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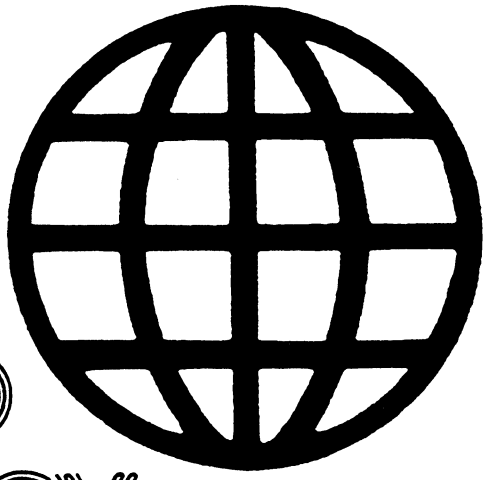

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PREFACE

The *Industry, Trade, and Technology Review* (*ITTR*) is a quarterly staff publication of the Office of Industries, U.S. International Trade Commission. The opinions and conclusions it contains are those of the authors and do not necessarily reflect the views of the Commission or of any individual Commissioner. The report is intended to provide analysis of important issues and insights into the global position of U.S. industries, the technological competitiveness of the United States, and implications of trade and policy developments.

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FINANCIAL SERVICES: AN OVERVIEW OF THE WORLD TRADE ORGANIZATION'S NEGOTIATIONS

The Uruguay Round agreements providing for the establishment of the World Trade Organization (WTO) contain the General Agreement on Trade in Services (GATS), which is the first multilateral, legally enforceable agreement covering trade and investment in the services sector.[1] The GATS includes financial services, which covers banking, insurance, securities, and diversified financial services. Each of these sectors have a great influence on international trade and investment.[2] However, responding to observations by some nations that the financial services commitments offered by some countries were unsatisfactory, ministers at the WTO's formal creation in Marrakesh in April 1994, agreed to extend these financial services negotiations until June 30, 1995.[3]

In negotiations ending in June 1995, the United States concluded that the overall financial services commitments undertaken by other countries were still insufficient. It therefore decided it could not commit to keep its financial services market open on an unconditional most-favored-nation (MFN) basis.[4] Although the United States is a full member of the WTO, it registered a broad MFN exemption in its final WTO financial services commitments that preserves a right to differentiate among foreign financial services providers, on a reciprocal basis, in terms of permitting them to establish a presence in the U.S. market, expand current operations, or conduct new activities. In large part, this action by the United States resulted in an interim, rather than permanent, WTO agreement for financial services.[5]

This article discusses the framework and objectives of the negotiations, explains the regional differences among some of the negotiation's principal participants, and outlines some of the possible benefits and costs that may accrue to the United States as a consequence of its stance.[6]

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[1] Uruguay Round Agreements Act (URAA) Statement of Administrative Action (SAA), published in H. Doc. 103-316, 103d Cong., 2d Session, 1994. The Statement of Administrative Action was submitted to the Congress on September 27, 1994, in compliance with section 1103 of the Omnibus Trade and Competitiveness Act of 1988, and accompanied the implementing bill for the Agreement Establishing the World Trade Organization and the agreements annexed to that Agreement (the Uruguay Round Agreements). In enacting the URAA, Congress approved the Statement of Administrative Action (see URAA, sec. 101(a)(2), approved Dec. 8, 1994; Pub. Law 103-465, 108 Stat. 4809; hereafter *URAA documents*). SAA, p. 297; URAA documents, p. 966.

[2] For example, the European Commission has reportedly estimated international financial business as $40 trillion of world banking assets and deposits, $2 trillion of world insurance premiums, $10 trillion of world stock-market capitalization and $10 trillion of the market value of listed bonds. *Journal of Commerce*, July 27, 1995, p.1 Also, *The Financial Times*, July 27, 1995, p. 5.

[3] Annex 2, SAA, p. 308-309; URAA documents, pp. 977-978.

[4] The MFN principle states that whatever trade liberalizing commitments a nation makes to one trading partner, it must also make to all WTO members.

[5] See, for example, U.S. Department of State telegrams, message reference numbers 5108, dated June 30, 1995, and 5812, dated July 26, 1995, prepared by the U.S. Mission, Geneva. Also Department of State telegrams, message reference numbers 7009 dated July 3, 1995, 7117 dated July 7, 1995, 7573 dated July 19, 1995, and 7726 dated July 20, 1995, all prepared by the USEU, Brussels. Additionally, *Wall Street Journal*, July 25, 1995, p.1. *Financial Times*, July 27, 1995, p. 5. *The Economist*, July 15, 1995, p. 58. *Journal of Commerce*, July 27, 1995, p.1.

[6] Throughout the financial services negotiations, the Office of the U.S Trade Representative (USTR) had primary responsibility for negotiating the insurance sector, while the U.S. Department of the Treasury had primary responsibility for the banking and securities sectors.

Financial Services

The Negotiation's Goal

The aim of these negotiations[7] was to create a rule-based global system for financial services, which could be enforced by impartial WTO expert panels.[8] The negotiations would define precisely whether, for example, a country that counts each installed automatic teller machine as a branch bank would subject those installations to foreign-investment limitations, and whether the United States would grant to foreign banks the newly created rights by 1994 legislation to offer banking services across U.S. State lines (interstate banking). Moreover, once in place, the system would not permit countries to withdraw commitments to provide specified levels of market access and national treatment[9] to foreign investors without paying compensation.[10] Thus financial institutions around the world would have a written, enforceable set of rules for international trade in financial services, and binding commitments to adhere to those rules, giving them a level of certainty and predictability in planning for foreign investment and operations that they never had before.

The Vehicles and Process to Accomplish the Task

The Uruguay Round's GATS agreement excludes no service sector; all sectors are included in the broad GATS "Framework" agreement signed in Marrakesh in April 1994, that took effect on January 1, 1995. However, the real vehicle that defines what a country offers to its trading partners is found in each individual country's "schedule of specific commitments." These schedules delineate the particular service sectors, financial or otherwise,[11] in which each nation bestows at least limited market access and national treatment commitments to its trading partners. The "theology" and overriding principle of the Geneva talks, under the new WTO as with the former General Agreement on Tariffs and Trade (GATT), is that any offer for liberalized trade a nation makes to one country is also made to all fellow WTO members (MFN treatment). This principle holds true for negotiations on tariffs, agriculture, service sectors, intellectual property, and investment.

It was the negotiation of these country schedules, done on a bilateral "request/offer" basis, that contributed to the protracted Uruguay Round negotiations. More than 100 nations made individual requests for liberalized trade to every other partner, which then decided if the request could be met on an MFN basis.[12] For example, in

[7] SAA, p. 297; URAA documents, p. 966.

[8] It is this enforcement mechanism that critically differentiates the General Agreement on Trade in Services (GATS/WTO) from the old GATT system. Under the new GATS, once a WTO panel has reached a decision, only a unanimous vote of the WTO's Council for Trade in Services can overturn it. There is also a modest formal appellate procedure, which is aimed at insuring that panel decisions form, over time, a cohesive set of rulings. Additionally, financial services panels must include members with expertise in financial matters.

[9] In according national treatment to foreign firms, countries confer on these firms the same rights and obligations conferred on domestic firms.

[10] "Progressive liberalization" could take place at any time; countries need not await formal negotiations to lift existing restrictions or liberalize their financial services market.

[11] The GATS/WTO exercise has, for example, committed individual countries to various trade liberalizing commitments in service sectors ranging from legal services (what services can foreign lawyers perform in your country), to enhanced telecommunications (not basic telephony), to education services, to tourism services, to some business services. Countries scheduled commitments on industries of their own choosing.

[12] In addition, the four "quad" nations of the United States, the European Union, Japan and Canada would meet often to share information and consolidate their own schedules, in order to keep the process moving forward.

the GATS negotiations, the United States requested that its major trading partners make commitments on market access and national treatment in as many of the 1,240[13] services "cells" as possible. Although negotiated bilaterally, the results were applied on a multilateral basis. Thus, for example, once a nation committed to allow all U.S. banking operations on its territory to offer foreign-exchange services, that country would have to permit all other WTO members' banks the same privilege.

In addition to listing the service sectors where it was making offers to liberalize trade, each country's schedule of commitments also had to enumerate for each service sector any restrictions it placed on both market access and national treatment[14] according to each of the four methods of supplying a service (figure 1):

- Cross-border: services supplied from the territory of one WTO member to the territory of another (e.g., an insurance company in country A sells policies to consumers in country B).

- Consumption abroad: services consumed in the territory of one member by the consumers of another (e.g., a tourism company in country A supplies a service to country B consumers traveling in country A).

- Commercial presence: services supplied through any type of business or professional establishment of one member in the territory of another, (e.g., a bank headquartered in country A supplies services through its branch established in country B).

- Presence of natural persons: services supplied by nationals of one member in the territory of another (e.g., a U.S. engineer helps build a dam in Latin America).

At the time of the formal ending of the Uruguay Round in Marrakech (April 1994), the financial services schedules of a number of key countries were not judged adequate by several nations.[15] In the view of some, not enough countries were offering sufficiently liberal commitments in financial services to enable those with already fairly open financial services markets, such as the United States, to offer broad access to their markets on an unconditional MFN basis.[16] Importantly, in the last months of the Uruguay Round Negotiations in 1993, the U.S. proposed a "two-tier" schedule of commitments in banking and securities (but not in the area of insurance), which would have institutionalized within the WTO differing treatment for firms from differing countries in financial services, depending on the treatment U.S. firms received in each

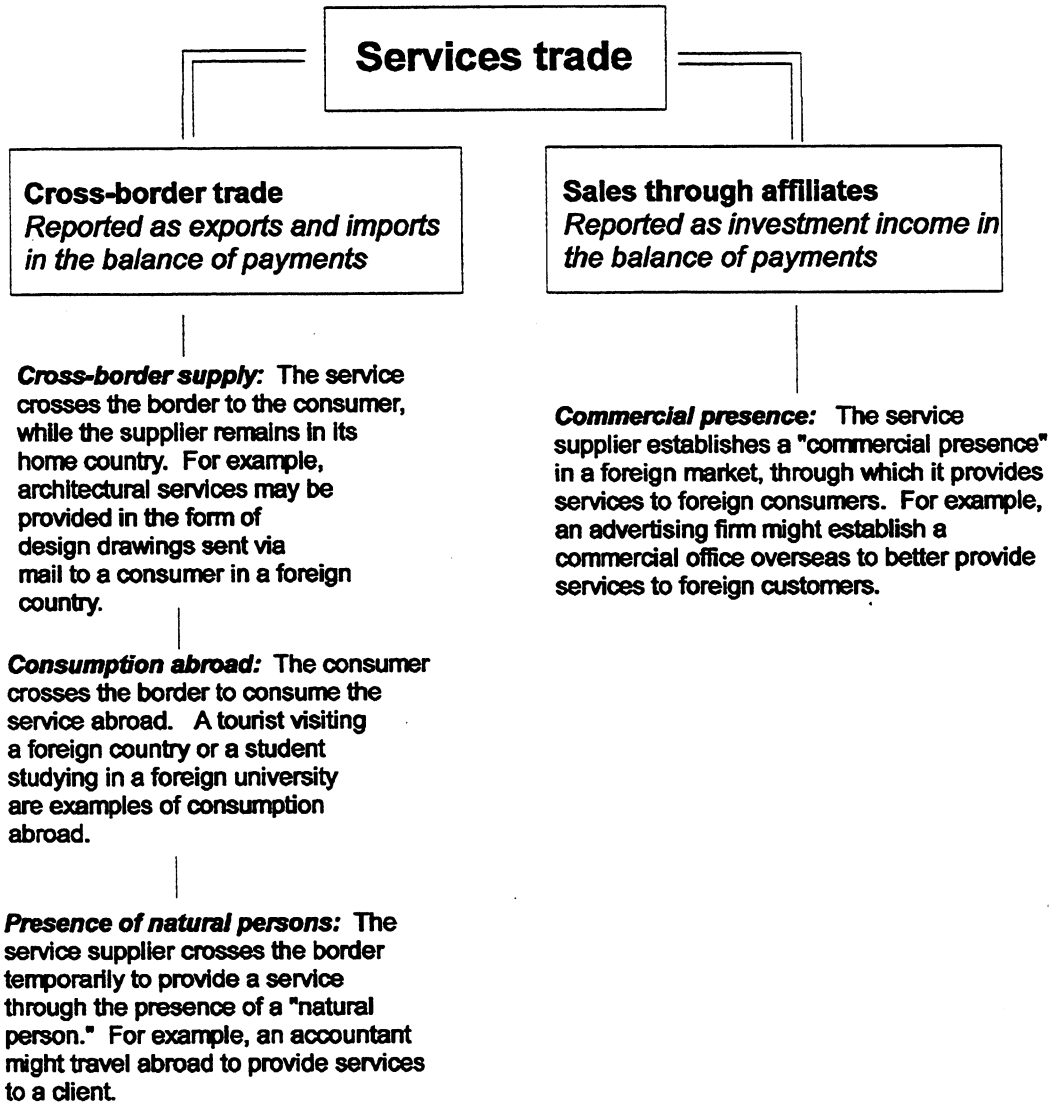
[13] The GATT Secretariat furnished a Services Sectoral Classification List, which included 155 service industries. Each of these had 4 possible methods of delivery (specified in text), with each "mode" subject to both market access and national treatment, thus equating to 1,240 services "cells" on which commitments were requested.

[14] Market access determines the conditions under which companies may enter a given market.

[15] Similar conclusions were reached with respect to other services areas, including basic telecommunications, maritime services, and the movement of natural persons.

[16] SAA, p. 309; URAA documents, p. 978.

Figure 1
Modes of supply for international delivery of services



Source: Compiled by the staff of the U.S. International Trade Commission.

country.[17] This approach was rejected by U.S. trading partners on the grounds that it would destroy the MFN principle.[18] Thus, the final U.S. offer had only one tier, offering all trading partners the same contract.[19] In banking and securities, the United States took a broad MFN exemption: existing banking and securities firms had guaranteed protection of existing investments, but liberalization commitments were reserved on a reciprocal basis for new access, additional expansion, or new activities.[20] In insurance, no MFN exemption was taken.[21] In any case, given the prominence and importance of the financial sector to international trade, the contracting parties decided in Marrakech to extend the financial services negotiations for 6 months after the inauguration of the WTO, i.e., until June 30, 1995, in an attempt to expand and improve trade liberalizing commitments.

Regional Development

Europe, Japan, Korea and Other OECD States

The European Union (EU) and the United States had largely negotiated mutually acceptable financial service offers by the end of the Uruguay Round in December 1993. The EU's single-market initiative of the late 1980s and early 1990s had brought very considerable liberalization to the EU financial markets. A GATS/WTO agreement on standstill measures, locking in both sides' existing treatment of each other's financial sectors, but with future opportunities for continued liberalization, was broadly acceptable.[22] The same was also true for nearly all the OECD member states.

Japan was an exception. Before the pause in financial services negotiations in December 1993, the Government of Japan was encouraged to clarify its intentions in regard to the liberalization and deregulation of its financial services market. Japan's GATS/WTO schedule of commitments

[17] Enforcement of such a provision could require modification of current U.S. law. There is little scope in current law that permits U.S. Federal regulators to treat foreign firms differently from domestic ones, with the exception of the Federal Reserve Board's power to have first approval powers over new bank applicants from a country not already having banks licensed in the United States. Some contend that the retaliatory provisions of Section 301 of the Trade Act could be used to enforce such measures, but it is unclear how such measures would be implemented. Future legislation could, of course, provide for reciprocity provisions. However, provisions for enforcement of reciprocity stipulations for insurance are even more problematic, given that insurance is regulated by the 50 U.S. States.

[18] See U.S. Department of State telegram, "Informal Group on Financial Services," message No. 08808, prepared by the U.S. Mission, Geneva, Oct. 14, 1994. The MFN principle is strongly held by many U.S. trading partners because they see it as the only practical way to move forward with trade liberalization in many countries; they also see MFN as the way to benefit from liberalization achieved with many countries. Also, not all countries are able to equally liberalize trade at the same time, so some must lead and encourage others to follow. Precedents include the old GATTS and OECD accessions. In both cases a small number of nations committed to a given course of action on an MFN basis, but waited for lengthy periods for a wider consensus to emerge. The U.S. did not formally abandon the two-tier concept until October 1994.

[19] World Trade Organization, General Agreement on Trade in Services, The United States of America: Schedule of Specific Commitments (GATS/SC/90), April 15, 1994, pp. 54 to 69.

[20] The MFN exemption in banking and securities was for 18 months, to be suspended from January-June, 1995, during the extended negotiations. See, for example, USTR, "Press conference by USTR Mickey Kantor and Sir Leon

(continued...)

[20] (...continued)
Brittan in Geneva, Switzerland, December 14, 1993."

[21] Ibid.

[22] See, for example, U.S. Department of State telegram, message reference No. 4362, prepared by the U.S. Mission, Geneva. The liberalized EU market became even more attractive with the accession of Sweden, Finland, and Austria in January 1995, which in the course of the GATS negotiations had significantly improved conditions of access and national treatment in their markets.

included relatively few significant trade limitations[23], but the United States thought that additional commitments were needed to accommodate deregulation and liberalization of the Japanese financial services sector.[24] From the U.S. viewpoint, significant obstacles to liberalization included the *keiretsu* system of interlocking company directorates, and an informal system of regulatory practices whereby "administrative advice," perceived as a government mandate, was provided to Japanese firms.[25] Japan's financial markets had grown exponentially in 20 years, but foreign penetration of financial markets had remained virtually unchanged during the period.[26] The United States and Japan agreed to a series of "Framework" bilateral negotiations to address deregulation and other issues in mid-1993.[27] Separate negotiations for both insurance and other financial services (including investment, pensions, and banking) opened in October 1993. These broke down in February 1994, with insurance bilateral talks restarting in April and concluding on October 11, 1994. Banking/securities/pensions services talks resumed later and finally concluded on February 13, 1995.[28] Both Japan and the United States announced that the provisions of both these financial services agreements would be offered to all WTO members on an MFN basis.[29]

In addition, Korea's GATS/WTO financial services schedule of commitments was viewed by many as having several of the same problems as Japan's schedule.[30] There were, for example, deregulation problems and economic needs tests.[31] Korea's WTO financial services schedule of commitments remained contentious to the end; the United States and other developed nations negotiated extensively with Korea at many points.[32] Korea's final offer of July 28, 1995,[33] still contains economic needs tests and other broad restrictions, including bank funding and capital

[23] The GATS permits governments wide latitude in regulatory procedures and methods, as long as market access and national treatment are maintained.

