possibilities of product differentiation in industries such as automobiles.

Our analysis in this paper indicates that free trade in itself may not be a sufficient condition to ensure competitive behaviour in an oligopolistic market. Until 1928-29, the domestic price of ammonium sulphate in Japan, though declining, was consistently higher than the landed price of imports (c. i. f. price) – an observation that does not lie easy with the conventional analysis. It is shown that only after the emergence of excess capacity in the international market as a result of technological innovation and diffusion on the supply side and a decline in demand in the late 1920s did the domestic price of ammonium sulphate in Japan fell below its landed import price. This ability of the Japanese ammonium sulphate industry to charge higher than international prices

was also reflected in the profit performance of the domestic firms exhibiting the classic case of structure-conduct-performance paradigm. Thus, for free international trade to act as an "effective" anti-monopoly measure some other conditions need to be met. This paper analyzes the Japanese ammonium sulphate industry during the interwar period and finds that factors such as availability and diffusion of technology and difficulties in supply diversion among export markets can make the international supply function inelastic in the short-run, allowing a domestic monopoly to continue exercising its monopolistic power.

The rest of the paper is structured as follows. In the next section we briefly discusses the theoretical underpinnings of the relationship between international trade and market structure. A short sketch of the development and growth of the Japanese ammonium sulphate industry follows, with special emphasis on the structure of the domestic market. We then turn our attention to the conduct and performance of the Japanese ammonium sulphate producers and finally try to make sense of the observed anomalies in their behaviour under free trade during the twenties.

TRADE AND INDUSTRIAL ORGANIZATION IN THEORY

Individual firms in a perfectly competitive industry face a perfectly elastic demand curve and no firm has can use price or quantity as a strategic variable to increase its profits beyond the normal profits. The product price is determined by the industry demand and supply. Each firm takes this price as a given and produces at a level that equates marginal cost to marginal revenue, which, in a competitive industry, also equals price. A monopolist, on the other hand, faces a forward falling demand curve and charges a price at the profit-maximizing output, given by the intersection of the marginal cost and marginal revenue curves, that exceeds marginal cost. The firm can use either price or output as a strategic variable to earn supernormal profits[1]. While this generates extra profits for the firm, it is usually considered detrimental for resource allocation and the consumer. Demerits of a

[1] This is not necessarily true. If markets are contestable in the sense that firms can enter or exit the industry without incurring substantial costs, any attempt by incumbent firms to earn supernormal profits will result in new entry, competing away the excess profits. In such "contestable markets" even a monopolistic firm equates its marginal cost to price in order to avoid potential new entry. Thus, potential competition renders a market competitive even if the industry is characterised by a small number of firms. See Baumol, et al., Contestable markets and Ito, et al., Sangyo seisaku.

non-competitive market structure are generally believed to outweigh any merits[2].

Until the mid 1970s, the impact of international trade on domestic market structure did not receive much attention[3] primarily because most research was confined to the US economy. The impact of external trade on the comparatively large and technologically advanced US economy was considered relatively unimportant. Beginning in the late 1970s, theoretical literature on the relationship between international trade and industrial organization began to proliferate[4]. However, most of this literature emerged in the context of introducing economies of scale as a source of intra-industry trade or in the context of trade policy determining either the effects of alternative protection regimes on welfare (via its impact on domestic market

[2] Developments in industrial organization theory in the context of industrial policies indicate that non-competitive markets invariably result in lower economic welfare. Ito, et al., Sangyo seisaku develops such an argument in the context of excess investment and excess competition in the presence of substantial scale economies or research and development competition.

[3] With the exception, perhaps, of Krause, Import discipline. Also see Krugman, Industrial organization, p. 1181.

[4] Krugman, Industrial organization provides a good overview of the developments in the field industrial organization and international trade. Bhagwati, On the equivalence, Caves, Intra-industry trade, Caves and Jones, Trade and payments, Caves, et al., Competition in the open economy, White, Industrial organization are some of the other early contributions to the debate.

power) or the use of trade policy as a stratagem for industrial development. While this literature has provided many interesting insights into the interaction between trade and industrial organization, the basic result, from the point of view of the present paper is that in the absence of government intervention – protection or promotion – free international trade severely curtails the power of domestic monopolies or oligopolies. This conclusion has held despite substantial developments in the theory of international trade in the context of imperfect competition as well as developments in the industrial organization theories. Thus, Jacquemin and Sapir, in their study of European market state that, "... liberalization of European market will indeed increase the competitive pressure on European industry and exert a constraint on the exercise of market power."[5]. Martin, studying industrial organization in Europe, states: "When markets are imperfectly competitive, an important benefit of foreign trade is that it limits the ability of the domestic producers to earn economic profit..."[6].

[5] Jacquemin and Sapir, European integration, p. 90.

[6] Martin, Industrial organization, p. 156.

Let us very briefly look at the fundamental mechanism by which international trade interacts with domestic market structure using the standard diagram[7].

[Figure 1 about here]

In Figure 1, DD represents the domestic demand curve and MC is the rising part of the marginal cost curve of the domestic monopolist, representing the domestic supply curve. In the absence of trade, the monopolist maximizes his profits by equating his marginal revenue (MR) to marginal cost (MC) and charging P_m, a price higher than the marginal cost. He earns supernormal profits on the infra-marginal units sold. Let us now introduce international trade and see how the monopolist changes his behaviour. Let us assume the international supply of the product is perfectly elastic at the prevailing international price P_w[8]. Further, let us also assume a homogenous product and no insurance, freight or other transaction costs. It is easy to show that the domestic producers cannot charge a price greater than P_w. The domestic producer supplies OQ_0 and $Q_0 Q_1$ is imported. There is no way

[7] Variations on this diagrammatic approach can be found in Caves, et al., Competition in the open economy, Krugman, Industrial organization, White, Industrial organization and others.

[8] This is only a simplifying assumption and the basic results do not change even if we allow for an upward sloping international supply (cost) curve. Bhagwati, On the equivalence allows for such an increase in comparing the effects of tariffs and quotas.

for the domestic monopolist to operationalise his monopoly power. International trade renders the domestic market, notwithstanding the number of domestic producers, perfectly competitive. Even with freight and insurance costs, as long as the world price, inclusive of such costs (c. i. f. price) is below P_m, the domestic monopolist maximizes his profits by equating his marginal cost to price (the competitive solution). The implicit threat of imports, until this level is reached, makes the domestic market contestable and disciplines the domestic monopolist[9]. If the insurance and freight costs are prohibitive, that is the c. i. f. price of imports exceeds P_m, international trade ceases to have any impact on domestic market structure. In terms of Bhagwati's analysis, insurance and freight costs[10] act exactly like imposition of a tariff. In the absence of any quantum restrictions on imports or prohibitive tariffs, therefore, the industry is locked into competitive pricing[11].

