
COMPLIANCE WITH THE MONTREAL PROTOCOL IN CHINA: AN INVESTIGATION IN TWO INDUSTRIAL SECTORS

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SUMMARY

An analysis of the household refrigeration sector and the foams sector investigates how Chinese enterprises have complied with the Montreal Protocol on Substances That Deplete the Ozone Layer. We demonstrate that the performance of the household refrigeration sector in reducing ozone-depleting substance consumption is superior to the performance of the foams sector, and we present two explanations for this outcome. First, market demand matters. The influence of the global market, multinational corporations, intense (and occasionally misleading) advertising about non-CFC products, and severe competition for consumers caused China's principal refrigerator manufacturers to adopt non-CFC production technologies. Similar incentives did not exist for enterprises in the foams sector. Second, industrial structure matters. The foams sector includes a large number of small enterprises with limited financial and technical capability and weak access to information and technology, and these factors obstructed technological change. In general, assistance from the multilateral fund established under the Montreal Protocol has motivated enterprises to shift to ozone-depleting substance reduction technologies, but complex and lengthy procedures for accessing the multilateral fund, difficulties in finding appropriate suppliers of non-CFC technologies and insufficient financial and technical capabilities of many enterprises have slowed down this shift. Our results provide a foundation for better compliance in the future.

1 INTRODUCTION

The ozone layer, which is in the upper reaches of our atmosphere between 10 and 50 km above the ground, protects us from harmful effects of ultraviolet radiation from the sun. During the 1970s, scientists discovered that the ozone layer was being depleted by emissions of ozone-depleting substances, which include chlorofluorocarbons (CFCs), halons, and a number of other chlorine and bromine compounds. Ozone-depleting substances have been used extensively in the manufacture of refrigerants, aerosol propellants, and foam blowing agents. To prevent the depletion of the ozone layer, more than 160 nations (including China) ratified an international environmental agreement called the *Montreal Protocol on Substances That Deplete the Ozone Layer*. (This agreement and amendments to it are hereinafter referred to as the "Montreal Protocol.") A key provision of the Montreal Protocol requires signatory developing countries to phase out use of CFCs and halons by 2010.

To assist in meeting the 2010 phase out requirement, Parties to the Montreal Protocol established a Multilateral Fund that offers financial and technical assistance to developing countries. The main task of the Multilateral Fund is to "meet, on a grant or concessional basis as appropriate, and according to criteria to be decided upon by the

Parties, the agreed incremental costs” incurred by developing countries in reducing production and consumption of ozone-depleting substances. “Incremental costs” are the additional costs incurred when a company switches from an ozone-depleting substance technology to a non-ozone-depleting substance technology.¹ The Multilateral Fund, together with provisions of Article 10 on technology transfer, provides an opportunity for developing countries to keep up with new technologies being developed in industrialized nations. Even though enterprises must pay project costs that are not defined as incremental by the Multilateral Fund Executive Committee, grants from the Multilateral Fund typically cover a significant fraction of funds needed by enterprises to shift to non-ozone-depleting substance technologies. In order to access this fund, a nation must first prepare a “country program” that lays out plans for meeting the Montreal Protocol’s goals.

Ten ozone-depleting substances controlled by the Montreal Protocol are commonly produced and consumed in China. During the early 1990s, three controlled substances, CFC 12, CFC 11, and halon 1211, accounted for over 90% of China’s total ozone-depleting substance consumption and production. The fire protection sector and the chemical industry sector produce most of the ozone-depleting substances used in China. The primary ozone-depleting substance consumers in China include nine sectors: foams, fire protection, household refrigeration, industrial and commercial refrigeration, aerosols, mobile air conditioning, solvents, tobacco, and soil fumigation and food disinfestation. In terms of ozone depletion potential, manufacturers of foams, halons, and refrigerators are the primary ozone-depleting substance consumers in China.²

China ratified the Montreal Protocol in 1991. To comply with the 2010 phaseout goal, China’s industries that consume or produce ozone-depleting substances will eventually have to switch to non-ozone-depleting substance technologies. Some enterprises have already switched to reduced-ozone-depleting substance or non-ozone-depleting substance technologies. This paper analyzes Chinese industries’ behavior in compliance with the Montreal Protocol, and it identifies incentives and barriers to compliance. We use two industrial sectors as examples, household refrigeration and foams. Firms in each of these sectors consume a notable fraction of total ozone-depleting substance consumption in China: in 1996, the household refrigeration sector was responsible for about 12% of total ozone-depleting substance consumption, while the foams sector accounted for 21%. As we demonstrate below, these two sectors have responded in very different ways to the requirements of the Montreal Protocol. This paper is based on ten-months of field research conducted in 1996 and 1997 in Beijing, Shanghai, Hangzhou, Qingdao, Tianjin, and Xinfai.

2 HOUSEHOLD REFRIGERATION SECTOR

China’s household refrigeration industry consists of enterprises manufacturing household refrigerators and freezers and the compressors used in those appliances. Most production equipment and technology in this sector was imported from Italy, Japan and Germany during the 1980s. As of the late 1990s, China had fewer than 40 enterprises in the household refrigeration sector and the sector’s total capacity to produce household refrigerators and freezers was over 15 million units per year. In 1995, China manufactured 12.1 million household refrigerators and freezers, which accounted for 50% of the total production of refrigerators in all developing countries that ratified the Montreal Protocol and have an annual ozone-depleting substance consumption of less than 0.3 kg per capita.³ These countries are often called “Article 5 countries”, because Article 5 concerns the “special situation of developing countries”.