[24] See, for example, the testimony of Ambassador Charlene Barshefsky, Deputy USTR, "Report on the United States-Japan Framework for a New Economic Partnership," House Committee on Foreign Affairs, Subcommittees on Economic Policy and Trade and Asia and the Pacific, July 21, 1993; "Status of the U.S.-Japan Economic Framework", same subcommittee, October 5, 1993; and "Status of the U.S. - Japan Economic Framework", before the Senate Finance Committee, Subcommittee on International Trade, November 8, 1993.

[25] Ibid.

[26] See, for example, *The Economist*, Sept. 30, 1995, p. 83, and *The Far Eastern Economic Review*, Sept. 28, 1995, p. 48. Also, USITC staff conversations with financial services executives in the United States, Japan, and Europe, Oct. 1993-Sept. 1995.

[27] See the testimony of Ambassador Charlene Barshefsky, Deputy USTR, "Report on the United Sates-Japan Framework for a New Economic Partnership," House Committee on Foreign Affairs, Subcommittees on Economic Policy and Trade and Asia and the Pacific, July 21, 1993.

[28] See U.S. Department of the Treasury, Office of Public Affairs, "Statement of Acting Treasury Secretary Frank Newman: Financial Services Agreement with Japan," January 10, 1995. Additionally, press release of Securities Industry Association's President Marc E. Lackritz, January 10, 1995.

[29] U.S. Department of State telegrams, message reference Numbers 611, dated Jan. 17, 1995; 2139, dated Mar. 14, 1995; and 3021, dated Apr. 12, 1995, prepared by U.S. Mission, Geneva.

[30] *Business Korea*, vol. 11, No. 7, pp. 25-26.

[31] Economic needs tests assess the impact of new market entrants on the indigenous industry. Such assessments may result in a negative determination if market entry is considered likely to have a detrimental effect on market structure, profitability, population density, geographic distribution, and job creation.

[32] See, for example, U.S. Department of State telegram, "GATS Financial Services Bilaterals," message reference No. 04691, prepared by U.S. Mission, Geneva, June 16, 1995.

[33] The WTO Council on Trade in Services extended the time period for the filing of final schedules to July 28, 1995. This action was taken on June 30, in response to the announcement that the United States would retain and extend its broad MFN exemptions in financial services (to include insurance as well as banking and securities).

market issues.[34]

Association of Southeast Asian Nations (ASEAN)

The ASEAN member states posed many of the thorniest problems to the financial services negotiations. Although their financial services sectors are relatively immature and small compared to those of the EU, Japan, and Korea, most ASEAN countries had experienced very high economic growth rates throughout much of the 1980s and 1990s. Broadly, the U.S. financial services industry viewed these nations as the places where they could expand most immediately and profitably since the U.S. financial sector had a comparative advantage in these markets.[35]

Some ASEAN member states were, however, still striving for consensus in their philosophical thinking: many were still caught between arguments for strengthening their own domestic financial services industries, versus those for encouraging direct foreign investment that would promote competition and draw in capital, expertise, training, and technology. The crux of the dilemma was whether to let market forces, rather than governments, strengthen and streamline their industries. With respect to goods, the decision had broadly already been made: let global markets and foreign investment play a large role. But for financial services, this decisive philosophical argument was still being debated.

By January 1995, all ASEAN governments were leaning towards gradual liberalization of financial services but arguing that the task could not be accomplished immediately.[36] For example, several ASEAN governments had increased their offers to permit foreigners to control 49-percent equity shares for investments in financial institutions. They asserted, however, that they could go no further immediately due to domestic political sensitivities. If foreign financial institutions insisted on majority control in order to protect their investment, they could easily find an absolutely reliable domestic investor to buy an additional 1.1 percent of a given enterprise.[37] Industry observers in developed nations generally replied that although 49-percent equity was certainly better than 30-percent, the point was to let market forces, rather than governments, decide the levels of foreign investment: some investors might agree to a 30 percent limitation whereas others would insist upon a 100 percent equity holding.[38]

There were other equally thorny problems. More than one ASEAN state had certain foreign investment limitations written into law or regulation, but also had implemented a more liberal policy. The result was a formal GATS/WTO offer that guaranteed 49-percent equity holdings for foreign financial services investors, when the reality was that several such investors already held perhaps as much as 80-percent equity investment. Some ASEAN nations solved this problem by formally "grandfathering" existing firms' current equity limits into their

[34] U.S. Department of State telegram, reference No. 4691, prepared by U.S. Mission, Geneva, June 16, 1995. Korea is also a candidate for OECD accession.

[35] USITC staff conversations with financial services executives, January-June 1995.

[36] In one nation's case, the year scheduled for several liberalizations was as far out as 2020. See, for example, U.S. Department of State telegrams, reference numbers 10352, 10358, 10361, and 10363, all dated Dec. 5, 1994; and 10893 dated Dec. 21, 1994, all prepared by U.S. Mission, Geneva. Also, *Journal of Commerce*, "Pacific Trade Officials to Shed 'Defensive' Posture," September 15, 1995.

[37] U.S. Department of State telegram, message reference No. 3022, prepared by the U.S. Mission, Geneva, Apr. 12, 1995.

[38] USITC staff conversations with financial services executives, 1992-July, 1995.

WTO schedule of commitments (and limiting new entrants to 49-percent equity limits), but others were unwilling to do this. Also, many ASEAN nations retained economic needs tests for new market entrants, including foreign direct investors. These ASEAN governments insisted they already had too many banks, insurance companies, and securities houses and, in some cases, too many foreign participants.[39] They maintained that too much competition could threaten the profitability and growth of their domestic institutions and thus disrupt the overall market.[40]

By July 1995[41], several ASEAN nations demonstrated a real willingness to make meaningful, if limited, financial services commitments, including in some cases a willingness to grandfather existing foreign investment shares.[42] However, in one case, that of Malaysia, a major problem remained with respect to forced disinvestment regulations (acquired rights).[43] Malaysia has long attempted to promote improved economic life for its indigenous Malay (Bumiputra) majority population by reserving portions of economic investment to that section of the population (i.e., insisting on allowing Bumiputra investment in various enterprises, even if at concessionary rates). The natural corollary was that it thereby restricted the investment of other, non-Bumiputra, domestic and international investors. But in the insurance sector, many foreign firms had held more than majority equity interests for decades, largely because they had entered the market early and had more-or-less created the insurance business in Malaysia. Over many years, the Malaysian Government had forced several of these foreign companies to divest their holdings to a 30-percent majority ownership.[44]

In June 1995, Malaysia submitted a newly revised conditional GATS/WTO schedule of commitments for insurance. Although it contained some new liberalization commitments, it also contained a regressive provision on acquired rights that was to have unfortunate side effects on the overall negotiation.[45] The new Malaysian offer raised the equity limits of foreign insurance investors from 30- to 49-percent equity investment, but also declared that any existing insurance investor who currently retained more than a 49 percent equity share, and who did not divest to that level by 1998, would be forced to divest to the old 30 percent level.[46]

The United States immediately indicated to Malaysia that this tactic was inconsistent with the

[39] U.S. Department of State telegram, message reference No 3022, prepared by the U.S. Mission, Geneva, Apr. 12, 1995.

[40] Ibid.

[41] The WTO Council on Trade in Services extended the time period for the filing of final schedules to July 28, 1995. This action was taken on June 30, in response to the announcement that the United States would retain and extend (to include insurance as well as banking and securities) its broader MFN exemption in financial services.

[42] See revised financial services schedules for the ASEAN member states. World Trade Organization, General Agreement on Trade in Services (GATS), Indonesia: Schedule of Specific Commitments (GATS/SC/43/Suppl.1); Malaysia: Schedule of Specific Commitments, (GATS/SC/52/Suppl. 1); Philippines: Schedule of Specific Commitments, (GATS/SC/70/Suppl. 1); Singapore: Schedule of Specific Commitments, (GATS/SC/76/Suppl. 1); and Thailand: Schedule of Specific Commitments, (GATS/SC/85/Suppl. 1), all dated Jul. 28, 1995.

[43] U.S. Department of State telegram, "GATS Financial Services Bilaterals," message reference No. 04649, prepared by U.S. Mission, Geneva, June 16, 1995.

[44] Ibid.

[45] Ibid.

[46] World Trade Organization, General Agreement on Trade in Services, Malaysia: Schedule of Specific Commitments (GATS/SC/52/Suppl.1), Jul. 28, 1995, p. 5.

core purpose of the GATS.[47] Rather than promoting trade liberalization, the United States argued, Malaysia was attempting to use a multilateral trade agreement to formally enshrine a regressive action in an enforceable document. In any case, Malaysia refused to reconsider its position, and the disinvestment provision remained in the final Malaysian schedule of July 28, 1995.

Latin America

By the end of the extended financial services negotiations in July 1995, several of the Latin America region's schedules of commitments were considered good or significantly improved in terms of liberalizing foreign investment in financial services.[48] Given the history of cycles of nationalization and privatization in Latin America and elsewhere, many negotiators, including many from Latin America, thought that one of the principal benefits of the financial services negotiations was to lock-in liberalizations on a multilateral basis.

The largest remaining Latin concern by the end of the negotiation was Brazil, which has constitutional and legal restrictions on foreign investment in the financial sector. Although by May 1995 it was notable that the newly elected government was attempting to liberalize Brazil's financial services sector and to make a meaningful GATS/WTO commitment, it soon became clear that the political constraints were too great to achieve this by June 30, which was the scheduled end of the negotiation.[49] Significant formal liberalization commitments by Brazil would have to await constitutional and legal reform, which by its nature could not be promised by a date certain. Given Brazil's size, this placed a significant damper on the late stage of the negotiations.[50]

India, Egypt, Pakistan

All three countries, with very large populations, represent major emerging financial services markets. All three, however, are generally in the early stages of financial liberalization, starting from a base that until recently was characterized by state-owned banks and insurance companies and only limited private-sector participation. Although some degree of private investment is now allowed in all these countries, the insurance market of India remains a state-owned monopoly.[51] India's inability to offer a commitment to liberalize insurance was a crucial disappointment.[52]

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[47] U.S. Department of State telegram, message reference No. 4649, prepared by U.S. Mission, Geneva, June 16, 1995.

[48] See, for example, World Trade Organization, General Agreement on Trade in Services, Schedules of Specific Commitments for Argentina (GATS/SC/04), dated April 15, 1994; Chile (GATS/SC18/Suppl.1); Columbia (GATS/SC/20/Suppl.1); and Venezuela (GATS/SC/92/Suppl.1), all dated July 28, 1995.

[49] See, for example, U.S. Department of State telegrams, message numbers 10362 dated Dec. 5, 1994, 3022 dated Apr. 12, 1995, and 4365 dated June 8, 1995, all prepared by the U.S. Mission, Geneva. Although the deadline for filing final schedules was extended to July 28, this extra time was not a period for continued negotiations, and would not have provided the time Brazil needed in any case.

[50] Ibid.

[51] In November 1993, a Government of India-appointed study commission (Moholtra) recommended that private investment and foreign participation in the insurance sector be permitted. This proposal is highly politically sensitive, due principally to the large numbers of people employed in this state sector who fear loss of their jobs. The current government has not yet found it possible to introduce legislation that would permit private investment in India's insurance market, although the national budget of March 1995 moved to create an insurance regulatory agency (previously unneeded due to the nationalized system).

[52] U.S. Department of State telegrams, message reference numbers 4362, dated June 8, 1995, and 4691, dated June 16, 1995, both prepared by U.S. Mission, Geneva.

Financial Services

With the exception of India's insurance sector, the three countries' schedules of commitments did, broadly, offer to bind a 49- to 51-percent foreign equity participation in several financial services subsectors.[53] These often were limited, however, by economic needs tests and other restrictions on foreign investment. Also, each of the three countries (plus the Philippines) continuously sought to link movement in the financial services negotiations to the parallel (but separate) WTO negotiation of the "Movement of Natural Persons" -- a negotiation to liberalize additional work permits/visas.[54]

Hungary, Czech Republic, Slovak Republic, Poland, South Africa, Morocco

Although the financial services sectors of these countries are only beginning to emerge, all of these countries have enacted or were considering
liberalized regulations during the last 2 years of the negotiations. Their schedules of commitments reflected the progress they had achieved.[55]

Results and Ramifications

On June 29, 1995, the United States informed the GATS Council in Geneva that it was offering a schedule of commitments with additional broad MFN exemptions. Its final offer for financial services essentially reverted to the level of commitments taken in December 1993 at the end of the Uruguay Round, but now also included (as noted earlier) a broad MFN exemption for insurance as well as for the banking and securities sectors.[56] Thus the final U.S. offer, effective June 30, 1995, grandfathered the current activities of foreign firms in the U.S. market. However, these companies' opportunities to expand, for example, by taking advantage of 1994 legislation for interstate bank branching and possible future Glass-Steagall reform,[57] or new companies' ability to enter the U.S. market, were not guaranteed and could be conditioned on reciprocity.[58] The United States had reached this decision on the grounds that the overall set of national schedules did not, in toto, provide a level of liberalization sufficient to warrant a broader U.S. commitment that guaranteed entry, expansion or access to new activities.[59] Rather, the United States would continue, on both a bilateral and multilateral basis, to seek commitments to liberalize financial services.[60]

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[53] World Trade Organization, General Agreement on Trade in Services (GATS), India: Schedule of Specific Commitments (GATS/SC/42/Suppl.1), pp. 3-7; Pakistan: Schedule of Specific Commitments (GATS/SC/67/Suppl.1), pp. 1,3,4, 6 and 7); Egypt: Schedule of Specific Commitments (GATS/SC/30/Suppl.1), pp. 2,3,7,11, and 12, all dated Jul. 28, 1995.

[54] U.S. Department of State telegrams, message reference numbers 4363, dated June 8, 1995, and 4647, dated June 16, 1995, both prepared by U.S. Mission, Geneva.

[55] The Czech Republic, for example, has liberalized its financial sector so rapidly that it is set to become an OECD member this year, with Poland and Hungary expected to join early next year. See the *Financial Times*, September 12, 1995, p. 20.

[56] World Trade Organization, General Agreement in Trade in Services, United States of America: Specific Schedule of Commitments, (GATS/SC/90/Suppl.1), July 28, 1995, pages 1 and 16; as well as United States of America: List of Article II (MFN) Exemptions (GATS/EL/90/Suppl.1), p. 1

[57] Based on proposals now before Congress, such legislation may permit the merging or greater interaction of commercial and investment banking, as well as other financial services.

[58] The EU and Japan were given a side letter saying the reciprocity provision did not apply to them, on the grounds that their financial services markets were acceptably open to U.S. firms.

[59] U.S. Department of State telegram, message reference No. 5108, prepared by U.S. Mission, Geneva, June 30, 1995. Also Department of State telegram reference No. 165936, prepared by Departments of Treasury/State, Washington, D.C., July 11, 1995.

[60] Ibid.

During the month of July the European Union persuaded negotiating partners[61] other than the United States to leave their most recently tabled schedules of commitments intact, and crafted a short-term interim agreement that would preserve the negotiated schedules until November 1, 1997.[62] During the 2 months following that date, nations will be able to withdraw or revise the commitments they have scheduled. If the agreement survives this process, then on January 1, 1998, WTO parties may agree to accept irrevocable[63] MFN commitments. Since the irrevocable provision is central to achieving the predictability and certainty that is the heart of the negotiation, this would constitute the beginning of a more lasting WTO financial services regime.[64] By 1998, a number of major countries (e.g., India and Brazil) may be able to substantively improve their schedules of commitments, perhaps motivating the United States to consider removing its MFN exemption.[65]

Some U.S. observers argue that the current state of affairs is a positive outcome[66] since the United States can, if it so desires, strike bilateral agreements with, or take unilateral actions against, trading partners that deny market access or national treatment to U.S. financial institutions. In the meantime, the United States is entitled to receive the benefits of the schedules of commitments offered by those who signed the Second Protocol to the GATS -- the implementing document of the interim accord. In short, the United States has lost nothing, and may make some gains, while retaining leverage simply by reserving the right to use reciprocity at home in order to help open financial markets elsewhere.

Some also contend that the U.S. position in taking broad MFN exemptions may be viewed by trading partners as an incentive to liberalize further their financial service sectors.[67] The United States market is so large that even smaller countries may well have financial institutions who already invest in the United States, or who may eventually wish to do so. Even if not, their financial institutions may well have an interest in expanding to countries near their home base, and thus have an interest in a lasting WTO financial services regime. Such a regime almost certainly requires that the largest, developed economies are

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[61] It is not yet clear if this includes all the approximately 30 countries that participated actively in the extended financial services negotiations.

[62] In addition to this short time frame, a series of additional insurance policies is also built in. For example, since several nations require that the agreement be confirmed by their legislative bodies (e.g., Japan, Philippines), the implementing protocol does not enter into force until June 30, 1996, if all necessary legal approvals are obtained. If some nations are unable to ratify the protocol, all parties, including the United States, have 60 days during which they may modify or withdraw their WTO financial services commitments. This ensures that all partners can be sure that all other partners ratified the document before it takes effect. In short, assuming the interim accord takes effect, the proposed financial services regime will only be in place from August 1, 1996 until November 1, 1997 before further negotiation is required. During the intervening period, trading partners will undoubtedly monitor progress, or lack thereof, of the major problem areas of the negotiations. If liberalization occurs in these problem areas, the chances of obtaining an irrevocable WTO financial services regime in 1998 will increase.

[63] Nations could not withdraw or regress on their schedules of commitments without paying compensation; they could only further liberalize their markets.

[64] Indeed, the WTO Committee on Trade in Financial Services continuously referred to the regime in place until December 31, 1997, as the "interim" financial services agreement. See U.S. Department of State telegrams, reference numbers 5549, dated July 17, 1995; 5717, dated (continued...)

[64] (...continued)
July 21, 1995; and 5811, dated July 26, 1995, all prepared by the U.S. Mission, Geneva.

[65] U.S. Department of State telegram, message reference No. 5812, prepared by the U.S. Mission, Geneva, July 26, 1995. Also, *The Financial Times*, "Financial services deal sidelines the U.S.," July 27, 1995, p. 5.

[66] *Inside U.S. Trade*, "U.S. pulls plug on WTO financial services talks, takes MFN exemption," June 30, 1995, p. 1.

[67] Ibid.

committed to high levels of liberalization, setting an example to others, if it is to succeed. Thus the United States' MFN exemptions may be considered a warning bell that other nations need to consider if the regime is to succeed.