It is thus clear that international trade places a ceiling on the price charged by the domestic monopolist, defined by the c. i. f. price of

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[9] The reasoning is very similar to that of contestable markets in Baumol, et al., Contestable markets.

[10] For that matter, any form of transaction costs that impinge on the price of the imports without restricting effective supply in the international market will have a similar effect.

[11] With quantum restrictions, the results differ as was shown by Bhagwati, "On the Equivalence," in his analysis of tariffs and quotas and also by White, "Industrial Organization,". We return to this aspect later in the paper.

imports. The analysis is complicated if we allow for product differentiation (or the possibility of international duopoly as in Krishna, (1989)) or collusive oligopoly (in which case the firms may be collectively able to influence price-quantity relationship in the international market). However, the basic result stands in most cases and especially for undifferentiated products. We do not delve on these issues here as we are dealing with a homogeneous product in this paper.

With this brief introduction to the role of international trade in preventing monopoly rents, let us embark on a study of structure, conduct and performance of the Japanese ammonium sulphate industry during the interwar period. The following section presents a brief discussion of the salient features of the growth process of the Japanese ammonium sulphate industry relating it to the structure of domestic production.

GROWTH AND STRUCTURE

Japan was quick to introduce ammonium sulphate after the product was first developed in Western Europe towards the end of the nineteenth and early twentieth century. Initially, ammonium sulphate was produced primarily as a bye-product of coking and refining industries, using waste gases generated in these processes. Tokyo Gas was the first to introduce this method of production in Japan in 1901

and other refining firms soon followed suit[12]. Production level, however, remained low and heavily dependent on the growth of the coking and refining industries. It never became a major source of supply and in 1905, only 467 tons of ammonium sulphate was produced rising to 1,905 tons in 1908[13].

An alternative technology to fix atmospheric nitrogen – the electric arc method – was developed in 1898 and tested in Norway and Sweden in 1902. However, this method of production vanished soon due to extremely high – about 70,000KWH per ton – energy requirements. Another energy consuming technology, the calcium cyanamide conversion process, however, took root; the energy requirements for this process though high, were only about one-fifth of what was needed for the electric arc method. In Japan, Soki Denki Co. (later Nippon Chisso Hiryo; Nichitsu here after) adopted this method in 1908 and gradually increased production of ammonium sulphate to about 7,000 tons a year by 1912[14]. This process was to remain the main source

[12] Ammonium Sulphate was first produced in Japan in 1898 but not commercially. See Molony, Technology and investment, p. 57.

[13] Most data for production volumes and values is from Norinsho, Hiryo yoran unless stated otherwise.

[14] For a detailed discussion of technological developments in the ammonium sulphate industry, see Haber, Chemical industry: 1900-1930, pp. 85-88. For developments in Japan, see Ishikawa, Kagaku hiryo, Shibamura, Nihon kagaku kogyo or, in a shorter version, Khosla, Entry barriers.

of ammonium sulphate production in Japan through early 1920s and formed the backbone of the substantive growth following the beginning of World War I.

[Table 1 about here]

Table 1 presents some of the most salient features in the growth process of this industry beginning the 1910s. Average annual production grew six fold, from 10,000 tons in 1912-14 to 60,000 tons in 1915-21. Thereafter it more than doubled every five years to reach 294,000 tons a year in 1927-32 and 787,000 tons per year in 1933-39. Prior to World War I, imports were the most important source of ammonium sulphate in Japan. Between 1912-14 over 90 percent of Japanese requirements were met by imports declining sharply to 41 percent in 1915-21[15]. Major cause for such a reversal was a cessation of supplies – as western powers, especially Britain who was a major supplier of the fertilizer to Japan, channelled their production to war needs – rather than increased competitiveness of the Japanese industry based on technological or other cost advantages.

The most efficient technique for obtaining ammonia, the basic ingredient in ammonium sulphate fertilizer, was synthesis of atmospheric nitrogen and hydrogen. The Haber-Bosch process, invented in 1913 in

[15] In 1908, against less than 2,000 tons being produced in Japan, 66,376 tons (98% of total supply) was being imported. See Molony, Technology and investment, Table 10, p.58).

Germany just before the beginning of the World War, was the first successful commercialisation of this technology. Due to the war and high cost of licensing this technology, the Japanese firms did not begin employing the synthesis method till mid 1920s[16]. Nichitsu was the first Japanese firm to use synthesis technology, though it employed an alternative technology – the untested Italian Cassale process – in 1924. From late 1920s, the synthesis-based technologies proliferated rapidly resulting in substantial weakening of entry barriers. A large number of new firms entered the market making it more competitive[17]. As a result, Japanese production of ammonium sulphate expanded substantially and in 1931, for the first time, exceeded imports barring the World War I years (1915-1918). The Japanese ammonium sulphate industry also began exporting, primarily to colonies, in the 1920s but it was not until the 1930s that exports became significant. Thus, the Japanese

[16] The Haber-Bosch technology was pioneering and was not easy to replicate. Effective alternatives to this process did not emerge till late 1920s. See Greenberg, et al., Regulation, Haber, Chemical industry: 1900-1930.

[17] Many Zaibatsu groups (family controlled conglomerates in prewar Japan) entered ammonium sulphate production during the late 1920s and early 1930s using alternative technologies and sources of power. For example, Mitsui substituted hydrogen produced in coke oven in the Claude process and used an improved Claude method (modified by Dupont) for its second plant, the Toyo Koatsu. The NEC process adopted by Sumitomo was also a coal-based process. See Molony, Technology and investment. Khosla, Entry barriers also discusses these technologies and the reasons for delayed entry by new firms.

ammonium sulphate industry matured from a fledgling industry at the beginning of the twentieth century to a mature industry within a short period of about 30-40 years.

How was the domestic production structured? Bye-product ammonia, being unresponsive to price changes, was never important source of supply and such producers could not affect the structure of the domestic market. Only two firms adopted the cyanamide conversion method –Nichitsu (established in 1908 as Soki Denki) and Denki Kagaku Kogyo (set up in 1915, Denka hereafter). These two firms dominated the market till early 1920s. The share of the two firms in domestic production fluctuated between 70 to 90 per cent, the highest being during World War I (Table 2). With new entry during the late 1920s and early 1930s, both these firms lost market share but still accounted for over 40 percent of production in 1936. Note that this reduction in the share of the dominant firms was not the result of increased imports since from 1930 onwards even import share of total supply was declining.

[Table 2 about here]

By 1929, excess capacity had emerged as a result of the agricultural depression of the late twenties and a proliferation of alternative methods of synthesising ammonia making it easy for new firms to enter. In Japan also, a number of new firms entered the market using these new techniques, increasing competitive pressures just at a time when

international excess supply was beginning to emerge. The number of firms in the industry rose during the thirties, and 2-firm concentration decreased. Still, the top six firms accounted for over 80 per cent of total production. With the emergence of excess supply, the Japanese ammonium sulphate industry consolidated itself by setting up an association that effectively acted as a cartel in setting production levels and prices in conjunction with the International Nitrogen Cartel[18].

