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The Post-9/11 Global Framework for Cargo Security

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Abstract

This paper reviews changes in global cargo security policies following September 11, 2001. The events of 9/11 led to the establishment of new protocols for tracking and screening cargo both in the United States and in foreign countries. These protocols have been incorporated into international frameworks such as those under the World Customs Organization (WCO), and in country-specific programs such as the Container Security Intiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT) administered by the United States. In addition, a host of foreign countries, including Australia, Canada, Sweden and New Zealand have introduced new cargo security programs following 9/11 or have strengthened previously existing programs. Many of these countries aim to harmonize their cargo security standards with those of the United States. Although substantial progress has been made in the development of post-9/11 cargo security programs, some have expressed concern regarding the programs' efficacy, their costs to business, and their effects on cross-border trade. At present, post-9/11 cargo security programs continue to be refined, which may ultimately lead to changes in the direction and implementation of these programs.

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Introduction

This article surveys changes in cargo security policies following the terrorist attacks of September 11, 2001. The events of 9/11 led the United States and its trade partners to re-assess and strengthen the global cargo security regime, resulting in new protocols for tracking, screening, and inspecting containerized imports and exports (Schmitz 2007).[2] These protocols have entered international frameworks such as those under the World Customs Organization (WCO), and have led to two new prominent U.S. programs; the Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT). Several U.S. trade partners have either established programs similar to those of the United States or participated in the mutual recognition of these programs.

Despite progress in the development and implementation of post-9/11 cargo security programs, however, concerns remain regarding their efficacy, their costs to business, and their effects on cross-border trade. For example, while the primary goal of post-9/11 programs is to prevent the cross-border movement of terrorist-related weapons, some have found that nonuniform security procedures among C-TPAT members and inadequate screening equipment at certain CSI ports may compromise this objective (GAO 2005). Separately, it is unclear whether the benefits of participation in post-9/11 cargo security programs outweigh their costs to participants. In particular, a 2007 study conducted by the University of Virginia found that whereas the annual costs to U.S. importers of participation in C-TPAT were more than $30,000, the benefits of such participation, including increased supply chain security and fewer customs inspections, had not yet been fully realized (CBP 2007b). Finally, a recent Canadian study found that while post-9/11 cargo security programs have had no measurable impact on the volume of cross-border trade between the United States and Canada, such programs have resulted in increased border delays and therefore higher costs for firms engaged in U.S.-Canada trade (CBP 2007b).

[2] In general, the objective of cargo security measures is to prevent the cross-border shipment of dangerous or illicit goods such as weapons of mass destruction (WMD), drugs, chemicals intended for destructive use, counterfeit or undeclared merchandise, firearms, currency, and hazardous materials.

Following a discussion of international agreements that address cargo security, this article will review U.S.- and foreign-country-based cargo security programs developed after 9/11.[3] The article will then outline the primary challenges and concerns of current programs, as plans to expand the global framework for cargo security move forward.

International Agreements on Cargo Security

The events of 9/11 precipitated a change in cargo security measures at national borders. Prior to 9/11, customs authorities were responsible primarily for clearing imported goods after such goods arrived at the border. They did so through the review of entry documentation accompanying such goods at the time of importation and, if necessary, their physical inspection. In contrast, the cargo security programs developed after 9/11 emphasize preshipment examination of exports. In particular, these programs require that exporters provide customs documentation in advance of their shipment of goods to the importing country. Such advanced documentation assists customs authorities employing sophisticated and multilayered risk assessment techniques to determine whether to admit goods at the border or to hold them for further inspection.[4]

Although advance information requirements and mandatory screening procedures can disrupt the flow of cross-border trade, recent international conventions aim, for example, to harmonize customs practices across countries and to require that individual customs administrations employ efficient, technologically advanced, and unburdensome procedures for inspecting and clearing cargo (De Wulf and Sokol 2005, xv).

After the events of September 11, 2001, the WCO ratified the revised Kyoto Convention on the Simplification and Harmonization of Customs Procedures and introduced a new set of protocols for cargo security called the Framework of Standards to Secure and Facilitate Trade (SAFE) (WCO 2006).[5] The objective

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[3] For a brief comparison of the cargo security programs discussed in the following pages, please refer to the appendix at the end of this article.

[4] In August 2007, President Bush signed the 9/11 Commission Recommendations Act, which requires that, by 2012, all U.S.-bound containerized cargo must be scanned by X-ray machine before entering the United States. For more information, see subsequent section on U.S.-based cargo security policies. Natter 2007.

[5] The revised Kyoto Convention, which was drafted in June 1999 and entered into force in February 2006, is an updated version of the International Convention on the Simplification and Harmonization of Customs Procedures (Kyoto Convention) of 1974. As of January 2007, 52 countries were parties to the agreement. WCO Instruments and Programmes.

of these documents was to address the specific security needs of the post-9/11 customs environment while strengthening procedures to facilitate the movement of goods across borders (Widdowson 2007). Building upon core principles found in the 1974 Kyoto Convention, the revised convention established guidelines to facilitate cross-border trade in response to the rapid growth in the volume and pace of international commerce. Among other things, the revised convention recommended that customs administrations (1) use electronically based systems to process and clear goods; (2) employ risk management techniques in selecting goods for inspection; (3) cooperate with customs authorities from other countries; and (4) ensure that customs-related laws and regulations are transparent and made readily available to the public (WCO2005; WCO2000). The revised Kyoto Convention encouraged customs authorities to advance beyond the role of gatekeeper to that of the trade facilitator (Widdowson 2007).

In June 2005, the members of the WCO adopted the SAFE Framework,[6] which further expanded trade facilitation principles in the Kyoto Convention and introduced new provisions on cargo security in response to 9/11 (Schmitz 2007). Like the Kyoto Convention, the WCO Framework viewed customs administrations as playing a key role in facilitating trade. The framework has two customs-centered supports: the customs-to-customs network and the customs-to-business partnership. Both support the international supply chain.[7]

The customs-to-customs network uses automated techniques to screen high-risk cargo; and the customs-to-business partnership sets up procedures to precertify shippers through an authorized economic operator (an AEO program).[8] The network and the partnerships help traders to realize the four primary concepts of the framework: (1) the harmonization of advance cargo information requirements across parties to the agreement; (2) the use of risk management techniques; (3) the inspection of outbound cargo upon the request of an importing country; and (4) the establishment of new programs to expedite customs processing for commercial shippers (CRS 2006).

[6] The SAFE framework was developed jointly by customs administrations and the private sector. As of February 2007, 144 of the 171 members of the WCO were signatories to the agreement (Schmitz 2007)

[7] A supply chain is defined as a network of interrelated activities including the production, transport, and storage of goods.

[8] Authorized economic operator (AEO), or trusted shipper, programs are an important component of trade facilitation measures in that they permit importers, exporters, manufacturers, and transportation firms who have met precertification requirements to clear their cargo quickly through customs. AEO programs also aim at mutual recognition, where a certified shipper from one country may benefit from expedited customs processing in another country. Kulisch 2006, 32; and Edmondson 2007, 17.

Box 1: Risk Management[1]

Risk management focuses on identifying and implementing measures to limit exposure to risk, or the likelihood of an event occurring with a negative or unwanted outcome. In trade, the focus of risk management is to systematically identify imports and exports that represent the greatest risk of noncompliance of customs laws and regulations, as well as the greatest risk to national security and safety.

By using multiple risk management strategies, U.S. and foreign customs agencies can identify and target those areas that pose the greatest risk, and allocate resources accordingly. U.S. and foreign cargo security programs generally implement similar risk management strategies based on the following: collecting data elements and detailed shipment information from a variety of sources; analyzing and assessing risk using rules-based computer programs and customs targeting teams; prescribing action, such as undertaking non-intrusive or physical inspection or seizure; and tracking and monitoring the risk management process and its outcomes (Laduba 2005).

In the United States, trade data and detailed shipment information are gathered from various government data sources in the Automated Targeting System (ATS), a vast database that uses targeting rules and criteria based on intelligence to filter through cargo data and flag high-risk shipments. Electronic manifests submitted 24 hours prior to foreign lading allow U.S. Customs and Border Protection to assess cargo risk earlier prior to U.S. arrival (CBU, n.d.). In addition, U.S. cargo security partnerships such as C-TPAT and CSI aim to mitigate risk by strengthening supply chain security in the case of the former, and by prescreening U.S.-bound cargo at foreign ports prior to departure for the latter.

Risk management techniques allow customs to identify shipments that represent little to no risk, and thus focus limited resources on shipments that pose the greatest risk of noncompliance. In contrast to inspection based on a shipment's risk profile, the aim of full inspection is either to physically inspect or scan 100 percent of imported containers. The 9/11 Commission Recommendations Act of 2007, signed into law August 3, 2007, mandates the scanning of 100 percent of all maritime cargo containers entering U.S. ports by 2012. Some industry observers believe that cargo inspection based on risk management is a more practical method to balance cargo security with the flow of legitimate (i.e., low or no risk) trade than 100 percent inspection of imported containers (Anderson 2007). Others question the cost of implementing 100 percent inspection, and who should pay for it (e.g., importers or exporters) (Lane 2007).

[1] Risk management procedures had been used by customs administrations prior to 9/11, but their use has expanded with the introduction of post-9/11 programs such as CSI and C-TPAT.

The cargo security principles included in the WCO SAFE Framework are designed to encourage rather than to impede cross-border trade (WCO 2005). The customs-to-customs network of the agreement outlines 11 substandards, or guidelines, for customs authorities to follow in implementing cargo security measures (WCO 2005). These guidelines recommend, for example, that (1) customs authorities use noninvasive equipment for the inspection of cargo; (2) establish automated systems for risk assessment; (3) develop consistent methods to distinguish high-risk from low-risk cargo; (4) require advance electronic information on cargo and container shipments; and (5) establish performance measures to track the efficacy of cargo security programs. The guidelines on risk management and cargo inspection, in particular, address trade facilitation concerns in that they recommend, to the extent possible, that customs authorities implement security procedures that do not interfere with cross-border trade flows (WCO 2005).

Similarly, the customs-to-business partnership fulfills the dual objectives of trade facilitation and cargo security. The partnership helps private-sector entities such as importers, exporters, freight forwarders, and transportation companies to complete self-assessments of their internal security regime. Those companies whose procedures meet specific criteria for protecting supply chains from the movement of dangerous goods are eligible for expedited customs processing under an AEO, or trusted shipper, program. By requiring that shippers inspect goods that are purchased from foreign manufacturers as they are prepared for outgoing shipment, the customs-to-business partnership enables customs authorities to engage the private sector in securing the international supply chain (WCO 2005).

