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Banken, R. and Stokes, R. (2010) *"The trauma of competition": the entry of Air Products Inc. into the industrial gases business in Britain and continental Europe 1947-1970*. *Business History*, 52 (7). pp. 1068-1085.
ISSN 0007-6791

<http://eprints.gla.ac.uk/39370>

Deposited on: 23 February 2011

“The trauma of competition”: The entry of Air Products Inc. into the industrial gases business in Britain and continental Europe, 1947-1970

The British Oxygen Company (BOC) had a virtual monopoly on the supply of industrial gases (e.g. oxygen and acetylene) on the British market through the 1950s, when it was finally challenged by an American-based company, Air Products. Air Products Limited (APL) was able to undercut BOCs position, overcoming high barriers to entry to gain significant market share in this sector, which shares some features of network industries. Factors in this success included conditions imposed by the Board of Trade, APL’s innovations, BOC’s slow response, and favourable market conditions. APL’s success had implications for the internationalisation of the industrial gases industry.

Keywords: industrial gases industry; British Oxygen Company; Air Products and Chemicals; monopoly; market entry; barriers to entry

Introduction

Economists have long noted that industries centred on physical networks (for instance, railways, electric grids, and so on) often constitute “natural monopolies” in which potential competitors are kept at bay by the extremely high barriers to entry embodied in the prohibitive cost of replicating the physical infrastructure itself. (Shy 2001; Economides 1996; Economides 2006; Mosca 2008) But, as we know, for these and other industries, other factors can also hinder market entry. Examples include brand recognition and ownership; limitations imposed by the regulatory environment (affecting for example construction of rival facilities); specialised technical competence; highly developed knowledge of the market; logistics capabilities; and so on. When one or more of these factors affects a sector particularly strongly, it can mimic the “natural monopoly” of a network industry, demonstrating some of the essential features of such an industry, but without the physical network.¹

¹ Economides (2006) notes that “virtual network” industries share features with physical network ones, with some of the same implications for competition policy. See especially p. 96. See also Shapiro and Varian (1999), pp. 116-130 for a useful classification of “switching costs” and sources of lock-in for information networks, which also apply to

The industrial gases industry (whose products include atmospheric gases such as oxygen, nitrogen, and argon and other “noble gases” such as xenon, neon, and krypton; and process gases like hydrogen, acetylene, and carbon dioxide; and some other gases such as helium) is one such industry. Entry by a newcomer can be very difficult indeed. One key barrier results from a peculiarity of the industry: atmospheric gases in particular, and especially oxygen, do not travel very well owing to evaporation as well as costs of transport. Even today, after extensive technological improvements, it is not economical to distribute beyond 400 km. Instead of centralisation of production, it thus tends to be regional, with companies involved in it requiring localised knowledge and often servicing a large number of customers. Despite this, though, these companies tend to be national, indeed most often international, in ownership and orientation. This is in large part because there are additional barriers to market entry owing to the capital-intensive nature of the industry’s production and distribution systems—air separation units (ASUs), which separate the component gases in air from one another; liquefiers, which cool the air gases to turn them into liquid, concentrating them and enabling easier and safer transport; and so on—and, in particular, its distribution and logistics networks, involving storage tanks, filling facilities, expensive gas cylinders, and fleets of vans, trucks, and rolling stock. It is therefore no accident that a 1968 consulting firm’s report on the industry noted that “an industrial gas company (in so far as it supplies gaseous products in cylinders) is really in the transport business.”² But it is a highly specialised transport business, and one which is inextricably linked to production and technical competencies associated with gases production and handling.

other networks, whether physical or virtual. On monopoly and regulation generally, see Gómez-Ibáñez (2003), especially pp. 4-11.

² Unpublished report commissioned by BOC and carried out by Stirling, Gadsby & Chown: “Growth potential set against the background of its markets”, August 1968, p. 32, in Linde Unternehmensarchiv Munich, BOC-

For all of these reasons, as well as owing to gentlemen's agreements made in the early twentieth century to resolve patent disputes and to carve up markets, national markets for industrial gases in western Europe were characterised by a monopolistic or duopolistic structure well into the 1960s. Despite the barriers to entry, however, it proved possible, beginning in the 1950s, for the American newcomer Air Products Inc. to develop a successful strategy to break into markets hitherto dominated by one or two firms, first in the United Kingdom, and then on the European continent. The entry of this competitor into these markets not only transformed the dominant market structure, but also started a general internationalisation of European industrial gases firms: longstanding "gentlemen's agreements" were simply no longer observed.

This paper examines the causes, course, and consequences of Air Products' entry into the European industrial gases market, with particular attention to the British case. Micro-level developments in company strategy and its implementation at both Air Products and British market leader British Oxygen Company (BOC) are assessed, while we also consider the broader economic and political context. We conclude by examining the long-term implications of Air Products' entry into the British and continental market for the internationalisation of the industry.

The "Ministry of Oxygen": BOC's monopoly in Britain in the 1950s

Founded as Brin's Oxygen Company Ltd in 1886 and renamed British Oxygen Company in 1906, BOC had a virtual—and completely unchallenged—monopoly position in the most important and lucrative areas of the British industrial gases market until well after 1945. Indeed, in 1954, the company enjoyed a market share of 98.5 percent in supply of oxygen and acetylene; the small remaining portion of the market was covered by a single supplier, Saturn Industrial

Windlesham collection (hereinafter BOC LUM), Box 535. Please see the appendix for a note on BOC archival sources.

Gases Ltd.³ It should therefore come as no surprise that BOC was popularly known as the British “Ministry of Oxygen”.⁴ The only other countries in which the company operated were in the former British colonies, e.g. India, Australia, and South Africa. It shied away from any activity in western Europe, although it did maintain close working relationships with the other European market leaders (in particular Air Liquide in France, and Linde, Messer, and Griesheim in West Germany), in particular with regard to technology. For instance, when it entered the so-called “tonnage” (i.e. large-scale industrial gases production) business beginning in August 1956, supplying a growing number of steel producers with massive quantities of oxygen for oxygen-steel processes, BOC relied on proven technology from Linde and Air Liquide for the plants it delivered to customers.⁵ In fact, already in 1954, BOC had entered into a joint venture with the German Linde company, the so-called British Oxygen Linde Ltd, in anticipation of constructing tonnage plants in its sphere of influence, i.e. Britain and the Commonwealth. The reason for this cooperation was not just BOC’s desire for technology transfer; it also wanted to profit from the

³ UK Monopolies and Restrictive Practices Commission (1956), p. 7; BOC International Ltd, “Air Products and Chemicals Incorporated—A review” (1979), in BOC-Windelsham/Wales collection (hereinafter BOCW), Box 20. Please see the appendix for a note on BOC archival sources.

⁴ “International gas man” (1972), p. 39.