Table 2 also presents data on the share of major domestic firms in total supply of ammonium sulphate. Except for 1916-18, the share of top two firms never exceeded 40 percent of the total supply defined as domestic production less exports plus imports. This is in sharp contrast to their over 75 percent share in domestic production. In the twenties, as imports resumed, the share of domestic production in total supply, though gradually, declined from about 54 percent at the beginning to about 40 percent towards the end. The same is true for the 2-firm share. This decline in the share of the domestic production and of domestic

[18] The Ammonium Sulphate Distribution Agency (Ryuan Haikyu Kumiai) was formed in 1932 with a view to stem the sharp decline in prices and determine production quotas in the absence of any governmental protection to mitigate competitive pressure from imports. See Kondo, Ryuan, pp. 177-179). This agency also negotiated with the International Nitrogen Cartel set up under the leadership of BASF of Germany (Convention de l'Industrie de l' Azote , CIA for short), on the level of imports and prices (Shibamura, Nihon kagaku kogyo, pp. 354-355). See Molony, Technology and investment, pp. 183-85, on the involvement of Nichitsu in the process.

firms in total supply can be interpreted to imply the effectiveness of international trade in curbing domestic oligopoly.

However, disaggregating the firms reveals some intriguing patterns in the share of the top two firms. Nichitsu saw its share of domestic production and total supply decline rapidly after the World War I. Denka's share, on the other hand, rose in terms of domestic production while staying stable in terms of total supply after an initial decline immediately after the war. This occurred even though Nichitsu had internalized supply of electric power[19] and switched to the more efficient synthetic ammonia process in the mid 1920s while Denka stuck with the calcium cyanamide process[20]. With new entry using synthetic ammonia process in the late twenties and thirties, Denka rapidly lost more market share than Nichitsu because of its cost disadvantage. That Denka, despite its known inferiority in terms of technology and electric power, could raise its share of production and maintain its

[19] Both of Nichitsu's plants, at Minamata and Kagami, had their own power supply and the firm was producing about 50,000 KW of electricity by 1918 (Nihon Chisso Hiryo (KK), Jigyo taikan, p. 454). As against this, Denka began construction of its first electric power station only after it faced difficulties in maintaining power supply. The power station, however, was completed only in 1925 (Denki Kagaku Kogyo (KK), Yonjugonen). As regards the high cost of purchased electricity, see Sato, Hiryo mondai, pp. 62-63).

[20] According to Pollitt (see Haber, Chemical industry: 1900-1930, p. 97), ammonia synthesis required only 6.3 to 7.3 tons of coal worth of energy per ton of nitrogen fixed as against 12.7 tons for calcium cyanamide process.

share in total supply, while Nichitsu, the more efficient firm was loosing share is an anomaly not easily explained by assuming the markets to be competitive: Denka should have suffered greater loss in share.

Thus the Japanese ammonium sulphate markets were imperfectly competitive during World War I years due to "natural" protection provided by the cessation of supplies; cartelisation of the domestic producers and the agreement with international cartel (CIA) rendered the market less than competitive in the thirties [21]. In the twenties, however, market entry whether of domestic producers or of imports was absolutely free[22]. Import share of the market did increase throughout this decade. However, if the market was unprotected and, therefore, locked into competitive behaviour, we cannot easily explain the anomalies in the market share of the domestic firms as discussed above.

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[21] The international agreement, known as Fujiyama-Bosch agreement, had following important clauses: i) Minimum imports of 100,000 tons, 80,000 tons and 30,000 tons for three years of agreement respectively plus any deficiency in domestic supply. ii) Mitsui and Mitsubishi were to be sole agents for the British and Dutch imports but were barred from making any direct purchases from these countries. iii) If the Japanese firms wanted to export, they had to come to an agreement for the prices with Britain and Germany. See Shibamura, Nihon kagaku kogyo, pp. 354-355.

[22] The lack of protection was possibly the result of the rural policy to keep fertilizer prices low. See, for example, Hashimoto, Ryuan shijo, p. 53 (383).

Changes in the rates of capacity utilization by the two dominant firms raise further questions about the competitiveness of the Japanese market during this period. Nichitsu, the technologically advanced firm with larger capacity, operated at 50-70% of its capacity through to 1926-27, despite its cost advantage over Denka. But, following increased competition from imports[23] and new entry in the late twenties, it suddenly expanded its output to near full capacity[24]. In contrast, Denka increased its production and its capacity utilization from about 45-50% in early 1920s to nearly full capacity as the decade progressed. To confirm our suspicion that the Japanese ammonium sulphate market in the twenties was still uncompetitive, we decided to investigate the movements in the prices and profits in the industry – the two most important conduct and performance variables.

CONDUCT AND PERFORMANCE

Ammonium sulphate is a relatively homogeneous product, difficult to differentiate by supply source and a single price is expected to prevail

[23] According to Norinsho, Hiryo yoran, on an average 181,000 tons of ammonium sulphate was being imported into Japan per year during 1922-26. This rose to 293,000 tons per year in 1927-32, a 62 percent increase.

[24] Nichitsu was capable of producing 90,000 tons per year in early 1920s while it was producing just about 55 to 60 thousand tons per year for a capacity utilization rate of about 60%. In 1929, the capacity had increased to 110,000 tons and the production to 109,000 tons for a capacity utilization rate of nearly 100%. For productive capacity, see Nihon Chisso Hiryo (KK), Jigyo taikan.

in a competitive market. Table 3 presents two sets of prices for the domestic and the imported product – unit value, calculated as value of domestic production or imports divided by respective quantities; and the wholesale price. Since the value of imports is at the port of entry, it is a good indicator of the c. i. f. prices of imports. The wholesale prices are used to confirm the observed movements in unit value series.

[Table 3 about here]

During WWI, given the limited domestic productive capacity, a decline in War induced imports allowed the domestic producers to charge higher prices as scarcity rents. A cursory glance at Table 3 indicates that prices dropped sharply in the immediate post WWI period but remained at fairly high level through the first half of the 1920s. This is true for domestic as well as import prices. Furthermore, in the absence of any import restrictions, lower of the domestic and import prices should have prevailed. But the price data show that import price, unit value or wholesale, consistently lagged behind the domestic price. In the later half of the 1920s, the difference between domestic and import price diminished and vanished during the depression. Price behaviour in the thirties is consistent with the freely competitive market. Existence of the domestic cartel in this period did not allow domestic prices to exceed import prices.