2.1 Compliance with the Protocol

In producing refrigerators and freezers, Chinese enterprises employ CFC 11 as a blowing agent and CFC 12 as a refrigerant. To phase out use of CFCs in the household refrigeration sector, enterprises must adopt technologies that employ non-CFC foams and refrigerants, and use compressor designs that accommodate the new refrigerants.

Some Chinese refrigerator manufacturers adopted non-CFC technologies or conducted research on non-CFC technologies before China signed the Montreal Protocol in 1991. An example of an early adopter is the Jingdezhen Huayi General Electric Appliance Company. Even before 1991, the firm had negotiated a deal to import a refrigerator compressor production line that would use hydrofluorocarbon (HFC) 134a, an expensive alternative to CFC 12. Other examples involve enterprises such as Qingdao Haier Group and Xinfei Refrigerator Company, which began their research on non-CFC technologies as early as 1989.

After China ratified the Montreal Protocol, the number of household refrigerator enterprises conducting research on non-CFC technologies increased, and many enterprises in the sector have followed the development of non-ozone-depleting substance technologies closely. As of 1995, over 90% of the ozone-depleting substance phase-out in the household refrigeration sector had been attained using a 50%-reduced CFC 11 technology. After 1995, some Chinese refrigerator manufacturers adopted "transitional technologies," i.e., technologies using "transitional substitutes" such as hydrochlorofluorocarbon (HCFC) 141b and HCFC 22. These materials, which have fewer impacts on the ozone layer than CFCs even though their ODPs are not zero, are being used in the transition to non-ozone-depleting substance technologies. Since 1996, a number of China's top refrigerator manufacturers have employed 100% CFC-free substitutes, such as cyclopentane for CFC 11, and isobutane or HFC 134a for CFC 12.

Some of the above-noted CFC-reduction activities have been supported by the multilateral fund. By the end of 1997, the Multilateral Fund provided US\$ 71 million to 46 projects in the sector. To complete these projects, enterprises used their own funds to cover costs that did not fall under Multilateral Fund Executive Committee's definition of incremental costs.

The Chinese Household Electrical Appliance Association estimated that of the 12 million units of household refrigerators and freezers manufactured in China in 1996, about 3 million units were produced with reduced- or non-ozone-depleting substance technologies, and production lines with over 5 million units of capacity were in the process of changing to non-ozone-depleting substance technologies; the remaining 4 million units had not reduced their use of CFCs. In other words, about two-thirds of the production lines have been or are being changed to reduced-CFC technologies. The output of household refrigerators and freezers has been rising by an average of 16% per year since 1991, and CFC consumption in the sector has been falling since 1995, the year in which the effects of the various ozone-depleting substance-reduction projects began to be seen (see Table 1).

Table 1 Household Refrigerators and Freezers: Total Production and Ozone-depleting Substance Consumption

Year	1991	1992	1993	1994	1995	1996	1997
Production (million units)	5.5	6.2	8.1	9.9	12.1	12.4	13.0
ODS Consumption (thousand tons)	6.15	6.96	8.46	10.7	8.45	9.59	7.39

Sources: CHRAA (1995) and NEPA (1998). Data are rounded

2.2 Incentives and Capabilities for Compliance

2.2.1 Market Demand

Of all the factors motivating Chinese household refrigerator producers to comply with the Montreal Protocol, market demand is the most significance. Five of the seven refrigerator manufacturers we visited during our research placed market demand as the number one reason for adopting CFC-reduction technologies. The importance of market factors is apparent in the following explanation for how decisions were made by a large refrigerator manufacturer:

If we could obtain a good market share for this product [refers to CFC-free refrigerators], we would conduct ozone-depleting substance reduction even if there were no financial support [from the Multilateral Fund]. But if we could not obtain a good market share, we would not carry out ODS reduction even if [Multilateral Fund] financial support were available.

Support for the prominence of market demand as a factor is given by the role of Chinese refrigerator manufacturers in China's ratification of the Montreal Protocol. Under the Montreal Protocol, Chinese refrigerator manufacturers would not have been able to export to countries that were Party to the Montreal Protocol unless China ratified the agreement. Once Chinese enterprises that had been exporting refrigerators learned about this trade restriction, they strongly encouraged the Chinese government to ratify the Montreal Protocol.

Access to global markets was the initial motivation for several Chinese refrigerator manufacturers to adopt non-CFC technologies. These enterprises saw China's household refrigerator exports fall by 58 percent between 1988 and 1991, a period in which European consumers began demanding refrigerators with environmental labels indicating they were CFC-free.⁴ European demand for CFC-free refrigerators resulted, in part, because many European nations had signed the 1987 Montreal Protocol. In order to compete in European markets, some Chinese refrigerator companies worked with universities and research institutes to develop non-CFC technologies. At the same time, those firms asked China's National Environmental Protection Agency⁵ to establish an environmental labeling program; the refrigerator manufacturers hoped that a Chinese environmental label would allow them to satisfy labeling requirements imposed by European countries. As a result of joint efforts by National Environmental Protection Agency, the China State Bureau of Quality and Technical Supervision, the Chinese Research Academy of Environmental Sciences, and industries, in March 1993, China began its environmental labeling program; reduced-CFC household refrigerators were included as products eligible to receive labels.⁶