But there are also contrary views. It has been reported that the United States surprised its trading partners greatly by taking broad MFN exemptions.[68] The U.S. action was seen by many as inimical to the infant WTO organization's standing and signalled a loss of U.S. leadership after nearly 9 years of negotiations.[69] Many contend that this action, coupled with the ability of other WTO members to put together an interim agreement without the active help of the United States, may have adverse effects on U.S. interests. Further, they assert that the United States' long time effective leadership of new WTO member accessions, for example, may be increasingly questioned.[70] They also expressed concern that the financial services outcome may adversely impact other continuing WTO services negotiations in basic telecommunication and maritime services, sectors where the United States has large interests.[71]

Some also have questioned whether the United States can proceed with bilateral or multilateral financial services liberalization outside the WTO framework. Any WTO member who concluded a bilateral agreement with the United States would now have to offer the result to all of its other trading partners, while the United States would not have such an obligation.[72] It thus seems likely that no substantive talks on financial services will occur for more than 2 years, i.e., until November 1997.[73]

Conclusion

It is a very considerable feat that over 100 countries have joined the World Trade Organization, and that many of them have made commitments towards liberalization of their financial services sector, including the United States. U.S. and other nations' financial firms will benefit from these commitments over time. However, the financial services part of the agreement is fragile and temporary.[74] The challenge to cement it permanently in place will come 2 years hence.

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[68] See, for example, *The Financial Times*, London, July 1, 1995, p. 1, and the *International Herald Tribune*, Paris, July 1, 1995, p. 1.

[69] *Wall Street Journal*, July 25, 1995, p.1. *Financial Times*, July 27, 1995, p. 5. *The Economist*, July 15, 1995, p. 58. *Journal of Commerce*, July 27, 1995, p.1. U.S. Department of State telegrams, message reference numbers 7573 dated July 19, 1995, and 7726 dated July 20, 1995, both prepared by the USEU, Brussels.

[70] China has been negotiating WTO membership for several years. Russia began the accession process in July, 1995. Other prospective WTO members include Taiwan, many Eastern European states and other emerging economies.

[71] U.S. Depart of State telegram, reference No. 7009, prepared by U.S. Mission, Brussels, July 3, 1995. Also, *Inside U.S. Trade*, June 30, 1995, p. 22.

[72] Any WTO member who has made financial services commitments on an unconditional MFN basis must offer the same benefits to all WTO trading partners. The United States, however, has offered only conditional MFN, based on reciprocity, for new market entrants, or, for foreign companies already operating in the U.S. financial markets, for the geographic expansion of their businesses, or to offer new products. See *Inside U.S. Trade*, "EU urges financial services deal, says U.S. not critical to success," July 7, 1995, p. 1.

[73] See statement of Sir Leon Brittan of the EU, as reported in U.S. Department of State telegram, message reference No. 7117, prepared by the USEU, Brussels, July 7, 1995.

[74] U.S. Department of State telegram, reference No. 5812, prepared by U.S. Mission, Geneva, July 26, 1995.

SOL-GEL: INDUSTRY SEEKS TO COMMERCIALIZE ENERGY-SAVING TECHNOLOGY FOR EXISTING AND EMERGING MARKETS

About this article...

The commercialization of new technology is considered an important factor in improving the competitiveness of national industries. This is the third article in a series presenting ongoing USITC Office of Industries research on the commercialization of new manufacturing processes for materials (NMPM). NMPM are viewed as potentially cost-effective means of ensuring increased productivity and efficiency.

This article highlights a number of industry and government efforts to develop and commercialize one such NMPM--sol-gel processing. This process is being used to create materials which possess mechanical and thermal properties that exceed the properties imparted by conventional ceramics and glass making processes. The use of products derived through sol-gel also promises significant energy savings in architectural, automotive, and commercial and residential insulation applications. This article explores key factors affecting commercialization of sol-gel, the role of certain domestic and foreign industry and government institutions involved in its research and development, and the short- and longer-term commercial prospects for this technology.

NOTE:

A glossary of technical terms (highlighted within the article by bold italics) appears at the end of this article.

The application of sol-gel processing to industrial production enables specialized materials (e.g. films and coatings, powders and grains, fibers, and porous gels and membranes) to be produced from the gel state. This method enables a more precise control of composition, purity, and microstructure, often at lower processing temperatures and reduced energy costs. Sol-gel materials possess mechanical and thermal properties that exceed the properties of similar materials produced under conventional processes.[1] The use of products derived through sol-gel processes also promises significant energy savings in certain applications. For these reasons, there is currently strong international competition to commercially develop this technology.

Although existing markets for sol-gel products tend to be lower-volume (estimated total annual U.S. sales of less than $200 million), this technology is reported to have significant commercial potential in large, international markets such as automotive and architectural glass, and thermal and acoustical insulation, where the energy-savings advantages of sol-gel products have been demonstrated. Recently, sol-gel technology has begun to be used in the commercial production of textile fibers. Other promising commercial applications and markets in which sol-gel may eventually be used include micro-optical components (in laser optical devices), electronic sensors, and vapor-separating membranes and filters (for use in environmental emission control and food processing applications). Although these markets are presently small, sol-gel manufacturers feel they

[1] Sol-gel manufacturing was first developed during the 1950s as a means to manufacture ceramics and glass with a wide range of advanced properties.

have large commercial potential worldwide.

This article examines the commercial potential for sol-gel processing in various current and emerging markets, and discusses efforts of individual firms to develop this technology. Cost and performance are examined as two of the critical conditions necessary for wider industry acceptance of sol-gel products. Finally, the article describes the role U.S. and foreign governments have played in helping to develop this technology.

The Sol-Gel Process[2]

Sol-gel processing involves a chemical synthesis of ***oxides*** that undergo a transition from a ***solution*** or ***sol*** state to the ***gel*** state. In this synthesis, oxides are transformed from small-sized units in a liquid phase into rigid material of greater molecular weight through partial loss of liquid. Both the initial chemistry of the mixture and the final stage of drying are critical to successful manufacture of the five possible types of end-product forms -- thin film and coatings, fiber, powder, porous gel, or ***monolith***.[3]

During the first stage of the sol-gel process, components are mixed to form a clear, homogeneous solution that then gels to produce a highly porous oxide. The chemistry of the mixture must be carefully controlled to induce liquid solvents to form a gel. In order to remove the solvent material, the elastic gel is then either dried, under high-pressure and high-temperature conditions, in an autoclave (a type of pressured furnace) to produce an ***aerogel***, or is dried naturally to produce a xerogel. If the drying temperature is raised too high or rises too rapidly, the solvent may escape too quickly, causing cracks in the gel structure. Generally, monoliths are the hardest materials to dry without cracking while thin films and fibers dry much easier.[4]

Principal advantages and disadvantages of sol-gel processing as compared to competing forming processes[5] are noted in figure 1. The prospects for reducing the current disadvantages and improving the competitive potential of sol-gel processing, principally related to cost and performance factors, are examined later in this article in the section dealing with the outlook for commercial production.

Product Applications and State of Process Adoption

The end-users of products made using the sol-gel process are likely to be most attracted to the energy-savings potential of these products and by their superior performance under extreme mechanical, chemical and thermal conditions. The glass and abrasives industries are currently the largest users of sol-gel processing (table 1).

As discussed below, a number of private sector firms are currently engaged in sol-gel related production, both on a prototype and a commercial basis. Manufacturers have identified some large existing markets that may justify investments in large-scale production; such economies of scale are necessary to make sol-gel products more cost-competitive with traditional processes and products. In other cases, production is being targeted toward future markets, such as micro-optical components, that are presently small but are expected to develop significant commercial potential.

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[2] See articles on sol-gel appearing in *Ceramics and Glasses*, Engineered Materials Handbook, Vol. IV, 1991.

[3] "Sol-Gel Process", Lisa C. Klein. Article appears in *Ceramics and Glasses*, Engineered Materials Handbook, Vol. IV, 1991, p. 209.

[4] Ibid. pp. 210-11.

[5] The sol-gel process principally competes in advanced materials processing, particularly in the application of thin films and coatings, with ***vapor deposition*** technology.

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Table 1
Sol-gel processing: Product form, end-use industry, specific end-use, properties, present estimated market value, estimated commercial market values over 10 years

Product form	End-use industry	Specific end-use	Properties	Present Estimated Market value	Estimated commercial potential market value over 10 years[1]
Coating	Optical glass	Large area displays senors, laser optiocs solar cells	Glare reduction Broadband light transmission	$50-100 million	$200 million
	Architectural/ Construction	Architectural glass	Thermal effriciency Control of light transmission	Minimal	$1 billion
	Automotive	Rearview missors,	Thermal efficiency	Minimal	([2])
Fibers	Aerospace/Defense	Thermal insulation for aircraft	Heat and abrasion resistance	Minimal	([2])
	Consumer	Fabric, tape, cordage	Strength, Heat-resistance	Minimal	([2])
Monolithics	Optical glass	Lenses, prismatic arrays, diffractive gratings	High purity Glare reduction	Minimal	([2])
Grains and powders	Cutting tools	Grinding wheels, abrasive belts sandpaper	Impact resistance Sharpness	$100 million	$200 million
Porous gels and membranes	Construction/ refrigeration	Thermal and acoustical insulation	Small pore size Thermal efficiency	Minimal	$2 billion
	Chemical	Filtration and separation systems	Abrasion and heat resistance	Minimal	$10-15 million
	Environmental	Emission controls	Small pore size	Minimal	$10-15 million
	Food processing	Filtration of food and beverages	Small pore size	Minimal	$10-15 million

[1]Estimates of potential market sizes are based on discussions with a limited number of firms currently involved in prototype or commercial production as cited elsewhere in this article and are somewhat speculative in nature.
[2]Not available.

Figure 1
Comparison of Sol-Gel Processing with Competing Technology

Advantages	Disadvantages
• The ability to produce high purity, homogeneous ceramic products. Chemical ***precursors***, which can be distilled and filtered, are used to produce final products that are relatively free of impurities. ***Homogeneity*** is guaranteed because particles are mixed in solution on a ***nanometer*** scale, allowing precise microstructure control in a relatively short time.[1] This enables particle size distribution, ***porosity***, and ***stoichiometry*** to be carefully controlled, either in the sol or in the sintering stage, to create high-purity structures which are ideally suited for such advanced applications as high-purity electronic coatings and sensors.	• Higher raw material coasts that result from the need to use expensive, high-purity precursors. • Removal of solvents and the overall shrinkage of the solution must be carefully controlled to avoid cracking and the dissipation of large amounts of volatile materials, because colloidal gels have very small pore structures and relatively low densities. Such concerns often limit the size of components that can be produced by this process.[2]
• Sol-gel's low-temperature process can achieve energy cost savings when compared with conventional processes.[3] Because ***colloidal*** particles have very high surface energies, sol-gel processing permits sintering (bonding) to occur at temperatures well below product melting temperatures.	[1]"Sol-Gel Process", Lisa C. Klein. Article appears in *Ceramics and Glasses*; Engineered Materials Handbook, Vol. IV, 1991, p. 213. [2] The New Materials Society: Challenges and Opportunities, Volume 2, U.S. Bureau of Mines, 1990. [3] C. Jeffrey Brinker and George W. Scherer, *Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing*, 1990, p. 840.

Sol-gel Technology

Thin Films and Coatings for Optical Applications

Films and coatings are the oldest and among the most commercially common applications of the sol-gel process.[6] Most sol-gel films and coatings are applied by "dipping", in which a ***substrate*** is lowered into a vessel containing the solution.[7]

Sol-gel coating techniques are increasingly used in the manufacture of optical coatings which alter the reflecting and light-transmission qualities, or heat absorption, of a substrate, most often glass. Industry sources believe the annual market potential for ***electrochromic glass*** alone could total more than $1 billion by 2005.[8] Critical factors that are involved with optical coating applications include precise control of coating thickness and degree of ***refraction*** and, in multilayer films, changes in the amount of refraction between films.[9] The ability to adjust these characteristics enables the manufacture of a number of products with significant energy-saving potential.

Coated electrochromic glass for "smart windows", in which light and heat to the interior of a building can be automatically controlled, is expected to become the most widely-used application for optical coatings. The exterior of coated electrochromic glass appears uniformly reflective; however, light transmission to the interior varies inversely with sun exposure, thereby minimizing heating and cooling costs. In addition to reflective coatings, oxide coatings can also be used to produce anti-reflective surfaces. Such glass is presently used in large-area displays (shop and museum windows), computer terminals, meter faces, automotive glass and rearview mirrors, and in laser-damage-resistant, anti-reflective coatings for laser optical devices.

One leading commercial U.S. producer of sol-gel optical coatings is Donnelly Corp. (Holland, MI) which uses sol-gel to produce optical barrier coatings for electrochromic displays, automotive rear view mirrors (Polychromic™) and sunroofs. Another company, Denton Vacuum Inc. (Moorestown, NJ), has used sol-gel technology for nearly 20 years to apply reflective and anti-reflective silicon dioxide and titanium dioxide optical coatings on laminated or tempered glass for use in CRT's and flat panel displays, meter faces, instrument windows, shop and museum windows, implosion panels, and architectural glass. According to Denton, the anti-reflective glass produced using sol-gel provides clearer images by reflecting less than 1 percent of all visible light transmitted, thus reducing glare by 99 percent.[10] Conventional glass may reflect as much as 8 percent of visible light transmitted, leading to noticeable glare on the surface of the glass.

Two of the promising markets for sol-gel coatings appear to be those for electrochromic glass used in architectural and automotive glazing applications. Both Donnelly Corp. and Sage Electrochromics, Inc. (Piscataway, NJ) are

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[6] Sol-gel has been used in the commercial production of reflective and anti-reflective glass coatings used in instrument meter faces and in large area displays for nearly two decades and has been widely used in the manufacture of advanced abrasive products since 1988.

[7] Film thickness can be increased by increasing withdrawal speeds from the vessel and by increasing the oxide content of the solution; coating thicknesses of 50 to 500 nanometers are typically produced. Sol-gel is not widely used for depositing thicker films and coatings which require repeated dipping and firing operations; such operations are costly and also increase the likelihood of contamination. Thicker films and coatings are generally deposited using vapor deposition techniques.

[8] John P. Cronin and A. Agrawal, "Large Area Transmissive Electrochromic Devices", (Draft), 1995, p. 1.

[9] C. Jeffrey Brinker and George W. Scherer, *Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing*, 1990, p. 847.

[10] Product literature, Denton Vacuum Inc., Moorestown, NJ.

actively involved in projects, financed partly by the U.S. Departments of Energy and Commerce, that may eventually lead to the commercial production of optical glass coatings for these markets. Although cost figures are difficult to establish, it appears that electrochromic glass is produced, using either existing sol-gel or vapor deposition technology, at a significant cost premium ($30-35/square foot) compared with conventional *low-emissivity* glass ($10-12/square foot) with which they would compete.[11] However, manufacturers contend that such cost comparisons do not account for the superior thermal efficiency of electrochromic windows. According to these manufacturers, electrochromic windows will be sold as "thermal insulating packages" that will not only replace conventional low-emissivity windows during the next decade, but will also add considerably to the thermal efficiency of the entire structure.[12] In addition, manufacturers are confident that they are on the path to reducing the cost of sol-gel electrochromic glass to $15-25 per square foot, a level at which such glass competes directly with low-emissivity glass.

Powders and Grains for Abrasive Applications

Future demand for sol-gel powders and grains for use as advanced abrasives appears promising due to the ability of the sol-gel process to control grain size and shape, to guarantee uniform and homogeneous microstructures, and to take advantage of lower processing temperatures.[13]

The principal advantage that sol-gel has over conventional abrasive production techniques[14] is the unique ability of sol-gel to produce small, submicron-sized particles; billions of submicron particles can be contained in one 60-grit abrasive grain with thousands of micron-sized cutting points in each grain. Although the abrasive grains shed micron-sized particles while grinding, new cutting edges are continually exposed. This enables less frequent sharpening or "dressing" of a cutting tool, and extended tool life. The advance in the production of longer-lasting abrasives which can operate at higher speeds provides to fabricators the capability of working on hard-to-grind materials, such as aerospace alloys and forged steels.[15]

Sol-gel alumina abrasive grains have been produced commercially by 3M Inc. and Norton Inc. since 1988.[16] Both firms use aluminum abrasive grains to produce such abrasive products as grinding wheels, coated abrasive belts, and sandpaper. Total U.S. sales of sol-gel abrasives are nearly $100 million per year. According to Norton Inc., the development of sol-gel abrasives represents a highly significant development in grinding wheel and coated abrasive applications, allowing the company to supply specialized customers such as aerospace manufacturers with abrasives tools that are lower maintenance and longer-lasting, leading to higher productivity and reduced grinding costs.[17]

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[11] John Van Dine, SAGE Electrochromics Corp., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[12] According to research conducted by Donnelly Corp., electrochromic glass is capable of reducing cooling and electric lighting energy requirements for a building containing low-emissivity glass by 50-80 percent. (John P. Cronin and A. Agrawal, "Large Area Transmissive Electrochromic Devices", (Draft), 1995, p. 6).

[13] To produce an abrasive powder or grain, a gel is formed from an aluminum oxide monohydrate solution, then extruded or spread out to a convenient shape and carefully dried before being sintered and finally crushed.

[14] For example, "fused" processing, in which powders are heated in a furnace and cooled under controlled conditions to form abrasive grains.

[15] Edward J. Kubel Jr., "Development and Application of Seeded Sol-Gel Abrasives," *ASM News*, October 1989, p. 4.

[16] In processes developed by Norton Inc. (known as "Seeded Sol-Gel", or "SG") and 3M Inc. (known as "Cubitron"), alpha alumina particles, or, "seeds" are introduced to an aluminum oxide solution to yield an abrasive grain with near-theoretical density and hardness.

[17] Edward J. Kubel Jr., "Development and Application of Seeded Sol-Gel Abrasives," *ASM News*, October 1989, p. 4.

Sol-gel Technology

Fibers for Heat-resistant and Reinforcement Applications

Sol-gel processes can be used to prepare continuous, refractory, polycrystalline fibers[18] that display high strength, thermal resistance, stiffness, and durability. The advantage of the sol-gel process in forming fibers is that highly refractory and chemically durable fibers can be economically formed at room temperatures; these fibers are difficult to prepare using conventional high temperature processes.[19]

Sol-gel fibers are finding commercial use in the aerospace, industrial textile, and electrical industries because of their purity and their ability to resist heat and corrosive gases. Reinforcement applications for these fibers include use in fabric, tape, and cordage. Refractory textile applications include use in furnace belts, flame curtains, and high-temperature gaskets and cables. Continuous ceramic fibers can also be combined with other fibers, whiskers, or powders and formed into porous shapes for use as insulation in the aerospace/defense industries (including use as insulating tiles in the U.S. Space Shuttle program).[20]

3M Inc., the only known U.S. manufacturer of sol-gel fibers, currently produces small, commercial quantities of continuous filament ceramic fibers (Nextel™) for use in fabrics, tapes, sleevings and cordage. According to 3M, the high-temperature performance (including low shrinkage, abrasion resistance, and thermo-electric insulation properties) of Nextel 312 and 440 ceramic fibers is superior to inorganic fibers such as fiberglass, or fused or leached silica.