⁵ On development of oxygen steel generally, see Landes (2003), p. 517, although he does not consider the role of the industrial gases industry in this innovation. See also Kipping, Raineri, and Dankers (2001), p. 87, for continental European developments, although again industrial gases are not mentioned. On BOC’s entry into the tonnage business: Notes of Interviews with a number of Directors and Seniors, here Interview with R. C. Hesketh-Jones from 5 and 24 January 1983, as well as the overview of “BOC History 1945-1975”. Additional detail is in interviews with John B. Gardner from 14 December 1982, David R. Harris from 15 February 1983, and Sir Leslie Smith from 21 and 26 July 1983. All sources in BOC LUM Box 488.

good name of the Germans in this area, not least to counter threats from a new competitor in plant construction in the British market.

“The British bricklayers of Air Products under Dexter Baker’s leadership”⁶: Air Products enters the British market, 1949-1963

In the early 1950s, the Butterley company, a mixed concern which operated not only brickworks and mines, but also plant construction and machine-building factories, found itself in possession of substantial liquid capital owing to the nationalisation of its coal mines, and it began looking for suitable investment opportunities.⁷ The company’s management decided to enter the industrial gases plant-building business, thus challenging BOC’s monopoly in this area. It did so on the basis of licenses from Air Products, a relatively new American company which had been founded in 1940 by Leonard Pool in Detroit and which, by the late 1940s, was headquartered in Allentown, in eastern Pennsylvania.

Air Products had grown initially through construction of mobile air-separation units which it supplied to Allied troops around the world, for instance for local production of oxygen for aircraft. After the war, owing to a collapse in defence contracts, Air Products oriented itself

⁶ This was the phrase used in jest to characterize the young but successful management team of Air Products in Britain under the leadership of Dexter Baker because of its cooperation for a time with the Butterley concern, which, among other things operated a brickyard. On this, see the Air Products Ltd. company magazine, *CryoGen*, especially the edition *CryoGen looks at 25 Years of Air Products* (Walton-on-Thames, 1982). Insofar as other sources are not mentioned, the following account is based on either this source; on Butrica (1990), especially pp. 74-76, 105, 161-164 and 177-179; or on interview with Dexter Baker, 28 October 2008, Allentown, Pennsylvania.

⁷ Butrica (1990), pp. 75-76, 105-161 and 163-164; *CryoGen looks at 25 years of Air Products*, pp. 2-3. Cf. short reports on the joint venture with Butterley and the first contracts for construction of air separation units or parts thereof in *The Times* from 9 July 1951 (“The Butterley Company Limited”, p. 11) and 1 July 1952 (“Butterley Company Limited”, p. 11).

to construction of tonnage plants for the U.S. steel industry and, on this basis, moved into production of industrial gases. Weak in capital, the young firm's behaviour was based on a range of strategies born of necessity rather than desire. For one thing, it built new large-scale plants using short-term, high-interest credit, since long-term supply contracts with established steel companies at the time were viewed by banks as sufficient security.⁸ The firm, newly started and short of capital, could otherwise not have come up with the funding for expensive investment in large air separation units. After the plants started operations, however, Air Products was able to convert the short-term borrowings into long-term, low interest loans, which were easily serviced on the basis of regular income from the sale of industrial gases, not only to the steel mill, but also to other customers. This was possible because the newcomer deliberately built overcapacity into its new plants in order to supply oxygen to other consumers in the proximity of the onsite facility. Based on this "piggyback principle",⁹ Air Products was able to offer very good prices and at the same time did not have to invest from the outset of its entry into the market in building a large distribution network.¹⁰

Although Air Products was able to gain considerable market share in America on the basis of this strategy by the early 1950s, the international market remained a key focus for the firm's management. As early as 1947, even before its successful expansion in the gases market

⁸ Butrica (1990), pp. 98-101; *CryoGen looks at 25 years of Air products*, p. 1; BOC-Report on Air Products for staff college, 1964, BOCW Box 536; Verbal Notes Board meetings 1958, BOCW Box 478.

⁹ The piggyback concept allowed delivery to the baseload, or primary, customer per pipeline; any gas beyond that customer's requirements could then be diverted to the merchant market. Harvard Business School Case Study 9-375-370, "Air Products and Chemicals, Inc." (1975), pp. 7-8.

¹⁰ BOC, Report on Air Products for staff college, 1964, BOCW Box 536; Verbal Notes Board meetings 1958, BOCW Box 478.

and as a reaction to the difficult transition from military to civilian contracts, Pool decided to license technology to produce and sell non-tonnage generators (small-scale air separation units) on the British Isles to Sperry Gyroscope Company Ltd. In spite of dramatically lower labour costs in Britain compared to the USA, however, Sperry remained unsuccessful owing to insufficient technical competence. The companies thus terminated the contract by mutual consent in 1950. Pool, however, did not wish to give up on the European market just yet, seeing a real market opportunity for supply of gases from Air Products plants, not least owing to the dollar weakness of European economies.

As soon as the Sperry contract was nullified, therefore, Air Products turned to co-operation with Butterley, which, in addition to having experience in engineering and mechanical construction, also offered the advantage of plentiful capital (still in short supply at the still young American firm) so that Air Products only had to bring its technology “in kind” for its share of the deal. Starting in 1954, with the aid of its American partner, Butterley moved into the tonnage-plant business, and in that same year was able (in competition with an offer from BOC) to secure a contract to build an onsite plant with a capacity of 200 tons per day (tpd) of high-purity oxygen to Stewarts & Lloyds’ Corby steelworks.¹¹ In addition, in 1957, a further contract was signed for a tonnage plant for the ICI factory at Billingham.¹² By this time, Air Products and Butterley had formed a joint venture, Air Products Ltd (APL), with the American firm holding a 51 percent stake.

¹¹ *The Times* from 20 May 1954 (“Butterley and Oxygen”, p. 4 [advertisement]), 1 July 1954 (“Butterley Company Limited”, p. 14), and 8 July 1957 (“The Butterley Company Limited”, p. 15).

¹² BOC, Report on Air Products for staff college, 1964, esp. p. I-4, BOCW Box 536.

Both projects—which finally brought the new competitor to the full attention of BOC—turned out to be disasters, however. For one thing, it took considerably more time to build the plants than was originally envisioned. Even more seriously, it proved impossible to get the plant at Corby to operate at all.¹³ The story at Billingham was not much better: the 240 tpd oxygen and nitrogen plant went into operation in April 1959, but soon thereafter was heavily damaged by an explosion. The American partner was, of course, extremely unhappy with Butterley owing to the severe problems in construction of the onsite plants. As Dexter Baker, the man sent from the parent company in Allentown to revive APL in 1957, later recalled:

Butterley didn't have very good engineers, and these two plants wouldn't work. One of them leaked, and the other one blew up. And so, Air Products is now 51 percent owner of this company with two failed plants. And so, we're not starting on the goal line, we're in the back of the end zone.¹⁴

But the American firm remained committed to the UK market, and so after a short period of deliberation, Air Products decided to dissolve its partnership with Butterley and to take sole control of the British subsidiary. It rebuilt the problem-ridden plants at Stewarts & Lloyds and at ICI Billingham at its own expense, and gained additional contracts, both small and large, within

¹³ Interview T. E. Potts from 30 November and 7 December 1982, as well as 19 January 1983, Interview John Strong from 13 May 1983, in Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

¹⁴ Interview with Dexter Baker, 28 October 2008, Allentown, Pennsylvania. BOC also believed that Butterley was not a suitable supplier of tonnage plants: BOC, "Air Products and Chemicals Incorporated—A review", 1979, p. 3, BOCW Box 20.

a short time afterwards.¹⁵ The company also expanded beyond manufacturing of production plant, entering the British industrial gases business in direct competition with BOC.