While trade with Europe was the initial motivation for the switch to reduced-CFC refrigerators, the labeling program had the effect of causing some enterprises who sell refrigerators only in China to adopt reduced-CFC technologies.⁷ This is notable because most

companies in the household refrigeration sector do not export. In 1993, enterprises exporting refrigerators to Europe introduced refrigerators labeled as “non-CFC” (*wufu*) into China’s domestic refrigerator market. Once this occurred, some companies that had no intention to export refrigerators felt pressure to adopt CFC-reduction technologies. These enterprises believed that adoption of reduced CFC technologies and acquisition of environmental labels would allow them to maintain or expand their market shares. By 1996, 38 categories of refrigerators sold by 12 enterprises had been certified to use environmental labels. To obtain certification, these firms had changed to either 50%-reduced CFC technologies or CFC-free technologies.

Some enterprises used advertising to stimulate consumer demand for their non-CFC refrigerators and consumers’ preferences promoted further CFC reductions in the sector. In 1996, many leading Chinese refrigerator manufacturers emphasized the non-CFC features of their refrigerators in newspaper and television ads. Some manufacturers’ ads misled consumers by implying that having refrigerators made with CFCs in their homes could be directly harmful to their health. Other manufacturers employed ads touting use of the world’s most advanced CFC-substitution technology in their refrigerators. Because of worries about health impacts and a high interest in buying “world class” refrigerators, many consumers bought non-CFC refrigerators during the first half 1996. This expression of consumers’ preference pushed more refrigerator manufacturers to adopt non-CFC technologies; even manufacturers with limited technical capabilities made the switch. Some of these enterprises produced low quality non-CFC refrigerators. In order to protect the public from misleading ads and to encourage firms to enhance their refrigerator quality, National Environmental Protection Agency and the Chinese Household Electrical Appliance Association used television and newspapers to educate the public about ozone layer depletion and non-CFC technologies. As a result, enterprises producing low quality refrigerators either went out of business or improved their product quality.

The importance of consumer demand on the choice of manufacturing technology is further demonstrated by the way Chinese refrigerator companies tailored technologies to suit markets in different parts of the world. Actions by Qingdao Haier Group are illustrative. In response to the sensitivity of Chinese consumers to energy costs, Qingdao Haier worked with the University of Maryland and the U.S. Environmental Protection Agency to create a CFC-free refrigerator that cuts energy use by 40%. These new refrigerators have sold well in China. Because of different preferences for non-CFC technologies in the European and United States markets, Qingdao Haier Group proceeded as follows: the firm used HFC 134a to replace CFC 12, and HCFC 141b to replace CFC 11 in manufacturing refrigerators for export to the United States, whereas it used isobutane to replace CFC 12, and cyclopentane to replace CFC 11 in refrigerators it sells in European countries. The group’s refrigerators in both the United States and Europe also had energy saving features.

2.2.2 Influence of Multinational Corporations

Many analysts have argued that multinational corporations are effective in disseminating new technologies when they begin manufacturing in developing countries, and this has occurred in China’s household refrigeration sector. Since 1995, an increasing number of refrigerator producers from the United States, Japan, Germany, Sweden and Italy have entered China either by creating “foreign enterprises” in China or by forming joint-ventures with Chinese enterprises. Currently over 30% of the firms in China’s household refrigeration sector are joint ventures involving Chinese and foreign firms and most of them employ CFC-free production practices. The presence of foreign corporations has contributed

to the spread of information about reduced-CFC technologies and pressured China's domestic enterprises to switch to non-CFC technologies. For example, one Chinese refrigerator company used its own funds to switch to CFC-free technology in 1996, even though the company had no intention to export. The manager of this enterprise provided the following explanation for why the company made the switch:

The multinational corporations have entered China's domestic market. Because we do not export refrigerators, we do not need to follow the requirements of foreign markets. However, China's market is part of the world market. If we had not changed, we would have lost China's domestic market.

Not all Chinese refrigerator manufacturers have been able to respond to the competitive pressure from multinationals by shifting to reduced-CFC technologies. Some state-owned and collectively-owned refrigerator manufacturers lacked the technical skill and financial means to make the change. As a result of competition, some of these enterprises have been forced out of business. Officials in the Office of Household Electrical Appliance Industry are very concerned that Chinese refrigerator firms not involved in joint ventures will be devastated by their competitors.

2.2.3 Assistance from the Multilateral Fund

The multilateral fund has also encouraged Chinese refrigerator manufacturers to adopt reduced-CFC technologies, but it has not been as significant an influence as either market demand or multinational corporations who have established a presence in China. The main effect of the Multilateral Fund has been to speed up adoption of reduced- or non-CFC technologies by enhancing the financial capabilities of Chinese refrigerator manufacturers.

Because an acceptable country program had to be in place before Multilateral Fund money could flow into China, enterprises in the household refrigeration sector pushed the government to complete China's Country Program quickly. Enterprises we visited indicated that even though they would have adopted non-CFC technologies without financial assistance, the opportunity to obtain Multilateral Fund support encouraged them to move more quickly because the Multilateral Fund money would provide them with the financial means to change technologies. By the end of 1997, US\$ 71 million had been granted to this sector for technology change, project preparation, and training; most of the Multilateral Fund money was used to change production technologies.