Because of their ability to withstand high temperatures, Nextel fibers are also being considered for use in ***matrix-composite*** materials and in heat exchangers and radiant gas burner tubes in power-generating plants.

Porous Gels and Membranes for Insulation and Filtration Applications[21]

Porous gels and membranes are characterized by high surface area and small pore volume, making them ideal for applications in thermal and acoustical insulation, in filtration and separation systems, and in catalytic applications.[22] These materials are often difficult to produce using traditional ceramic processing methods. Sol-gel pore films and membranes offer a number of advantages over conventional materials:

- they can be used at high temperatures
- they do not swell or shrink in contact with liquids
- they are highly thermal- and abrasion-resistant
- pore sizes can be carefully controlled to avoid pin holes and cracks.

The principal immediate market for porous gels and membranes is likely to be thermal insulation, where much research is presently

[18] Fibers are typically either drawn from solution or extruded from monolithic shapes that have been dried and sintered.

[19] For example, fibers for reinforcement of concrete and glass that contain more than 20 percent zirconia oxide are difficult to prepare conventionally because of high melting temperatures required. (C. Jeffrey Brinker and George W. Scherer, *Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing*, 1990, p. 862)

[20] John Mack "Advanced Ceramics Processing; Cracking the Problem", *Materials Edge*, July/August 1990, p. 29.

[21] Porous gels are distinguished from membranes by pore size. The most common form of porous gels and membranes are aerogels, which are lightweight, nearly transparent, porous materials in which the particles and the pores between them have dimensions of less than 100 billionths of a meter.

[22] C. Jeffrey Brinker and George W. Scherer, *Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing*, 1990, p. 868.

concentrated. Eventually, the use of these materials may also extend to the microfiltration of water, wine, and beverages; the ultrafiltration of milk; the separation of gases in various industrial processes; and environmental applications such as catalysts to reduce nitrogen oxide emissions in automobiles.

The NanoPore Co. (Albuquerque, NM), relying on research pioneered by Sandia National Laboratories and the University of New Mexico's Center for Micro-Engineered Ceramics in Albuquerque, has developed a sol-gel process for producing aerogel using normal pressures and temperatures rather than the high pressures and high temperatures required under older sol-gel technology.[23] NanoPore believes that its process will lead to quicker and less-costly commercialization of aerogel for use in refrigerators, water heaters, vacuum bottles, walls, and window panes.

Aerogel thermal insulation is reported to possess ten times the thermal insulating properties of ordinary glass fiber insulation. NanoPore's pilot aerogel production plant has a rated annual manufacturing capacity of 100,000 pounds and the firm anticipates that near-term markets for aerogel insulation could total nearly $1-2 billion in annual sales within the next decade.[24] The company expects to begin commercial production of aerogel within the next two years provided certain performance difficulties are overcome which have limited their use in some insulation applications. One of the largest performance problems is poor light transmission (opacity), which has prevented the use of aerogel as a thermal barrier in window glazing, another potentially large market for aerogel.[25]

Aerogel thermal insulation is presently manufactured at a significant cost premium over conventional insulation. For example, glass fiber insulation and urethane insulation, produced commercially at a cost of 2-3 cents per board foot[26] and 6-7 cents per board foot, respectively, cost far less than aerogel insulation, which is produced at a cost of nearly 10 cents per board foot.[27] Although the cost of aerogel insulation presently exceeds conventional insulation by a factor of between two and four, it is reported that the higher thermal resistance achieved with aerogel insulation translates to significant weight and volume savings that makes aerogel insulation more nearly cost competitive with conventional insulation.[28]

Joint Government/Industry Support of Sol-Gel Projects

Both the U.S. and foreign governments have joined with private firms to assist in the development of products made using the sol-gel process. Support by the U.S. Government of promising technological projects, which often have difficulty attracting private capital, has both important commercial benefits for industry and contributes toward achieving higher levels of energy efficiency for the entire economy. The financial and technical assistance provided by such partnerships allows smaller firms, which tend to be less well capitalized than larger firms, to raise the large sums required to develop these expensive technologies. Access to government resources offers smaller firms a means of leveraging costs, thus neutralizing many of the financial advantages of some larger firms. In some cases, participation in a joint project has allowed participants to share research information and to pool scientific talent with Government agencies and with other organizations doing similar research, such as national laboratories and universities. Sharing research has resulted in

[23] Doug Smith, NanoPore Inc., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[24] Ibid.

[25] "Aerogels Set to Take Off", *Chemical Engineering Progress*, June 1995, p. 14.

[26] A board foot is defined as a volume equal to 1 square foot multiplied by a thickness of one inch, or 144 cubic inches.

[27] Doug Smith, NanoPore Corp., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[28] Ibid.

certain technical breakthroughs for some firms that potentially shortens the lead time required to bring products to market.[29] Finally, industry representatives believe that continued backing by national governments of sol-gel projects lends credibility to the commercial products developed and serves to remove much of the uncertainty associated with adoption of new designs that incorporate these products. This is particularly true of sol-gel electrochromic coatings for architectural windows where the conservative nature of architects has reportedly proved an obstacle to the broader application of sol-gel products in construction markets.[30]

The U.S. Federal Government contributes to sol-gel development by funding various industrial efforts to commercially produce components using sol-gel. These efforts are made through a variety of federal agencies and programs, including the Advanced Technology Program (ATP) of the U.S. Department of Commerce's National Institute of Standards and Technology (NIST), the U.S. Department of Energy, and the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense (table 2). Barring an immediate termination of funding, the present period of anticipated reductions in federal expenditures for research and development projects is not expected to affect the funding of projects already underway. However, because these anticipated reductions will affect the funding of projects in the future, some agency officials feel they may dampen the enthusiasm of many in industry to present project proposals.[31]

Although detailed specific information on sol-gel related research and development funding by foreign private firms and governments is often not available, it appears that there has been a major commitment by leading industrial nations to develop advanced materials technology as a means of stimulating economic growth and competitiveness. Financing of sol-gel research and development in Europe is being done through private and public institutions (both individual EU governments and through EU agencies). In Japan, there also appears to be considerable government involvement in sol-gel research and development. Support by the Japanese Government for sol-gel technology is channeled through its Ministry of International Trade and Industry (MITI) and is included with other technology assistance in a number of specific materials research projects. Such projects include: High-Performance Ceramics; High-Performance Materials for Severe Environments; Advanced Material and Machining System; and Advanced Chemicl Processing Technology. Germany provides support for sol-gel projects principally through the Federal Research Ministry (BMFT),[32] which supports activities dedicated to the following sectors: Physical and Chemical Technologies; Ceramics and Glass; and Composite Systems.

[29] John Van Dine, SAGE Electrochromics Corp., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[30] Dr. Niall Lynam, Donnelly Corp., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[31] John Gudis, U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Aug. 1995.

[32] In 1994, the total ministry budget was DM 450 million.

Table 2
Some current sol-gel related projects financed partially with Federal funds: Participants, U.S. government agency, product, and end-use

Participants	U.S. government agency	Product	End-use
Geltech Inc.	Department of Commerce (NIST)	Silica glass	Optical components
SAGE/3M/Rutgers	Department of Commerce (NIST)	Electrochromic glass	Architectural glass
3M	Department of Defense (ARPA)	Fiber	Aerospace and other structural applications
Aerojet/ Livermore National Labs/ Lawrence Berkeley National Labs	Department of Energy	Aerogel	Thermal and acoustical insulation products
Donnelly Corp.	Department of Energy	Glass	Electrochromic Architectural and automotive glass

Domestic Sol-Gel Activity

Following is a discussion of some projects financed, in part, by the U.S. Government. Many of these projects are still in the prototype stage but all are expected to result in commercial production within a 3-5 year time frame.

U.S. Department of Commerce (Advanced Technology Program--ATP)

Geltech Inc. (Alachua, FL) received a $1.3 million grant under the ATP in 1994 to further develop its patented sol-gel process for the molding of high-purity silica glass for monolithic micro-optical components to be used as lenses, diffractive and refractive optical devices, and ***diffractive gratings***. These high-quality silica glass products are reported to have excellent broadband (ultraviolet to near-infrared) light transmitting properties[33] enabling their use in electronic sensors and in laser systems where they are used as diffractive gratings and micro-lens ***arrays*** to split incoming laser beam energy into many equal intensity beams. Traditional molding and finishing techniques often cannot be used to

[33] Jean-Luc Nogues, R. Layne Howell, "Fabrication of Pure Silica Micro-Optics by Sol-Gel Processing," July 1992, pp. 1-6.

process silica glass for such high-performance optical applications because the high temperatures required in using these techniques are cost-prohibitive. Moreover, conventional grinding and polishing processes are limited in their ability to manufacture small and complex micro-optical components.[34] Geltech hopes to use its sol-gel process to cast ***net-shape*** silica glass micro-optical components at room temperature, resulting in products that are extremely pure and homogeneous, and are also lower in cost than products produced using conventional techniques. Thus far, Geltech has been manufacturing dense silica glass for optical products using sol-gel technology on a prototype basis, and expects to shortly begin commercial production.[35] Geltech has also begun commercial production of porous glass for electronic sensor applications as a direct result of its sol-gel work under the ATP grant.[36]

SAGE Electrochromics, Inc., in cooperation with 3M Inc. and the Rutgers University Center for Ceramic Research, was awarded an ATP grant of nearly $3.5 million in 1992 to facilitate the manufacture of electrochromic glass for use primarily in architectural windows (SAGEGLASS™). In this process, sol-gel technology is used to deposit several layers of thin films on a transparent glass base. The momentary flow of electric current to the glass base then alters the transparency of the glass from clear to heavily shaded. The largest potential application is in "smart windows," electronically controlled windows that conserve energy by automatically lightening or darkening, depending on the amount of sunlight, the time of day, the season, or the preference of the user. The amount of incoming sunlight could be regulated through simple operation of a switch or a remote control to allow buildings to be shaded on warm days and opened to sunlight on cloudy or winter days. Success in this application could eventually allow the process to be used to produce similar electrochromic coatings in sensors, superconductors, and optoelectronic circuits. SAGE is presently producing demonstration prototypes of its electrochromic glazing product and anticipates commercial production by 1997.[37]

U.S. Department of Energy

Donnelly Corp. is currently in the first year of a three-year, $800,000 joint project with the U.S. Department of Energy to produce electrochromic glass for the architectural and automotive industries using the sol-gel process.[38] Donnelly anticipates that commercial production of its electrochromic glass will begin in the third year of this project.[39] The firm anticipates some resistance to its product in the marketplace due to its higher initial cost and the reluctance of some architects to depart from the practice of specifying familiar building materials with well-established properties. Similarly, automotive designers are also reluctant to introduce new design concepts to replace materials with proven acceptance in the marketplace. However, Donnelly Corp. is confident that once the advantages of electrochromic glass are demonstrated and the cost is reduced to more competitive levels, it will be able to effectively compete in these huge markets.[40] According to the company, the expected sales of electrochromic glass could exceed $1 billion within the next 5 to 10 years.[41]

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[34] Jean-Luc Nogues, Geltech Inc., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[35] Ibid.

[36] William Moreshead, Geltech Inc., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[37] John Van Dine, SAGE Electrochromic Corp., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[38] Dr. Niall Lynam, Donnelly Corp., telephone interview by USITC staff, Washington, DC, July 1995.

[39] Eugenie Uhlmann, Donnelly Corp., telephone interview by USITC staff, Washington, DC, July 1995.

[40] Dr. Niall Lynam, Donnelly Corp., telephone interview by USITC staff, Washington, DC, July 1995.

[41] John P. Cronin and A. Agrawal, "Large Area Transmissive Electrochromic Devices", (Draft), 1995, p. 1.

Donnelly is confident that it will eventually lower the cost of its electrochromic glass from the present $30-35 per square foot to $15-25 per square foot as it continues to make technical innovations in product technology. At this lower cost level, electrochromic glass would begin to compete effectively with conventional low-emissivity glass produced at $10-12 per square foot. Donnelly is now focusing its research efforts on finding cost-effective means to produce electrochromic coatings.[42]

Aerojet Corp. (Sacramento, CA) has begun production and testing of organic aerogels as part of a 15-month, $2.6 million Cooperative Research and Development Agreement with Lawrence Livermore and Lawrence Berkeley National Laboratories. Commercial manufacture of these aerogels is expected to begin following the expiration of the agreement in 1996. Potential aerogel identified by Aerojet include refrigeration systems, automotive door panels, ceilings, catalytic converters, and a number of aerospace applications.[43]

U.S. Department of Defense (Advanced Research Projects Agency--ARPA)

3M Inc. is currently working with ARPA to develop Nextel 610, a new generation 99.5 percent aluminum oxide fiber to improve the strength and thickness of reinforced metal-matrix and ceramic-matrix composites. Thus far, 3M has supplied a limited quantity of Nextel 610 fibers from its pilot plant to ceramic composite manufacturers for experimental use in aircraft engines. 3M also anticipates selling Nextel 610 fibers to reinforce metals such as aluminum or titanium for use in aerospace applications such as missile fins, and for strong, lightweight parts for aircraft, bicycle frames, or automobiles. The company anticipates a ten-year time horizon before large-scale production and commercialization of Nextel 610 begins.[44]

Foreign Sol-Gel Activity

The following is a brief discussion of some of the known sol-gel activities by foreign competitors.

Schotte Glaswerke (Germany) is the world's leading volume producer of optical coatings using sol-gel technology, producing reflective and anti-reflective products used in computer monitors, meter faces, and large-area display glass. Asahi Glass and Hitachi of Japan are also seeking to establish commercial production of sol-gel optical coatings for use in similar applications. There is no known foreign commercial production of electrochromic glass; however, Pilkington Ltd. (United Kingdom), New Materials Technology Corp. (Germany), Saint-Gobain (France), and Toyota and Nikon in Japan are seeking to commercially develop this technology. Pilkington and New Materials Technology will reportedly begin commercial production of electrochromic glass by late 1996 or early 1997.[45] In addition to its production and research facilities in the United States, Donnelly Corp. also has facilities in Ireland, France, and Germany from which it intends to eventually supply the European market with sol-gel coated materials.[46] Although there is yet no known foreign commercial production of aerogel, a number of foreign firms are producing aerogel on a prototype basis with commercial production expected soon. Both BASF and Hoechst of

[42] Anoop Agrawal, Donnelly Corp., telephone interview by USITC staff, Washington, DC, Sept. 1995.

[43] "Aerogels Set to Take Off", *Chemical Engineering Progress*, June 1995, p. 16.

[44] Robert Carlton, 3M Corporation, telephone interview by USITC staff, Washington, DC, Aug. 1995.

[45] Dr. Helmut Schmidt, New Materials Technology Corp., telephone interview by USITC staff, Washington, DC, Nov. 1995.

[46] Eugenie Uhlmann, Donnelly Corp., telephone interview by USITC staff, Washington, DC, Nov. 1995.

Germany are producing aerogel in pilot plants with commercial production reported to be imminent. BASF reportedly has annual aerogel production capacity of 100,000 square meters in its plant and will soon begin selling aerogel for use as a translucent (semi-transparent) thermal insulating barrier in window glazing.[47] Hoechst is manufacturing aerogel under technology licensed by NanoPore Inc. (United States). The manufacture of aerogel for use in the refrigerator and hot-water heater markets is being encouraged by tighter environmental legislation in Germany.[48] Despite its higher initial cost, aerogel use is being encouraged in Germany because it is easier for refrigerator manufacturers to handle, process, recycle, and reuse aerogel than conventional insulation.[49] Airglass (Sweden) is preparing for commercial production of aerogel in a plant capable of producing nearly 100,000 pounds of aerogels annually, comparable to the rated capacity of NanoPore's pilot plant.

Outlook for Commercial Production

The principal obstacles to wider use of the sol-gel process in manufacturing are the related problems of cost and performance. Because sol-gel is still a relatively expensive production process, its use presently can only be justified, on a cost basis, for high-performance applications which tend to be low-volume. Manufacturers of sol-gel components believe the cost of such components eventually will substantially decline. This is expected to occur through a combination of increased demand sufficient to allow average production costs to decline, and further technical breakthroughs aimed at reducing manufacturing costs of sol-gel products to costs of competing products. Another obstacle is the requirement to develop manufacturing processes that guarantee consistent high-volume production of quality components. Because of existing low production levels for many sol-gel products, process technology has not advanced sufficiently to produce components of a consistent level of quality. Further advances and refinements in processing technology are needed to guarantee consistent levels of quality before large production runs can begin.[50]

Existing large-volume markets which sol-gel manufacturers expect to enter include markets for architectural and automotive glass, and for thermal and acoustical insulation. Within the next 5 to 10 years, the expected sales of electrochromic glass used in architectural and automotive applications could exceed $1 billion.[51] Manufacturers are seeking to demonstrate the ability to produce consistent, high-quality material in the dimensions required for architectural and automotive glass at a competitive cost.[52] Entry into these markets would allow manufacturers to produce in sufficient quantities to demonstrate consistent high quality and also to realize economies of scale, thereby reducing costs further.

Similarly, the market potential for aerogel use in thermal and acoustical insulation is also potentially large; estimates of potential U.S. annual sales of aerogel products over the next

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[47] Dr. Helmut Schmidt, New Materials Technology Corp., telephone interview by USITC staff, Washington, DC, Nov. 1995.

[48] "Aerogels Set to Take Off", *Chemical Engineering Progress*, June 1995, pp. 17-18.

[49] Ibid.

[50] Doug Smith, NanoPore Inc., telephone interview by USITC staff, Washington, DC, Aug. 1995.

[51] John P. Cronin and A. Agrawal, "Large Area Transmissive Electrochromic Devices", (Draft), 1995, p. 1. This market estimate is based on gaining just a small market penetration of the more than 35 million new cars and trucks produced annually worldwide, and a modest penetration of the market for low-emissivity windows, which now command 40 percent of the residential window market and nearly 30 percent of the commercial window market.