Trade Facilitation Principles Under the World Trade Organization[9]

Although the World Trade Organization (WTO) General Agreement on Tariffs and Trade (GATT) does not address cargo security directly, the provisions of the agreement on trade facilitation under articles V, VIII, and X are complementary to cargo security measures under the WCO (WCO, Information Note 2007). Article V addresses freedom of transit, and states that a country should permit cargo that originates from or is destined for another country to pass through the territory of the former without being delayed by local customs authorities. Article VIII recommends that countries simplify import and export procedures, including customs documentation requirements. Article X requests transparency in the publication of a country's customs-related rules and

[9] As of July 2007, 151 countries were members of the WTO.

regulations (GATT 1986, 12). These provisions correspond closely with WCO recommendations on trade facilitation, including the cooperation between national customs authorities, the simplification of customs procedures, and the assurance of predictability in customs operations (WCO Information n.d.a.). Under the SAFE Framework, the WCO introduced implementation guidelines for GATT Article VIII, in particular, that form the basis of post-9/11 cargo security measures, such as those pertaining to the electronic processing of customs documentation, the use of risk management, and the pre-authorization of commercial shippers.

In August 2004, the WTO initiated trade facilitation negotiations to strengthen members' commitments under articles V, VIII, and X. Several members submitted proposals on specific aspects of these articles: for example, Canada on the importance of coordination between national customs agencies; Korea on the reduction of administrative burdens in customs processing; and Japan on the pre-arrival examination of cargoes and the use of risk management. (WTO 2005 a, b, c, d).

Trade facilitation negotiations under the WTO remain ongoing, with members working toward the development of a draft text on key principles under articles V, VIII, and X to be finalized by the conclusion of the Doha Round (WTO 2005a).

Cargo Security Provisions Under the International Maritime Organization[10]

Acknowledging the importance of the maritime sector to international trade, the International Maritime Organization (IMO) established new security measures following the events of 9/11 to ensure the safety of maritime ports and cargo.[11] These measures are outlined in the International Ship and Port Facility (ISPS) Code, which entered into force on July 1, 2004.[12] The objective

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[10] The International Maritime Organization (IMO) was established by the Safety of Life at Sea Convention (SOLAS), adopted in 1948. A specialized agency of the United Nations (UN), the IMO maintains regulations regarding maritime safety, security, and technical cooperation, as well as environmental protection (IMO 2007).

[11] According to one estimate, more than 80 percent of world trade is transported by sea. The global maritime industry consists of 46,000 vessels and over 4,000 ports (OECD 2007).

[12] The International Ship and Port Facility (ISPS) Code was adopted as an amendment to the 1974 IMO Safety of Life at Sea (SOLAS) Convention and based on provisions of U.S. legislation entitled the Maritime Transportation Security Act (MTSA) of 2002. Con- tracting parties to SOLAS, which number 148 countries, must comply with ISPS regulations. However, compliance by parties noncontracting to SOLAS is voluntary (CRS 2006).

of the ISPS Code is to establish a set of uniform measures to be implemented jointly by governments, port facility operators, and shipping firms for the assessment of and response to security threats to international ports.[13] The code is divided into two parts: the first part contains mandatory guidelines on security plans to be established by ships, shipping firms, and ports. National governments are responsible for overseeing the implementation. The second part of the framework provides recommendations on how to execute port security plans (Australian Government 2007). Plans developed and implemented by contracting parties to the ISPS Code are intended to pre-empt security threats to maritime trade (IMO FAC, 2007). As such, participants in the code are requested to develop plans based on three predefined threat levels to port security (fore example, "normal," "heightened," or "exceptional"), and to use risk assessment to determine which threats represent the highest vulnerability to ships and ports and, therefore, which merit a response (IMO FAQ 2007).

Compliance with the ISPS Code is estimated to lead to significant costs for participant countries. One study assesses such costs as reaching nearly $300 million in the first year of participation, and $700 million in each subsequent year. However, these costs are reportedly outweighed by the potential benefits of compliance with ISPS regulations, which include not only the avoidance of a shutdown in port operations due to a security threat, but in faster vessel turnaround times and expedited customs processing (OECD 2003).

Air Cargo Security Measures

Post-9/11 security measures on air cargo have been discussed both at the national and international level, but unlike measures for maritime cargo, such measures have not been codified under a single agreement. Prior to 9/11, the International Civil Aviation Organization (ICAO) established standards for shippers, freight forwarders, and transportation firms to maintain the security of cargo while in transit. The standards also included recommendations to facilitate the cross-border movement of goods.[14] Among the recommendations

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[13] Ibid.

[14] The International Civil Aviation Organization (ICAO) was established under the Convention on International Civil Aviation (also known as the Chicago Convention), signed in December 1944. ICAO is under UN auspices, and its purpose is to maintain standards on aviation safety and security.

established by ICAO and outlined in the Chicago Convention are, where possible, the use of risk management techniques over the physical inspection of cargo, the acceptance of customs documentation in electronic formats, and the use of "authorized importers" to expedite customs processing. In addition, the Chicago Convention mandates that both airports and airlines establish security programs and that contracting states to ICAO cooperate in matters of air cargo security (Buzdugan 2006).

More recently, the International Air Transport Association (IATA), whose membership includes 250 global airlines, developed a list of best practices with regard to the protection of air cargo and created an internal working group to establish a strategic plan on air cargo security and trade facilitation (IATA 2006; and IATA 2007). IATA initiatives emphasize all-cargo versus passenger air transport[15] and aim to ensure that cargo security measures, such as screening and clearance procedures, are harmonized across countries both to ensure their maximum efficacy and their minimal interference with air transport operations (Task Force 2007; Peck 2006).

United States-Based Cargo Security Policies

Customs-Trade Partnership Against Terrorism (C-TPAT) and the Container Security Initiative (CSI)

Shortly after 9/11, the U.S. Government introduced two programs to secure the movement of imports into the United States: the Customs-Trade Partnership Against Terrorism (C-TPAT) and the Container Security Initiative. C-TPAT, launched in April 2002, is a voluntary program with participation by all members of the supply chain—including manufacturers, transportation firms, customs brokers, and warehouse and port terminal operators—who are required to complete security self-assessments and security enhancements to meet the criteria of the program.[16] The idea behind C-TPAT is that by engaging private-sector participants to help screen low-risk cargo, the U.S. Customs and

[15] Although up until resently, emphasis had been placed on the screening of air passenger baggage, recent U.S. legislation entitled the 9/11 Commission Recommendations Act, signed into law by President Bush on August 3, 2007, requires that all cargo transported in the storage cabins of passenger planes be screened (e.g., by X-ray, explosive detection systems (EDS), physical search, or canine inspection) by 2010. Earlier legislation proposed by the U.S. Senate recommended the screening of cargo transported by both passenger aircraft and air freighters. See Air Cargo Security Act 2003; Natter 2007, 9; and Putzger 2007, 40-42.

[16] A company that applies for voluntary membership in C-TPAT is required to sign a memorandum of understanding stating that it will follow security guidelines established by the program and will submit a security profile regarding procedures it uses to protect its supply chain, including information from its suppliers. CBP 2007; Tuttle 2007.

Border Protection (CBP) agency[17] can focus its resources on detaining high-risk shipments that represent the greatest security threat (Feldman 2007). Participants in C-TPAT include U.S. companies as well as U.S.-based affiliates of foreign companies, all of whom must be involved in the movement of goods between U.S. and non-U.S. ports. As of June 2007, there were 7,200 companies that were members of the C-TPAT program (Lodbell 2007).

In general, companies that participate in C-TPAT benefit from fewer container searches and faster customs processing of goods that are imported into the United States. In addition, companies under C-TPAT are eligible to participate in the Free and Secure Trade (FAST) program, created to expedite the movement of goods between the U.S.-Canadian and the U.S.-Mexican borders, and a maritime "greenlane" to reduce customs wait times for cargo arriving at U.S. seaports.[18] Once more, companies that have achieved a higher level or higher tier, status within C-TPAT, receive additional customs benefits, such as a guarantee of expedited customs processing during times of elevated security threat levels, and a further reduction in the number of cargo inspections.[19] According to a 2007 study conducted by the University of Virginia at the request of CBP, the annual cost to a U.S. importer of compliance with C-TPAT is more than $30,000. Approximately 33 percent of the companies surveyed for the study stated that the benefits of the program outweigh the costs, compared with 16 percent who stated that the costs exceed the benefits. Twenty-four percent of the companies surveyed believed that the costs and benefits of participation in C-TPAT are roughly equal (CRS 2007). At the same time, many small- and medium-sized businesses have noted that the costs of compliance with C-TPAT are high enough to deter them from participating in the program (Lodbell 2007).

Under the Container Security Initiative (CSI), begun in January 2002, CBP representatives are placed at foreign seaports where they work with local

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[17] The CBP agency was established under the Department of Homeland Security in 2003 to help deter the movement of terrorist and terrorist weapons across U.S. borders. Prior to 2003, the U.S. Customs Service resided under the Department of the Treasury. CBP 2007.

[18] For a discussion of the FAST program and the greenlane for maritime cargo, see subsequent sections on Mutual Assistance Programs and Post-9/11 Cargo Security Legislation, respectively

[19] The C-TPAT program consists of three tiers of participation. Tier 1 participants are those companies that have passed a preliminary review of their supply chain security based on a written profile submitted to the CBP agency and are certified to participate in C-TPAT. Tier 2 participants undergo an on-site inspection by CBP to ensure that their security procedures are sufficient to protect against a terrorist weapon being transported through their supply chain and are then validated as C-TPAT members. Tier 3 participants are certified and validated members of C-TPAT that have security procedures in place which exceed criteria established by CBP under the C-TPAT program. They are rewarded with the most extensive customs benefits. CRS 2006; Feldman 2007.

customs officials to prescreen U.S.-bound containerized cargo (CBP 2007d). Containers are prescreened, in particular, to determine if they are used to transport terrorists or terrorist weapons to the United States. The prescreening process includes a review of customs documentation, along with other intelligence information, to determine which containerized cargo poses a security threat and, if warranted, requires the use of x-ray machines or radiation detection devices to examine the contents of such cargo (CBP 2007d). Potentially dangerous cargo may be further subject to physical inspection and/or withheld from shipment. At present, 58 foreign ports participate in CSI, with the majority of ports being in Asia and Europe (CBP 2006; and CBP 2007g).[20] The program also allows for reciprocity: customs officials from Canada and Japan are currently stationed at U.S. ports to screen U.S.-outbound containerized cargo destined for these countries. Like C-TPAT, participation in CSI has a trade facilitative effect in that it reduces customs processing at U.S. ports of destination and expedites the clearance of those containers that have been pre-screened at foreign ports (CBP 2007d). The estimated costs to an individual port of participation in CSI was $230,000 in 2005, which is reported to be significantly less than the amount of annual revenue that would be lost by a port closure due to a terrorist attack (CBP 2006).