The newly constituted firm and its parent in the United States, it has to be emphasised, were much smaller than BOC. In 1957, Air Products' profits worldwide amounted to about \$2 million in all on sales of approximately \$33 million. In the same year, BOC's profits amounted to nearly \$12 million, about six times as much as BOC, on sales of just over \$120 million, a little less than four times those of the American firm: in other words, it was not only far bigger, but also far more profitable than Air Products.¹⁶ The fledgling British subsidiary was led by Baker, who was 29 years old when he arrived in Britain in 1957. Baker had previously gained experience within Air Products in the United States as a sales engineer specialising in leasing of tonnage plants to the chemical industry. He was able to gain additional contracts rapidly, for instance for a 150 tpd nitrogen plant for the Esso refinery at Fawley near Southampton. (Butrica 1990, pp. 161-164) He also was able to gain three smaller 15-year tonnage gas supply contracts with steel firms in Wales and the Midlands. On the basis of these onsite facilities, which were all owned by APL, the area immediately around the plants could be supplied with liquid industrial gases via the piggyback principle. From Baker's perspective, the plan from the beginning was for

¹⁵ Stirling, Gadsby & Chown, "Growth potential," August 1968, BOC LUM Box 535; and "Tonnage Oxygen Steel Plant for Italy," *The Times* (10 December 1962), p. 18. On the contracts from 1957 to 1960 cf: *CryoGen looks at 25 years of Air Products*, p. 4; Email communication from Dexter Baker, 9 October 2009.

¹⁶ Figures for Air Products from Butrica (1990), p. 50. Figures on profits for BOC from "The British Oxygen Company Ltd.," reprint from *The Financial Times* (26 April 1958), in BOC LUM, Box 425; and on sales from a report in a box labeled "Reports and Accounts 1908-80" in BOC LUM. The prevailing exchange rate in 1957 was £2.8 to the dollar. See Pacific Exchange Rate Service, "Foreign currency units per one British pound, 1948-2007," available at <http://fx.sauder.ubc.ca/etc/GBPages.pdf> (accessed 9 February 2010).

a quick expansion within the next two years after 1962 to cover all of Britain and to take significant market share from BOC.¹⁷ Thus, by 1964 APL opened production facilities in Southampton for the south; in Cardiff, Ebbw Vale, and Shotton (Chester) for the west; in Stoke on Trent for the Midlands; and in Sunderland and Thornaby-on-Tees for the north.¹⁸ Even before the expansion was completed, by the beginning of August 1963, APL had already made significant inroads into the British market in nitrogen (16.9% share) and hydrogen (14.2%), although gains were less impressive for other industrial gases (e.g. liquid oxygen 0.95%, carbon dioxide 2.75%, acetylene 1.45%, argon 3.5%).

It was in fact a favourable time for APL to enter the British market. One of the key factors here was that BOC's hands were tied to some degree by conditions imposed by the Monopolies Commission. Based on the Monopolies and Restrictive Practices (Enquiry and Control) Act of 1948, a report on BOC's position in the British market for industrial gases was compiled and published at the end of 1956.¹⁹ To address the commission's concerns, BOC came to an agreement with the Board of Trade in 1958 which involved a number of restrictions on the company's behaviour. For example, BOC was not allowed to engage in local price competition until such time as there were competitors with significant market shares. Until then, it also had to offer identical prices to all its customers and was able (with the exception of the tonnage

¹⁷ BOC, "Air Products and Chemicals Incorporated—A Review," 1979, p. 5, in BOCW Box 20.

¹⁸ Stirling, Gadsby & Chown, "Growth potential...", August 1968, BOC LUM Box 535, and in BOC, Report on Air Products for staff college, 1964, p. I-6, BOCW Box 536.

¹⁹ BOC History 1945-1975, BOC LUM Box 488. For public discussion about the Monopoly Commission and the BOC case, see also: Robinson (1957), pp. 459-460 and 475; Guénault and Jackson (1974), pp. 75-76, 81-84, 110 and 132; Jewkes (1958), in particular, pp. 14 and 16-18; Broadberry and Crafts (2001).

business) to sign supply contracts for a maximum of one year.²⁰ What is more, BOC had to publish its prices, which for a time at least gave considerable advantages to APL; APL for its part did not have to reciprocate. Finally, BOC was not permitted to take over any of its competitors, of which there were of course only two, APL and Saturn Industrial Gases Ltd in Sunderland. Again, this restriction did not apply to the American firm which was able to purchase Saturn for £ 0.5 million, thus consolidating its position in northeast England at a single stroke.²¹ Owing to the growing competitive power of APL, BOC was freed of many of the restrictions of the monopolies commission in 1962. From that point, the British market leader no longer had to publish national prices and was also again able to sign longer-term contracts with customers, even small ones.²²

Although the restrictions imposed by the monopolies commission facilitated the entry of APL into the British market, there were other, even more important, reasons for the newcomer's success. For one thing—and this was confirmed in the monopoly report—BOC had a bad reputation in some quarters on account of a strike in the late 1950s and also because a gas cylinder shortage hampered deliveries to smaller customers for a period of time. It was not just BOC's shortcomings which accounted for APL's success, though; the American-owned company also had considerable innovative strengths. In addition to pioneering new forms of credit financing, APL concentrated much more heavily on the nitrogen business than on

²⁰ Internally, BOC repeatedly emphasised the advantages that Air Products received on the basis of these restrictions. E.g. interview with Sir Leslie Smith, 2 and 26 July 1983, Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

²¹ BOC, Report on Air Products for staff college, 1964, BOCW Box 536.

²² Letter from BOC to the Board of Trade, 4 June 1962, in BOC History 1886-1979 in BOC LUM Box 488. In 1966, all remaining restrictions were lifted. See "British Oxygen Freed," *The Times* (14 June 1966), p. 19.

oxygen.²³ Since it could also offer better applications technologies owing to its experience in America, and thus in fact co-developed the newly emerging British market for liquid nitrogen (LN) for freezing and cooling, it was able within a relatively short time to gain a market share of 40 percent in this market sector, which in turn accounted for about one-third of APL's own LN production.²⁴ For this reason, APL had a considerably better position than BOC in terms of its sales ratio between oxygen and nitrogen, which in turn permitted better capacity utilisation at the American company's onsite facilities and, because of better distribution of fixed costs, allowed APL to offer lower prices. Thus, in the early 1960s the young firm had a nitrogen-oxygen ratio of 2.4 as opposed to an average ratio of 1.45 for its European competitors.²⁵

Several innovations in distribution and logistics also accounted for APL's growing success. APL used not just tank trucks and large-scale liquid gas storage facilities to supply its customers, but also bulk cylinder bundles and batteries,²⁶ which in turn permitted considerable

²³ Market study on "The Industrial Gases Industry" commissioned by BOC and carried out by William Blair & Company, September 1976, BOCW Box 1143.