[52] Dr. Niall Lynam, Donnelly Corp., telephone interview by USITC staff, Washington, DC, July 1995.

decade approach $2 billion.[53] Commercial prospects for aerogel depend on the ability of manufacturers to resolve technical problems such as opacity and to reduce costs to levels that would make aerogel insulation competitive with conventional insulation. Industry officials believe that further reductions in the cost of producing aerogel, combined with aerogel's superior thermal qualities, will eventually unlock this large potential market.

Many of the advanced technology markets for sol-gel products do not presently exist in volumes large enough to justify increased volume production of sol-gel components. However, this situation is likely to change as such devices as optical lasers, optical waveguides, solar cells, and optical fibers find increasing applications in the 21st century.

The U.S. Government has played an important role in facilitating the financial investment and innovative research efforts required to bring this technology to market and to match research and development efforts of foreign governments. A variety of jointly funded U.S. programs have committed significant resources to developing the commercial viability of this technology. Continuation of joint efforts is viewed by some industry officials and end-users as an important component in ensuring the domestic commercial success of this promising technology, and the overall global competitiveness of the United States in this new technology field.

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[53] Doug Smith, NanoPore Inc., telephone interview by USITC staff, Washington, DC, Aug. 1995.

Glossary of Terms

Aerogel	The most common form of porous gels and membranes, which are lightweight, nearly transparent, porous materials In which the particles and the pores between them have dimensions of less than 100 billionths of a meter.
Arrays	An arrangement of micro-lenses of equal diameter and curvature which are assembled into compact units. Micro-lens arrays are typically used in semiconductor laser devices.
Colloid	A state in which small particles of solid, liquid, or gas are distributed in a gas, liquid or solid. The dispersed particles are so small that they do not form an obviously separate phase, but they are not so small that they can be said to be in true solution.
Diffractive grating	An optical device, used in laser systems, to produce discrete beams of energy by diffracting various incoming wavelengths of electromagnetic energy.
Electrochromic glass	Glass or layers of glass upon which several layers of thin, transparent, and conductive coatings of materials such as tungsten oxide are deposited. By varying the amount of electrical energy supplied to the glass, the transparency of the coatings can be altered to vary the amount of light or heat penetrating the glass.
Gel	A colloid in which a liquid contains a solid arranged in a fine network extending throughout the system to produce a viscous, jelly-like product.

Low-Emissivity	A surface coating for glass that permits the passage of most shortwave electromagnetic radiation (especially light), but reflects most longer-wave radiation (heat).
Matrix-composites	Advanced materials in which discrete or continuous reinforcing fibers are embedded in a matrix, often of metal or ceramic. Composites have very high strength and stiffness in the direction of the fibers.
Monoliths	Bulk gels that are cast to complex shapes. Monolithic gels are often formed at room temperature and consolidated into final shapes at lower temperatures.
Nanometer	A unit measuring thickness in billionths of a meter.
Net-shape	A processing method which is used to produce a semi-manufactured part which is close to the final manufactured part. Eliminates the need for extensive and more costly finishing operations.
Oxide	A binary compound of oxygen with another element. Most oxides are prepared by reacting an element with oxygen at an appropriate temperature.
Porosity	The state of a material which allows the passage of gas or liquid through pores in the material. Porosity varies with the particle size of the material.
Precursor	An intermediate compound used in the formation of specific final materials.
Refraction	The change of direction in the propagation of a light wave as it passes through a medium such as glass.
Sintering	The bonding of adjacent surfaces in a mass of particles by molecular or atomic attraction. Sintered materials are heated at temperatures below the melting temperature of any component part in the material.
Sol	Sometimes known as a colloidal solution. A liquid colloidal dispersion.

Solution	A uniformly dispersed mixture, at the molecular or ionic level, of one or more substances (the solute) in one or more substances (the solvent). These two parts of a solution are called phases.
Stoichiometry	The branch of chemistry that deals with the quantities of substances that enter into and are produced by chemical reactions.
Substrate	Any solid surface on which a coating or layer of a material is deposited.
Vapor Deposition	A process used to apply a thin coating with a desired set of properties to an inexpensive substrate. The most popular vapor deposition methods used by industry include Chemical Vapor (CVD) and Physical Vapor Deposition (PVD).

CHINA'S EVOLVING GRAIN TRADE OPENS NEW MARKETING OPPORTUNITIES FOR U.S. EXPORTERS

Considerable U.S. trade policy debate has existed over China's restrictive market practices,[1] and over the magnitude of the U.S.-China merchandise trade imbalance which has grown sharply in China's favor over the past decade. For example, the U.S. merchandise trade deficit with China rose between 1986 and 1994 from about $2 billion to over $29 billion, second only to the deficit with Japan.

Unlike the surging U.S. imports of Chinese merchandise, U.S. exports to China have been disappointingly small, and have even declined in some categories. A leading U.S. merchandise export to China has been grain, composed mostly of wheat. However, annual U.S. exports of grain to China declined from 10 million metric tons (MMT) in the early 1980s to 3 MMT in 1993 despite China's rapid industrialization, rising per capita income, and sharply increased food purchases. U.S. grain exports to China began a modest recovery in 1994, reaching 5 MMT as the Chinese appetite for grain and grain-fed livestock outpaced domestic crop production. In that year and in crop year 1994/95, China increased net grain imports and became the leading world import market for wheat, the second global market for rice, and the sixth market for corn (coarse grain), all products in which the United States is the leading or a significant exporter.[2]

China announced a $2-billion grain infrastructure project in 1993, likely to be the largest single grain industry investment in the world in modern history.[3] China is aiming to modernize its distribution network for grain moving into and out of five leading coastal ports, thereby facilitating domestic distribution as well as international trade in grain.

This article examines China's grain trade, focusing on the factors at play within China that spurred Chinese demand for this important U.S. agricultural export to 5 MMT ($600 million) in 1994/95. The implications of rapid industrial development in China's coastal provinces and the lagging transportation infrastructure in China's vast interior and in its coastal ports are noted. The article also discusses China's adjustments in grain marketing policies that have sharply increased its grain imports, and financial assistance from the World Bank designed to lessen logistical bottlenecks that restrain both internal and international flow of grain throughout China. This

[1] The significant barriers to entry of imports maintained by the Chinese Government led to negotiation of a *Memorandum of Understanding (MOU) on Market Access* that China signed with the United States on October 10, 1992. The *MOU* committed China to dismantle almost 90 percent of its nontariff import restrictions over 5 years and to lower tariffs on a large number of products. It is reported that China still uses an intricate system of tariff and nontariff administrative controls to implement its industrial and trade policies. For further explanation, see United States Trade Representative, *National Trade Estimate Report on Foreign Trade Barriers, 1994, 1995,* and U.S. Department of State, *Country Reports on Economic Policy and Trade Practices* (Washington, DC; GPO, Feb. 1994).

[2] Frederick Crook and Francis Tuan, "China A Major Force in World Ag. Markets," *Agricultural Outlook,* USDA, June 1995, p. 26. China is a leading world market for vegetable oil and cotton as well as grain, and its imports of these agricultural products have risen dramatically.

[3] "China Vastly Expands Grain Infrastructure," *Milling and Baking News,* Aug. 31, 1993, p. 1.

investment in Chinese infrastructure is expected to augment Chinese grain imports and benefit U.S. grain exporters (particularly of corn and wheat).

Rising Incomes Spur Chinese Demand for Grain

China's rapid economic growth in recent years has provided the income for the emerging middle class to consume an increasing variety of grain-based products. Feed and flour mills, breweries, grain processing for industrial products, and the food processing industry are all generating significant additional demand for grain.[4]

Consumption of all grain in China rose by nearly 9 percent during 1990/91 to 1994/95 (figure 1). However, consumption of rice remained stagnant during these years, unlike that of wheat and coarse grains (used mostly for animal feed) which rose by 18 MMT or by 9 percent during the five most recent years. Use of coarse grain in animal feed rose by nearly 21 MMT during this period. The sharply higher consumption of beef, pork, and poultry in China, particularly in the booming industrial areas in the coastal provinces, led to a sharply higher demand for coarse grain and also boosted the demand for soybean and other protein meals used in animal feed.

Production Trends

China is the world's leading producer of grain, accounting for 23 percent of world grain production of 1,740 million metric tons (MMT) during the 1994/95 crop year.[5] Rice is the leading grain grown in China, followed in importance by coarse grains (mostly corn and sorghum) and wheat. In 1994/95, rice accounted for about 44 percent of Chinese grain output (table 1).

Annual grain production in China over the past 5 years fell by 7 MMT to 392 MMT in the latest crop year 1994/95. Over the same period, China's rice production fell by nearly 16 MMT due largely to changing consumption patterns; however, a 9-MMT rise in wheat and coarse grains output partially offset this decline. China's government has announced a production goal of 500 MMT for grain by the year 2000;[6] this goal would require a 4-percent annual increase in grain production over the next 6 years, a goal many observers believe will be difficult to achieve. Although Chinese grain farmers have become more productive as evidenced by rising crop yields, a smaller harvested area has more than offset this achievement.[7]

Infrastructure Problems Heighten Shortages in Coastal Provinces

Although grain is grown throughout China, most of the heavily populated provinces along the eastern coast of China (shaded in figure 2) do not harvest sufficient volumes to satisfy local demand, and must import grain either from

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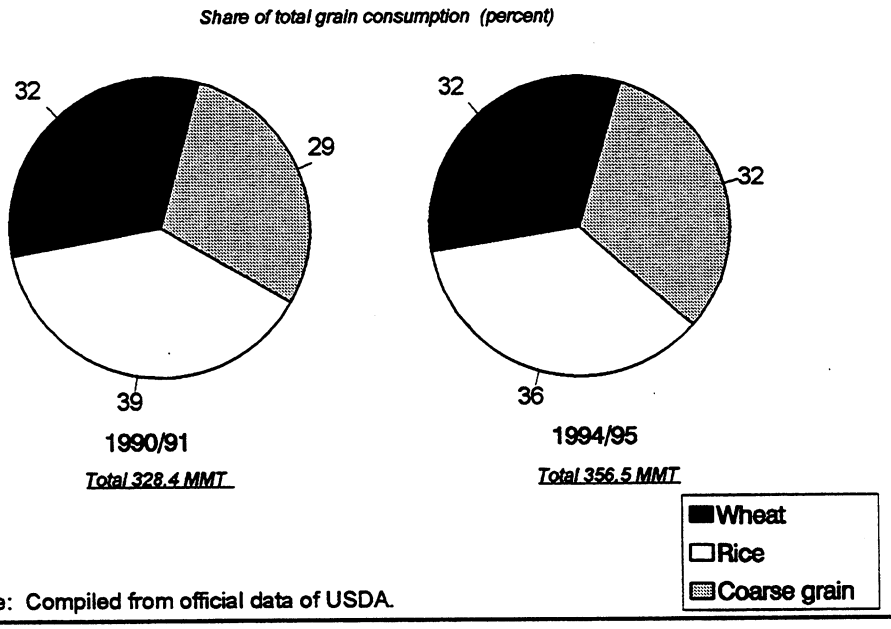
[4] USDA, FAS, *Grain and Rice Annual*, American Embassy, Beijing, Mar. 15, 1995, p. 2.

[5] "Grain production" includes the production of rice, coarse grains (mainly corn), and wheat. Source: U.S. Department of Agriculture, Foreign Agricultural Service, *Grain: World Markets and Trade*, April 1995. China officially reports its grain production as including dry beans, root products, and other miscellaneous field crops; and, therefore, there are slight differences between the USDA and official Chinese data on grain.

[6] USDA, FAS, *Grain and Rice Annual*, American Embassy, Beijing, Mar. 15, 1995, p. 2.

[7] Crop yields of wheat and coarse grains in China rose by 8 percent from an average 3.6 metric tons per hectare in 1990/91 to 3.9 metric tons per hectare during 1994/95 as the area harvested remained mostly unchanged at 56 million hectares. The yield of rice per hectare meanwhile rose by 4 percent during the 5 years to 5.9 metric tons per hectare. However, with the area harvested in rice declining by 11 percent to 30 million hectares in 1994/95, total rice production in China fell by about 8 percent.

Figure 1
Chinese consumption of grains, crop years 1990/91 to 1994/95



Source: Compiled from official data of USDA.

Table 1
China's grain output

Crop	1994/95 Production (Million metric tons)	1994/95 Share (Percent)	1990/91 Production (Million metric tons)	1990/91 Share (Percent)
Wheat	103	26	98	25
Coarse grains	116	30	112	28
Rice	174	44	189	47
Total	392	100	399	100

Source: U.S. Department of Agriculture, Foreign Agricultural Service.

Figure 2
China's Coastal and Inland Regions

Source: U.S. Department of Agriculture.

the inland provinces or from abroad. The coastal region accounted for 29 percent of the cultivated crop area in 1990, and 38 percent of the 1.1 billion Chinese population.[8] Moreover, since 1990, the coastal provinces have attracted many more millions of immigrants from the inland provinces seeking work,[9] and the region's demand for meat and poultry has expanded rapidly. Further, in the Southern Coastal and Yangtze River basin regions, high-cost rice (used directly as food) is being diverted into hog and poultry feed when lower cost coarse grains (coming either from abroad or from China's Northeastern corridor) would be more suitable.[10] In 1991, the coastal region had a grain deficit[11] of 4.2 MMT, while the central inland region had a grain surplus of 17.7 MMT.[12]

The Northeastern Corridor provinces of Heilongjang, Jilin, and Liaoning[13] are among the leading grain producing regions in China, particularly of corn, wheat, and soybeans. These provinces in the Northeastern Corridor are major net grain producers of about 9 MMT annually. However, the lack of internal storage and grain handling in this Corridor has resulted in a high loss of grain, while the adjacent grain-deficit coastal region experiences grain shortages and high prices.

Exacerbating regional supply problems are China's transportation and marketing systems. With antiquated and inefficient rail and river transport facilities, the system is inadequate to move sizable grain volumes from Northeastern and inland China to the coastal centers of demand. For example, China has 50,000 kilometers of track to service the second largest land mass in the world; the track ratio in China of 56 kilometers per 10,000 square kilometers of land mass places China in 70th place among world countries.[14] The rolling stock in the rail system is inadequate for moving bulk grain in hopper cars. According to trade analysts, there were only 700 grain hopper cars in China in 1995 compared with 26,000 in Canada.[15] Moreover, the poor grain storage system, both on farms and in intermediate grain terminals, results in high losses as grain is moved from the farm to the urban consumer.

China's Marketing Policy Changes Whipsaw Grain Trade

China has long had a grain procurement system in which the government acquires grain to supply food for urban residents and the military, and for industrial or processing use by mills or breweries. In urban areas, grain coupons are given to individual consumers to ration grain sales and to keep urban food prices low.

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[8] USDA, ERS, *Situation and Outlook Series: China International Agriculture and Trade Report*, July 1993, p. 43.

[9] In the 1990s, farmers in the coastal provinces, particularly in Guangdong Province (adjacent to Hong Kong), shifted from production of grain to that of fish, fruit, and vegetables in order to supply adjacent urban markets for these high-valued agricultural products. Rapid industrialization and urbanization in the coastal region further reduced the availability of cultivated land. In 1993, the Guangdong Province imported 5 MMT of grain from other provinces and from abroad, according to USDA.

[10] The World Bank (Bank for Reconstruction and Development), *China: Options for Reform in the Grain Sector*, 1991, p. ix.

[11] Measured by the difference between "grain procurement" (production) and grain sales (demand).

[12] Francis Tuan, ERS/USDA, "Rural Development in China: Pace Varies by Region," *Agricultural Outlook*, Oct. 1993, p. 36.

[13] Liaoning is also a coastal region province, but is a net grain exporter unlike the other coastal provinces (see figure 2).

[14] Frederick Crook, Economic Research Service, USDA, "China's Input Delivery System in Flux," *China: International Agriculture and Trade Reports*, July 1993, p. 3.

[15] Joseph Goldberg of the World Bank, quoted in Kim Archer, "U.S. Agricultural Exports to China on the Upswing," *Journal of Commerce/Knight Ridder-Tribune Business News*, July 3, 1995.

Grain Trade in China

In the early 1990s, China's central government began relaxing its procurement system by loosening grain price controls and by allowing wholesale markets to operate in order to facilitate the transfer of grain from surplus regions to the deficit coastal areas. The Chinese government also temporarily halted the procurement system in some regions, and ended grain coupons for urban consumers. The Chinese government continued its policy of substantial grain exports, and few imports of grain, except wheat.[16]

As part of this marketing policy shift, the Chinese government reduced the subsidies paid to state grain trading companies, and raised procurement prices paid to farmers.[17] By 1993-94, the higher grain procurement prices quickly led to rapid increases in urban grain prices, which actually exceeded world market prices. By late 1994, the urban price of corn meal in China of US$236 per ton was more than twice the $103 per ton U.S. export price of No. 3 yellow corn.[18] However, with the advent of the rapid inflation in China during 1993-94 (to a large extent fueled by these higher grain prices), the central government reinstated government grain procurement measures in 1994 and re-issued grain coupons in some urban areas. It also banned the export of corn and rice, increased wheat imports, and imported a sizable volume of corn for the first time since 1990, substantially increasing grain imports to dampen inflation.[19] The dilemma for the Chinese government in this marketing policy shift in 1994 was the maintenance of low urban food prices, while at the same time supporting farm and rural incomes to sustain and to induce more grain production.

China's Grain Trade Affected by Policy Shift

China has generally been a net exporter of rice, a recent exporter of coarse grain, and historically a major net importer of wheat. During 1990/91-1993/94, Chinese net exports (gross exports less imports) of rice remained at about 1 MMT annually. Chinese exports of coarse grain rose irregularly from less than 1 MMT in 1983/84 to about 7 MMT in 1990/91. From that year and until 1992/93, Chinese coarse grain exports continued to rise, reaching 12 MMT in 1993/94. However, as a result of the shift in Chinese Government marketing policies in 1994/95, Chinese exports of coarse grains fell by 9 MMT to 3 MMT. Similarly, 1993/94 rice exports of 1.5 MMT fell by 1 MMT to 0.5 MMT in 1994/95.

While historically a relatively consistent wheat importer, China has followed an irregular pattern of importing rice and coarse grain to compensate for periods of low domestic production. However, the volume of wheat imports into China has also fluctuated sharply between 4 MMT and 16 MMT annually during the past 5 years, largely reflecting weather-induced constraints on the volume of the domestic wheat crop. Prospects are improving for future grain and rice imports into China. In 1994/95, China had net imports of 4.7 MMT of coarse grain, mostly corn, despite relatively good domestic production.[20] In the 1994/95 crop year, China also became a net importer of rice for the first time since World War II.