Post-9/11 Cargo Security Legislation

Finally, following 9/11, several U.S. policies were set up to address cargo security. The first of these policies is the Maritime Transportation Security Act (MTSA) of 2002, which requires that participants in the U.S. maritime sector, including operators of passenger vessels, cargo vessels, and ports complete security assessments of their facilities and establish procedures to counter the threat of terrorist attacks (DHS 2003). The act recommends that participants deploy specific safety measures to ensure the security of their facilities, such as the screening of both passengers and baggage, the establishment of identification procedures for onsite personnel, and the use of surveillance equipment. In addition, regulations under MTSA provide for the implementation of the Automatic Identification System (AIS), which monitors vessel movement through the electronic exchange of ship-to-ship and ship-to-shore information (DHS 2003).

Also in 2002, the CPB introduced the Operation Safe Commerce (OSC) program and the 24-Hour Advance Manifest Rule. Operation Safe Commerce

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[20] For a listing of ports in the CSI program, see CBP 2007a. Ports that participate in CSI are selected on the basis of the volume of goods that they export to the United States, and whether or not their geographic location makes them likely to be the source of terrorist activity. See CBP 2006; and CBP 2007.

provides government funding for private-sector initiatives to better secure containerized cargo moving into and out of U.S. ports. Such initiatives may include the development of information systems to track and monitor cargo or the use of electronic seals on cargo containers. Participants in the program represent all levels of the supply chain, including customers, shippers, and transportation firms (DOT 2002). Separately, the 24-hour rule requires ships and nonvessel operating common carriers (NVOCCs)[21] to provide CBP with a declaration of the items within a U.S.-bound cargo container 24 hours before the container is loaded onto a vessel. The rule permits U.S. Customs to determine if a specific container represents a security threat and, consequently, whether it should be denied further shipment CBP 2003; Maersk n.d.).

In 2005, the U.S. Senate introduced the GreenLane Maritime Cargo Security Act and, in 2006, the Secure Freight Initiative. The GreenLane Maritime Cargo Security Act provides additional customs benefits to C-TPAT participants if the participants meet certain criteria regarding the screening and inspection of cargo (U.S. Congress 2006; Heritage 2007). These benefits include priority customs processing, reduced cargo or container searches, and the expedited release of goods through customs. The Secure Freight Initiative calls for the increased scanning of U.S.-inbound containers for nuclear or radiological weapons. Under this initiative, nuclear detection equipment is deployed in overseas ports to scan containers before they are transported to the United States. Currently seven foreign ports—including Hong Kong, and those in Honduras, Korea, Oman, Pakistan, Singapore, and the United Kingdom—participate in the program (DHS 2006; CBP 2007c). Finally, also in 2006, Congress passed the Security and Accountability for Every (SAFE) Port Act, which built upon previous U.S. legislation to secure maritime ports and cargo. Among other things, the Act codified into law C-TPAT, required the placement of radiation detection equipment in 22 U.S. ports, established a new identification card system for employees at 40 U.S. ports, and set aside $400 million in government funding for port security grants (Edmundson 2006; White House 2007).

Foreign-Country-Based Programs

Countries outside of the United States have either updated or introduced new cargo security programs following 9/11. Some of these programs contain measures that are compatible with provisions under the U.S.-based program C-TPAT. The following section discusses cargo security programs in the EU, Sweden, Australia, New Zealand, and Canada.

[21] Nonvessel operating common carriers (NVOCCs) purchase cargo space from shipping lines at wholesale rates and resell such space at retail rates to shipping customers.

The European Union

In 2005, the European Union introduced a series of measures aimed at protecting the internal EU market, securing international supply chains, and facilitating legitimate cross-border trade through improved customs procedures. These measures, which are embodied within the EU Customs Security Program, introduce three changes to the Community Customs Code[22] by (1) requiring traders[23] to provide customs authorities with advance electronic information prior to the import of goods to or the export of goods from the EU (pre-arrival and pre-departure declarations); (2) creating a uniform risk management approach based on common risk-selection criteria for EU-Member States, and (3) creating an AEO program to provide reliable and customs-compliant traders with simplified customs procedures to facilitate legitimate cross-border trade (EC 2006a). Each measure will enter into force at a different time. For example, a new framework to establish EU-wide risk-based procedures entered into force in early 2007, with computerized risk management systems scheduled to be put into place by 2009. At the same time, provisions regarding the AEO program entered into force on January 1, 2008, while requirements for traders to submit to customs authorities advance information on all goods entering or leaving the EU will become mandatory on January 7, 2009 (EC 2006a).

Under the AEO program, reliable and customs-compliant traders will benefit from the streamlining of EU-Member State customs procedures and/or from facilitation with customs controls related to supply chain security or from both (EC 2006a; EC 2006b). Benefits for operators granted AEO status—dependent on the type of AEO certificate granted—include, among others, the simplification of customs procedures, fewer physical inspections and documentation requirements, and priority treatment for shipments (EC 2006b, 7, 14; 2006c, L360/67-68).[24]

Under the program, EU-Member States will be able to grant AEO status to an economic operator involved in the international supply chain that is able to

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[22] The Community Customs Code contains the basic customs legislation of the EU customs territory.

[23] A trader refers to a supply chain participant involved in the cross-border movement of goods. Such entities include, for example, manufacturers, importers, exporters, freight forwarders, warehousing firms, customs agents, and transportation firms.

[24] Types of AEO certificates include customs simplification certificates, security and safety certificates, and joint certificates. Holders of either the AEO security and safety certificate or a joint certificate may benefit from reduced data information requirements and prior notification for physical inspection of shipments (effective July 9, 2009).

demonstrate a history of compliance with customs requirements, appropriate record-keeping standards, proven financial solvency, and adequate security and safety standards (EC 2005). Economic operators eligible for AEO status include manufacturers, exporters, freight forwarders, warehousing firms, customs agents, transportation firms, and importers. The program is voluntary; economic operators may apply for AEO status through an application process to determine program eligibility based on the criteria outlined above. The application process involves a security self-assessment followed by a formal assessment by the customs authority of an economic operators' risk. The risk assessment is based on the Compliance Partnership Customs and Trade (COMPACT) framework, a methodology that incorporates risk mapping along with security guidelines established under the AEO program.[25]

Sweden

In addition to the security measures adopted by the European Union at the supranational level, Sweden, an EU-member country, has developed the Stairsec program aimed at improving customs compliance and supply chain security. The Stairsec program is an integrated supply chain security program developed within Sweden's existing Stairway customs accreditation program, which focuses on increasing the quality of customs compliance (Tullvereket 2002). The objective of the Stairsec program is to increase supply chain security through an accreditation process for all private-sector stakeholders in the international supply chain, including importers and exporters, brokers, forwarders independent of transport mode (e.g., air, sea, and land), and terminals. Stairsec became operational with the certification of pilot operators on January 15, 2004, following the CSI-certification of the Port of Gothenburg in May 2003. Currently, more than 40 Swedish companies are certified in Stairsec or are in the processing of becoming so (Tukkverket n.d.a.). According to former U.S. CBP Commissioner Robert Bonner, Stairsec mirrors closely the objectives of C-TPAT (Bonner 2004). The two programs are compatible, and discussions between Sweden and the United States on ways C-TPAT and Stairsec can be further harmonized are ongoing (Tullverket n.d.b.).

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[25] The COMPACT framework acts as a pre-audit to determine an economic operator's eligibility for AEO status. If AEO status is granted, customs authorities issue an AEO certificate to the operator. However, if customs authorities conclude that the security profile of an AEO applicant is high risk and requires additional improvements, then the applicant is asked to address such improvements and re-apply for assessment under COMPACT. See EC 2006b.

Australia

Australia's Frontline program, established in 1990, is a cooperative effort between the Australian Customs Service and Australian private-sector firms to deter illegal activities such as drug trafficking, wildlife and flora smuggling, money laundering, and the illegal importation and exportation of prohibited items (Australian Customs 2003). After 9/11, the program shifted its primary focus from the prevention of the movement of narcotics to counterterrorism although the former remains an important program objective (Embassy of Australia 2007a). The Frontline program currently has 705 members that are involved in international trade and transport, including shippers, freight forwarders, airlines, customs brokers, warehousing firms, air couriers, and postal and port authorities (Parliament 2003; Embassy of Australia 2007a). The program is voluntary in nature although membership is essentially by invitation from the Australian customs administration (Parliament 2003). Companies sign a memorandum of understanding (MOU) with customs to formalize the agreement. However, the MOU is not a legally binding or enforceable contract (Australian Customs 2007a). Program participants receive awareness training on illegal drugs and activities and correspond regularly with Australian customs to report any suspicious activities.

Within the context of the WCO SAFE Framework, Australia is conducting an AEO pilot program involving Australian customs, industry, and foreign customs administrations in the Asia-Pacific Economic Cooperation (APEC) region. The aim of the pilot program is to test the AEO application and assessment processes for the security accreditation of supply chain operators (e.g., importers, exporters, freight forwarders, and customs brokers), with the ultimate objective of achieving mutual recognition between Australian Customs and other customs administrations participating in the AEO pilot program (Australian Customs 2007b).

New Zealand

In 2004, the New Zealand Customs Service initiated the Secure Exports Scheme (SES), an export-oriented voluntary partnership between customs and exporters to strengthen security measures that protect goods against tampering when containers are packed and uploaded for shipment (Australian Customs 2007b). To participate in the program, potential SES participants are required to submit advance export information and maintain security measures approved by New Zealand's customs administration in return for "greenlane" status, or expedited customs processing.[26] SES partners' security measures comply with standards outlined in the WCO SAFE Framework.

On July 1, 2007 the United States and New Zealand signed a Mutual Recognition Agreement (MRA) under which C-TPAT and SES-certified trading partners receive reciprocal benefits from each other's program. SES-certified trading partners will be eligible for direct benefits such as faster customs clearance times for exports arriving in the United States and reduced customs inspections (New Zealand Embassy 2007).

Canada's Partners in Protection (PIP) Program

Administered by Canada's Border Services Agency (CBSA), the Partners in Protection (PIP) program is a voluntary initiative between CBSA and private-sector firms engaged in international trade to enhance border security, increase awareness of customs compliance issues, help detect and prevent smuggling of contraband goods, and combat organized crime and terrorism (CBSA 2007c). In a cooperative effort based on a voluntary MOU (CBSA and PIP partners develop joint action plans, conduct assessments of security measures, and participate in security awareness sessions (CBSA 2007c). PIP participants benefit from reduced shipment processing times and improved security levels. PIP participants also become eligible to participate in the FAST program developed jointly between Canada and the United States (CBSA 2007a). The Canadian Government plans to harmonize measures established under the PIP program with those of C-TPAT with the eventual goal of mutual recognition between the two programs (CBSA 2007A; Anderson 2007).