²⁴ BOC, Report on Air Products for staff college, BOCW Box 536. For innovation and the emerging market for chilled and frozen foods, see for instance Cox, Mowatt, and Prevezer (2003) and Josephson (2008), although only the former mentions the gases industry at all, and only in a footnote referring to BOC Transshield, which was a subsidiary of BOC set up to deliver chilled foods to Marks and Spencers. See p. 211, note 18.

²⁵ Demand from the food processing industry for nitrogen had the added advantage for gas companies in that it was hardly cyclical at all, which made demand for liquid nitrogen more resistant to recession than for instance that for liquid oxygen (LO) for the steel industry. "The industrial gases Industry", William Blair & Company, September 1976, BOCW Box 1143.

²⁶ BOC, Report on Air Products for staff college, 1964, p. I-7, BOCW Box 536.

reductions in personnel needed while at the same time speeding up the unloading of cylinders.²⁷ The heavy reliance by APL on deliveries of liquid product also allowed less frequent deliveries to customers, who could in turn store large quantities of gas on site in containers provided by APL. At the same time, it must be noted that this policy was possible only because the American firm decided not to enter the market for individual gas cylinders delivered to small customers, especially in the area of welding. Instead the company concentrated on larger users and focused its financial means and human capital on lucrative—and usually long term—contracts.²⁸

Thus, in the vicinity of its own onsite plants, APL aggressively courted large-scale customers to gain additional contracts, and at the same time made great efforts to hold on to existing customers, among other things through low prices.²⁹ The reason for the level and energy

²⁷ Stirling Gadsby & Chown put it this way in their study commissioned by BOC in 1968: “When APL [Air Products Ltd] came into the business rationalization of distribution was one of its fundamental commercial contributions. In those days cylinders had round bottoms and were transported lying on their side; APL used only flat bottomed cylinders, thus enabling it to ship more cylinders per lorry load. Man-handling of cylinders was a problem, and so APL introduced as many mechanical handling techniques as possible; mechanical, ‘tail-lift’ [sic] loading on commercial vehicles was one. The reduction in the number of physical handling operations which APL was able to make enabled it to sell cylinder gases such as oxygen (where technical specification is relatively unimportant) at prices lower than those of BOC.” Stirling, Gadsby & Chown, “Growth potential...,” August 1968, p. 31, BOC LUM Box 535. Dexter Baker noted that one additional problem with the round-bottomed cylinders was that they could only be unloaded by pushing them off the end of the truck, often breaking the concrete on the customer’s loading dock. Interview with Dexter Baker, 28 October 2008, Allentown, Pennsylvania.

²⁸ BOC, “Air Products and Chemicals Incorporated—A review,” 1979, p. 7, BOCW Box 20; “The industrial gases Industry”, William Blair & Company, September 1976, BOCW Box 1143; BOC History 1945-1975, BOC LUM Box 488.

²⁹ BOC-Aide Memoire Air products, 1963, BOC LUM Box 535.

of this activity was that customers who bought a particular industrial gas would often buy other gases they needed from APL as well, often switching eventually to the American firm to supply all of their needs. The American newcomer did more than this, though: it also concentrated on providing better service than did BOC, for instance by filling orders within a single day.

The result of all of this was that, from the mid-1960s, it was possible for APL to finance the lion's share of its investments from cash flow, as a 1978 market analysis by BOC made clear:

Table 1: Financing Air Products Ltd's expansion, 1959-1978 (millions of £, current prices)

	7-year period, totals	7-year period, totals	5-Years period to Sept 1978, UK prices Commission report
	1959-1965**	1966-1972**	1972-1978
Cash flow from operations	2.0*	14.8*	48***
Net increase in borrowings, and (new) equity	7.4	1.6	Approx nil

* = depreciation plus retained earnings; ** = dividends nil in this period; *** = comprising capital expenditure £25 million, working capital increase £6 million, tax £10 million, and dividends £8 million

Source: BOC, "Air Products and Chemicals Incorporated—A review," 1979, p. 4, BOCW Box 20.

Clearly, both the weaknesses of BOC and the strengths of Air Products Ltd played key roles in the successful entry of the American firm into the British market. At the same time, one of the most important sets of explanatory factors had to do with the extremely favourable economic and industrial context of the time, not least the fact that demand for all industrial gases rose so strongly in the 1960s that BOC could hardly have satisfied it in any case on its own. In this respect, it is noteworthy that APL grew above all in those market segments where BOC was

not active, or else ones which were completely new and co-developed by the Americans. In the more traditional oxygen and acetylene businesses, in contrast, APL was only able to gain slim market shares. For instance, the American firm entered the oxygen tonnage business five years too late since BOC had already mastered the market. As APL extended and consolidated its initial inroads into the British gases market by the late 1960s, it had gained a total market share of 40 percent in nitrogen, and in the case of hydrogen a whopping 60 percent. In the case of oxygen, however, its share was just 15 percent.³⁰ These market shares were enough, though, to guarantee a sustainable presence for the American firm in most areas of the British industrial gases market by the end of the 1960s:

Table 2: The market share of Air Products Ltd in the UK in 1968

Gas	Total	Market	BOC	Share		Air Products	Share	
	Ton/Year	£m	Ton/Year	£m	%	Ton/Year	£m	%
O ₂	360,000	11	316,000	9.4	85	44,000	1.6	15
N ₂	192,000	4	115,000	2.4	60	77,000	1.6	40
H ₂	800 mscf	2	300 mscf	0.8	40	500 mscf	1.2	60
Argon	12,000	0.5	8,000	0.3	66	4,000	0.2	34
Acetylene		4		3.5	88		0.5	12
Total		21.5		16.4	76		5.1	24

Source: Stirling, Gadsby & Chown, “Growth potential...”, August 1968, p. 30, BOC LUM Box 535. mscf = millions of standard cubic feet.

“The trauma of competition has been faced”: BOC’s reaction to its new competitor, 1957-1965

³⁰ “The industrial gases Industry”, William Blair & Company, September 1976, BOCW Box 1143.

After its great successes through the mid-1960s, APL made markedly fewer inroads into BOC's market share in the years that followed. This had to do in the main with BOC's recalibration of company strategy in reaction to the initial onslaught. Since 1957 at the latest, the market leader had closely observed the actions of the newcomer in great detail.³¹ Initially, though, it had grossly underestimated the chances of success for the rapid market entry of APL. In fact, BOC itself later conceded that "We were in part a monopoly. As such we operated virtually as a public utility. We had a certain monopoly mentality; could adopt a 'take it or leave it' attitude, and occasionally did. In return, however, we gave a very fine service. By and large, we were respected rather than liked."³²

One key reason for the underestimation of the American competitor lay in the newcomer's failed projects in Corby and Billingham. BOC's sense of superiority was underscored by its head start in the onsite oxygen business for the steel industry: by 1960, it already operated more than a half dozen plants, and it had contracts to build and operate several more.³³ The British company concluded not only that it was clearly advanced in comparison to APL, but also that APL's parent company's piggyback principle, which it had successfully

³¹ Interview R. C. Hesketh-Jones 5 and 24 January 1983, as well as interview with Sir Leslie Smith 21 and 26 July 1983, in Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

³² Memo from F. Lewin-Harris and R.C. Hesketh-Jones, "Competition, BOC Advertising and P.R.," 4 January 1963, BOC History 1945-1975, BOC LUM Box 488. This position was later confirmed in the market study "Growth potential set against the background of its markets", carried out by Stirling Gadsby & Chown for BOC in August 1968: "... [BOC's] approach to its business was similar to that of many national monopolies; unenterprising, self-satisfied and old-fashioned." Citation from page 26. BOC LUM Box 535.