2.2.4 Access to Information and Technology

In contrast to firms in other sectors that use CFCs, most refrigerator manufacturers have imported equipment, and some have close connections with foreign firms. Because refrigerator manufacturers have technically skilled workers and easy access to information, it was relatively easy for them to adopt reduced-CFC technologies. A number of these enterprises learned about the Montreal Protocol and its requirements from their foreign partners. Moreover, some joint-venture refrigerator manufacturers adopted technologies used by their foreign partners. For example, Xiling, now uses HFC 134a and HCFC 141b as a CFC substitutes in its new refrigerator production line; Xiling made these change at the request of Sanyo, its Japanese partner.

Refrigerator manufacturers also have good access to information through the Chinese Household Electrical Appliance Association. In addition to holding annual meetings that provide a forum for exchanging technical information, Chinese Household Electrical Appliance Association publishes the *Household Electrical Appliance Journal* to keep Chinese

companies up-to-date on technical innovations. Because there are only about 40 refrigerator manufacturers in China, information flows easily between the Chinese Household Electrical Appliance Association and the companies.

In comparison to companies in other sectors, refrigerator manufacturers could more easily learn about alternative financing methods and new technologies, and thus they could more readily take advantage of the Multilateral Fund. China's Country Program, which was prepared in 1993, contained a sector-by-sector estimates of funds required from the Multilateral Fund in order for China to cut production and use of ozone-depleting substances. The household refrigeration sector received 163% of the funds specified for that sector between 1991 and 1996 in China's Country Program, whereas most other sectors received only about 10% of the funds called for in the Country Program. These differences are partially explained by the ability of refrigerator manufacturers to access information and thus be better able to satisfy requirements of the Multilateral Fund Executive Committee.

2.3 Obstacles to Compliance

Most enterprises in the household refrigeration sector have the incentives and abilities to adopt cleaner technologies. However, contrary to the expectation of enterprise managers, complex Multilateral Fund application procedures and difficulties in technology transfer have slowed down the adoption process.

2.3.1 Complex Multilateral Fund Application Procedure

Although managers at the seven refrigerator manufacturing enterprises we visited were initially excited about the Multilateral Fund, they each expressed frustration with the Multilateral Fund application and fund disbursement procedures. In the administrative process set up by the Multilateral Fund, proposals for projects identified in a country program are first approved by the country itself and then submitted to one of four agencies implementing the Multilateral Fund: the World Bank, the United Nations Development Program, the United Nations Environment Program, and the United Nations Industrial Development Organization. The implementing agency conducts its review and may suggest revisions in the proposed project. After the implementing agency approves a proposal, it submits the proposal to the Ozone Fund Secretariat, an organization that supports the Multilateral Fund Executive Committee in managing the Multilateral Fund and acts as a liaison between the implementing agencies and the Executive Committee. Following an evaluation by the Ozone Fund Secretariat, a proposal is sent to the Executive Committee for final approval. After a project receives approval, the implementing agency must create detailed plans to administer funding for the project.

In addition to the above-described procedures, each implementing agency has its *own* multistage process for reviewing proposals before sending them to the Ozone Fund Secretariat. Moreover, changes suggested by the Ozone Fund Secretariat or mandated by the Executive Committee must again go through the implementing agency's review process. Although these complex procedures may contribute to making projects better, they slow down the project implementation process. Some enterprise managers we interviewed said they would not have applied for Multilateral Fund money if they had known in advance of the burdensome and lengthy administrative procedures involved.

Chinese enterprises have spent much time sorting out the Multilateral Fund procedures. At the outset, the various Chinese agencies involved in implementation were not familiar with the Multilateral Fund application process and could not provide clear guidelines for companies. Indeed, many Chinese enterprises did not even know which

agency they should contact. They had to send staff to Beijing many times to clarify application procedures and to revise project proposals. For the seven refrigerator manufacturers we visited, it took a minimum of one and a half years from the time a proposal had been submitted to National Environmental Protection Agency to the time approval was granted by the Multilateral Fund Executive Committee.

2.3.2 Difficulties in Technology Transfer

Another impediment faced by Chinese refrigerator companies involves problems in finding appropriate suppliers of ozone-depleting substance reduction technologies. One set of difficulties centers on disagreements about which technology suppliers to use. In some cases, Chinese enterprises disagreed with the choice of technology suppliers selected through bidding or other procedures used by international experts working for the Multilateral Fund implementing agencies. In at least two cases, Chinese refrigerator manufacturer spent considerable time negotiating with experts at the implementing agencies over the choice of suppliers. In the end, each of these enterprises dropped its objections to the choice of technology suppliers in order to allow their projects to go forward. Chinese enterprises complained that international experts did not understand "China's situation" (i.e., the criteria Chinese companies considered important in selecting suppliers); managers we interviewed claimed that international experts selected technologies they preferred, but these technologies were not necessarily the best for the enterprises. In contrast, some international experts at the Multilateral Fund implementing agencies argued that ambiguities in the documents prepared by Chinese companies are what caused disagreements in selecting technology suppliers.

The Montreal Protocol requires "the best available, environmentally safe substitutes and related technologies" to be transferred to Article 5 countries "under fair and most favorable conditions." However, some enterprise managers we interviewed complained that the tough conditions for technology transfer provided by suppliers caused delays because much time was required in negotiating agreements. In some instances, talks broke down and Chinese enterprises pulled out. For example, after winning the bid to transfer a compressor technology, one foreign supplier insisted that the transfer could only take place if the Chinese company paid the supplier 3% of its gross sales. The Chinese company balked at this condition. Even though the Chinese enterprise eventually found a new supplier, the ozone-depleting substance-reduction technology was not as mature as the one offered by the first supplier.