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[16] China has had a long-prevailing policy ideology of grain self-sufficiency and only limited imports; this was restated emphatically in early 1995 by Agricultural Minister Liu Tiang. Scott Sindeler, "Agriculture Recent Focus by China's Top Leaders," Fas, USDA, American Embassy, Beijing, Mar. 7, 1995.

[17] Crook and Tuan, USDA, June 1995.

[18] Crook and Tuan, USDA, June 1995.

[19] USDA, FAS, *Grain and Feed Annual*, American Embassy, Beijing, Mar. 15, 1995, p. 2.

[20] USDA projects China to be a net importer of 3.2 MMT of coarse grain (gross imports of 4.8 MMT and exports of 1.6 MMT) in 1995/96, despite an 8.7 MMT rise in its domestic crop. USDA, *Grain: World Markets and Trade*, Oct. 1995, p. 41.

U.S. Grain Exports

U.S. grain production accounted for about 20 percent of the world output during 1994/95, although U.S. exports accounted for a substantial 48-percent share of world grain exports in that year. During the past 5 years, U.S. grain exports to world markets averaged about 86 MMT annually, rising irregularly from 82 MMT to 96 MMT (figure 3). U.S. exports to China averaged 3.5 MMT annually during the 5 years (figure 4). Wheat and coarse grains (mainly corn) dominated U.S. grain exports in 1994/95, while rice exports have consistently accounted for about 2 percent of the total U.S. export volume.

For four of the five crop years of 1990/91 to 1994/95, the United States primarily exported wheat to China, along with minor volumes of rice or coarse grain. In 1994/95 when China changed its grain marketing policy, U.S. grain exports, led by nearly 2 MMT of corn exports, rose to nearly 5 MMT, a significant increase over 1993/94. However, U.S. exports of grain in 1994/95 were still at a level below the 7 MMT China imported from the United States in 1988/89. On a value basis, U.S. grain exports to China averaged $375 million annually during 1990/91 to 1994/95, with the 1994/95 level having reached $600 million (figure 5), a level still well below the nearly $1 billion of U.S. grain sales to China in 1988/89.

A Two Billion Dollar Investment to Upgrade the Distribution System

China's 5-year, $2 billion grain infrastructure project underway since 1993 involves the construction of a storage network of nearly 40 MMT of grain, located at 370 sites[21] in the Northeastern Corridor of China, the provinces of Heilongjiang, Jilin, and Liaoning, and along the Yangtze River in Southern China (figure 2).[22] The project entails building 280 primary grain elevators in the Northeastern Corridor and 80 intermediate terminals which will initially receive grain by truck, but ultimately by rail once the rail system is upgraded.[23] There will be substantially more grain hopper cars added to the 700 currently in use in China, thereby easing movement of grain to ports and terminals.[24]

The two largest ports in Northeast China (at Daya Bay and Yingkou, both located in Liaoning Province) will be expanded with two new port terminals accepting grain from the intermediate terminals. The Daya Bay port terminal is the largest of the new deepwater, ocean port facilities in China, with 300,000 tons of grain storage, and equipment for handling grain ships of up to 30,000-ton capacity for corn and soybeans, and up to 80,000-tons of wheat capacity.[25] The Daya port is the third largest port in China, following Shanghai and the Hebeii Province's Quanhuangdao.[26] An estimated $350 million is to

[21] *Milling and Baking News*, p. 1.

[22] China relies on two large river systems (the Yangtze and Yellow Rivers) and on a rudimentary rail system to transport grain. China's longest river, the Yangtze, goes from the remote western Sichuan province in Southeastern China near the foothills of the Himalayas to the South China Sea at Shanghai, passing through densely settled portions of fertile crop lands. Small river vessels and barges transport grain (particularly rice) up and down the lower and middle reaches of this river.

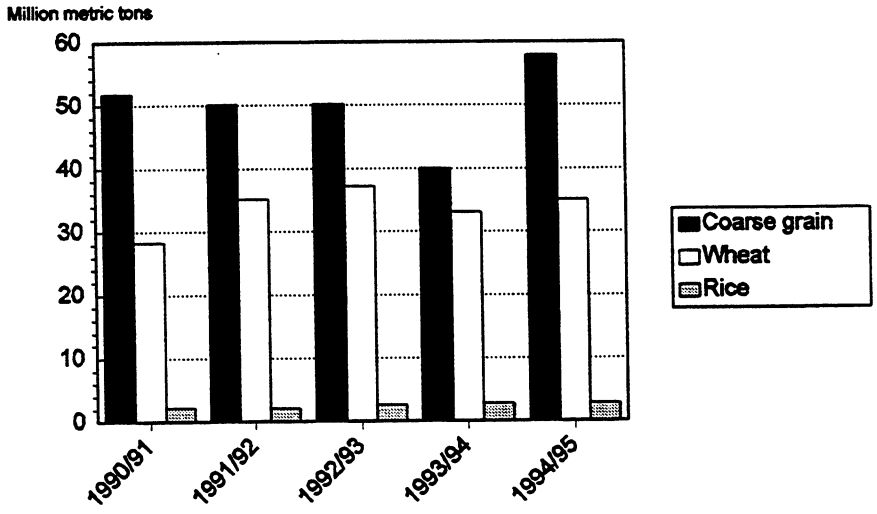
[23] *Milling & Baking News*, pp. 24-25. See also Frederick Crook, "China's Input Delivery System in Flux," *China: International Agriculture and Trade Reports*, July 1993, p. 9.

[24] Joseph Goldberg of the World Bank, quoted in Kim Archer, "U.S. Agricultural Exports to China on the Upswing," *Journal of Commerce/Knight Ridder-Tribune Business News*, July 3, 1995.

[25] *Milling and Baking News*, p. 24-25.

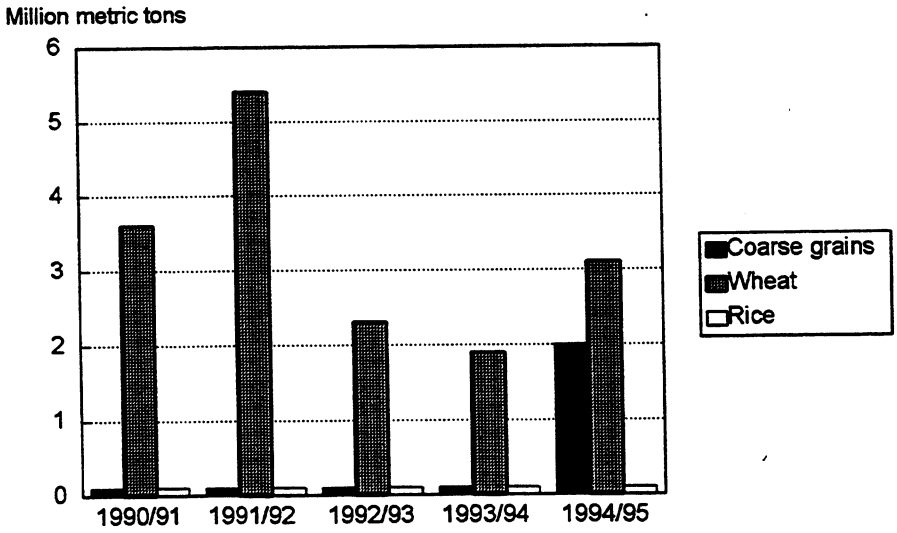
[26] U.S. Department of State, "Liaoning's Major Ports Move Forward with Big Expansion Projects," message reference No. 030634Z, Dec. 3, 1993.

Figure 3
U.S. grain: U.S. exports, by principal grain, crop years 1990/91 to 1994/95



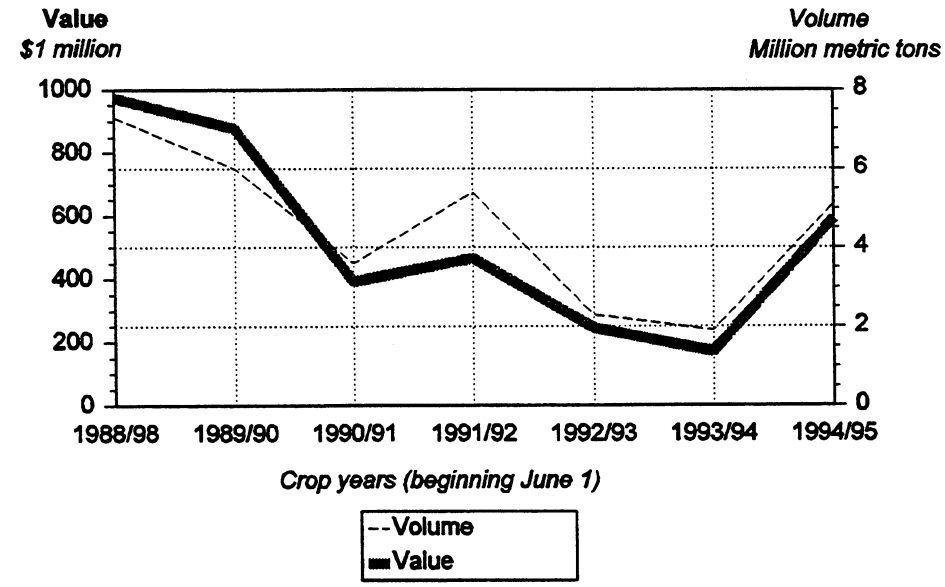
Source: Compiled from official data of USDA.

Figure 4
U.S. grain exports to China, crop years 1990/91 to 1994/95



Source: Compiled from official data of the USDA.

Figure 5
U.S. grain exports to China: crop years 1988/89 to 1994/95



Source: Compiled from official statistics of USDA.

be expended in the Daya port's large, automated bulk grain handling terminal for ocean-going, bulk cargo ships.

In Southern China, the grain investment project adds deepwater grain terminals at the mouth of the Yangtze in Shanghai to receive ocean-going grain vessels. The grain received from ocean vessels in Shanghai is offloaded at the terminals to smaller river vessels and barges that transport the grain to provincial wharves along the lower and middle reaches of the Yangtze. Surplus rice from the Yangtze Corridor can also move down to the Shanghai terminals to be exported abroad or to move in ocean vessels to rice-deficient northern China.

Financing

The World Bank has provided the impetus for this grain investment project based on a detailed 1991 study of China's grain production and trading system.[27] The study recommended, among other things, an expansion of public investment to improve the technical efficiency of the state-owned grain distribution system. The Bank team also urged policy changes to allow grain price liberalization and other measures to promote competition.

In 1993, the World Bank pledged $590 million over a 5-year period largely to acquire the engineering and equipment required for the project

[27] The World Bank (Bank for Reconstruction and Development), *China: Options for Reform in the Grain Sector*, 1991. p. ix.

from suppliers outside China.[28] Chinese Government officials in 1993 indicated the total cost of the grain investment project will exceed $1.75 billion. The Chinese national government and the provincial governments will thus provide the equivalent of $1.15 billion in funds to complement the World Bank funds.[29] The British engineering firm, L.G. Mouchel & Partners, with past experience in directing similar grain infrastructure projects by the World Bank in Turkey, was named the consulting engineer by the Chinese Government's Ministry of Internal Trade. The Chinese Ministry of Internal Trade is administering the project for the Chinese Government although provincial governments have a role as well.[30] The World Bank funds specifically finance ship loading and unloading equipment for ports in Guangxi Autonomous Region, Liaoning Province, six ports along the Yangtze River, and railway transportation grain storage, countryside storage, grain dryers, and transportation vehicles.

Benefits to U.S. and Foreign Firms

Few U.S. companies are likely to participate directly in the construction of the grain infrastructure project, but industry sources believe that U.S. grain exporters are likely to gain additional sales as the completed investment eases the flow of foreign grain into China. However, U.S. industry sources remain hopeful that U.S. companies may be able to compete for some of the machinery sales by capitalizing on their competitive advantage of producing state-of-the-art grain handling and processing equipment. Foreign suppliers are expected to provide China with the ship loading and unloading equipment, grain drying and aeration systems, and conveying and related machinery. U.S. companies may also consider joint ventures with foreign operators and or investors at some later point of time, but at this juncture, the facilities are state-owned.

U.S. grain exporters--most of which are multinational companies--are likely to supply some of the increasing grain requirements that are expected to arise from China's grain marketing improvements. With the United States accounting for nearly two-thirds of world coarse grain exports, U.S. exporters are poised to supply a large share of China's increased coarse grain imports. With regard to wheat, the one-third U.S. share of world wheat exports suggests that U.S. exporters may supply less than other wheat exporters to China's market. However, given the fungible nature of international grain trade, any increase in world imports of wheat, coarse grain, and/or rice resulting from higher Chinese purchases will likely benefit U.S. exports if not from shipments to China directly, then from demand by third-country markets that are left not supplied by other exporters now exporting more to China.

Effects of Changing Patterns of U.S.-Chinese Grain Trade

China, with slightly over a fifth of the world's population to feed, has had a significant influence on world production, consumption, and trade in grain, despite high self-sufficiency in

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[28] *Milling & Banking News*, pp. 24-25; and U.S. Department of State, "IMI--Update on the World Bank Grain Distribution and Marketing Project," message reference No. 031134Z, prepared by U.S. Embassy, Beijing, Sept. 3, 1993. A $490 million loan commitment is composed of a $325 million initial loan, and a credit of $165 million from the International Development Association (a World Bank subsidiary). An additional $100 million is also pledged in concession aid.

[29] In addition to this grain infrastructure project, the Chinese Government has also secured additional foreign funds for related agricultural development from the United Nations (UN) and the Asian Development Bank (ADB). The UN and ADB are committing funds totaling (together with the World Bank funds already mentioned) about $1.4 billion during 1993-94, according to Ma Yongwei, president of the government Agricultural Bank of China. "China Attracts Overseas Funds to Boost Agriculture," (Bejjing, Oct. 15, 1993), Comtex Scientific Corporation.

[30] U.S. Department of State, Sept. 3, 1993, Ibid.

meeting its grain consumption needs (less than 3 percent being imported in the five most recent years). Specifically, the enormous size of China's market has a major effect on U.S. trade in grain and related agricultural products, as the United States is the world's leading agricultural product exporter. Changes in China's grain marketing and production policies thus have important ripple effects on U.S. farmers and the U.S. farm sector.

Although the primary goal of China's 5-year grain system modernization project is to improve internal distribution and to reduce losses by enhancing grain storage facilities, the project also will reduce logistical barriers to foreign grain entering Chinese markets because of significantly improved handling techniques for import and export trade. International sources of grain are likely to become more prevalent in the coastal region provinces where 40 percent or more of China's 1.2 billion people live. Since, at current prices and favorable foreign exchange rates, U.S. wheat and coarse grains are less expensive than Chinese grain located in the more remote inland regions, there are likely to be economic advantages for the Chinese in purchasing foreign feed grain to meet the rapidly rising consumer preferences for poultry and meat.

However, even without this additional grain handling investment, China is poised to remain the largest single market for U.S. wheat exports, and among the top-ten markets for U.S. corn exports over the next few years. This trend stems from China's rapid economic growth that is generating significant additional demand for grain. Over the next 6 years, China is expected to face great difficulty in meeting its stated goal of growing 500 MMT of grain and is likely to turn to foreign grain to supply its demand because of agronomic and climatic constraints. Whatever marketing policy China chooses to follow, the size and historical volatility of its internal grain needs should continue to dramatically affect world grain markets and prices.

As with many economic opportunities in China, the extent to which China turns to market forces to influence grain prices and purchasing decisions will largely determine whether future U.S. grain exports will expand beyond their already significant levels. If China chooses to turn to international suppliers to balance its urban needs, then U.S. grain exporters are likely to reap a sizable portion of the expanding sales.

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NAFTA UPDATE: EARLY SIGNS CONFIRM BENEFITS

The North American Free Trade Agreement (NAFTA), providing for a free-trade area comprising the United States, Canada, and Mexico, was implemented on January 1, 1994. The agreement phases out tariffs on U.S., Canada, and Mexico trade in most industrial goods and agricultural products in the first 10 years after implementation, with tariffs on the remaining, mostly agricultural products being eliminated over 15 years. The pact also provides for uniform minimum protection of intellectual property (patents, copyrights, and trademarks) and reduces barriers in services and investment. Most of the 22 chapters in the agreement reflect trilateral agreements among the United States, Canada, and Mexico; however, several chapters--notably that on agriculture--reflect separate bilateral arrangements between NAFTA partners.[1]

Inquiries about the effect of NAFTA as well as attempts to assess its immediate impact since implementation are inevitable, despite the significant difficulties with drawing conclusions on economic effects after less than two years of a 15-year phased elimination of barriers. In addition, it is difficult to meaningfully isolate the effects of NAFTA from other economic developments associated with the December 1994 devaluation of the Mexican peso,[2] and the implementation of further liberalizing tariff and nontariff provisions reached under the Uruguay Round Agreements implemented in January 1995.[3] Notwithstanding these limitations, a review of recent economic literature and trade information supports the view presented to Congress during the debate on NAFTA approval that the benefits of NAFTA to the U.S. economy would exceed the costs of dislocations caused by increased competition for U.S. industries, cheaper Mexican labor, and lower U.S. tariffs.[4] This article discusses key developments affecting U.S.-Mexico trade, the maquiladora industry, and employment since NAFTA's implementation, as reported in major trade, U.S. government, and professional publications that are included in the bibliography at the end of the article.

U.S.-Mexico Trade

NAFTA has accelerated the interdependency and integration of the U.S. and Mexican economies. Mexico is the third largest trading partner of the United States (after Canada and Japan) accounting for 10 percent of the value of total U.S. exports in 1994 and 7 percent of U.S. imports.[5] U.S. exports to Mexico climbed by 22

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[1] NAFTA incorporated most of the provisions of the U.S.-Canada Free Trade Agreement and in many instances expanded upon the earlier (1987) agreement.

[2] For added detail on the peso crisis, attributed to several major economic, financial, and political factors rather than to NAFTA, see *The Year in Trade 1994*, U.S. International Trade Commission, Publication 2894, July 1995, p. 85; Mata, Ruben, "NAFTA Update: Steady U.S. Bilateral Trade Growth with Mexico Faces Mixed Prospects in 1995," in *USITC, Industry, Trade, and Technology Review*, March 1995; and Kornis, Magda, "Financial Crises in Mexico," in *USITC, International Economic Review*, March 1995.

[3] For added detail, see USITC, *Potential Impact on the U.S. Economy and Industries of the GATT Uruguay Round Agreements* (inv. No. 332-353), USITC Publication 2790, June 1994.