Mutual Assistance Programs

Mutual assistance programs are established to harmonize cargo security practices between two or more countries thereby increasing the effectiveness of such practices, while at the same time facilitating the cross-border flow of goods. The United States currently participates in two separate mutual assistance programs: the U.S.-EU Mutual Assistance Agreement and the Free and Secure (FAST) Program between the United States-Canada and the United States-Mexico.

[26] The program requires that participants meet formal security guidelines established by New Zealand's customs administration, but also recognizes and incorporates participants' existing security practices (New Zealand Customs 2006); Secker 2007).

U.S.-EU Mutual Assistance Agreement

In April 2004, the United States and European Union reached an agreement to improve cargo security on a reciprocal basis while ensuring equal levels and standards of control for U.S. and EU ports and operators (Europa 2004). The objective of the agreement is to achieve mutual recognition of C-TPAT and the EU-AEO program. The agreement expanded the existing U.S.-EU Customs Cooperation and Mutual Assistance in Customs Matters Agreement (CMAA), signed in 1997, to include supply chain security (Europa 2004). The new agreement established a U.S.-EU Joint Customs Cooperation Committee (JCCC) and two working groups to identify and examine activities to achieve the objectives outlined in the agreement, including minimum standards for CSI ports, common risk criteria, and trade partnership programs (EC 2007b). In 2007, the 8^{th} U.S.-EU JCCC formalized a work plan to move towards mutual recognition, including an in-depth comparison of C-TPAT and the AEO program, a pilot program to identify and assess any differences between the two programs, and a draft plan outlining additional steps to take towards mutual recognition prior to the formal implementation of the AEO program in 2008 (EC 2007b; EU-U.S. 2007).

Free and Secure (FAST) Program Between the United States-Canada and the United States-Mexico

As noted earlier, the FAST program comprises two bilateral initiatives between the United States and Canada and the United States and Mexico that allow pre-approved eligible or low-risk shipments to cross the U.S.-Canadian and U.S.-Mexican borders with greater speed through dedicated highway lanes and with reduced customs inspections (CBSA 2007b; CBP 2007f). Participants eligible for expedited goods clearance under the FAST program include importers, transportation firms, and drivers that are enrolled in C-TPAT and/or the PIP program for U.S.-Canadian highway carriers, or that are enrolled in C-TPAT for U.S.-Mexican highway carriers. By allowing expedited transborder shipments from carriers certified in C-TPAT and/or the PIP program, the FAST program aims to promote increased supply chain security while facilitating legitimate cross-border trade, permitting U.S. Customs to focus resources on high-risk shipments.

Assessment of Post-9/11 Cargo Security Programs

Although cargo security programs had been in place prior to the events of September 11, 2001, post-9/11 cargo security initiatives differ from earlier programs in three important ways. First, although like previous programs, post-9/11 efforts generally target the movement of illegal or dangerous cargo, their primary emphasis is on preventing the cross-border transport of terrorist weapons of mass destruction (WMD). Second, while earlier cargo security programs focused on the role of national customs administrations in policing the transborder movement of goods, post-9/11 programs have engaged private-sector supply chain participants-—from manufacturers to importers to transportation providers—in achieving this objective. As such, post-9/11 programs offer a more holistic approach to cargo security by recognizing both the need for cooperation between private-sector entities and customs administrations and by acknowledging the importance of "behind-the-border measures" in securing the international supply chain. Finally, whereas post-9/11 programs have introduced new and additional procedures for screening and clearing cargo through customs, many of these programs also contain trade facilitation components. As noted, such components may be based on the pre-authorization of shippers, the use of risk management techniques, or the simplification of customs documentation requirements. Post-9/11 programs therefore attempt to strike a balance between security and facilitation, recognizing that rather than being mutually exclusive, the two objectives may be mutually reinforcing.

Despite progress in the development of cargo security programs six years after the events of 9/11, some key concerns remain. In particular, participants in post-9/11 cargo security programs have asked whether these programs are effective in securing the international supply chain; what their impact is on cross-border trade; and whether the benefits of compliance with post-9/11 programs outweigh their costs to participants. Recent studies evaluating post-9/11 cargo security programs offer at least partial answers to these questions. For instance, on the question of efficacy, a May 2005 report completed by the United States Government Accountability Office (GAO) reviewed both the C-TPAT and CSI programs and found that certain factors may compromise their effectiveness in preventing the movement of terrorist weapons. For example, the report stated, among other things, that uniform standards for assessing the supply chain security of C-TPAT members are not in place; that screening equipment used at some CSI ports may not be capable of detecting weapons of mass destruction (WMD); and that ship manifest data, used by CSI officials to prescreen containerized cargo, may often be inaccurate and thereby ineffective in identifying dangerous goods. However, improvements to both these programs continue to be made, some of which may address the above issues (GAO 2005).

Separately, regarding the effect of cargo security measures on cross-border trade, a study conducted by the Conference Board of Canada found that while tighter security along the U.S-Canadian border has had no measurable impact on the volume of Canadian exports to the United States, it has in many cases increased the overall costs to firms of engaging in U.S.-Canada trade. Some of these costs result directly from companies' compliance with new security measures; others are indirect costs, such as those arising from increased border delays (Conference 2007). Finally, on the issue of whether the benefits of participation in cargo security programs outweigh the costs to individual participants, a study cited earlier in this article by the University of Virginia on C-TPAT found that while the costs of C-TPAT membership are high, compliance with the program may result in several potential benefits to participants such as increased supply chain security, fewer customs inspections, enhanced reputation with customers, and improved inventory control. However, although these so-called "secondary" benefits are important to C-TPAT participants, the majority of the companies surveyed for the study indicated that such benefits have not yet been fully realized (CBP 2007e).

Conclusion

Following the events of 9/11, many programs have been developed both at the international and national level to ensure the secure movement of goods across borders. The United States appears to be at the forefront of these efforts, and has established the most comprehensive cargo security programs to date. Although post-9/11 programs have as their primary focus preventing the cross-border movement of dangerous cargo and, in particular, terrorist-related weapons via the international supply chain, they also contain trade facilitation measures designed to expedite customs processing and enhance trade. Nonetheless, current cargo security programs face certain implementation challenges that some claim may compromise their effectiveness and minimize their potential benefits to participants. Overall, however, as many cargo security programs continue to be refined, conclusions regarding their efficacy, their costs to business, and their effects on trade will likely change, in turn influencing the future direction of these programs.

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Appendix Selected post-9/11 programs on cargo security and trade facilitation

Program	Year implemented	Country of origin	Main objectives	Participants
The Revised Kyoto Convention	2006	Global	- Customs/ trade facilitation - Simplification and harmonization of customs procedures across countries	- 52 member countries as of January 2007
WCO SAFE Framework	2005	Global	- Customs/ trade facilitation - Supply chain security	- 144 member countries as of February 2007
IMO International Ship and Port Facility (ISPS) Code	2004	Global	- Maritime port security - Cargo/supply chain security	- National governments - Maritime port facility operators - Shipping firms
International Civil Aviation Organization (ICAO)	([a])	Global	- Air cargo security - Customs/trade facilitation	- Airlines and airports of contracting parties to ICAO
Customs-Trade Partnership Against Terrorism (C-TPAT)	2002	United States	- Security of cargo transported by land, air, and sea into the United States - Supply chain security	- Importers, manufacturers, transportation and logistics firms, customs brokers, warehouse and port terminal operators [b]
Container Security Initiative (CSI)	2002	United States	- Cargo security for U.S.-inbound maritime containers	- Maritime port facility operators of U.S. trade partners [c]

Appendix Selected post-9/11 programs on Cargo security and trade facilitation–*Continued*

Program	Year implemented	Country of origin	Main objectives	Participants
European Union's Authorized Economic Operator (AEO) program	2008[d]	European Union	-Customs/ trade facilitation -Supply chain security	- Importers, exporters, manufacturers, customs brokers, transportation firms of EU member-states
Stairsec	2004	Sweden	-Customs/trade facilitation -Supply chain security	- Importers, exporters, customs brokers, freight forwarders, and terminal operators
Frontline Program	1990[e]	Australia	- Cargo security, with a new focus on counter-terrorism following 9/11	-Shipping firms, freight forwarders, airlines, customs brokers, warehousing firms, postal and port authorities
Secure Exports Scheme (SES)	2004	New Zealand	- Strengthen and ensure security of New Zealand's containerized exports to its trading partners	- New Zealand's Customs Service and firms involved in exporting goods from New Zealand
U.S.-EU Mutual Assistance Agreement	2004	United States, European Union	-Mutual recognition and harmonization of customs procedures	- Customs administrations and port terminal operators in the United States and the European Union

Appendix Selected post-9/11 programs on cargo security and trade facilitation–*Continued*

Program	Year implemented	Country of origin	Main objectives	Participants
Free and Secure (FAST) Program	2002/2003[f]	United States, Canada, and Mexico	-Expedited customs clearance for firms operating between the U.S.-Canadian and U.S.-Mexican borders	-Trucking firms operating along highways between the U.S.-Canadian and U.S.-Mexican borders
Partners in Protection (PIP) program	1995[g]	Canada	-Enhance security with respect to cargo crossing the Canadian border -Increase customs compliance	-Canadian customs authority and firms involved in U.S.-Canadian cross-border trade

Source: Compiled by USITC staff from various sources.

[a] The agreement establishing ICAO, known as the Chicago Convention, was introduced in 1944. Annexes to the Chicago Convention, including those on air cargo security, have been subsequently amended as recently as 2006.
[b] Although C-TPAT is a U.S.-based program, Canadian and Mexican manufacturers are eligible to enroll in the program, as are highway transportation carriers operating between the United States and Canada and the United States and Mexico.
[c] As of October 2007, 58 foreign maritime ports were participating in the CSI program.
[d] Year the program enters into force.
[e] Although originally introduced in 1990, Australia's Frontline program was revised in response to 9/11.
[f] FAST-Canada was introduced in December 2002, and FAST-Mexico was introduced September 2003.
[g] According to officials from the Canada Border Services Agency, membership in the PIP program increased notably in the aftermath of 9/11. In 2008, security criteria under PIP will be revised so that the program meets standards under the WCO SAFE Framework and is also more closely aligned with the U.S.-based C-TPAT program.

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The Link Between Openness and Long-Run Economic Growth

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Authors:
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Abstract

We review the most cited empirical analyses of the relationship between international trade and economic growth and more recent empirical analyses of the link between trade and productivity growth. We conclude that there is likely to be a positive relationship between international trade and economic growth. There are, however, two caveats. First, we are concerned about the way problems of measurement error and endogeneity are handled in much of the empirical literature. The second caveat relates to the ability of developing countries to gain productivity growth through trade liberalization. To do so, it may very well be necessary to invest in, e.g., education facilities, to ensure property rights and to build up institutions.