Another enterprise we visited managed to find a large supplier willing to provide it with a non-ODS technology at a purchase price of US\$ 200,000 in early 1996. As a condition for transferring its technology, the supplier asked the Chinese company to make a separate, US\$ 500,000 purchase of equipment (unrelated to ozone-depleting substances), and the enterprise agreed. However, as of mid-1997, a final agreement between the two firms had not been signed. At that time, the Chinese enterprise doubted whether this technology transfer would take place.

One possible reason for the tough negotiating positions taken by technology suppliers may be related to China's weak record in protecting legal rights to intellectual property such as designs for equipment. If a supplier felt it would lose control of its technological innovations once it sold them to a Chinese enterprise, the supplier might well insist on creating a joint venture or obtaining very favorable financial conditions at the time of sale.

3 FOAMS SECTOR

China's foams sector includes enterprises using CFC 11 and CFC 12 as blowing agents in the production of rigid and flexible polyurethane foams, and extruded polystyrene and polyethylene foams, respectively.⁸ About 1,240 polyurethane foam manufacturers and 160 polystyrene and polyethylene foam manufacturers operate in China (SEPA, 1998). At least 1,000 of the polyurethane foam manufacturers are classified as small, and most of these small firms are Township and Village Industrial Enterprises,⁹ which are dispersed throughout rural areas. Typically, small Township and Village Industrial Enterprises have weak financial and technical capabilities, and because they are widely scattered, government ministries have difficulties exchanging information with them.

3.1 Compliance with the Protocol

Under the Montreal Protocol, manufacturers of polyurethane and polystyrene and polyethylene foams that use CFCs will eventually have to change to non-CFC technologies. In China, the Plastic Industry Office under the National Council of Light Industry (NCLI) is responsible for coordinating CFC substitution within the foams sector. As of 1997, no national policies and regulations existed to promote CFC substitution within this sector.

After China ratified the Montreal Protocol in 1991, foam manufacturers began to apply for Multilateral Fund grants to implement ozone-depleting substance-reduction technologies. As of 1997, there were 71 foams-sector projects funded by the Multilateral Fund with grants that totaled US\$ 31 million. Of these, only 54 were for investments in production facilities; most other grants were for project preparation, training, and sector strategy formulation. Upon completion, the 54 investment projects would reduce approximately 7,430 tons of ozone-depleting substances. As of 1997, only seven Multilateral Fund projects had been completed and they phased out use of 1,240 tons of ozone-depleting substances. Enterprises that have changed to non-CFC technologies *without* Multilateral Fund support have phased out about 800 tons of CFCs.

Despite the Multilateral Fund projects, most of the 1400 enterprises in the foams sector that once used CFCs still do so; only about 70 of these enterprises (5%) have changed or are changing to non-CFC technologies. Total CFC consumption in the foams sector increased between 1991 and 1995 (see Table 2). The 1995 increase was related to a rise in demand for commercial refrigeration and for rigid foam. There was a drop in 1996, and it may have resulted from the closure of unprofitable enterprises and the completion of projects involving use of CFC substitutes. CFC consumption in 1997 was 10,000 tons more than that of 1991. Why have so few enterprises in the foams sector changed to cleaner technologies, and what has motivated the enterprises that have changed?

Table 2 CFC Consumption in the Foam Sector

	1991	1992	1993	1994	1995	1996	1997
Consumption	13,200	15,600	19,400	22,500	24,700	20,900	23,900

Source: PIO (1997) and SEPA (1998). Data are rounded.

3.2 Incentives for Compliance

In contrast to the household refrigeration sector, market demand for foam produced without CFCs is weak, and the main motivation for companies to switch to non-CFC technologies is the advantage of financial and technical assistance from the multilateral fund. Six of the seven foam manufacturing enterprises we visited indicated that receiving Multilateral Fund grants was their most important reason for shifting to non-CFC technologies. Moreover, of approximately 70 foam manufacturers that have adopted or are adopting non-CFC technologies, 54 used Multilateral Fund money. Many firms in the foams sector have few financial resources and low technical capabilities, and the Multilateral Fund provides them with a means to bring in new production technologies. Without the assistance provided by the Multilateral Fund, some of these enterprises would not have adopted non-CFC technologies because they lacked both the incentives and the capabilities to do so.

Most of the foam manufacturers that changed to non-CFC technologies *without* Multilateral Fund assistance were motivated by decreased production costs. They adopted methylene chloride as a substitute for CFC 11, and butane as a substitute for CFC 12. If China had not ratified the Montreal Protocol, those enterprises would probably have continued to use CFCs, because methylene chloride is highly toxic and butane is flammable and explosive. After China ratified the Montreal Protocol and it became clear that CFCs would be eventually phased out, the price of CFC 11 increased from 9 yuan/kg to 14 yuan/kg. By comparison, methylene chloride was priced at about 9 yuan/kg. Also, the price of butane was lower than that of CFC 12. The use of these substitutes involves no major changes in production equipment.

Interestingly, 44 of the 54 foam enterprises that received Multilateral Fund money for investment projects utilized either methylene chloride or butane as CFC substitutes. Proposals involving these substitutes were routinely approved by the Multilateral Fund Executive Committee because they were less costly than other non-CFC technologies. These 44 enterprises were motivated to change for two reasons: they received Multilateral Fund money *and* they decreased production costs. Some of the firms that switched to methylene chloride or butane without Multilateral Fund grants were unable to satisfy Multilateral Fund criteria, typically, because the firms were very small. A number of firms that paid for non-CFC substitutes on their own were simply unaware of the Multilateral Fund.