³³ Interview with T. E. Potts from 30 November, 7 December 1982 and 19 January 1983, as well as with Sir Leslie Smith, 21 and 26 July 1983, in Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

applied in the United States, could not be implemented in the UK. The judgment was correct in that, as we have seen, the Americans were not able to make inroads into BOC's tonnage business in the steel industry, being able only to build and operate a few plants near steelworks.³⁴

What BOC management overlooked, however, were APL's alternative opportunities, i.e. in onsite plants outside of the steel sector such as at the Esso oil refinery in Fawley. Such plants provided a sufficient production basis to allow the American subsidiary to serve customers in each of their respective surrounding areas. It is also worth bearing in mind that Baker and his management team never intended to supply all of Great Britain, but rather concentrated initially on the country's most important industrial regions in order to enable better capacity utilisation.

BOC was completely wrong, however, in its assessment that its distribution network would offer protection against an onslaught from a competitor. For too long the market leader rested confident in its belief that construction of a rival large-scale distribution network that would serve every single customer, no matter how small, in every nook and cranny of the country would take too long and be far too expensive. As was noted in a board meeting in 1958:

I don't think in this industry now that the threat is very great of any competitor building up a distributive business in compressed gases from surplus until they have established a number of plants so that they can back their installations on a national pattern such as our own. They could not put down a single installation at Fords and another in Glasgow and possibly a third in the Midlands, and back up all requirements in industry in the event of breakdown, to compete with the terms and conditions that we have proved.³⁵

³⁴ Stirling, Gadsby & Chown, "Growth potential...", August 1968, pp. 26-27, BOC LUM Box 535.

³⁵ Verbal Notes of Board meeting 23 September 1958, p. 3/33, BOCW Box 478.

It was only some time later that BOC recognised that APL could do just that by focusing only on large industrial centres. Furthermore, APL limited its operations to supply of large-scale customers, generally neglecting the distribution of small quantities of industrial gas by means of individual cylinders.³⁶

Initially, BOC managers also failed to understand that APL's innovations in distribution and delivery (larger tankers, liquid transport, gas-storage tanks held by consumers, cylinder bundles, and so on), together with the higher proportion of nitrogen sold and concentration on large-scale customers, led to a substantially more favourable cost structure at APL compared to BOC. For some time, the British firm sought to explain the cost differential by looking at production costs, but came to the apparently baffling conclusion that APL could not possibly have produced more cheaply than it did.³⁷ Thus, BOC could only assume that the American firm was willing to lose money in order to gain market share. As we have seen, APL did indeed gain market share, but not by selling below cost.

In addition to these false assessments, another factor played a role in the American newcomer's successful entry into the British market: for quite some time, BOC management did not recognise new markets with large potential—such as nitrogen—and therefore neglected them in the short term.³⁸ The reason for this may lie in part in the head start in an area such as nitrogen enjoyed by APL's parent company in the USA, but another factor had to be BOC's concentration

³⁶ Memo from F. Lewin-Harris and R.C. Hesketh-Jones, "Competition, BOC Advertising and P.R.," 4 January 1963, BOC History 1945-1975, BOC LUM Box 488.

³⁷ Verbal Notes Board meetings 23.9.1958, Verbal Notes Board meetings 1958, BOCW Box 478.

³⁸ BOC, "Air Products and Chemicals Incorporated—A review, 1979, pp. 3-4, in BOCW Box 20.

on the oxygen tonnage business, which required not just extensive capital investment, but also involved commitment of considerable personnel resources.³⁹

Despite their initial miscalculations, those responsible at BOC were able to develop a successful strategy within two to three years to fend off the challenge of the new competitor, among other things by imitating APL's innovations.⁴⁰ BOC started by attempting to reform its own distribution systems to make them more service and customer friendly. For instance, in a staff training initiative in 1964, it was noted that "Poor service is the easiest way of encouraging a customer to jump at the opportunity of letting someone else supply his industrial gases. The heading 'poor service' must also include broken promises."⁴¹ Critical points were identified, such as unfriendly truck drivers or delays in promised deliveries by distribution personnel, but also shortages of gas cylinders. In addition, BOC began to fight to secure every single reasonably large-sized contract even if profit margins were very slim or even non-existent since the company finally began to recognize the significance of follow-up sales: "All gases are important: allow a competitor to provide one and it provides him with a foothold from which to develop his contact and business."⁴²

As important as improvements in customer service and engaging actively in competition were, the adoption by BOC of numerous APL innovations in distribution and delivery was even

³⁹ BOC History 1886-1979 in BOC "LUM Box 488.

⁴⁰ BOC not only introduced numerous labour-saving innovations that had been pioneered by Air Products into its distribution system, but also tried—like Air Products—to carry out applications research for nitrogen to attract potential customers. BOC History 1886-1979 in BOC LUM Box 488; BOC, Report on Air Products for staff college, 1964, BOCW Box 536.

⁴¹ BOC, Report on Air Products for staff college, 1964, BOCW Box 536.

⁴² BOC Chairman's Committee Minutes, Regional Management Meeting from 16 June 1965, BOCW Box 478.

more so. For one thing, the British company moved rapidly to introduce larger tankers, cylinder bundles, liquid transport, and large storage tanks at customer premises. Thus, the consultants Stirling Gadsby & Chown noted that BOC was able between 1962 and 1965 to reduce the number of handling operations in delivery of gas cylinders from 20 to 10. In the case of vertical cylinders (BOC used horizontal loading of round-bottomed cylinders until it recognised the advantages of flat-bottomed vertically loaded ones used by APL), the number of handling operations was reduced by 1968 to as few as two or three. What is more, a single 6,000 gallon tanker truck could replace “as many as 30 cylinder trucks in terms of gaseous content.”⁴³ It is noteworthy that it was only at this point that BOC management realized that its cylinder gas business had long been in deficit because of its inefficiency of operation, and that the company had lost a lot of money in it. As the consultants commented in 1968: “Money is made in the merchant market by solving the distribution problem... When BOC had a monopoly, it probably had little or no idea about its profit from selling cylinder gases. It is possible that in the nineteen-fifties BOC lost money on a third of its cylinder business.”⁴⁴

The appearance of Air Products as a serious competitor on the British market, and in particular the American’s company’s successful public relations work, stimulated other organisational and operational innovation at BOC in the mid-1960s. The British market leader began, through advertising and other public relations efforts, to get away from the image of the inflexible, unfriendly, and expensive monopolist.⁴⁵ More importantly still, BOC also mimicked APL’s financing methods and used credit to finance the construction of numerous additional

⁴³ Stirling, Gadsby & Chown, “Growth potential...”, August 1968, pp. 31-32, quotation p. 32, BOC LUM Box 535.