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Introduction

Increasingly, the countries of the world seem divided into performers and non-performers regarding their ability to provide decent standards of living for their inhabitants. The underlying causes that have allowed some countries to attain high income levels and have kept others at lower echelons have been debated at least since Adam Smith published his seminal work on the growth of nations. For a long period, this debate was focused on static level effects. Yet nowadays, it is increasingly recognised that high living standards are the product of sustained significant additions to per capita GDP over time – or in other words maintaining significant growth rates. To illustrate this, consider the economic development of Japan during the last 100 years. By the end of the 19th century, Japan was not a rich country. The real GDP per person was well behind Argentina's and only a third of the levels of the United States and the United Kingdom. But during the ensuing 100 years, Japan maintained an average growth rate of GDP per capita of 2.81 percent implying that, today, Japan is among the richest countries of the world with a GDP per capita that is higher than that of the United Kingdom. If Japan had only been able to generate an average growth rate of 1.16 percent (the average growth rate of Pakistan and Bangladesh 1900-2000), then Japan's GDP per capita today would be in line with that of China and less than 20 percent of that of the United Kingdom (numbers from Mankiw, 2004). The example illustrates that "if we want to understand why countries differ dramatically in standards of living, then we have to understand why countries experience . . . sharp divergences in long-term growth rates" (Barro and Sala-i-Martin 1995, 4).

Significant growth rates are often associated with countries embracing the ongoing globalisation and increasing openness to the international exchange of goods and services as well as ideas and technologies. Many researchers believe that participation in the international economy was the primary source of growth in many East Asian countries that have experienced fast economic development during the past 50 years (World Bank 1993). And there is hardly any doubt that international trade facilitates technological development. "When a country exports wheat and imports steel, the country benefits in the same way as if it had invented a technology for turning wheat into steel" (Mankiw 2004, 551). The question is how strong the correlation between openness and economic growth is, and whether international trade liberalization is sufficient to ensure sustained improvements in living conditions in developing countries.

In his fellows address at the AAEA conference in 2006, lead World Bank economist Kym Anderson (2006) posited that we need better empirical analysis of the link between openness and economic growth. In this paper we examine this statement by reviewing the literature that examines the openness-growth link. The paper is organised as follows. In the following section, we turn to some of the most cited empirical analyses of the relationship between international trade and growth. In section 3 we dig a bit deeper and examine through which channels international trade may affect the growth rate. We conclude that the primary potential channel is through an increase in the productivity growth rate, and consider empirical analyses of this link. Throughout the paper we focus on cross-national evidence and exclude microeconometric studies. The final section contains concluding remarks.

Empirical Studies of the Link Between Trade and Economic Growth

Conventional trade theory determines the pattern of international trade and the distribution of welfare across countries in a static setting. It relates trade patterns to comparative advantage, and suggests that for nations that engage in trade, each will specialize in the production of goods in which it has a comparative advantage, i.e., in production processes with lower opportunity costs prior to trade than the other country (e.g., Dixit and Norman 1980). Each country thus exports goods in which it has a comparative advantage. Usually, comparative advantage is assumed to be derived from either exogenous technological differences (the classical Ricardian model) or different factor endowments (the Heckscher-Ohlin model). Hence, conventional trade theory associates international trade with a reallocation of resources within the national borders determined by exogenous differences across countries. This reallocation of resources generates efficiency gains that increase the level of aggregate national income.

Static models of monopolistic competition and economies of scale (Krugman 1979, 1980) suggest two other sources of gain from international trade. First, opening up for trade between two countries that produce differentiated products implies that there are more varieties available for consumption, which is a source of gain for consumers. Second, the increased competition lowers the equilibrium prices because the increased size of the market allows firms to realize economies of scale. The lower prices raise real wages, which is another source of gain for consumers.

Even though the size and distribution of the welfare gains from trade may be disputed, there is strong consensus within the economics profession of a positive relationship between international trade and aggregate national income. The same degree of consensus does not appear to hold for the growth effects of international trade.[2] Many empirical analyses estimate positive growth effects of trade liberalization, but the size of these effects is often rather small, and the empirical methods used to estimate the effects have been subject to substantial criticism.

A fundamental problem with empirical analyses of the trade-growth link is how to measure openness. The most obvious approach is to use the simple concept of the total trade volume (exports plus imports) relative to GDP. The OLS estimator is, however, likely to be biased and inconsistent due to endogeneity of the trade volume.[3] What economists and policy makers are interested in is the hypothesis that an economy's trade volume is a significant contributor to growth, thereby providing policy makers with an income-generating tool. It is, however, likely that a higher level of economic activity in society leads to increased exchange of goods and services, that is, enhanced trade volume. In that case, there is a bidirectional link between growth and trade volume implying that the total trade volume is correlated with the error term, whereby the OLS estimator is biased and inconsistent.

An alternative indicator of openness is a measure of trade policies. A potential advantage of this approach is that it is directly informative about the role of trade *policy* for growth. Simple measures of trade policies such

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[2] A level effect occurs when, for example, a tariff reduction increases income in a given period but not in subsequent periods. In this case, the growth rate of income increases one period and then it is back to the normal rate. If, on the other hand, a change in the trade policy induces consecutive increases in the income level such that the growth rate is above normal in many periods, then the policy change elicits growth effects. These may be temporary or permanent.

[3] Also, one may doubt whether any particular measure of openness or trade is likely to include all aspects of how trading activities affect growth. For example, Alcalá and Ciccone (2004) point out that measuring openness as exports plus imports relative to nominal GDP has drawbacks due to the treatment of nontradable goods. They propose, instead, to use a measure which they refer to as real openness.

as an average tariff rate or a coverage ratio for nontariff barriers to trade have, however, drawbacks such as inordinate weight to categories of goods that are relatively unimportant for a country and gaps between statutory rates and actually collected tariffs (in the case of an average tariff rate) and data that do not provide information on how binding barriers to trade are and excludes less-easily quantifiable barriers to trade (Pritchett 1996). A further concern is that these measures have little correlation with observed trade volumes (Dollar and Kray 2003). Therefore, a variety of other trade policy indicators have been constructed in the literature.

An often-cited attempt to measure the protection level was carried out by Dollar (1992). He used distortions in the real exchange rate to test the hypothesis that the law of one price holds in the long run.[4] The contention is that deviations from the law of one price are maintainable if potential importers/exporters face barriers preventing them from taking advantage of the price differences. Thus, real exchange rate deviations embody an aggregate estimate of the protection level. Dollar found a significant negative correlation between real exchange rate distortions and growth, which indicates a positive trade-growth link. Rodriguez and Rodrik (2001) noted, however, that the law of one price may not hold for a variety of other reasons. In particular, monetary and nominal exchange rate policies have a significant impact on the real exchange rate regardless of trade policies. Moreover, Rodriguez and Rodrik applied the Dollar procedure to an updated version of the same data and found that the same regressions now yield the oppositely signed result. Baldwin (2003) agrees with Rodriguez and Rodrik that Dollar failed to demonstrate a significant relationship between outward orientation and growth.

Another attempt to construct a reliable openness measure was done by Sachs and Warner (1995). They designed an openness variable that combined five different indicators: nontariff barriers to trade, average tariff rates, a black market premium, whether the economy is socialist, and government monopolies on exports. Sachs and Warner found evidence that openness had a significant and positive influence on growth between 1970 and 1989. Rodriguez and Rodrik's (2001) reestimations of Sachs and Warner's regressions suggested that only two out of the five indicators account for the bulk of the variation in the data. The first indicator suggested effects of a state trading enterprise's monopoly power over exports. Since state trading enterprises in Sachs and Warner's dataset are

[4] The law of one price says that within a single market identical goods must sell at identical prices.

mostly confined to sub-Saharan Africa, this indicator corresponds to a dummy variable for sub-Saharan Africa. Thus, this variable captures other features specific to this region rendering the state trading enterprise effect indistinguishable from other factors. Rodriguez and Rodrik concluded that this indicator's ability to reflect only trade barrier impacts is dubious. The second significant indicator is the black market premium that may conceivably arise from a host of policies other than trade barriers. They concluded that with these qualifications on the two indicators it is unlikely that the aggregate measure with five indicators provides a reliable estimate of openness per se. Bosworth and Collins (2003) regressed growth on an array of potential growth determinants including the Sachs-Warner indicator. They found only limited evidence associating the indicator with growth. Frankel (2003) noted that the indicator is a bit idiosyncratic.

Edwards (1998) tested the robustness of the openness-growth relationship to the use of nine existing indicators including the Sachs-Warner indicator and other trade policy indicators. He found that six of the measures are statistically significant in the expected direction when controlling for per-capita GDP and the average number of years of education in 1965. Rodriguez and Rodrik (2001) demonstrated that his results are dependent on the fact that he weights his regression by per-capita GDP. If one weights differently, the number of measures that are significant drops to four or five, and Rodriguez and Rodrik also criticized these measures based on recalculations with more recent data.

Using trade policy measures is not necessarily a solution to the problem of endogeneity of trade since trade policies are likely to be correlated with factors that are omitted from the regression but are likely to affect income (such as free-market domestic policies and stable fiscal and monetary policies) implying correlation between the regressor and the error term (Sala-i-Martin, 1991). An alternative solution to the endogeneity problem is to use Instrumental Variable Estimation (IVE) where either lagged values of openness or other economic indicators that are uncorrelated with the error and highly correlated with openness serve as instruments. Dollar and Kraay (2003) instrumented openness via lagged values of trade as a fraction of GDP assuming that trade volumes are correlated with contemporaneous and lagged GDP growth but uncorrelated with future GDP growth. They found a significant effect of trade on growth. This approach is, however, also problematic if part of the growth rate in the future is driven by investment today that requires imported goods, implying that the degree of openness today affects future growth rates (Lee, Ricci, and Rigobon 2004). Frankel and Romer (1999) used geographic characteristics such as the size of countries, their distance from each other, whether they share a border and whether they are landlocked as instruments for trade. They found that trade has a quantitatively large but only moderately statistically significant positive effect on income. Irwin and Terviö (2002) evaluated this finding across different time periods and obtained the same result. Geography may, however, be a determinant of income through channels other than growth – for example via a relationship between geography and health conditions, the quality of institutions and the availability of natural resources, respectively (Rodriguez and Rodrik, 2001; Durlauf, 2000). Rodriguez and Rodrik showed that when any of three summary indicators of geography is introduced as a control in Frankel and Romer's regression, the result that trade has a positive effect on income disappears. Noguer and Siscart (2005), using a richer data set, confirmed Frankel and Romer's findings and demonstrated that the estimator remains positive and significant even after introducing the geographic controls of Rodriguez and Rodrik.