[4] For reference to major economic studies, see USITC, *Economy-Wide Modeling of the Economic Implications of a FTA with Mexico and a NAFTA with Canada and Mexico* (inv. No. 332-317), USITC Publication 2516, May 1992, and *Potential Impact on the U.S. Economy and Selected Industries of the North American Free Trade Agreement* (inv. No. 332-337), USITC Publication 2596, Jan. 1993.

[5] See Rorke, Jennifer, "Mexico", in USITC, *U.S. Trade Shifts in Selected Industries: Merchandise--1994 Annual Report* (inv. No. 332-345), Publication 2924, Sept. 1995.

percent in 1994, whereas U.S. exports to other nations grew minimally. The United States accounted for over 70 percent of Mexico's foreign trade that year. U.S.-Mexico trade in 1994 totaled over $100 billion and represented an increase of 23 percent on top of the 13 percent growth in 1993. The United States in 1994 had a trade surplus of $1.3 billion with Mexico.

Several factors contributed to the rapid expansion of U.S.-Mexico trade in 1994. While some growth can be attributed to the first stage of tariff reductions under NAFTA, other factors included: (1) the psychological effects of the agreement's passage, leading to a boost in investment; (2) a rise in Mexican consumer confidence together with an overvalued peso which resulted in increased purchases of durable goods purchased on credit; (3) heightened awareness of the opportunities for U.S. exports to the Mexican market ; (4) real economic growth in Mexico in 1994 of 2.8 percent following a small gain of 0.4 percent in 1993; and (5) a strong 4.1 percent growth in GDP in the United States and expanded consumer spending which strengthened both U.S. production and imports.

Mexico's peso devaluation in December 1994 was expected to materially, although temporarily, change the U.S.-Mexico trade picture in 1995.[6] The resulting slowdown in the Mexican economy has reduced U.S. merchandise exports so far in 1995 (January-September) by 11 percent from comparable 1994 export levels. However, despite a sharp drop in spending in Mexico caused by the peso-related austerity measures, U.S. exports were $32.3 billion in the first nine months of 1995--$2.4 billion higher than the pre-NAFTA level of $29.9 billion in 1993 (figure 1).[7] In some respects, NAFTA cushioned the effects of the peso devaluation on both the U.S. and Mexican economies. Although U.S. imports from Mexico rose 30 percent to $45.4 billion during January-September 1995, it is significant that trade generated by production sharing (maquiladora) operations[8] was accelerated by the peso crisis. The increase in U.S. imports from Mexico's maquila plants of 10 percent (totaling $18.3 billion) was accompanied by a 10 percent increase in exports of U.S. manufactured components (totaling $9.4 billion) to assembly plants in Mexico. Other U.S. exports to Mexico fell by 17 percent (table 1).

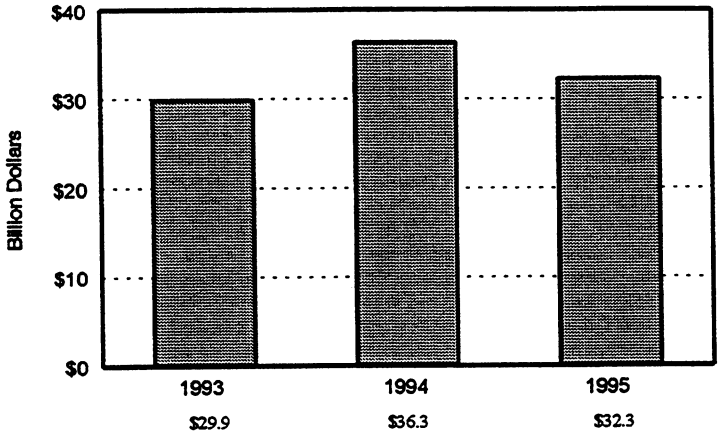
In response to the foreign exchange crisis, Mexico has increased its tariffs on products imported from non-NAFTA nations but continued

[6]For further information, see Mata, "NAFTA Update."

[7]U.S. Department of Commerce, Bureau of the Census data for U.S. merchandise exports to Mexico.

[8]The sector in Mexico that assembles products for foreign firms is called the maquiladora industry. Mexico's maquiladora law, in effect since 1965, allows the Government to grant licenses permitting companies (called maquiladoras or maquilas) to import components and machinery free of duty but under bond, provided that the machinery and components are subsequently exported. If the goods are not exported, the bond is forfeit and the importer is subject to a full assessment of duties. Failure to comply with the stipulations of the maquiladora law can result in the forfeiture of the importer's license to operate as a maquila. Maquilas are assembly plants that use foreign-made components, most of which are imported from the United States. Most maquilas are subsidiaries of U.S. manufacturers or perform assembly under contract with U.S. firms. The maquiladora law is part of the Maquiladora Program, a Mexican Government initiative to attract foreign investment in assembly plants in towns along the border with the United States. For background on the maquiladora industry, see Watkins, Ralph, "The Origins and Growth of Mexico's Maquiladora Industry," in USITC, *Production Sharing: U.S. Imports Under Harmonized* Tariff Schedule Provisions 9802.00.60 and 9802.0080, 1989-1992, February 1994. For a discussion of the likely impact of NAFTA on the maquiladora industry, see Watkins, Ralph, "NAFTA and Mexico's Maquiladora Industry," in USITC, *Industry, Trade, and Technology Review*, February 1994, and Echeverri-Carroll, Elsie, "Flexible Production and the North American Free Trade Agreement," in *NAFTA and Trade Liberalization in the Americas*, Bureau of Business Research, University of Texas at Austin, 1995.

Figure 1
U.S. Exports to Mexico (January-September) in 1994 and 1995 Exceed Pre-NAFTA Levels of 1993



Source: Compiled by the U.S. International Trade Commission from official statistics of the U.S. Department of Commerce

to reduce tariffs on imports from the United States. By May 31, 1995, Mexico had declared a tariff increase of 35 percent on some 502 products. Mexico reported to the World Trade Organization that it will raise tariffs and set quotas on products such as textiles, apparel, footwear, leather, and sugar. These measures will primarily affect labor intensive goods produced in the Far East that compete with Mexican-produced goods. Not only did NAFTA protect U.S. and Canadian companies from increased duties, it also gives them a competitive advantage in the Mexican market relative to imports from non-NAFTA suppliers.

The current U.S. trade deficit with Mexico of $13.1 billion so far (January-September) in 1995, following annual surpluses during 1991-94, should be considered in the context of the more significant bilateral U.S. trade deficits with Japan ($66 billion), China ($29 billion), and Canada ($25 billion) in 1994. The U.S. trade deficit with Mexico is widely attributed to the peso's devaluation in December 1994 rather than to the NAFTA,[9] and is expected to narrow gradually as the Mexican economy recovers from the shock of the devaluation.

U.S. industries exporting transportation equipment (automobiles), auto parts, and electrical goods to Mexico have been negatively affected since the devaluation of the peso. In the U.S. auto sector, for example, companies had record sales with Mexico in 1994 following NAFTA implementation; automobile companies sold 15 million vehicles in 1994, representing an increase of $850 million over 1993.[10] U.S. exports of new passenger vehicles to Mexico rose 500 percent,

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[9]See, for example, Vargas, Lucinda, "The Mexican Economy in 1995: A Post-Devaluation Assessment," *Business Frontier*, El Paso Branch of the Federal Reserve Bank of Dallas, Vol. 2, No. 4, Nov. 1995.

[10]U.S. Department of Commerce, International Administration, *The Case for NAFTA*, Sept. 26, 1995, p.1. For further information on the current performance of the U.S. motor vehicle industry in the Mexican market, contact Juliet Bender at the U.S. Department of Commerce, Office of NAFTA.

Table 1
Analysis of "Maquiladora" trade, 1990-94, January-September 1994, and January-September 1995

(Million dollars)

Item	1990	1991	1992	1993	1994	January-September 1994	January-September 1995
Total imports from Mexico	29,506.0	30,445.1	33,934.6	38,667.7	48,605.3	34,992.9	45,441.1
U.S. imports from "Maquiladoras":							
Total value	13,024.6	14,334.3	16,502.0	18,967.7	23,068.2	16,715.4	18,337.6
Percent of total imports	44.1%	47.1%	48.7%	49.1%	47.5%	47.8%	40.4%
U.S. components:							
Total value	6,544.8	7,254.8	8,691.9	9,871.9	11,608.4	8,535.3	9,388.2
Percent of "Maquiladora" imports	50.2%	50.6%	52.7%	52.0%	50.3%	51.1%	51.2%
Percent of total imports	22.2%	23.8%	25.6%	25.5%	23.9%	24.4%	20.7%
U.S. imports under HTS subheadings:							
9802.00.60	188.3	183.5	229.4	206.3	130.5	104.2	143.5
U.S. components	140.7	137.1	169.5	156.1	97.9	78.0	110.5
Percent	74.7%	74.7%	73.9%	75.7%	75.0%	74.9%	77.0%
Foreign value added	36.1	46.4	59.9	50.2	32.6	26.2	33.0
9802.00.80	12,836.3	14,150.8	16,272.6	18,761.4	22,937.7	16,611.2	18,194.1
U.S. components	6,404.1	7,117.6	8,522.4	9,715.8	11,510.5	8,457.2	9,277.8
Percent	49.9%	50.3%	52.4%	51.8%	50.2%	50.9%	51.0%
Foreign value added	6,432.2	7,033.1	7,750.2	9,045.6	11,427.2	8,154.0	8,916.3
Total exports to Mexico	27,467.6	32,279.2	39,604.9	40,265.5	49,136.1	36,298.4	32,316.2
U.S. exports of components to maquiladora industry[1]	6,544.8	7,254.8	8,691.9	9,871.9	11,608.4	8,535.3	9,388.2
Percent of total U.S. exports	23.8	22.5	21.9	24.5	23.6	23.5	29.1
Estimated net exports for Mexican consumption	20,922.8	25,024.5	30,913.0	30,393.6	37,527.7	27,763.1	22,928.0
Estimated net imports from Mexico[2]	22,961.2	23,190.3	25,242.7	28,795.8	36,996.9	26,457.6	36,052.9
Net U.S. merchandise trade balance with Mexico[3]	-2,038.4	1,834.2	5,670.3	1,597.8	530.8	1,305.5	-13,124.9

[1] Based on the value of U.S.-made components contained in U.S. imports from Mexico under Harmonized Tariff Schedule (HTS) provisions 9802.00.60 (metal processing) and 9802.00.80 (assembly) which Commission staff believes is substantially equivalent to the value of U.S. exports of components to the maquiladora industry.
[2] Includes the dutiable value (value added in Mexico) of products assembled in Mexico and imported into the United States under HTS provisions 9802.00.60 and 9802.00.80
[3] - indicates trade deficit.

Source: Compiled by U.S. International Trade Commission staff from official statistics of the U.S. Department of Commerce.

from $90 million in 1993 to $569 million in 1994,[11] attributed largely to the reduction of Mexican tariffs on U.S. vehicles from 20 percent in 1993 to 10 percent in 1994 as called for under NAFTA. The remaining tariffs on autos will be eliminated by the year 2003. NAFTA's phased elimination of Mexico's export performance requirements was also a critical factor in boosting U.S. motor vehicle exports to Mexico in 1994.

Although first quarter 1995 exports of U.S. passenger vehicles to Mexico totaled $144 million (an increase of $37 million compared with the first three months of 1994), nine-month exports (January-September 1995) of automobiles to Mexico, totaling $164.8 million, reflected a decrease of $196.1 million compared with the 1994 period. Despite a slump in U.S. exports of autos and auto parts in the second and third quarters of 1995--attributable to interrelated aspects of Mexico's peso devaluation, high interest rates, and reduced consumer spending--exports have the potential to rebound in 1996 because one-third of the automobiles in Mexico are 10 years or older, and U.S. vehicles have a price advantage in Mexico compared with cars from non-NAFTA countries of Europe and Asia.[12]

Maquiladora Industry Remains Strong

Importing goods that are assembled in Mexico's maquiladora plants with cheaper labor and U.S.-made components enables U.S. producers to sustain domestic operations by having the labor-intensive assembly functions performed in Mexico, and allows many U.S. manufacturers to compete more effectively with cheaper imports from Asia in both the U.S. and Mexican markets.[13] Under NAFTA, U.S. companies no longer are required to produce goods in Mexico in order to sell to the Mexican market.[14] The elimination of tariff and nontariff barriers to U.S. goods entering the Mexican market removes what had been a major incentive for U.S. companies to establish production facilities in Mexico rather than export to Mexico from the United States.

Prior to NAFTA, practically all products assembled in the maquiladora industry had to be exported; only limited exceptions were allowed for products to be sold directly to the Mexican market. This NAFTA provision giving the maquiladora industry direct access to the Mexican market reduces their costs and makes products assembled from U.S. components more competitive in the Mexican market, especially with products from Asia. Under NAFTA, exports of U.S. parts to maquiladora plants rose by $1.74 billion in 1994 to $11.6 billion. The United States imported $7.4 billion of auto parts from Mexico in 1993 and $9.7 billion in 1994. The increased U.S. imports of auto parts from Mexico in 1994 was due to greater consumer demand for automobiles[15] and not the reduction of U.S. tariffs under NAFTA.[16]

U.S. imports from Mexico's maquiladora industry amounted to $23 billion in 1994, nearly one-half of total imports from Mexico that year.

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[11] *Ibid,* p.3.

[12] *Ibid,* p. 6.

[13] For further explanation, see USITC, *Production Sharing: Use of U.S. Components and Materials in Foreign Assembly Operations, 1990-1993* (inv. No. 332-237), USITC Publication 2886, May 1995, and Spalding, Josephine, "Comparison of Production-Sharing Operations in the Caribbean Basin with those in Mexico and in Selected East Asian Countries," in USITC, *Industry, Trade, and Technology Review*, September 1995.

[14] For further explanation, see Watkins, "NAFTA and Mexico's Maquiladora Industry."

[15] U.S. production of vehicles increased 13 percent to 12.3 million units in 1994 from 10.9 million units in 1993. "Motor Vehicle Facts and Figures," *American Automobile Manufacturers Association*, 1995, p. 3.

[16] U.S. Department of Commerce, International Trade Administration. *The Case for NAFTA,* Executive Summary, p.4-5.

U.S. exports to the maquiladora industry of nearly $12 billion made up one-fourth of the value of total U.S. exports to Mexico in 1994, and represented approximately one-half of the value of U.S. imports from the maquiladora industry (table 1). Employment growth in this industry had leveled off to approximately 465,000 workers by 1994, as average hourly compensation for manufacturing workers in Mexico grew steadily and U.S. companies looked to China, Indonesia, and elsewhere in Asia for the production of labor-intensive goods. Although average wages for production workers in Mexico were higher than those in China, Indonesia, and Thailand, employment in the maquiladora industry was sustained by relatively higher levels of productivity and the proximity to the U.S. market which somewhat compensated for the increased Mexican wages.[17]

The devaluation of the Mexican peso, however, has lowered labor costs in Mexico and resulted in a boom for business in the export-oriented maquiladora assembly plants. The halving of the value of the Mexican peso during December 1994-January 1995 resulted in a 30 percent reduction in maquiladora wages in the first six months of 1995; a 10 percent increase in both maquiladora exports to the United States and U.S.-component exports to Mexico in the first nine months of 1995; and a sharp rise in foreign investment in assembly plants and technology centers for the production of auto parts and electronic products.[18]

Impact on Employment

The effects of NAFTA on employment in the United States since the agreement's implementation have been the focus of numerous articles by journalists, but little in-depth analysis has been published. Before NAFTA was approved, the predictions of net job gains or losses in the more than 20 studies published on the subject ranged from a gain of 175,000 jobs over the Agreement's 10-15 year phase-in period to a loss of 636,000 jobs.[19] Since limited data is available linking employment trends and the effects of trade agreements, a number of sources asserting the loss of jobs caused by NAFTA rely on certifications by the Office of Trade Adjustment Assistance, U.S. Department of Labor. That Office has certified 51,334 workers as losing their jobs because of plant relocations to--or increased exports to the United States from-- Mexico or Canada between January 1, 1994 and December 11, 1995.[20] The Department of Labor includes in its job loss estimates those employees separated when companies moved assembly operations to Mexico or Canada regardless of the reason. The principal reason that companies relocate operations to Mexico is to take advantage of lower labor costs to remain globally competitive, not because of NAFTA per se. There is no comparable mechanism for "certifying" job gains because of NAFTA. However, the U.S. Department of Commerce estimates that every $1 billion in

[17]Library of Congress, Congressional Research Service, *United States-Mexico Economic Relations: Has NAFTA Made a Difference?* Mar. 15, 1995, p. 1-15.

[18]Morrison, Scott, "The Maquila Miracle," in *U.S.-Latin Trade*, July 1995, p. 24. In a telephone interview with USITC staff on Dec. 4, 1995, Don Michie of NAFTA Ventures in El Paso, Texas, cited examples of numerous investments in Mexico's maquiladora industry in 1995, in part because of reduced labor costs following the devaluation of the peso and in part because of improved market access resulting from NAFTA. These included investments in research and development centers by General Motors in Juarez and by Asian firms in Tijuana; and construction of assembly plants by Nokia (Finland) in Reynosa, by Motorola in Chihuahua, and by Scientific Atlantic in Juarez.

[19]Bolle, Mary Jane, *NAFTA: U.S. Job and Industry Trade Trends After One Year*, Library of Congress, Congressional Research Service, May 30, 1995, p. 1.