What about performance? One measure of performance of an industry or a firm is its profit rate. Before we look at the performance of individual firms in the Japanese ammonium sulphate industry, let us see how the fertiliser industry performed relative to some other leading industries of the time. Figure 2 presents the performance of the machinery, chemicals, and fertiliser industries as well as that of Nichitsu[25] relative to the manufacturing industry as a whole. The data for industry-wide profit performance pertains to rate of return on paid-up capital net of depreciation, taxes and interest payments on borrowed funds and is taken from Asahi Shimbunsha, (1930) for the period 1914-1928. For 1929-1940, the data are from Mitsubishi Keizai Kenkyujo, (Various Years) and are, therefore not strictly comparable to those in the earlier period. The difference is in terms of coverage: while the former source covers all firms capitalised at over ¥50,000, the later covers only large firms. Figures for fertilizer industry as a whole are used here to proxy ammonium sulphate industry since separate industry wide figures are unavailable and ammonium sulphate was the most important commercial fertilizer of the time. Figure 2 also includes Nichitsu, by far the largest producer of this fertilizer for comparative

[25] The figure omits years 1918 and 1919 due to lack of availability of data for manufacturing sector as a whole for these two years. The rates of return on paid-up capital for individual industries for the two years were in the following order: Machinery (104.6% and 61.0%); Chemicals (61.1% and 38.0%) and fertilizers (38.2% and 53.4%). The rate of return for Nichitsu (on net worth) was 46.8% and 49.8%.

purposes. However, here the performance is measured by return on networth, which is probably lower than it would be on paid-up capital.

[Figure 2 about here]

The data show that despite the war boom, fertilizer industry was a poor performer compared to machinery, chemicals and even manufacturing as a whole. Nichitsu did not perform badly though it performed much better in the twenties. During the 1920s, fertilizer industry led the pack in terms of rate of return, followed by chemicals, manufacturing as a whole and machinery in that order. In the 1930s (from 1933 to be precise), once again, fertilisers were at the bottom of the heap. This is quite intriguing: ammonium sulphate and fertilizer industries performed their best, relative to other industries, in the period when the competitive pressures were supposed to be the strongest.

Table 4 presents the rate of profit on net worth for major ammonium sulphate producers from 1914 to 1940. The high profits experienced during the WWI boom fell by half during the 1920s. But, after a steep initial fall, the profits were stable in the early 1920s. In the late twenties, the profit rate declined gradually, stabilizing at around ten percent for the established firms in the 1930s. The relatively new firms showed

higher levels of profits in the early thirties though by late thirties all firms showed roughly similar profit rates[26].

[Table 4 about here]

Table 5 gives a better picture of the comparative profit performance of different firms. It shows a tendency for profits to decline over time, especially up to the great depression. This appears to corroborate the result of the standard theory of industrial organization in the presence of international trade; international trade cuts into the excessive profits. However, if we look at the performance of individual firms, we once again find some intriguing patterns. First, one can discern that while profitability in both Nichitsu and Denka was declining, the former outperformed the latter consistently by a wide margin. Second, even though Nichitsu saw its profits dwindle, the decline was gradual (Table 4) and the year-to-year variability was relatively small. As against this, Denka's profits show very sharp declines with high variability, especially during 1927-32 period when competition from imports and new entry hit the firm with full force. If we include Denka's figure for 1927, mean profit turns negative and variance is much higher.

[Table 5 about here]

[26] This may have to do with the gradual militarization of the Japanese economy but we are not directly interested in this period here.

In part, this difference in inter-firm performance was due to Nichitsu's decision early on to internalize electric power production while Denka depended on the market. As long as there was surplus in generation capacity, it was possible to buy cheap electricity. As electric power supply shortage developed in the immediate postwar period, costs rose and Denka saw a steep decline in its profits during 1919 and 1920[27]. While costs were definitely a cause of the differential performance, these were not solely responsible for the whole of the difference since both firms were using the conversion method of production up to 1924.

During the late 1920s, emergence of excess capacity in the ammonium sulphate industry at the international level, and the advent of agricultural depression in Europe (1930-31) created conditions for over production. Again, weakening of licensing barriers and lower setup costs brought new entry in its wake[28]. The threat of new entry also induced the established firms to increase production. As mentioned

[27] Table 4 shows that Denka's profit rate fell sharply from 44% in 1918 to about 27-28% in 1919 and 1920. Nichitsu, on the other hand, did not show much change till the postwar depression of 1921. Even at that time, Denka's decline was steeper.

[28] As mentioned earlier, till late 1920s, Haber-Bosch process was the only major tested commercial technology to directly fix atmospheric Nitrogen. Some other technologies appeared but there were no takers. Nichitsu introduced one of these – the untested Italian Cassale process, in 1924. For a further discussion of licensing and high costs of borrowing existing technology, see Hashimoto, Ryuan dokusentai, Khosla, Entry barriers, Morikawa, Senkanki ni okeru.

earlier Nichitsu increased its rate of capacity utilization from 50-70% before to full capacity towards the end of 1920s. As a result, profit rates fell further.

Even in this period, Denka's profits were far below those of Nichitsu and variability much higher. Denka, in fact, suffered a severe loss in the 1927 financial crisis. Average profits of Denka (excluding 1927) were about a third of those for Nichitsu and variability about four times as high. This increased variation was to be expected as a result of severe competition. The fall in the rate of profits for Nichitsu was small in the earlier years because it had already shifted to better techniques of production and was able to compete effectively with imports.

In the 1930s, the rate of profit, in the new as well as the old companies was highly stable as reflected in low coefficient of variation. Surprisingly, Nichitsu shows the lowest average profit rate for this period. This may be accounted for by the fact that ammonia production using electrolytic hydrogen became relatively costlier compared with the use of hydrogen generated by water gas shift method using coal[29] as a result of a decline in the relative prices of coal. Also, some new entries such

[29] That electrolytic hydrogen was costlier than the water-gas shift method can be inferred from the much larger proportion of new capacity created in the 1930s using the water shift method. Shibamura, Nihon kagaku kogyo, Table 225, pp. 439-440, shows that the coal-based hydrogen capacity accounted for 94.6% of the total increase in capacity.

as Sumitomo and Mitsui were advantaged in use of coal (with control over coal mines).

It is clear from our discussion that in terms of conduct and performance, major Japanese ammonium sulphate producers were perhaps in a position to exercise market power during the 1920s. The fact that Nichitsu was earning higher rates of profit than Denka at the same time as its market share was declining at a much faster pace, indicates that it was possibly a price leader because of its better cost structure, capacity and technology. But how can this be possible if the industry was not subject to import restrictions?