In conclusion, the surveyed analyses indicate the existence of a positive link between trade and growth, but the validity of the results may be questioned based on (i) the robustness tests performed by Rodriquez and Rodrik; (ii) the fact that many of the analyses fail to address the endogeneity problem; and (iii) the "open endedness" of growth theories, which makes IVE disputable. Durlauf (2000) describes growth theories, as "open ended" in the sense that if one variable influences growth it does not typically imply that other variables do not. In this case, the error term is the cumulation of omitted growth determinants and a valid instrument is uncorrelated with these variables. Since many growth determinants are ex ante plausible, acceptance of an instrument variable estimator is based on subjective criteria. Frankel (2003) puts it this way, "The proper test of the ex ante plausibility of one's claim that a variable is a good candidate for an instrumental variable… is not whether or not one can think of a story whereby it *might* be correlated with other independent variables, but rather how convoluted and implausible the story has to be." (p. 196). Presently, there seem to be some agreement among economists that the most promising way forward is to solve the endogeneity problem through instrumentation with geography as proposed by Frankel and Romer.

Studies of the Link Between Trade and Productivity Growth

To enhance our understanding of the trade-growth link, it is instructive to consider the particular channels through which openness may affect a country's growth rate. The economic theory distinguishes between two sources of GDP-per-capita growth: capital accumulation (physical and human) and productivity growth. Openness may affect both. First, openness to international flows of capital may raise the speed at which physical capital and human capital are accumulated locally (at least temporarily). Second, openness may speed up productivity growth through faster technological progress.[5] Empirical evidence suggests that (i) capital accumulation is not the primary source of growth (Hall and Jones 1999; Klenow and Rodriguez-Claire 1997), and (ii) growth effects of trade work primarily through productivity (Frankel and Romer 1999). Therefore, we focus on the effects of international trade on productivity growth.

Various theoretical analyses of the link between trade, productivity and growth exist in the innovation-based growth literature (Grossman and Helpman 1991; Rivera-Batiz and Romer 1991). These frameworks combine productivity growth through increased product variety with intentional research and development (R&D) by profit-seeking firms where the outcome of research generates designs for new product varieties. The productivity of primary factors in manufacturing depends positively on the number of product varieties that exists. In this sense each new product variety constitutes a new technology for manufacturing. Monopolistic competition in the market for product variety and a license law that prevents any firm from producing a variety without the consent of the patent holder of the design ensures that successfully innovating firms are compensated with monopoly rents. Hence, the outcome of R&D is excludable but it is also nonrival in the sense that each research project contributes to a stock of general knowledge representing a collection of ideas and methods that is useful to later generations of innovators. The degree of this knowledge spillover is crucial to the long-run behaviour of the model. Often it is assumed that the output of designs is linear in the stock of general knowledge, which ensures perpetual endogenously determined per-capita growth (Romer 1990).

[5] In theory one distinguishes between two components of productivity: technology and efficiency. Openness may affect both. Here, we focus on the effects on technology since these have been modelled theoretically and tested empirically.

In this set-up, international trade may affect the growth rate of productivity through three channels: it gives access to foreign intermediate inputs or, implicitly, technologies; it expands the market size for new product varieties; and it facilitates the international diffusion of general knowledge. Countries that are open to trade are able to import product varieties from abroad that are not invented locally, thereby increasing productivity in manufacturing. This is often referred to as a level effect because it raises the productivity level in manufacturing permanently but it does not change the innovation rate of new products. A permanent growth effect of access to foreign intermediate inputs may appear if product varieties are used as input to research. In that case, more varieties increase productivity in the research sector, which raises the innovation rate and may ensure a permanent increase in the growth rate. An expansion of the market size for new product varieties raises the expected profit from R&D, which gives greater incentives to engage in research. These greater incentives may ensure a faster innovation rate and faster economic growth. The third channel through which international trade may affect the productivity growth rate is if trade facilitates the international diffusion of general knowledge capital. If that is the case, then the stock of general knowledge available locally increases as a result of trade which raises the productivity in the research sector, thereby speeding up the innovation rate.

Is it then the case that the innovation-based endogenous growth theory predicts an unambiguous positive relationship between international trade and productivity growth? No, frameworks have been developed where international trade induces some countries to specialize in the production of goods with relatively low growth potential (Grossman and Helpman 1991; Matsuyama 1992; Young 1991; Galor and Mountford 2006). To illustrate this possibility, consider the following example. There exist two types of final goods: a traditional good that is produced with the use of labour and a high-tech good that is produced with the use of differentiated intermediate goods. Invention of new intermediate goods requires labour and the stock of general knowledge generated nationally in the past. Consider trade between two countries with identical labour forces but one country has accumulated slightly more general knowledge in the past than the other country. This country has a comparative advantage in R&D and devotes relatively more labour to innovation activity than the other country. Therefore, this country specializes relatively in R&D and high-tech manufacturing while the country with the lower stock of general knowledge specializes relatively in traditional goods production. Since productivity of the traditional manufacturing sector is constant while productivity of high-tech manufacturing increases with product development, it follows that the country with the lower amount of general knowledge experiences a trade-induced reduction in the growth rate.

Crucial to this type of result is the existence of knowledge spillovers in some sectors that are confined to the national level. If the knowledge spillover in research were international then the stocks of general knowledge would be identical in the two countries and neither would have a disadvantage in conducting research. Empirical studies of the extent to which a country's productivity level depends on the foreign stock of general knowledge suggest the existence of international knowledge spillovers. By comparing total factor productivity among OECD countries with the stock of foreign knowledge proxied by cumulative R&D expenditure, Coe and Helpman (1995) found that foreign R&D enhances domestic productivity. This result is confirmed by Keller (1998) and Lumenga-Neso, Olarreaga and Schiff (2005). Coe, Helpman and Hoffmaister (1997) found substantial R&D spillovers from developed countries in the North to less developed countries in the South.

Another reason why countries may fail to gain productivity growth through international trade is a lack of complementary inputs (Basu and Weil 1998; Acemoglu and Zilibotti 2001). For developing countries to copy and adapt goods or techniques invented in more technologically advanced countries may require some basic inputs, for example a minimum level of human capital. A lack of complementary inputs may, however, prevent developing countries from obtaining productivity gains through technological innovations in developed countries. Consequently, technologies designed for optimal productivity in developed countries may incite little or no productivity growth in developing countries, even though there are no barriers to the technology's diffusion. There are many dimensions in which technological needs of developing countries differ from those of developed countries, including skill levels, capital intensities, climate, geography and culture.

Summarily then, the growth theory points to three distinct channels through which international trade may raise the productivity growth rate of countries: through diffusion of intermediate goods or, implicitly, technologies; through an expansion of the market for output from innovation; and through diffusion of general knowledge. We have, however, also pointed towards examples in the theoretical literature that predicts a negative relationship between international trade and productivity growth. So, the question of the link between international trade and productivity growth is an empirical one, but the theory may serve as a guide for more targeted empirical analyses than the ones surveyed in the previous section.

The above-mentioned studies of the geographical extent of knowledge spillovers also shed some light on the question of a positive correlation between trade and international diffusion of general knowledge. Coe and Helpman (1995) proxied the foreign stock of general knowledge by import-weighted cumulative R&D expenditure and found that the benefits increase with the degree of openness. Keller (1998) questions the robustness of this finding by obtaining the same positive link using random trade shares. Lumenga-Neso, Olarreaga and Schiff (2005) reconciled the results of Coe and Helpman and Keller by incorporating indirect trade-related R&D spillovers. The idea is that countries may benefit from general knowledge in countries with which they have no direct trade relation if these countries export to trading partner countries. They found evidence of both direct and indirect trade-related R&D spillovers. Geography may be important for trade-induced international diffusion of general knowledge. Keller (2002) used sectoral data and distance to trading partners as the weight and found that the benefits from spillovers are declining with distance.

As to the question of growth effects of international trade due to the extension of the market, we turn to some studies that focus on the importance of market size for growth. There is no empirical evidence of scale effects on growth, i.e., that the size of countries matter for economic growth, when one does not control for international trade (Jones 1995a, 1995b; Backus, Kehoe and Kehoe 1992). Market size depends, however, both on country size and trade openness and, since small countries adopt more open trade policies, a regression of growth on country size without controlling for international trade is biased towards zero (Alesina, Spolaore, and Wacziarg 2005). Controlling for international trade, Frankel and Romer (1999) and Alcalá and Ciccone (2004) found significant positive relationships between country size and productivity. Another group of cross-country growth regressions found that the coefficient on an interaction term between openness and country size is significantly less than zero which the authors interpreted as evidence of a substitutability between openness and country size (Ades and Glaeser 1999; Alesine, Spolaore, and Wacziarg 2000; Spolaore and Wacziarg 2005; Alcalá, Spolaore, and Wacziarg 2005). Since both country size and openness enter significantly in the regressions, these results provides further evidence of the existence of growth effects from trade liberalization due to the extension of the market.

Finally, a much diverse group of papers investigates the correlation between product variety and productivity growth. These papers include, e.g., Eaton and Kortum (1999, 2001, 2002) who estimate a Ricardian model of trade, and some very recent analyses by Broda and Weinstein (2006) and Broda, Greenfield, and Weinstein (2006) who employ Feenstra's (1994) method of estimating the elasticity of substitution between product varieties. Eaton and Kortum (1999, 2001, 2002) assumed that trade is based on differences in technology and that unit transaction costs are increasing in geographic distance. For a cross-section of 19 OECD countries in 1990 they found that trade allows countries to benefit from foreign technological advances but for big benefits to occur, the country must be near the source of the advance and be able to reallocate resources to activities outside manufacturing. Keller (2004) questions Eaton and Kortum's model because it predicts that rich countries have higher equipment prices than poorer countries, which is the opposite of Summers and Heston's price data.

A prerequisite for variety growth to affect productivity is a relatively low elasticity of substitution across varieties – if new varieties are close substitutes to existing ones, increasing the number of varieties does not increase productivity much. Feenstra (1994) developed a method for estimating the impact of new varieties on an exact price index of a single good using only the data available in a typical trade database. Broda and Weinstein (2006) modified Feenstra's estimation strategy and used it to estimate 30,000 elasticities of substitution for the United States based on 8-digit and 10-digit trade data. Broda, Greenfield and Weinstein (2006) applied the same method to estimate elasticities of substitution for 73 countries using 6-digit trade data. They found that new imported varieties increased productivity by 0.27 percent per year on average in the period 1994-2003 implying that 15 percent of the average annual total factor productivity growth rate in that period is caused by new imported varieties. Splitting the sample into developed and developing countries revealed a large difference between the importance of new import varieties in the two groups of countries. In developed countries new import varieties account for only 5 percent of the average annual total factor productivity growth while the comparable number is 32 percent in developing countries. Part of this difference may be due to the level of aggregation in data. The estimation method precludes measurement of gains from new varieties which appear in categories in which the country already imports. Especially large, developed countries typically import most goods at the 6-digit level such that more detailed data are needed to measure the true productivity gain due to increased product variety in these countries. For the US, for example, it was estimated that new import varieties raise productivity by only 0.024 percent per year using 6-digit trade data but using 10-digit trade data Broda and Weinstein (2006) estimated a gain that was 3 times larger.