Many firms that switched to methylene chloride or butane on their own failed to invest in adequate ventilation systems and other required safety measures. In some instances, costly fires broke out. Firms that used Multilateral Fund money to adopt methylene chloride or butane did not experience safety problems, because the Multilateral Fund provided funds sufficient to cover required safety measures. The need for new ventilation systems and other measures helps explain why so few enterprises adopted the methylene chloride or butane on their own even though production costs could be lowered. Many firms felt that the (unsubsidized) switch to methylene chloride or butane was not economically beneficial when the cost of adequate safety features was included.

3.3 Barriers to Compliance

Several factors explain why most foam enterprises have not changed to non-ozone-depleting substance technologies even though production cost could be cut by making the change. The cost of ventilation systems has already been noted. In addition, the absence of consumer demand for foam products manufactured without CFCs means enterprises have

no incentive to change. Moreover, lack of access to information and technology, and insufficient financial resources and technical skills impeded the ability of small foam manufacturers to access the Multilateral Fund and thereby make technology changes.

3.3.1 Market Demand for Foam Products

China's foams sector primarily supplies the domestic market. Since the early 1990s, China's polystyrene and polyethylene industries have grown rapidly to meet packaging needs for food, instruments, and handicrafts. In addition, polyurethane industries have grown to keep pace with rising demand for commercial refrigeration equipment, and the development of automobiles, and building materials. In response to the increased demand for foams between 1991 and 1997, many new Township and Village Industrial Enterprises were formed. In addition, numerous firms existing in 1991 were able to increase their outputs rapidly because they had been operating far below full capacity.

The sharp increase in the output of foams was accompanied by a corresponding rise in consumption of CFCs in the foams sector. This occurred because both individual consumers and foam consuming industries made their purchasing decisions without any concern for the CFC issue.

3.3.2 Lack of Access to Information and Technology

One reason so few firms adopted CFC substitutes is that small Township and Village Industrial Enterprises dominate the forms sector and many of them have little access to information about the ozone depletion problem, the Montreal Protocol, the Multilateral Fund, and alternatives to CFC-based foam manufacturing technologies. Most of these small firms serve local markets and do not have access to information outside their areas.

Under China's centrally controlled administrative system for implementing the Montreal Protocol, government ministries coordinate ODS phaseout activities in industrial enterprises. SEPA and the Plastic Industry Office have organized workshops and seminars about CFC substitution and Multilateral Fund application procedures. The Plastic Industry Office also publishes a quarterly newsletter, *CFC Substitution*, describing CFC-reduction technologies. Because no formal connection exists between ministries and enterprises owned by township governments and village committees, ministries have difficulty in keeping these enterprises informed. Township governments and village committees, which own most of the Township and Village Industrial Enterprises in the foams sector, are outside the vertical hierarchies under industrial ministries. and they have had little involvement with ODS reduction activities. Township and Village Industrial Enterprises are generally unaware of *CFC Substitution* and events organized by SEPA and the Plastic Industry Office. This is particularly true for small Township and Village Industrial Enterprises dispersed throughout hard to reach rural areas.

3.3.3 Insufficient Financial and Technical Capabilities and Shortage of Multilateral Funds

Even though the cost of producing foams using methylene chloride or butane is lower than using CFC 11 and CFC 12, most small- and medium-sized foam manufacturers did not switch to these non-ozone-depleting substances. As noted above, production costs are lower using methylene chloride or butane, but required safety measures using this technology involve offsetting costs and risks. This is one barrier to change. Another barrier to making this technology change was enterprises' limited resources. Because staff in small foam

enterprises have modest technical skills, they often focus on routine operations required to meet production targets, and they avoid undertaking new activities such as ozone-depleting substance phaseout projects. Moreover, some of these firms are barely profitable, and they resist changing existing operation methods and technologies out of fear that they would be driven out of business. Some of these enterprises adopted a "wait and watch" policy, hoping to identify a workable non-ozone-depleting substance technology that involves minimal risk.¹⁰

Small- and medium-sized foam manufacturing enterprises also have problems in accessing Multilateral Funds. For example, the Multilateral Fund requires a proposed project to be cost effective i.e., the project must attain a given level of ozone-depleting substance reduction at minimum cost. Small- and medium-sized foam enterprises have difficulties meeting this criterion because the cost per unit of ozone-depleting substance reduction is high compared to unit costs of ozone-depleting substance reduction at a large foam company. In addition, small foam manufacturers are often incapable of preparing project proposals in the manner and format prescribed by the Multilateral Fund. Also, small firms typically have problems coming up with funds to cover costs not defined as incremental by the Multilateral Fund Executive Committee. Foam manufacturers that have received Multilateral Fund grants are relatively large, with production capacities of more than 1000 tons annually. None of the more than 1,000 small firms in the foams sector have received Multilateral Fund assistance.