⁴⁴ Stirling, Gadsby & Chown, “Growth potential...”, August 1968, p. 30, BOC LUM Box 535.

⁴⁵ BOC History 1945-1975, BOC LUM Box 488; Stirling, Gadsby & Chown, “Growth potential...”, August 1968, p. 30, BOC LUM Box 535.

plants.⁴⁶ This set of measures, introduced already by the mid-1960s, eventually led to a large program of investment under the aegis of its overall strategy for developing its gas business, “Plan 70”. This ambitious plan envisioned considerable expansion of capacity through numerous new factories, extension of existing onsite operations, as well as further modernisation of distribution systems.⁴⁷ Because of the company’s high interest burden while profit margins at the same time remained slim owing to the new competition, BOC’s financial situation remained strained until the end of the 1960s.⁴⁸ By 1968, though, the “trauma of competition” had finally been mastered. It was characteristic of the cultural change within the firm that from that point BOC management looked less at market share and more at profitability in assessing its activities.⁴⁹

“If the previous situation had been a monopoly or duopoly supply, there will be some customers who welcome a fresh face”:⁵⁰ Air Products’ expansion into continental Europe and the end of the gentlemen’s agreements

⁴⁶ On the development of the so-called “tonnage debenture concept” at BOC, interview with Sir Leslie Smith from 21 and 26 July 1983, Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

⁴⁷ BOC, “Air Products and Chemicals Incorporated—A review,” 1979, p. 4, BOCW Box 20; BOC History 1945-1975, BOC LUM Box 488.

⁴⁸ Interview with R. C. Hesketh-Jones from 5 and 24 January 1983, in Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

⁴⁹ The full citation is: “The Trauma of Competition has been faced. The company recognizes that, on balance, the effect upon it of APL’s competition has been beneficial. It is, now, probably rather easier for BOC to penetrate APL’s market than it is for APL to erode still further BOC’s position.” Stirling, Gadsby & Chown, “Growth potential...”, August 1968, p. 27, BOC LUM Box 535.

⁵⁰ BOC, “Air Products and Chemicals Incorporated—A review,” 1979, p. 7, in BOCW Box 20.

The entry of Air Products into the British market had consequences far beyond simply breaking up BOC's monopoly, especially in the longer term. For one thing, Dexter Baker took the decision to enter the continental European market even before the situation of the then still young subsidiary in Great Britain was consolidated. He managed to win over management of Air Products at its American headquarters in Allentown, Pennsylvania, which was initially sceptical of the wisdom of this step, warning of overly rapid expansion. In a first move in 1964, APL tendered for the construction of an onsite plant for a steel mill in Sidmar, Belgium, not far from Ghent. Once the contract was secured, a new company was established in the same year for the operation of the plant together with Société Générale, "Air Products SA".⁵¹ The new company, which Air Products led operationally with a 60 percent stake, enabled penetration of the Belgian industrial gases market using the piggyback principle and other methods which had already demonstrated their effectiveness in the British Isles.

Shortly after gaining the contract for the Belgian onsite plant, Baker pushed the expansion further into Germany. Here, Air Products GmbH was established in Düsseldorf, not long after the first large-scale contract had been secured in the country. Air Products assumed the construction and operation of an onsite plant for the Rhestahl Hüttenwerk AG at its steel mill in Hattingen, which meant that the American company was now challenging the sphere of influence of Linde, Griesheim, and, above all, Messer.⁵² By 1967, these steps had been taken still further with the establishment of subsidiaries in the Netherlands and France, which were also

⁵¹ *CryoGen looks at 25 years of Air Products*, p. 9; "Air Products £2.5 M. Belgian Plant," *The Times* (5 November 1964), p. 19; BOC, Market observation of Air Products 1980-1988, BOCW Box 874.

⁵² Information kindly provided by the Thyssen-Krupp Concern Archives, Duisburg. Griesheim and Messer became Messer-Griesheim in 1965, which meant that two rather than three German firms now dominated the West German market.

linked to construction of onsite plants. In Holland, Rotterdam was chosen as the production site, which allowed supply of industrial gases to the surrounding region.⁵³ In France, Air Products concentrated its efforts in the south, where the dominant market leader, Air Liquide, was less strongly represented.⁵⁴ Air Products thus was able to enter the market in all four of these countries by the end of the 1960s, although the company was able to gain only small market shares in the larger markets compared to what it had achieved in Britain. In France, overall market share for the subsidiary of Air Products amounted to just 7 percent in 1967, while in West Germany it was 15 percent. In Belgium (23 percent) and in the Netherlands (34 percent), shares were healthier.⁵⁵

BOC, which observed Air Products' European activities closely, saw the limited success of the Americans in the German market resulting from idiosyncrasies of West German entrepreneurs, who preferred working with domestic suppliers, unlike British customers who paid more attention to price and pure business arguments: "AP [Air Products] discovered by hard experience that, for example, where British cylinder Argon customers were often open to temptation from keen price and good service, the Germans took a nationalistic attitude – why buy from a foreigner?"⁵⁶ BOC did concede, however, that competition in Germany was much

⁵³ BOC, Market observation of Air Products, 1980-1988, BOCW Box 874.

⁵⁴ BOC, "Air Products and Chemicals Incorporated—A Review," 1979, pp. 5-6, BOCW Box 20; BOC, Market observation of Air Products, 1980-1988, BOCW Box 874.

⁵⁵ Comparison of APL Performance versus BOC Gases Division from 24 March 1980 (JM/AL); Press report: Interview with Senior Air Products financial executives, June 1977; both in BOC, Market observation of Air Products 1980-1988, BOCW Box 874. On the more intensive competition on continental Europe, "The industrial Gases Industry", William Blair & Company für BOC, September 1976, BOCW Box 1143.

⁵⁶ BOC, "Air Products and Chemicals Incorporated—A review," 1979, p. 5, BOCW Box 20.

more intensive than it was in the British Isles even before the arrival of Air Products since, in addition to a large number of small suppliers, there were three large firms active in the industrial gases business. What is more, German and other continental European companies in the industrial gases sector were well aware of the success of Air Products in the United Kingdom and were thus also better prepared for the Americans when they arrived.⁵⁷

One further effect of the new competition from Air Products on individual national markets in western Europe was to cause a reorientation of corporate strategies of the European market leaders, who now began to be interested in markets beyond their own borders. Already in 1964, BOC began to eye up continental European markets, especially in Italy, and the British firm moved in this same year to take a 20 percent stake in the medium-sized Italian firm Rivoira and other firms in gases and related businesses.⁵⁸ Although BOC withdrew from the Italian market in 1969 owing to quarrels with the Rivoira family (which still owned the majority share in this firm), the fact that the British company even considered moving into in a non-Commonwealth foreign country, let alone actually doing so, marked a watershed in its corporate strategy. After the Italian adventure, the company remained committed to continental European expansion, and BOC explicitly linked this commitment to the intrusion of Air Products into both the British and European markets. The assumption was that it would be possible for other European industrial gas companies to find a place in the British market, just as Air Products had done. To even things out, the British firm wanted corresponding market shares on the continent:

⁵⁷ “West German shake up in industrial gases,” *European Chemical News* (8 March 1968).