Broda, Greenfield and Weinstein also obtained some results that may highlight the relative importance of the level versus the growth effect of increased product variety identified in the theory. They found that the ongoing level effect accounts for an increase in the growth rate of 0.13 percent per year while the growth effect accounts for only 0.02 percent in the typical country. These findings suggest that the primary channel through which increased product variety affects the productivity growth of countries is through an impact on the productivity level in manufacturing. The estimate of the growth effect may, however, be downward-biased due to the above-mentioned problem of not measuring the true productivity gain from new import varieties in large developed countries. Since these countries conduct most of the world’s R&D, the growth effect will primarily be encountered in large, developed countries, but the level of details in the data prevents measurement of the true productivity gains in these countries. It would, therefore, be interesting to see the result for only developed countries where detailed trade data exist.

In conclusion, the empirical findings lend support to the hypothesis that the extent of the markets matters for productivity growth, to the existence of a positive correlation between openness and the international diffusion of general knowledge and to the existence of level effects of increased product variety. There may be some potential for ongoing level effects for some time to come, since only 15 percent of the world's countries imports a good that is currently exported. And in turn, this may imply productivity growth due to increased product variety over an even longer-run horizon (see Broda, Greenfield, and Weinstein, 2006). Also, more empirical work is needed before we can rule out the existence of positive effects on productivity in the research sector from increased product variety.

Conclusion and Policy Perspectives

Is there a link between openness and growth? Based on this survey of the more recent empirical and theoretical literature, we believe that the answer is yes. Nearly all the empirical analyses confirm this. There are, however, two “buts” or caveats. The first is related to our concern regarding the way problems of measurement error and endogeneity are handled in much of the empirical literature. The second caveat relates to the ability of developing countries to gain productivity growth through international trade. We consider each of the two in turn.

We have highlighted two fundamental problems related to empirical tests of the link between trade and growth. First, it is not clear whether international trade causes growth, whether growth causes trade, or if there is a bidirectional link between them. The second flaw is a measurement problem. Since openness may affect growth through many channels, it is difficult to develop a single, universal measure that includes all aspects of how trade affects growth. These problems imply biased and inconsistent estimators and invalid inference when not handled with care. Some promising attempts have been made to solve the problems. The instrumental variable approach is a step in the right direction and Frankel-Romer's geography instrument may be criticized but it is the best thus far. Also, the empirical analyses that quantify the exact channel through which trade affects growth are interesting. In particular, attempts to quantify level versus growth effects of new product varieties based on detailed trade data (Broda, Greenfield, and Weinstein 2006) may deliver results that enhance our understanding of the link between trade and growth.

The second caveat is related to the ability of developing countries to gain productivity growth through international trade. The findings of Broda, Greenfield and Weinstein suggest that perhaps developing countries are the countries that may gain the most from trade liberalization. The theory, however, warns us of the danger that the countries that mostly need economic development will not benefit from openness due to a lack of complementary inputs, institutions, general knowledge capital, etc. Therefore, policy makers cannot "just" liberalize world trade and then all countries of the world will automatically converge towards a high-growth trajectory in the long run.

The Doha Development Agenda of the World Trade Organisation (WTO) places the needs and interests of developing countries at the heart of the international trade negotiations. The ministerial declaration begins by asserting a firm link between trade and growth.[6] Our review clearly demonstrates that even though a full Doha agreement is certainly a right

[6] "The multinational trading system embodied in the WTO has contributed significantly to economic growth, development and employment throughout the past fifty years", Ministerial Declaration, Doha WTO Ministerial 2001.

step in the direction of eradicating poverty, developing countries may very well require more to ensure positive growth effects. Education facilities, property rights, the political environment, infrastructure, institutions, business environment etc. are all matters that may interactively determine to which degree poor countries are able to benefit from trade liberalization.

The exact recommendations of what to do in order to be able to gain productivity growth through trade liberalization are to be revealed in micro studies. But we need more cross-national evidence of the exact channels through which openness may affect productivity growth. First, trade may enhance productivity growth through the diffusion of technology, but it may also affect productivity through a positive effect on the efficiency in production (Trefler 2001; Dollar and Collier 2001). Second, and related to the first point, is the potential relationship among trade, institutions and growth. A prerequisite for R&D of new product varieties to take place in the innovation-based growth theory is the existence of institutions that can enforce patent protection. Institutions that secure property rights may also be essential for profit-seeking firms to spend resources on adoption and imitation activity. So, a necessary condition for countries to gain productivity growth through international trade may very well be the existence of institutions of a certain quality. A number of empirical analyses find evidence of a positive relationship between the quality of institutions and economic growth (Hall and Jones 1999; Acemoglu, Johnson, and Robinson 2001). There exists, however, many different types of institutions (different types of social arrangements, laws, regulations, enforcement of property rights, etc.) and we know little about what specific types of institutions are important for countries to benefit from openness. Acemoglu, Antras, and Helpman (2007) analyse the link between contracting institutions and technology but more work needs to be done on this topic. There may also be a link from openness to the quality of institutions. So, empirical analyses of the partial effects are needed (Dollar and Kray 2003; Alcalá and Ciccone 2004).

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Industrial Biotechnology in China Amidst Changing Market Conditions

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Abstract

The increasing use of industrial biotechnology by the Chinese liquid biofuels and chemical industries is expected to help offset energy security and environmental concerns generated by China's robust economic growth. The expanding use of bioprocesses to produce products such as fuel ethanol and bioplastics is also likely to contribute to continued innovation, productivity gains, and cost savings. This, combined with strong government promotion of the country's bio-based economy, coincides with the two industries' growing global prominence; China is currently the world's third largest producer of ethanol and second largest producer of chemicals. This growth has encouraged expanded domestic and foreign investment, including in bio-based projects, and generated related gains in exports, particularly in the chemical industry. Market conditions facing many ongoing and prospective ventures, however, are changing as a result of a combination of factors, including the strength of the Chinese currency, new labor regulations, tax changes, and volatile energy prices.

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Introduction

Industrial biotechnology is often defined as the use of enzymes and micro-organisms[2] to produce goods and services (e.g., through bioprocesses such as fermentation and biocatalysis).[3] This definition, however, does not include the growing trend of converting renewable resources into finished products by any process, including conventional chemical processes (e.g., the production of biodiesel). As such, this article uses the definition used by the U.S. International Trade Commission in its report on industrial biotechnology (2008, 1-4):

> "The manufacture of liquid fuels and chemicals using (1) enzymes or micro-organisms at any stage of the production process, regardless of the type of raw materials used (e.g., renewable, fossil fuel-based, or inorganic); or (2) renewable resources and conventional chemical processing."

Industrial biotechnology is increasingly being utilized by the liquid biofuels and chemical industries in many countries because of its technical, economic, and environmental advantages,[4] including process simplification, lowered greenhouse gas emissions, reduced use of fossil-based inputs and energy, decreased waste generation, and related reductions in production costs and capital expenditures.

In the energy sector, industrial biotechnology is used to produce liquid biofuels (e.g., ethanol and biodiesel**)** from renewable resources for use in

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[2] Enzymes are biologically-derived, biodegradable proteins that initiate or accelerate chemical reactions. Micro-organisms are simple life forms such as bacteria and yeasts. Inasmuch as enzymes are an inherent part of micro-organisms' metabolism, micro-organisms are not only used to generate enzymes but are also themselves used in the manufacture of liquid biofuels and bio-based chemicals.

[3] Biocatalysis and fermentation are two types of bioprocesses. Biocatalysis generally utilizes isolated enzymes and/or micro-organisms to conduct chemical reactions. Fermentation processes, defined by some as a subset of biocatalysis, use micro-organisms to break down complex organic compounds into simpler ones. Ethanol, for example, is produced via a fermentation process in which sugars from corn and other renewable resources are converted by yeasts into ethanol and carbon dioxide. (USITC 2008, v-vii, and 1-4).

[4] Environmental benefits accrue from both the production and use of liquid biofuels and bio-based chemicals but vary by sector. (USITC 2008, 1-1).

blends with or as substitutes for gasoline and diesel. In the chemical industry, in addition to increased use of renewable resources as feedstocks, bioprocesses are used with or instead of conventional chemical processes to produce a wide variety of products ranging from biodegradable biopolymers to specialty chemicals and pharmaceuticals. Industrial biotechnology allows for the production of chemicals that might otherwise not be technically or economically feasible.[5]

China's ongoing use of industrial biotechnology to manufacture liquid biofuels and bio-based chemicals has been spurred in part by its long-standing use of fermentation, a key bioprocess. China produced fermented beverages as early as 9,000 years ago; other fermented products include chemicals and foods (McGovern et al 2006). China's increased use of industrial biotechnology is also attributed to concerns about energy security; the country's increasing energy consumption; volatility in fossil fuel prices, including crude petroleum; a focus on rural development; and environmental concerns (Liu 2005; Latner, O'Kray, and Jiang 2006a, 5; and Jiang 2008, 3, 5, and 6).[6]

Government support, characterized by Jiang (2008) as "strong," plays an important role in promoting China's development of a bio-based economy, particularly in regard to biofuels. Long-term support of industrial biotechnology and related strategic planning are reflected in the country's 11th Five-Year Plan. The Chinese government's approach has been expansive in scope, addressing research and development (R&D) as well as measures supporting supply and demand. In addition to promoting the use of renewable resources, the government has focused on the supply side by providing various types of financial support, including monetary incentives and preferential taxation policies (Ke 2006; author, pers. comm., December 18, 2006; and Embassy of the People's Republic of China in the United States of America 2006). China has also implemented mandatory use programs for ethanol, stimulating demand.

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[5] Also called "white biotechnology," industrial biotechnology is often referred to as the "third wave" of biotechnology following upon the relatively longer-term use of biotechnology in the healthcare sector ("red biotechnology") and the agricultural sector ("green biotechnology"). Biotechnology processes generally used in red and green biotechnology (e.g., genetic engineering) will not be addressed in this article.

[6] As noted by Jiang, China's rural residents–about two-thirds of China's population, or 800 million people–earn a net annual income of less than $500. Industrial biotechnology has the potential to provide additional income for farmers (e.g., for agricultural residue) and create rural employment. Jiang also notes that one of China's environmental goals is to reduce greenhouse gas emissions by 1.4 billion metric tons. (2008, 3, 5, and 6).

This article first presents information about China's liquid biofuels and chemical industries and their use of industrial biotechnology. Related business strategies are then discussed, followed by information regarding government policies. Each industry discussion concludes with an outlook as to potential outcomes within the context of changes in market conditions affecting each industry.