TRADE AND NON-COMPETITIVE BEHAVIOUR – MAKING SENSE

How can we explain these perverse patterns in market share, prices and profits? It appears that somehow the supply of imports to the Japanese market was restricted since the observed pattern of price movements is very similar to the effect of quota as depicted in Figure 3. A quota fixes the level of imports and once the quota is known, the domestic monopolist takes the residual demand curve and maximizes his profits by equating marginal revenue in the residual market to its marginal cost and charging a higher price. In Figure 3, if the domestic producer believes that only Q_1Q_{if} will be imported, he can take D_1D_1 as his residual demand curve and can charge a higher than import price (c. i. f.) without having to worry about increased imports. If in the next

period, the imports expand as a result of higher prices in the import market in the previous period, the demand function will shift inwards and lead to a reduction in domestic price. The import and domestic prices will converge only if the domestic demand function shifts sufficiently inwards so that MR curve intersects the MC curve of the domestic producer at P_w. Thus, we obtain a "shifting-quota effect" over time.

The continuous decline in domestic and import prices in Japan with the former staying above the later suggests the existence of short-run fixity in the Japanese import supply function and a "shifting-quota" effect in Japan. This probably allowed the domestic firms to keep their prices above that of imports. What caused this fixity since there were no import restrictions, quantitative or otherwise, during the 1920s?

[Figure 3 about here]

The implications of international trade for structure conduct and performance of potentially non-competitive industries in the classical model depicted in Figure 1 is based on the crucial assumption of instantaneous adjustment of international supply to demand conditions. In the absence of this assumption, there is room for extracting monopoly rents and the constraint on domestic firm behaviour is ineffective. One can visualize three scenarios under which such an assumption can obtain: (a) readiness in the exporting country to build

new capacity at short notice; or, (b) existence of excess capacity in the exporting countries; or, (c) possibility of costless diversion of exports from one market to another in response to price differentials.

Scenario (a) is likely to obtain in industries with low set-up costs and small minimum efficient scale. In industries beset with high-fixed costs and substantial economies of scale, creating new capacity solely on the basis of uncertain export demand can be risky[30]. Even if the increase in export demand is large enough and expected to last, gestation period to bring the supply on line is likely to be long, creating short-run fixity in supply. In the meantime, producers in the export market can continue to exercise their market power. Moreover, if the producers in the export market are holding excess capacity, exporters may be deterred from increasing supply to this market[31]. Scenario (b) is possible if exporters have excess capacity not justified by existing market conditions: plausible, for example, if the exporter maintains

[30] White, Industrial organization also treats risk but with respect to its impact on domestic producers' expectations and behaviour. Holding excess capacity or adding new capacity on the basis of a sudden surge in demand by individual firms is risky. Besides, uncertainties regarding exchange rates, uncertain prices and uncertain transport costs that usually affect the behaviour of the domestic producers in White's analysis apply to exporters as well.

[31] Use of excess capacity as a strategic tool to deter new entry is discussed in any standard work on industrial organization. See, for example, Spence, Entry, capacity, investment, Teranishi, Sannyu boshi for some early formulations.

excess capacity as a strategic tool but not very likely in a competitive international market. Scenario (c) is possible if international contracts are easily and quickly altered with a minimum of cost (pecuniary or non-pecuniary), a condition not likely to occur very often.

Another source of short-run fixity of import supply may be a time lag between setting up import contracts and actual supply allowing the domestic producers to treat residual demand for the contract period as captive and set prices higher than import prices. This may be aggravated if the exporter sets his prices in advance on the basis of information on the existing state of demand and supply in the export markets. In the absence of conditions of international excess supply or capacity, underestimation of demand growth or an overestimation of the supply capacity in the export market can result in "shifting-quota effect".

In order to underpin our analysis, however, we need to provide some evidence of possible fixity in the Japanese import supply in the twenties and also for the emergence of international excess capacity in the late twenties that rendered the market competitive. While direct evidence is hard to come by, we can definitely line up strong circumstantial evidence to support our argument.

As discussed before, ammonium sulphate, especially via the synthesis process, was a high fixed cost industry with a large minimum efficient

scale. The Haber-Bosch process based plant with a minimum capacity of 100,000 tons/year, for example, required ¥50 million to construct. While there were other inventions, these did not see commercialization till late 1920s. The processes such as Cassale (invented 1916), Claude (invented 1919) and Fauser (invented 1923) were all commercialized only in the mid to late 1920s and also had a large minimum scale[32]. Licensing conditions for existing technology were too stringent to allow easy entry. In 1919, for example, a consortium of Mitsui, Mitsubishi and Sumitomo, the largest of the three prewar *zaibatsu* (financial cliques), considered licensing Haber-Bosch process, but decided against it due to high set up and licensing costs and the expected decline in price due to increased capacity[33]. Besides, access to the tested technology was not easy. Despite German defeat in WWI, the best possible efforts by the British to get hold of the technology from Oppau came to a naught and ICI was unable to set up a synthetic ammonia plant till 1927[34]. Technological imperatives and limited diffusion was, therefore, one possible factor restricting expansion of short-run international capacity and supply during the early 1920s.

[Table 6 about here]

[32] The processes introduced in Japan ranged from 50,000 tons to 100,000-ton/year in capacity. See, for example, Hashimoto, Ryuan dokusentai, Khosla, Entry barriers, Morikawa, Senkanki ni okeru for further details.

[33] See Molony, Technology and investment and discussion in Khosla, Entry barriers.

[34] Reader, Imperial chemical industries, pp. 353-60.

Table 6 presents data on self- sufficiency ratios for four major European importers of ammonium sulphate in proximity to the main exporters – Germany, England and the US. It is clear from that until around 1926-27, all these countries depended heavily on imports to meet consumption requirements though import substitution progressed rapidly in Belgium and Italy. The Table also indicates that as indigenous capacity developed in these countries, surplus available for diversion to other export markets increased, raising the adjustment speed of import supply function in late twenties. This data, in conjunction with that in Table 7 indicates that there were probably constraints on diverting export destinations until late 1920s, accounting for rigidity in the international supply function.

[Table 7 about here]

Table 7 provides data on the demand-supply imbalance for man-made nitrogen. The figures show that in 1926-27, production and consumption in the international market were exactly balanced. Thereafter, production began to overshoot consumption and surplus was largest for 1929-30 at 15 per cent. This explains the increased severity of competitive forces during the final years of the twenties and also accounts for the greater flexibility of the import supply forcing Japanese firms to price more competitively.

Hashimoto, (1977) documents the development of the Japanese ammonium sulphate market during the 1920s and indicates that one reason that ammonium sulphate prices were sustained during this period was the expansion of demand due to a fall in its relative price with respect to other nitrogenous fertilizers as well as the agricultural product prices. It is possible to envisage that foreign suppliers failed to gauge the demand expansion accurately, creating a window for domestic producers to extract monopoly rents. The Hashimoto analysis, however, fails to account for the perverse differentials the domestic and import prices, the share of Nichitsu and Denka and their profit performance.