⁵⁸ Memo from F. Lewin-Harris and R.C. Hesketh-Jones, “Competition, BOC Advertising and P.R.,” 4 January 1963, BOC History 1945-1975, BOC LUM Box 488.

BOC would appear to be well placed with its now strong, market-orientated management. It should be able to offset any further drop, should it occur, in its share of the market by optimising profits throughout its extensive distribution system; but it must also be prepared to defend interests more vigorously than it has had to do in the past. It might turn its attention to parts of Europe in which the market is not so highly developed, e.g. Italy, Spain, Yugoslavia, Greece, and try to be first in.⁵⁹

At the forefront of BOC's interest initially, however, were Italy and the Benelux countries, although BOC decided not to move into the Dutch market at the beginning of the 1970s since it saw profits there as not guaranteed.⁶⁰ In the event, though, instead of moving further into western Europe at this particular time—especially after a prospective joint venture with Linde and Messer-Griesheim came to naught after lengthy negotiations—,⁶¹ BOC decided instead to use a unique opportunity to purchase a 34 percent share in the second largest American industrial gas producer, Air Reduction Corporation (Airco), a holding which rose to 100 percent in 1978.⁶²

⁵⁹ Stirling, Gadsby & Chown, "Growth potential...", August 1968, p. 29, BOC LUM Box 535.

⁶⁰ Interview with David R Harris on 15 February 1983, Notes of Interviews with a number of Directors and Seniors, BOC History 1945-1975, BOC LUM Box 488.

⁶¹ In 1972, BOC, Messer-Griesheim, and Linde had agreed in principle in initial negotiations to establish a joint venture for the European markets (Belgium, Denmark, Finland, France, Holland, Italy, Luxemburg, Norway, Portugal, Sweden, and perhaps later also Spain and Greece) for industrial and medical gases outwith each of the firms' domestic markets (West Germany, Austria, Switzerland, Great Britain, and Ireland). However, the company, which was to be named "Eurogas" never came to fruition. BOC History 1886-1979, BOC LUM Box 488.

⁶² The BOC participation in Air Reduction, with which the British firm had an agreement on cooperation for plant construction on the American market already in 1968, is detailed in Stirling, Gadsby & Chown, "Growth potential...", August 1968, p. 24, BOC LUM Box 535; BOC History 1886-1979, BOC LUM Box 488.

But it was not just BOC which began to think in terms of foreign investment. So did the other European producers, although it must be said that the others were already much more heavily engaged beyond their borders than were the British. Linde and Messer-Griesheim established a joint venture to move into the Benelux states and France in 1973; the Swedish company AGA and French Air Liquide, for their part, established a joint venture for Belgium and the Netherlands.⁶³ Thus, beginning in the 1970s, the formerly virtually purely national industrial gas producers adopted a much stronger international orientation, as can be seen clearly in the following table:

Table 3: The market entry of industrial gases producers into key countries

	USA	GB	FRG	France	Benelux	Japan
Air Products	HM	195860	1964	1969	1964	1980s
Air Liquide	1916	1992	1971	HM	1906-13	1907
Linde AG	1997	1990	HM	1973	1973	-
UCC/Praxair	HM	-	1973	1980	1979-1984	1984
BOC	1973-78	HM	1993	1994	1993	1990s
AGA	1977	1975	1971	1987	1971	-
Nippon Sanso	1980	1989	1990	n.a.	n.a.	HM
Messer	1975	1987	HM	1973	1973	1978

HM = Home Market

Source: MacLean (1973). (John R. MacLean was at the time General Manager, Gas Products, Linde Division, Union Carbide Corporation, New York.)

As can be seen, it was not just European firms which strengthened their foreign investments in the industrial gases business beginning in the early 1970s (for instance, Air

⁶³ The Swedish industrial gases company AGA also considered becoming active on the British market and to invest heavily to this end. *The Times* commented in its business section: "There is not only room for as third force in the gas market in this country. It can be argued that there is a positive need for one." "Gas move by AGA," *The Times* (20 January 1970), p. 22.

Liquide gained market share in the USA through the purchase of smaller producers beginning in 1968), but also the American market leader, Union Carbide Corporation Linde Division (UCC).⁶⁴ UCC, however, was able to gain only small market shares in the European markets it entered in the plant construction business (from 1968) and in gases (from 1973). The reason for this was more intensive competition. Clearly, UCC mistimed its expansion into Europe, coming too late to the game. Simple conquest of market share by taking on an existing competitor was no longer possible; it had come to cost far too much.⁶⁵

Summary and conclusions

Air Products' entry into the British market represented not just the end of the monopoly of BOC, but also the end of the previously existing gentlemen's agreements in Europe. It was not just the appearance of the American firm on the western European market; instead, the mere fact of a possible competitor appearing on markets which had previously been entirely dominated by the national leader was sufficient to cause the regional cartels which had hitherto existed to implode. Certain institutional and legal frameworks (e.g. the creation of the European Economic Community or cartel and competition legislation) played a role in this development. Still, the mere fact that a new competitor not beholden to previous agreements entered the market was enough to undermine mostly monopolistic or duopolistic markets and usher in instead highly competitive oligopolies. The consulting firm of Stirling Gadsby & Chown commented on this explicitly in 1968:

Prior to the emergence of Air Products as an international industrial gas supplier ... the world outside the U.S.A. was supplied through a series of 'gentleman's agreements'. For

⁶⁴ Thus, already in 1968 BOC was expecting an expansion of Union Carbide into the European market for industrial gases: Stirling, Gadsby & Chown, "Growth potential...", August 1968, pp. 28-29, BOC LUM Box 535.

⁶⁵ "The industrial Gases Industry", William Blair & Company, September 1976, BOCW Box 1143.

example, there are very few l’Air Liquide plants in the old Commonwealth, nor BOC plants in the old French dependencies. No one bid seriously in anyone else’s back-yard – until Air Products came along. APL [Air Products Ltd] has no understanding of ‘gentleman’s agreements’ – it made none in the U.S.A. and saw no reason to make any in Europe.”⁶⁶

The successful conquest of substantial market shares in Europe by Air Products made it clear to western European producers that other firms, too, could penetrate their home markets, which Stirling Gadsby & Chown summarised as follows:

The continental European producers watched the hammering which BOC took and drew the inference: keep APL out at all costs. It was trying hard to get in, and the corollary arose, therefore, that the European companies said that if AP was going to hammer them in their own home markets, they must look more keenly at all other markets. The conclusion was that gentleman’s agreements ceased to exist. The emergence of the Japanese industrial gas companies as major contenders for plant orders in world markets gave impetus to the trend. Every European plant manufacturer bid for a major South African order, lost it to the Japanese, and were frightened half to death.