Some foam manufacturers believe the lack of adequate money in the multilateral fund has slowed the shift to non-CFC technologies in their sector. During the period from 1991 to 1996, companies manufacturing foams received only 23% of the Multilateral Fund money targeted for foams in China's Country Program.¹¹ A number of firms that submitted applications to Multilateral Fund received no support because of the shortage of money in the fund. Some enterprises that received Multilateral Fund money to change to methylene chloride or butane technologies indicated that the Multilateral Fund Executive Committee preferred to support these technologies because of their low cost. These enterprises preferred other technologies such as those involving CO₂, because they would be free of safety problems and the foams produced have a higher quality.

As in the case of refrigerator companies, foam manufacturers have been stymied by the Multilateral Fund's complex application procedures. Of the 54 investment projects funded by the Multilateral Fund in the foams sector, only three had been completed by the end of 1996. Managers at each of the seven foam manufacturing companies we visited complained about administrative hurdles and technology transfer problems, including the Multilateral Fund Executive Committee's willingness to approve the transfer of obsolete CFC-reduction methods rather than paying for up-to-date technologies. The managers also noted difficulties in finding appropriate technology suppliers. However, based on our interviews, technology transfer presented fewer difficulties in the foams sector than it did in the household refrigeration sector. This may be because the technology used by the foams sector is relatively simple.

4 COMPARISON OF PERFORMANCE IN THE TWO SECTORS

The household refrigeration sector has outperformed the foams sector in compliance with the Protocol. By the end of 1997, over two-thirds of the production lines for household refrigerators had been changed to non-CFC technologies or were in process of changing, while about 95% of foam manufacturing enterprises (including new enterprises) still used CFCs. What factors contribute to this difference in performance?

4.1 Demand Patterns and International Trade

Preferences of consumers in European markets along with requirements from international trading partners motivated the initial move to reduced-ODS technologies in China's household refrigeration sector. These factors, plus the influence of multinational corporations that began manufacturing refrigerators in China pushed Chinese refrigerator firms to cut their use of CFCs. Even Chinese manufacturers that sold only in China's domestic market for refrigerators and freezers felt they had to adopt reduced-CFC technologies to compete. Corresponding market pressures for change did not exist in the foams sector: the influence of international trade and multinational corporations in the foam sector is minimal, and consumers have not expressed a preference for foams manufactured without CFCs. The experience of refrigerator manufacturers supports the view that international trade can have beneficial environmental consequences through its effects on the technological characteristics of production, and that multinational corporations can be effective in transforming technology when they begin manufacturing in developing countries.¹²

4.2 Industrial Structure

The household refrigeration sector contains only about forty firms; most of them are large and a notable fraction are foreign or joint-venture enterprises. Because of the small numbers involved, it is easy for enterprises and industrial ministries to exchange information. In addition, refrigerator manufacturers generally employ imported, post-1980 technologies, and their strong financial and technical capabilities allow them to either implement technological changes on their own or satisfy Multilateral Fund funding criteria and receive Multilateral Fund grants.

In comparison, the foams sector includes over 1,000 small-sized enterprises, many of which are small Township and Village Industrial Enterprises scattered in rural areas. These enterprises have little access to information about the Montreal Protocol from industrial ministries, and they lack the technical skills and financial resources to do research, adopt new technologies on their own, and compete for Multilateral Funds.

4.3 Roles of the Montreal Protocol

One thing manufacturers of foams and household refrigerators have in common is the Multilateral Fund. For firms in the foams sector, the Multilateral Fund provides a key incentive for adopting non-CFC technologies. In contrast, refrigerator manufacturers are more motivated to change by market forces. They take advantage of Multilateral Fund grants, but the availability of grants is not the key stimulus for adopting cleaner technologies. Indeed, because of difficulties some household refrigerator companies have had with Multilateral Fund application procedures and problems in negotiating with technology suppliers, several of these companies question whether the Multilateral Fund has speeded the adoption of cleaner technologies within their sector. Managers within the foams sector have also complained about the Multilateral Fund, particularly the complex application procedures and the shortage of money. However, the importance of the Multilateral Fund grants in motivating change in the foams sector is notable, since many firms in that sector see no other reason to switch to non-CFC technologies.

The Montreal Protocol's influence in China extends the Multilateral Fund. The CFC phaseout requirements in the Montreal Protocol caused some European nations to impose restrictions on refrigerators manufactured using CFCs. This requirement, which was manifested in the context of environmental labeling restrictions, was a major force in causing

some Chinese refrigerator manufacturers to stop using CFCs. An analogous effect in creating markets for non-CFC products did not take place in the foams sector. Arguably, the overall influence of the Montreal Protocol in promoting cleaner technologies has been weak because China has until 2010 to eliminate CFCs. Since firms have over a decade to meet the 2010 target, the pressure caused by the phaseout requirement has not been intense.

5 POLICY IMPLICATIONS

Because our analysis includes only two sectors it does not allow us to reach general conclusions. However, our results suggest some changes that could be made to enhance the compliance with the Montreal Protocol. One such change concerns the allocation of Multilateral Funds. In China, refrigerator manufacturers that were motivated to adopt cleaner technologies in response to consumer demand received a notable fraction of Multilateral Fund money distributed in China. In contrast, small and medium-sized foams manufacturers, which see little financial advantage in eliminating use of CFCs, received relatively little Multilateral Fund money. A change in the allocation of Multilateral Fund money to favor firms that are not otherwise motivated to adopt reduced-CFC technologies might prove more effective. A simplification of Multilateral Fund application and disbursement procedures would also enhance the fund's influence. Another way is to augment resources used to provide information to Township and Village Industrial Enterprises that use CFCs. Experience with the foams sector demonstrates that many Township and Village Industrial Enterprises were completely unaware of the Montreal Protocol, and thus the Multilateral Fund grants could not possibly influence their behavior.