Again, maintenance of excess capacity by Nichitsu till the international supply became highly elastic cannot be accounted for by assuming a competitive market. Given the tight demand and supply conditions as evident in Table 7, the exporters probably set the price for the Japanese market taking into consideration available capacity in Japan. However, once the contracts were set, it was possible for the Japanese producers to restrict supply and charge a higher price without fearing an onslaught of imports due possibly to high costs of breaking international contracts. This argument can thus explain the maintenance of excess capacity by Nichitsu and very probably as a strategic variable. Once the international excess supply emerged and new domestic entry became a reality, Nichitsu no longer had an

incentive to restrict production in the domestic market, as any shortage could be easily met by increased imports or domestic supply. Capacity could no longer be used as a strategic variable to restrict imports or new entry into the Japanese market. Full capacity production, therefore, would be a natural choice.

Thus, we may conclude that relative fixity of international supply due to technological constraints, lead-lag relation between import and domestic price setting, and difficulties in costless diversion of supplies from other export destinations, possible underestimation of demand growth in Japan and existence of excess capacity in Japan, all contributed to the ability of the Japanese ammonium sulphate producers to indulge in non-competitive behaviour during the 1920s. Thus the nature of the industry and the technological imperatives of an industry can be important determinants of structure, conduct, and performance of an industry in the presence of international trade, at least in the short-run.

Table 1. Supply of ammonium sulphate in Japan 1912-39 (annual average)

Year	Production	Imports	Exports	Consumption	Self Sufficiency Ratio
	1000 tons	1000 tons	1000 tons	1000 tons	%
	[1]	[2]	[3]	[4]	[1/4]
1912-14	10.0	101.0		111.0	9.9
1915-21	60.0	43.0	1.0	102.0	58.8
1922-26	117.0	181.0	23.0	275.0	42.5
1927-32	294.0	293.0	72.0	515.0	57.1
1933-39	787.0	261.0	149.0	899.0	87.5

Source: Norln sho, Shizai Bu, (1941).

Table 2. Share of top companies in domestic production and total supply 1914-1936 (per cent)

Year	Nichitsu*	Denka	Jinzo	Showa	Sumitomo	Toyo	Top 2	Top 3	Domestic Production	Imports
1914	47.2 (6.2)								100.0 (13.2)	(86.8)
1915	53.8 (33.1)	9.4 (-)					63.2 (38.9)		100.0 (61.5)	(38.5)
1916	55.4 (46.5)	16.1 (5.8)					71.5 (60.0)		100.0 (83.9)	(16.1)
1917	51.3 (37.5)	24.6 (13.5)					75.9 (55.4)		100.0 (72.9)	(27.1)
1918	65.5 (64.2)	20.8 (17.9)					86.3 (84.6)		100.0 (98.0)	(2.0)
1919	66.7 (29.2)	22.8 (20.4)					89.5 (39.2)		100.0 (43.8)	(56.2)
1920	64.1 (33.7)	23.7 (10.0)					87.8 (46.2)		100.0 (52.6)	(47.4)
1921	57.7 (31.4)	17.9 (12.5)					75.6 (41.2)		100.0 (54.5)	(45.5)
1922	57.1 (28.5)	20.4 (9.8)					77.5 (38.7)		100.0 (50.0)	(50.0)
1923	53.6 (22.4)	20.3 (10.2)					73.9 (30.9)		100.0 (41.7)	(58.3)
1924	56.2 (22.0)	28.1 (8.5)					84.3 (33.0)		100.0 (39.2)	(60.8)
1925	46.8 (18.3)	29.4 (11.0)					76.2 (29.8)		100.0 (39.2)	(60.8)
1926	46.3 (15.5)	28.8 (11.5)					75.1 (25.1)		100.0 (33.4)	(66.6)
1927	47.8 (19.9)	28.2 (9.6)					76.0 (31.6)		100.0 (41.6)	(58.4)
1928	46.7 (21.1)	27.6 (11.7)	6.8 (3.1)				74.3 (33.6)	81.1 (36.7)	100.0 (45.1)	(54.9)
1929	41.0 (15.7)	27.5 (12.5)	10.4 (4.0)				68.5 (26.2)	78.9 (30.2)	100.0 (38.3)	(61.7)
1930	58.8 (32.4)	15.8 (10.5)	11.9 (6.5)				74.6 (41.1)	86.5 (47.6)	100.0 (55.1)	(44.9)
1931	56.1 (40.2)	12.0 (08.7)	8.0 (5.8)	11.0 (8.0)	4.7 (3.4)	0.9 (0.7)	68.1 (49.0)	79.1 (57.0)	100.0 (72.9)	(27.1)
1932	46.9 (40.0)	10.7 (8.8)	7.0 (5.9)	20.1 (17.1)	4.8 (4.1)	4.4 (3.6)	67.0 (57.1)	77.7 (66.2)	100.0 (85.2)	(14.8)
1933	45.6 (39.6)	7.7 (9.1)	6.3 (5.5)	21.3 (18.5)	7.3 (6.3)	3.5 (3.1)	66.9 (58.1)	74.6 (64.8)	100.0 (86.9)	(13.1)
1934	44.5 (37.1)	6.7 (6.7)	6.1 (5.1)	19.4 (16.2)	10.0 (8.3)	4.3 (3.6)	63.9 (53.3)	74.9 (61.6)	100.0 (83.4)	(16.6)
1935	41.8 (33.5)	6.4 (5.6)	5.7 (4.6)	17.2 (13.8)	7.7 (6.2)	9.0 (7.2)	59.0 (47.3)	68.0 (54.5)	100.0 (80.2)	(19.8)
1936	36.0 (28.9)	5.8 (5.1)	4.6 (3.7)	14.3 (11.5)	10.0 (8.0)	16.1 (12.9)	52.1 (41.8)	66.4 (53.3)	100.0 (80.2)	(19.8)

Notes: Figures in parentheses are the share of total supply defined as production + imports – exports; outside parentheses is the share of domestic production.
Nichitsu: Nippon Chisso Hiryo, Denka: Denki Kagaku Kogyo, Jinzo: Daiichi Nippon Jinzo, Showa: Showa Hiryo, Sumitomo: Sumitomo Chemicals, Toyo: Miike, Toyo Koatsu,
* Nichitsu includes production by its subsidiary, Korean Chisso from 1930 onwards

Source: Suzuki (1980), Table 6, pp. 128-29.

Table 3. Domestic and import prices for ammonium sulphate 1912-1940 (¥/ton)

Year	Domestic Production		Imports	
	Wholesale	Unit Value	Wholesale	Unit Value
1912		123	157	143
1913		156	153	143
1914		141	139	143
1915		149	157	147
1916		179	199	171
1917		232	306	191
1918		282	378	310
1919	361	302	337	272
1920	309	287	274	276
1921	186	165	157	139
1922	192	171	177	137
1923	220	184	191	171
1924	187	168	169	158
1925	200	188	185	163
1926	174	157	156	152
1927	144	128	134	131
1928	137	128	130	128
1929	128	128	123	126
1930	90	90	87	98
1931	73	65	71	71
1932	72	79	72	59
1933	95	87	95	87
1934	95	86	95	86
1935	113	93	105	88
1936	100	89		108
1937	101	87		90
1938	104	93		107
1939	104	90		100
1940				

Source: Norinsho (1941), pp. 2-8 and 51.