[20]U.S. Department of Labor, NAFTA Office. Although these job losses are certified to be the result of plant relocations to Mexico or Canada and/or increased imports from these countries, NAFTA may not have been the cause of plant relocation decisions or the reason for the increase in imports.

exports supports 16,000-17,000 jobs.[21] According to this formula, a base of approximately 40,000 jobs has been supported by increased U.S. exports to Mexico since implementation of NAFTA.[22]

Outlook

The current U.S.-Mexico trade situation and its impact on the U.S. economy and employment could have had far greater implications without the NAFTA. Mexico's response to a collapse of petroleum prices in 1982 and an ensuing debt crisis[23] serves as an illustration of why the NAFTA is beneficial in protecting U.S. interests. Mexico instituted protectionist measures in 1982 to restrict imports of U.S. goods in order to conserve foreign exchange for the payment of interest on its foreign debt. These measures included levying 100 percent duties on U.S. products and requiring import licenses. These measures, along with a devalued peso, high inflation, tight credit, and reduced real income in Mexico, resulted in a 50 percent reduction in U.S. exports. It was 6 years before U.S. exports recovered to pre-debt crisis levels. Although Mexico is currently pulling itself out of a recession, it has remained committed to the NAFTA and cut tariffs on U.S. imports in January 1, 1995. If the NAFTA was not in force, the potential deleterious effects on U.S. businesses from the recent peso devaluation may have been far worse. The U.S. Department of Commerce has projected that were it not for NAFTA, U.S. exporters could have lost up to $25 billion in sales; once again, it might have taken U.S. exporters five years to rebuild to their pre-peso devaluation performance.[24]

It will take several years to be able to begin assessing the final results of the phased-in NAFTA. Even then, it will be difficult to isolate the effects of other factors occurring simultaneously, such as the peso devaluation, the Uruguay Round of trade liberalization under GATT, the integration of North American industries that would have occurred even without an agreement (but at a slower pace), technology-based improvements in productivity that reduce demand for labor, and the general globalization of industries. NAFTA helped accelerate an already rapid growth in U.S.-Mexico trade in the Agreement's first year and boosted U.S. export-related employment. In its second year, NAFTA cushioned the effects of the peso's devaluation, reducing both the number of export-related jobs lost as consumer spending in Mexico contracted and jobs that could have been lost if Mexico reverted to more restrictive trade policies to correct its external imbalances. U.S. exports remain above pre-NAFTA levels and are anticipated to rebound as the Mexican economy adjusts to the revalued peso and regains the confidence of foreign investors.

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[21]Bolle, Mary Jane, *Plant Closing, Mass Layoffs, and Worker Dislocations: Data Issues,* Library of Congress, Congressional Research Service, Washington, D.C., March 29, 1993.

[22]U.S. exports to Mexico were $2.4 billion greater in the first nine months of 1995 than during January-September 1993, the comparable period preceding the implementation of NAFTA.

[23]Mexico was dependent on the export of oil to earn foreign exchange to pay interest on international debts accumulated when oil prices were high.

[24]U.S. Department of Commerce, International Trade Administration, *The Case for NAFTA,* Sept. 26, 1995.

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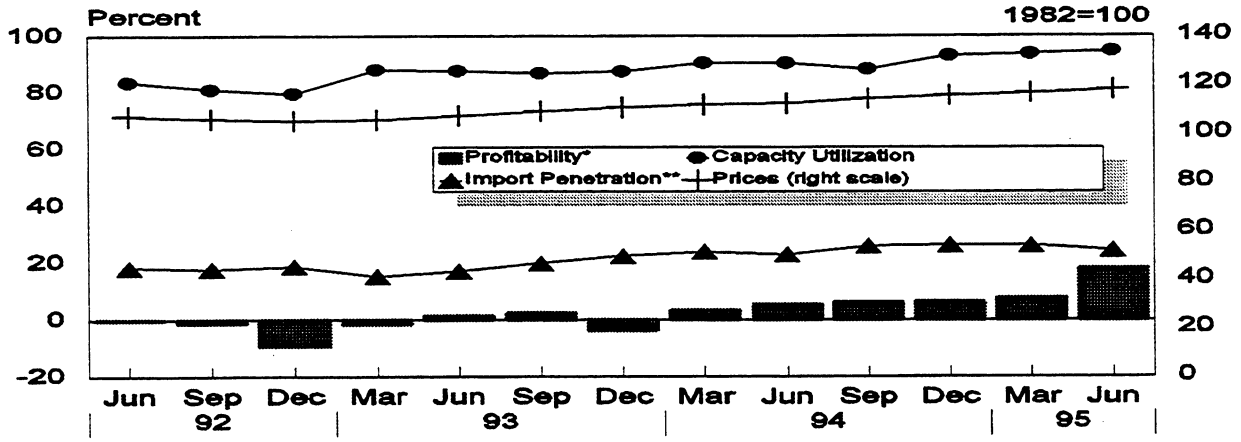
APPENDIX A
KEY PERFORMANCE INDICATORS OF SELECTED INDUSTRIES

- ☐ **STEEL** (Felix Bello, 202-205-3120)
- ☐ **AUTOMOBILES** (Michael Hagey, 202-205-3392)
- ☐ **ALUMINUM** (Karl S. Tsuji, 202-205-3434)
- ☐ **SERVICES** (Christopher Melly, 202-205-3461)

STEEL

Figure A-1. Steel mill products, all grades: Selected Industry Conditions



*Operating income as percent of sales for companies representing about 65% of production.
**Imports share of apparent supply.
Source: American Iron and Steel Institute, U.S. Bureau of Labor Statistics.

- Demand in steel consuming industries remained strong during the second quarter despite falling 1.3 percent. For the first six months of 1995, shipments reached 49.4 million tons, the highest level since 1981 when first-half shipments reached 47.7 million tons. Prices continued to rise, climbing an additional 2.3 and 6.2 percentage points for the quarter and six-month period, respectively. Increased demand and high capacity utilization rates fueled the price increase.

- Strong market demand resulted in increased imports, including semifinished steel purchased by U.S. steelmakers. Import penetration in June 1995 (22.7 percent) was slightly lower than in March 1995, at the same time imports' share of apparent open market supply dropped 1.3 percent below levels one year ago.

- For the second quarter, U.S. steelmakers posted $1.6 billion operating profit as a result of strong demand, particularly from the automotive, construction, and machinery sectors.

[1] Based on financial data reported to the American Iron and Steel Institute by producers accounting for approximately 65 percent of domestic shipments.

Table A-1
Steel mill products, all grades

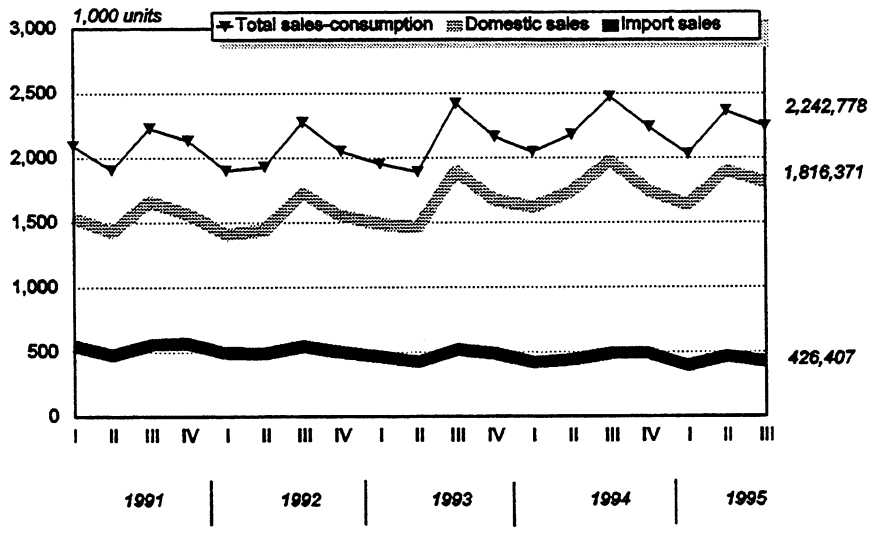
Item	June 1995	Percentage change, June 1995 from March 1995	January-June 1995	Percentage change, Jan.-June 1995 from Jan.-June 1994
Producer's shipments (1,000 short tons)	8,321	-1.3	49,435	5.5
Imports (1,000 short tons)	2,089	-10.0	14,264	3.9
Exports (1,000 short tons)	642	25.9	2,697	43.3
Apparent supply (1,000 short tons)	9,768	-4.5	61,001	3.9
Ratio of import to apparent supply (percent)	21.4	-5.6	23.4	-0.3

[1] Based on unrounded numbers.
[2] Percentage point change.
Note.--Because of rounding, figures may not add to the totals shown.

Source: American Iron and Steel Institute.

AUTOMOBILES

Figure A-2
U.S. sales of new passenger automobiles, by quarter



Note.--Domestic sales include all automobiles assembled in Canada and imported into the United States under the United States-Canadian automobile agreement, these same units are not included in import sales.
Source: *Automobile News; prepared by the Office of Industries.*

Table A-2
U.S. sales of new automobiles, domestic and imported, and share of U.S. market accounted for by sales of total imports and Japanese imports, by specified periods, Jan. 1994-Sept. 1995

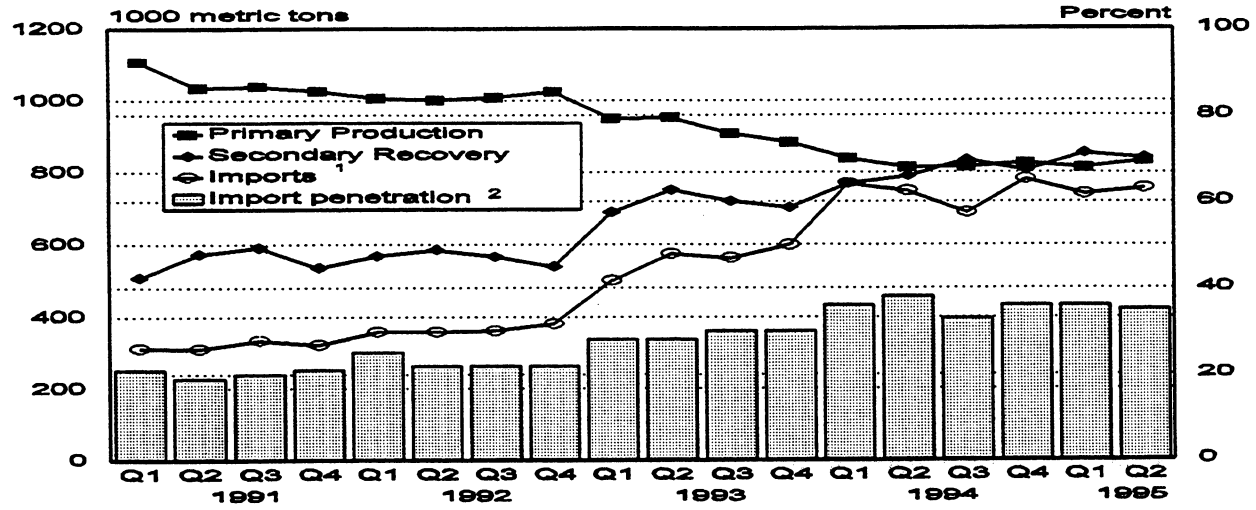
Item	July-Sept. 1995	Jan.-Sept. 1995	Percentage change-- July-Sept. 1995 from Apr.-June 1995	Percentage change-- Jan.-Sept. 1995 from Jan.-Sept. 1994
U.S. sales of domestic autos (*1,000 units*)[1]	1,816	5,358	-4.4	-2.1
U.S. sales of imported autos (*1,000 units*)[2]	426	1,277	-8.4	-9.9
Total U.S. sales (*1,000 units*)[1,2]	2,243	6,655	-5.1	-3.7
Ratio of U.S. sales of imported autos to total U.S. sales (*percent*)[1,2]	19.0	19.2	-3.6	-6.8
U.S. sales of Japanese imports as a share of the total U.S. market (*percent*)[1,2]	14.1	13.0	+17.5	-9.1

[1] Domestic automobile sales include U.S.-, Canadian-, and Mexican-built automobiles sold in the United States.
[2] Does not include automobiles imported from Canada and Mexico.

Source: Compiled from data obtained from *Automotive News*.

ALUMINUM

Figure A-3. Aluminum: Selected U.S. industry conditions



[1]Crude (metals and alloys) and primary (e.g. plates, sheets, and bars) forms for consumption.
[2]Percent share of imports to apparent domestic supply.

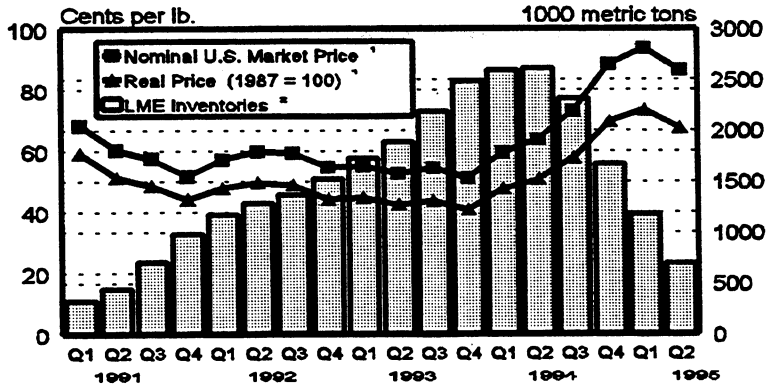
Source: U.S. Bureau of Mines

- Production by the six signatories of the 1994 Memorandum of Understanding (Australia, Canada, the European Union, Norway, Russia, and the U.S.) remained relatively stable in the second quarter of 1995 at about 34 thousand metric tons per day. For the U.S., primary and secondary aluminum production for the second quarter of 1995 totaled just under 1.7 million metric tons, little changed from the previous quarter. However, prices of primary aluminum softened in the second quarter of 1995, as fabricators desiring to reduce their inventories cutback on purchases. The average U.S. market price for primary aluminum during April through June 1995 slipped about eight percent to 86.5 cents per pound from the previous quarter's average price of 93.8 cents per pound.

- LME inventories continued to be drawn down for the fifth consecutive quarter, falling below one million metric tons in early May 1995, a level not seen since the end of 1991. By the end of June 1995, inventories dropped sharply to 693 thousand metric tons, about 40 percent less than the 1.2 million metric tons on hand at the end of March 1995, and more than 70 percent less than the all-time high of 2.6 million metric tons at the end of June 1994.

- U.S. imports of crude metal and primary forms were up slightly (two percent) to 757 thousand metric tons compared to the previous quarter. Import penetration averaged about 36 percent for the first half of 1995.

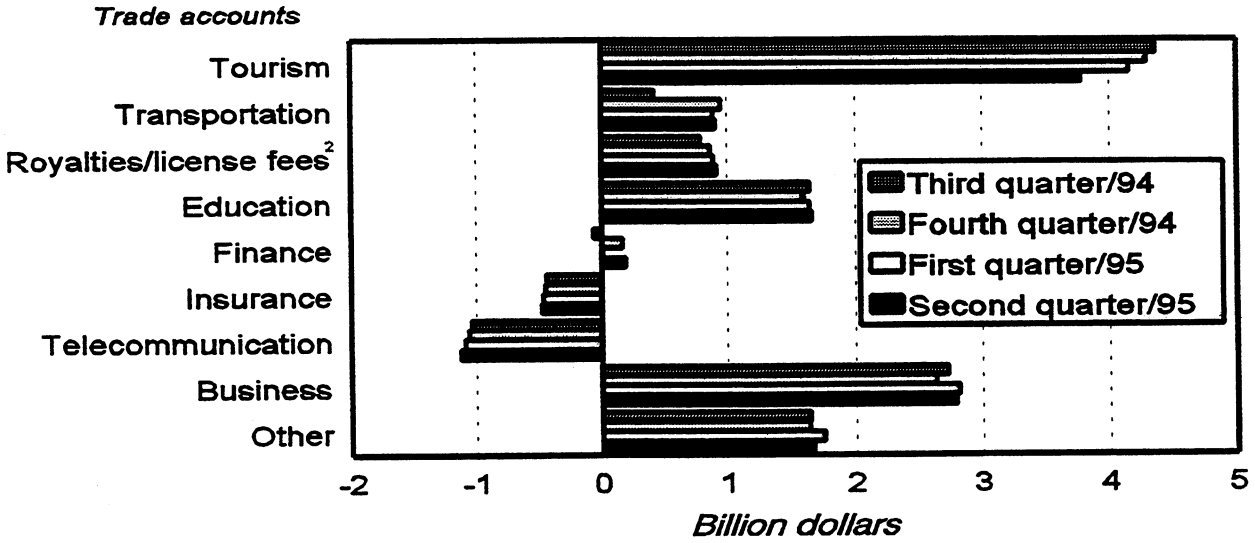
Figure A-4 Aluminum: Price and inventory levels



[1] Quarterly average of the monthly U.S. market price of primary aluminum ingots.
[2] End of quarter inventories.
Sources: U.S. Bureau of Mines, World Bureau of Metal Statistics, Metals Week, and U.S. Bureau of Economic Analysis.

SERVICES

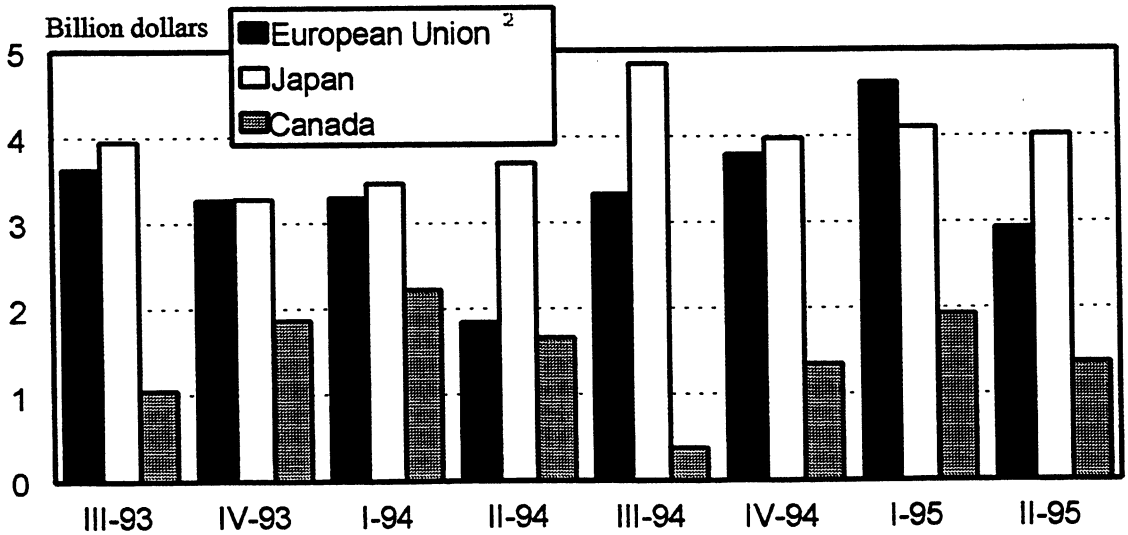
Figure A-5
Balances on U.S. service trade accounts,[1] third quarter 1994 through second quarter 1995



[1] Figures reflect trade among unaffiliated firms only.
[2] Includes port fees.

Source: Bureau of Economic Analysis, Survey of Current Business.

Figure A-6
Surpluses on cross-border U.S. service transactions with select trading partners,[1] by quarter, 1993-95



[1] Figures reflect private-sector transactions only; military shipments and other public-sector transactions have been excluded.
[2] Beginning with the first quarter of 1995, the European Union also includes Austria, Finland, and Sweden.

Source: Bureau of Economic Analysis, Survey of Current Business.