Finally, our results for the household refrigeration sector highlight the importance of the media as an instrument for influencing consumer demand for environmentally friendly products. The results also show how quickly enterprises can move to cut their use of ozone-depleting substances if the market signals are right. The environmental awareness of most Chinese citizens is quite low, but the government is well positioned to change this by using the media to promote environmentally friendly products and enhance the public's understanding of environmental problems. In the end, consumer demand may prove to be the key force in moving Chinese enterprises to comply with the Montreal Protocol.

REFERENCES

- 1 The basis for the Multilateral Fund is contained in Article 10 of the London Amendments to the 1987 Montreal Protocol. These amendments were developed at the Second Meeting of the Parties to the Montreal Protocol held in London in June 1990. The Multilateral Fund Executive Committee has developed categories of costs defined as incremental in "Indicative List of Categories of Incremental Costs." For more information about the Montreal Protocol and the Multilateral Fund, see Benedick, R. E. 1998 *Ozone Diplomacy: New Direction in Safeguarding the Planet*, Enlarged edition, Cambridge MA: Harvard University Press; Multilateral Fund Secretariat, 1997, *Multilateral Fund for the Implementation of the Montreal Protocol: Policies, Procedures, Guidelines and Criteria*, Nairobi: UNEP.
- 2 A chemical substance's effect on the ozone layer is measured by its ozone depleting potential, a numerical estimate of the total quantity of ozone destroyed by a given mass of the substance over its entire atmospheric life. ODP is the

ozone depleting effect of 1 kg of a chemical relative to 1 kg of CFC 11. For example, halon 1211 has an ODP of 3 because it is three times more effective in destroying the ozone layer than CFC 11.

- 3 Information about the household refrigeration sector is collected from personal interviews and referred to the following materials. Chinese Household Electrical Appliance Association (CHEAA), 1995, ODS Reduction Strategies for Household Refrigeration Sector (*Bingxiang hangye Chouyang haosun wuzhi xiaojian zhanlue*), Beijing: CHEAA; Office of Household Electrical Appliance Industry (OHEAI), 1997, Draft Progress Report on ODS Reduction in the Household Refrigeration Sector (*bingxiang hangye chouyang haosun wuzhi xiaojian jinzhan baogao*). Beijing: OHEAI; National Environmental Protection Agency (NEPA), 1993, Country Program for the Phaseout of ODS under the Montreal Protocol (*zhongguo xiaojian shouyang haosun wuzhi guojia fangan*). Beijing: NEPA; and NEPA, 1998, Update of China's Country Program for Ozone Depleting Substances Phaseout (draft), Beijing: NEPA.
- 4 French, H. F. 1997. "Learning from the Ozone Experience." In Brown, L. R., Flavin, C. and French, H. *State of the World*. New York: W.W. Norton & Company.
- 5 In March 1998, as part of a major restructuring of government agencies, NEPA was upgraded to a full ministry and renamed as the State Environmental Protection Administration (SEPA). For events that occurred before March 1998, we use NEPA instead of SEPA.
- 6 Xia, Q. and Liu, Z. 1995. *Environmental Labeling (Huanjing Biaozhi)*. Beijing: China Environmental Science Press. Xia, Q. and Zhao, J. 1999. "Environmental Labeling Program in China." *Environmental Impact Assessment Review* (forthcoming).
- 7 Some analysts argued that the Montreal Protocol's restrictions on a China's ability to export goods produced using CFCs would not influence its refrigeration sector (e.g., Getz, K. A. 1995. "Implementing Multilateral Regulation—A Preliminary Theory and Illustration." *Business & Society*. 34(3): 280-316). According to this view, China would continue to use CFCs in refrigerators because China's enterprises were primarily interested in providing a means of food preservation for China's population, not in exporting refrigerators. As demonstrated below, this argument is not supported by the facts.
- 8 In China, enterprises producing PU foam panels for use in household refrigerators and freezers are categorized as part of the household refrigeration sector, not the foams sector. Other foam producers include firms that manufacture molded expandable polystyrene (EPS) and polyvinyl chloride (PVC) foam. However the production of EPS and PVC foams does not involve use of substances controlled by the Montreal Protocol. Information about the foam industry is collected from personal interviews and from the following materials: Plastic Industry Office (PIO). 1997. Draft Progress Report on ODS Reduction in the Foams Sector (*paomo hangye chouyang haosun wuzhi xiaojian jinzhan baogao*). Beijing: PIO; and NEPA, 1998, see Endnote 3.

- 9 In general, township and village industrial enterprises (TVIEs) are located in rural areas, and the majority of their investment funds come from rural collective organizations or farmers. Currently TVIEs are located in almost every town and village of the country and are involved in most sectors of the national economy. They are often supervised by the township governments and village committees that own them.
- 10 Hu, S. 1995. ODS Reduction in China's Small and Medium Enterprises, UNEP Round Table Discussion on Knowledge Sharing Networks for ODS Phaseout. Washington D.C.
- 11 Center for Environmental Sciences. 1998. Review of the Implementation of China's Country Program for ODS Phaseout (draft). Beijing: Beijing University.
- 12 Johnstone, N. 1997. "Globalization, Technology, and Environment." In *Globalization and Environment—preliminary perspective*. Paris: OECD.