Table 4. Rate of profit on net worth for selected firms (per cent)

Year	Nichitsu	Denka	Sumitomo	Toyo	Showa
1914	13.40				
1915	36.00	19.50			
1916	30.20	31.20			
1917	39.30	31.70			
1918	46.80	44.10			
1919	49.80	27.40			
1920	40.40	28.80			
1921	13.60	9.20			
1922	15.90	11.50			
1923	20.70	17.10			
1924	23.10	8.80			
1925	21.40	11.10			
1926	19.70	13.20			
1927	16.80	-33.80			
1928	16.40	11.10			
1929	16.20	11.80			
1930	13.70	6.50	1.30		
1931	10.40	-3.70	1.90		
1932	7.90	3.40	2.70		
1933	8.10	8.70	11.10		15.80
1934	8.40	9.60	16.10		12.50
1935	8.40	10.30	15.00	18.40	15.00
1936	10.10	11.10	14.70	21.40	14.50
1937	9.30	11.30	11.70	10.60	12.00
1938	10.10	11.30	10.90	10.30	10.00
1939	9.50	12.00	10.40	10.50	9.10
1940	10.40	11.10	9.40	10.80	

Source: Up to 1929-30, Toyo Keizai Shinposha (1932)
From 1930-31, Mitsubishi Keizai Kenkyujo (Various Years).

Table 5. Variations in average profit rate on net worth

Company		1915-20	1921-26	1927-32[1]	1933-40[2]
Nichitsu	Mean	40.42	19.07	13.57	9.29
	s	7.13	3.60	3.68	0.89
	cv	0.18	0.19	0.27	0.10
Denka	Mean	30.45	11.82	5.82	10.68
	(s)	8.00	3.05	6.34	1.08
	cv	0.26	0.26	1.09	0.10
Sumitorno	Mean	-	-	2.00	12.41
	(s)	-	-	.70	2.48
	cv	-	-	0.35	0.20
Toyo	Mean	-	-	-	13.67
	(s)	-	-		4.92
	cv	-	-		0.36
Showa	Mean	-	-		12.70
	(s)	-	-		2.55
	cv	-	-		0.20

1 Denka 1928-32, Sumitomo 1930-32

2 Toyo 1935-40, Showa 1933-39

Source: See Table 4

Table 6. Self-sufficiency in ammonium sulphate in the 1920s in some European Countries (per cent)

Year	Spain	France	Belgium	Italy
1924	0.08	0.45	?	0.47
1925	0.07	0.45	?	0.56
1926	0.19	0.50	0.71	0.92
1927	0.09	0.52	0.73	1.14
1928	0.09	0.67	0.80	1.15
1929	0.10	0.61	1.11	1.16
1930	0.07	0.88	1.36	1.32
1931	-	0.88	-	1.38

Note: Self-sufficiency refers to the ratio of domestic production to total consumption.

Source: Suzuki (1981), Table 1, p.49 (587).

Table: 7 World Production and Comsurnption of Pure Nitrogen (synthetic)

Year	Production N_2 tons	Consumption N_2 tons	Surplus to Production (%)
1926-27	934,300	934,300	nil
1927-28	1,122,900	1,091,200	2.82
1928-29	1,334,000	1,294,700	2.95
1929-30	1,700,300	1,452,600	14.57
1930-31	1,518,800	1,586,900	-4.48
1931-32	1,493,200	1,377,000	7.78
1932-33	1,469,200	1,417,100	3.55

Since decomposition of consumption figures for Ammonium sulphate, Calcium cyanamide and others were not available, we clubbed these together for production side as well. Ammonium sulphate, however, provides for an overwhelming proportion of the total.

Source : Suzuki (1980), Table 5, pp. 126-127.