... [T]en years ago no continental European producer would have given a second thought to bidding for a plant in the U.K., but now they face competition from APL in their own markets, i.e. West Germany (a plant supplying Rheinstahl and the merchant market) and Benelux. Why, they ask, might not BOC follow APL’s lead? Conversely, why not enter the U.K. market if the opportunity occurs?⁶⁷

⁶⁶ Stirling, Gadsby & Chown, “Growth potential...”, August 1968, p. 28, BOC LUM Box 535.

⁶⁷ Stirling, Gadsby & Chown, “Growth potential...”, August, 1968, p. 28, BOC LUM Box 535.

As a consequence of all of this, the large producers began to consider becoming active on foreign markets themselves in order to pre-empt other competitors. On account of their very good knowledge of the market and the competition, the oligopolists began to react not to initiatives actually undertaken by the competition, but rather to perceived actions that might be undertaken. Anticipation of the corporate strategies of the competition thus caused countermeasures to be undertaken, which in turn often led to the expected reaction of the competitor, a classic prisoner's dilemma. Within ten years of Air Products' entry into Britain, by the early 1970s, all large producers in the industrial gases industry therefore departed from exclusive reliance on the domestic market and began to expand internationally. Even if all of the individual firms were not immediately active on all attractive industrial markets, this internationalisation of industrial gases companies represented a first stage in the continuing wave of globalisation in this industrial sector.

This case study is important for other reasons as well, however. There is no question that Air Products' challenge to BOC, and then to companies on the continent, was not only audacious, but also carried out on the basis of considerable innovation in financing, distribution, customer service, and product applications. In challenging BOC in particular, the American firm faced a company which was both slow to react and hampered by monopoly commission restrictions. But one key factor explaining Air Products' successful entry into British and continental European markets was its timing: it was crucial that demand for industrial gases in the economy and society was growing steeply just as Air Products was expanding aggressively.

But even under these extraordinarily favourable conditions, there were distinct limits to the Air Products' success in entering the British market. After all, it proved extremely difficult even for this agile newcomer to break into BOC's traditional or established markets, e.g. tonnage

oxygen. It proved much easier to break into new markets, for instance nitrogen, for which the American firm co-developed new applications for freezing and cooling food with its customers. Indeed, as a market study carried out for BOC in 1979 put it, Air Products' "drive for growth in gases has been through the creation of new market segments rather than seeking to share the pre-existing market with those that were there before them."⁶⁸

Conditions were not quite as favourable when Air Products moved onto the European continent, not least because its competitors had seen what had happened to BOC. But no further major competitors appeared on the British market in the course of the decades that followed. The difficulties of the other industrial gases producers in gaining large market share outside their domestic markets demonstrated clearly how important distribution networks have been for the development of the industrial gases sector, and how significant these are as a barrier to entry for a network industry without a physical network.

⁶⁸ BOC, "Air Products and Chemicals Incorporated—A review," 1979, p. 8, BOCW Box 20.

Appendix: BOC Archival Sources

The British Oxygen Corporation (BOC) ceased to exist after some 120 years as an independent company in autumn 2006, having been acquired by the German-based Linde AG. Linde has continued to trade in Britain under the BOC name, but the process of integration has led to a number of changes, including the closure of the former BOC headquarters in Windlesham and a move to a smaller facility in Guildford. One consequence of this was that a home had to be found at short notice for historical material held in Windlesham, and the safest alternative was to transfer the records to the Linde AG archive in Pullach (in Munich). These records, designated above as BOC LUM, are available for consultation subject to the permission of Linde AG. For contact details, see its web site, www.linde.com.

Additional archival material was identified by the authors as being held in a document storage facility in Wales, and these materials were made available with the permission of Linde AG for consultation at the Centre for Business History in Scotland at the University of Glasgow. This material proved to be extremely rich, and included a large number of documents compiled by the firm in anticipation of its 100th anniversary in 1986, including the interviews with key BOC personnel which we have cited in the article. A large number of these sources, including all of those designated BOCW in the notes above, have been photocopied and/or digitised and will be deposited in 2011 in the Linde AG archive in Pullach.

References

- Broadberry, Stephen, and Crafts, Nicholas (2001), "Competition and innovation in 1950s Britain," *Business History* 43: 97-118.
- Butrica, Andrew (1990). *Out of thin Air. A History of Air Products and Chemical Inc. 1940-1990*. New York/London: Praeger.
- Cox, Howard, Mowatt, Simon, and Prevezer, Martha (2003). "New product development and product supply within a network setting: The chilled ready-meal industry in the UK," *Industry and Innovation* 10: 197-217.
- CryoGen looks at 25 Years of Air Products* (1982). Walton-on-Thames: Air Products Limited.
- Economides, Nicholas (1996). "The Economics of networks," *International Journal of Industrial Organization* 14: 673-699.
- Economides, Nicholas (2006). "Competition policy in network industries: an introduction," pp. 96-121 in Dennis W. Jansen, ed., *The New economy and beyond: Past, present and future*. Cheltenham: Edward Elgar.
- Gómez-Ibáñez, José (2003). *Regulating infrastructure: Monopoly, contracts, and discretion*. Cambridge, MA: Harvard University Press.
- Guénault, Paul H. and Jackson, J.M. (1974). *The Control of Monopoly in the United Kingdom*. 2nd ed. London: Longmans.
- Harvard Business School Case Study 9-375-370 (1975). "Air Products and Chemicals, Inc.", Prepared by Hassel H McClellan, Supervision Joseph L Bower. Cambridge, MA: Harvard Business School.
- "International gas man" (1972). *Industrial Management* (February): 38-42.

Jewkes, John (1958). "British Monopoly Policy 1944-1956," *The Journal of Law & Economics* 1 (October): 1-19.

Josephson, Paul (2008). "The Ocean's Hot Dog: The development of the fish stick," *Technology and Culture* 49: 41-61.

Kipping, M., R. Rainieri, and J. Dankers (2001), "The emergence of new competitor nations in the European steel industry: Italy and the Netherlands, 1945-65," *Business History* 43: 69-96.

Landes, David (2003). *The Unbound Prometheus: Technological change and economic development in western Europe from 1750 to the present*. Cambridge/New York: Cambridge University Press. 2nd edition.

MacLean, John R. (1973). "Cryogenic and Industrial Gases – a worldwide Marketing Opportunity," *IOMA Broadcaster* Nr. 2 (March-April): 12-18.

Mosca, Manuela (2008). "On the origins of the concept of natural monopoly: Economies of scale and competition," *The European Journal of the History of Economic Thought* 15: 317-363.

Robinson, Joan (1957). "The Control of Monopoly in British Industry," *The Listener* Vol. LVII Nr. 1460 (21 March): 459-460 and 475.

Shapiro, Carl and Varian, Hal R. (1999). *Information rules: A strategic guide to the network economy*. Boston: Harvard Business School Press.

Shy, Oz (2001). *The Economics of network industries*. Cambridge: Cambridge University Press.

UK Monopolies and Restrictive Practices Commission (1956). *Report on the Supply of Certain Industrial and Medical Gases*. London: HMSO.