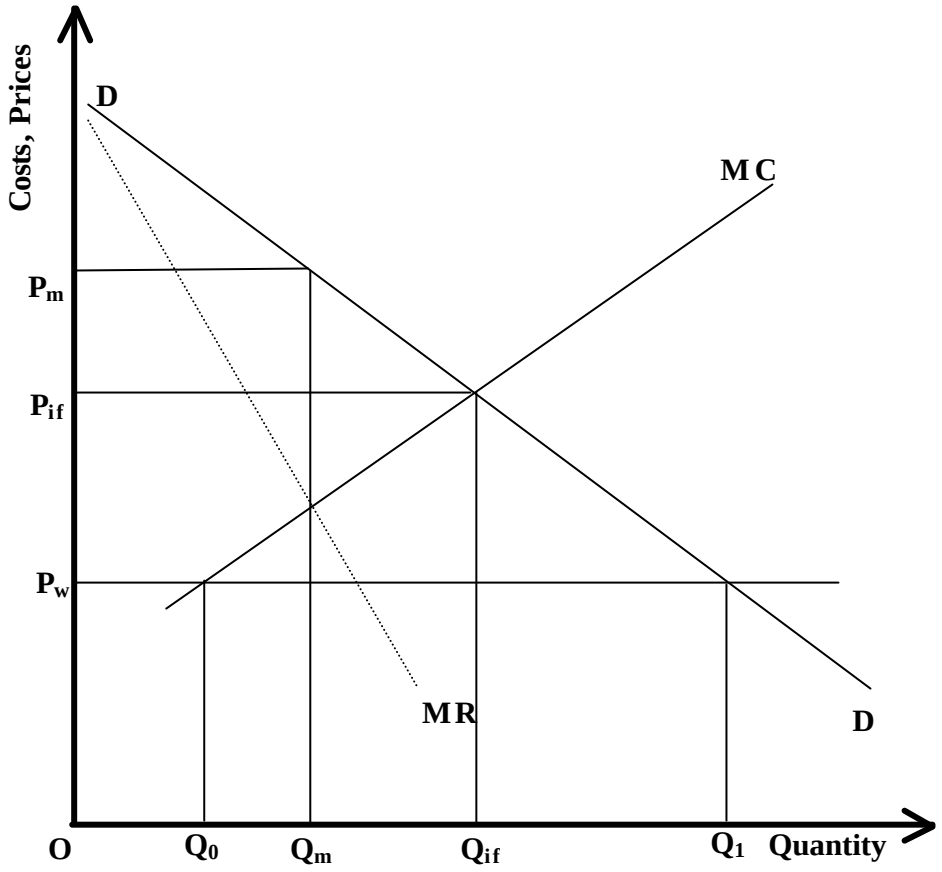

Figure 1. Market structure and international trade

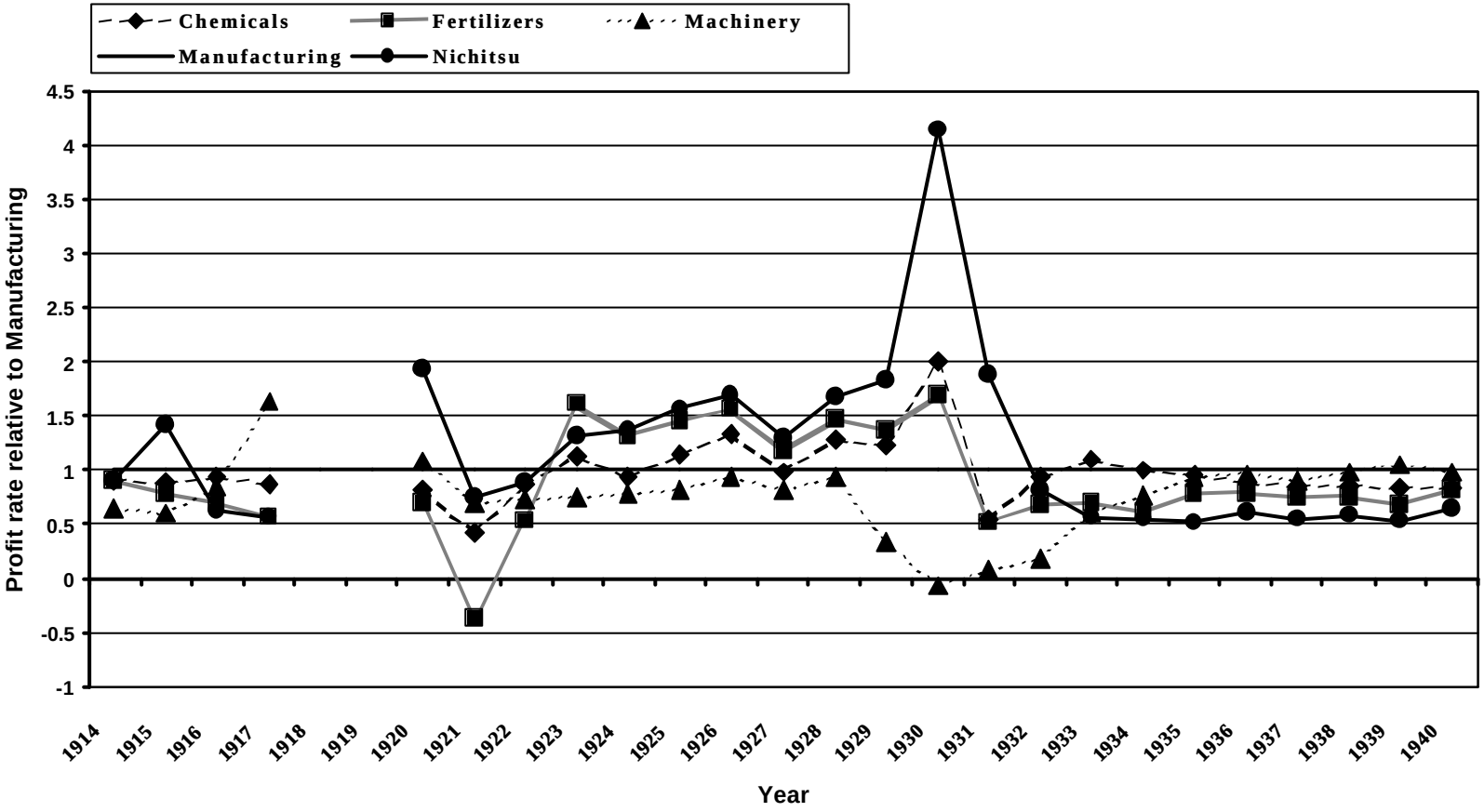

Figure 2. Relative profit performance

Notes: Figures for 1918 and 1919 are not included as the numbers for manufacturing as a whole were unavailable.

Source: 1914-28 from (Asahi Shimbunsha 1930); 1929-1940 from (Mitsubishi Keizai Kenkyujo Various Years)

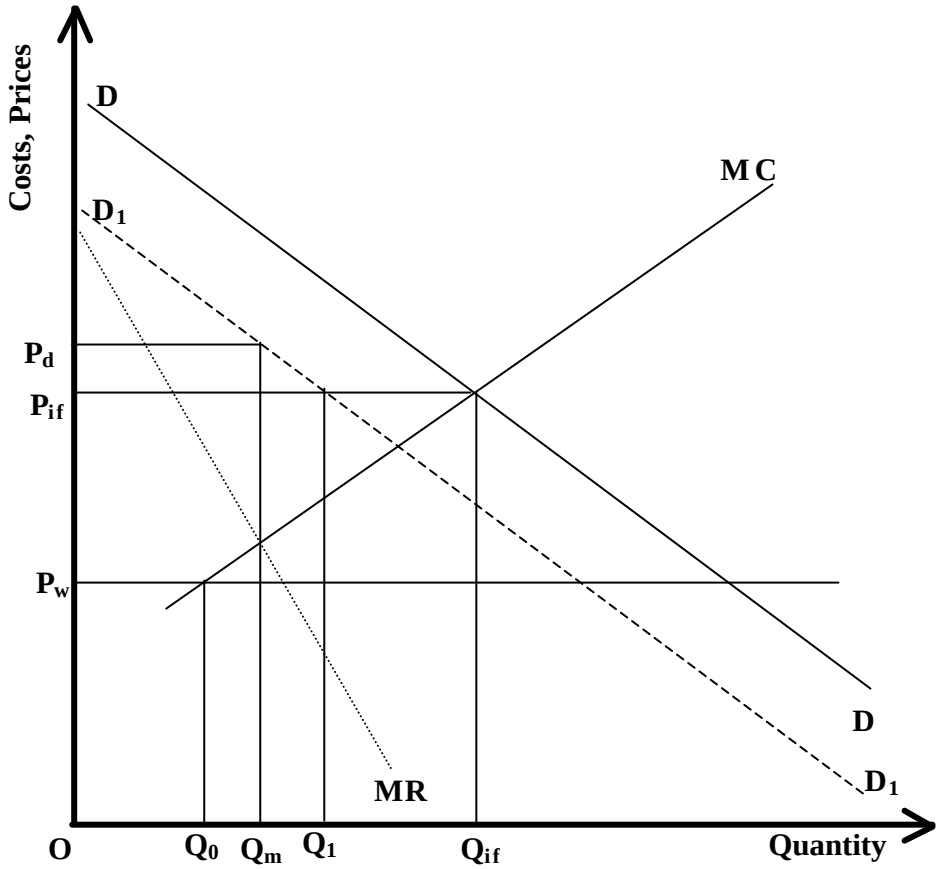

Figure 3. Supply rigidity, international trade and firm Behaviour

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