Liquid Biofuels

China's methodical progression towards the development of a national biofuels program began in the mid-1980s with ongoing R&D related to ethanol. This program then expanded into the formulation of a legislative framework, the 2001 launch of an ethanol initiative, and inclusion of "The Bioethanol Utilization Plan" in the country's 11th Five-year Plan.

China is the second largest energy consumer behind the United States. After having doubled from 1996 to 2006, its energy consumption is expected to nearly double again by 2020. Consumption of crude petroleum alone increased to 6.5 million barrels per day in 2004, an increase of more than 100 percent since 1994, before growing to 7.6 million barrels in 2007. Imports account for a growing share of the total, increasing from 19 percent of the total in 1999 to 43 percent in 2005 and projected to continue increasing to 60 percent by 2010 (EIA 2008 and Jiang 2008). As a result, China, a net importer of crude petroleum since 1993, has been actively searching for energy supplies to meet its steadily growing energy needs stemming from its population growth, robust economic growth, and burgeoning number of vehicles.[7] This search for energy has influenced China's foreign policy efforts, spurring numerous alliances with energy- and resource-rich countries (Earth Policy Institute 2005; Leggett 2005, A1; and Rohter 2008, 1).

China is the world's second largest market for automobiles. After growing by almost 47 percent in the first half of 2006 alone compared with the like period in 2005, sales grew by 24 percent in 2007 and continued to exhibit strong growth through early 2008, resulting in a corresponding increase in gasoline consumption. In 2005, China mandated that ethanol blends (mostly E10, a gasoline blend containing 10 percent ethanol) would

[7] See, Wang et al. 2006, 9 and 17; InfoPlease 2004; GreenCar Congress 2006c; and Cha 2008, A1.

replace conventional gasoline for all vehicles nationwide. Since that time, the use of pure gasoline has leveled off while consumption of E10 has increased (Sanchez and Junyang 2008). The National Development and Reform Commission (NDRC), the agency that oversees biofuels and other energy products, projects in its "Mid- and Long-Term Renewable Energy Development Plan" that the E10 plan is expected to be implemented on a national basis by 2020 (Speckman 2008).

The increase in energy costs through the first half of 2008 was said to be curbing domestic sales of larger, "gas-guzzling" vehicles such as sedans, sport utility vehicles, and light trucks. Sales of such vehicles slowed in July 2008, increasing by only 6.8 percent compared with July 2007, continuing a 4-month trend. In August 2008, in a reported effort to reduce increasing consumption of gasoline, the Chinese government doubled the sales tax on larger cars from 20 to 40 percent and reduced taxes on smaller cars. Moreover, the cascading progression of the global economic slowdown resulted in a downward revision in October 2008 of growth in sales of light vehicles in 2008 (including passenger cars and light commercial vehicles) to 9.7 percent, less than half that of 2007 (*IHT* 2008; EIU.com 2008; GreenCar Congress, 2006c; Cha 2008, A1; and Schuster 2008).

Industry Profile

Ethanol[8]

China is the third largest producer of ethanol worldwide, accounting for about 5 percent of world biofuel production. The importance of biofuels to the country's goals is reflected in the highly concentrated nature of the sector. According to the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA), although China has numerous companies producing food-grade ethanol, the country has to date limited its fuel ethanol production and, in turn, its production incentives, to five state-owned companies: China Resources Alcohol Co. (CRAC); Jilin Fuel Ethanol Co.; Henan TianGuan Fuel-Ethanol Co.; Anhui BBCA Biochemical Co.; and Guangxi COFCO Bio-Energy Co. The marketing and distribution of ethanol is also controlled by the government; state-owned entities China Petroleum and Chemical Corporation (Sinopec) and China National

[8] Except as noted, much of the information in this section was compiled from the Foreign Agricultural Service's annual reports on biofuels in China (Sanchez and Junyang 2008, 5-6; Latner, Wagner, and Junyang 2007, 5 and 9; Latner, O'Kray, and Jiang 2006a, 11, 12 and 14; and Latner, O'Kray, and Jiang 2006b).

Petroleum Corporation (CNPC) are the only companies authorized to blend ethanol with gasoline and distribute the blend.

Official production of fuel ethanol began in 2004. The FAS reports that annual production increased from initial levels of about 101 million gallons in 2004 to 469 million gallons in 2007, an increase of 367 percent.[9] Annual growth has been slowing. Following increases of 1400 percent (2004), 206 percent (2005), and 41 percent (2006), production grew by only 8 percent in 2007. Most of the ethanol produced in China is derived from corn. One company–Henan TianGuan Fuel-Ethanol Co.–has been using stale wheat as its primary feedstock but supplies of stale grains are reportedly running low. China's promotion of stale grain as an ethanol feedstock allowed for the eradication of a large stockpile of outdated grain that had accumulated because of overproduction resulting from policies promoting agricultural production (Sanchez and Junyang 2008, 5, 2007, 5, 6, and 9, and 2006, 9; Bilin 2007; Cao 2006; and Liu 2005).[10] Another company, Guangxi COFCO Bio-Energy Co., which started commercial production in April 2008, uses cassava as a feedstock. It is the first large-scale, commercial nongrain project approved in China.[11]

Biodiesel[12]

Information about the size and composition of the Chinese biodiesel industry varies. The industry is very fragmented. Most of the estimated 100 companies producing biodiesel have only about 30,000 to 6 million gallons capacity. Although China is the world's largest importer of soybeans, edible vegetable oils are used primarily for food, reducing the supply for biodiesel consumption. As such, many companies face insufficient supplies of the renewable resources used as feedstocks (i.e., animal fat or vegetable oil feedstocks) and have to limit production to a few months a year. Biodiesel production in 2007 reportedly amounted to about 90 million gallons,

[9] In comparison, according to the U.S. Department of Energy, U.S. shipments of ethanol in 2007 amounted to 6.5 billion gallons. (USITC 2008, 2-5).

[10] Fuel ethanol production costs vary depending on the input; if a company using stale wheat as a feedstock has to convert to new wheat, production costs will increase. It costs about $1.68 per gallon of ethanol if stale grain is used as the input versus about $1.56 per gallon for cassava or about $1.95 per gallon for corn.

[11] See, Sanchez and Junyang 2008, 5 and 7, and author, pers. comm., November 30, 2008. The Guangxi ethanol production facility's feedstock requirements were said to provide additional income for 1.1 million farmers (*The Standard* 2006).

[12] The information and data in this section were compiled from various sources including Wang 2007; Wang et al. 2006; Sanchez and Junyang 2008, 9; and Latner, Wagner, and Junyang 2007, 7.

although it has been reported that it often did not meet quality standards for fuel-use biodiesel. Unlike ethanol, biodiesel is marketed directly to end users.[13]

Business strategies

Ethanol

Ethanol production capacity is expected to increase to slightly over 1 billion gallons per year by 2010 and to about 3.3 billion gallons by 2020. Given food security concerns, however, a cap has been put on the amount of corn that can be used as a feedstock. New fuel ethanol projects being approved focus on nongrain feedstocks such as cassava and sweet potato; studies are also underway addressing the use of other nongrain feedstocks such as sweet sorghum and sugar beet. Tiger Ethanol, for example, has proposed using sugar beet at its majority-owned joint venture in Fujian Province to produce both ethanol and refined sugar, and has signed an agreement with the local government to cultivate an estimated 1.5 million tons of sugar beet by 2014. The use of sugar beets will give Tiger Ethanol flexibility to shift ethanol and sugar production levels depending on world prices. It will also provide additional income to farmers of as much as $100 per acre (for a total of about $250 per acre), as they will be able to grow two crops each year–barley from March through June and sugar beets from July to October.[14]

China is also emphasizing the use of lignocellulosic feedstocks such as agricultural and forestry residue, energy crops (e.g., switchgrass), and municipal waste for ethanol production with commercial production expected to start during 2011-15. Existing corn starch production plants are expected to be retrofitted to produce cellulosic ethanol once the technology becomes feasible. The industry is expected to produce an estimated 3 billion gallons of ethanol from lignocellulose by 2015-20, or one-half of total projected ethanol production from all sources.[15]

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[13] In comparison, U.S. shipments of biodiesel in 2005 amounted to slightly over 106 million gallons and increased to more than 495 million gallons in 2007. (USITC 2008, 2-4 and 2-5).

[14] See, *Farms.com* 2006; GreenCar Congress 2006b and 2006e; Latner, O'Kray, and Jiang 2006a and Latner, Wagner, and Junyang 2007, 4 and 5; Kojima, Mitchell, and Ward 2007, 93; Bilin 2007; Garten Rothkopf LLC n.d., 373, and *BioFuelsBusiness.com* 2008 and *Biomass Magazine* 2008.

[15] Latner, O'Kray, and Jiang 2006a, 19; Li, Shi-Zhong, 2007; Embassy of the People's Republic of China in the United States of America, 2006; *Forbes* 2007; Bilin 2007; and Speckman 2008.

China is working with domestic research institutes and foreign entities to develop cellulosic ethanol production. Two demonstration-scale[16] plants are currently operating in Henan and Heilongjiang Provinces (Sanchez and Junyang 2008, 8). In 2006, state-owned CRAC, the second largest producer of ethanol in China and a unit of COFCO Limited (formerly China National Cereals, Oils & Foodstuffs Corp.), brought onstream a corn stover cellulosic ethanol pilot plant in Heilongjiang Province through an agreement with SunOpta (Canada) and Novozymes A/S (Denmark) with plans to expand operations.[17] Another ethanol producer, Tianguan Group, has converted 40 percent of its grain-based production in Henan Province to nongrain inputs such as cassava and sorghum following the government's directives of June 2007. It also operates a demonstration scale plant that converts wheat straw into cellulosic ethanol that is expected to be a model for plants built within the province through 2020. The company chairman cites a focus on creating "clusters" of smaller-scale plants given logistical and infrastructure limitations such as collecting and transporting the wheat straw feedstock, the volume of enzymes needed in the production process, and waste treatment (Jing 2008; also, Sanchez and Junyang 2008, 8, and author, pers. comm., September 16, 2008). Despite the projected increases in capacity, however, industry sources have stated that it is possible that future supply may not meet domestic demand. Demand for fuel ethanol in 2010 is expected to amount to 5.4 billion gallons and ethanol blends are expected to account for one-half of China's consumption of gasoline.[18]

Chinese imports of ethanol, mainly undenatured, spiked in 2005 at almost 5 million gallons before declining substantially to almost 185,000 gallons in 2007, reportedly because Chinese feedstock advantages reduced the price competitiveness of imported ethanol versus domestically-produced ethanol Sanchez and Junyang 2008, 11). China emerged as a major net exporter of ethanol in 2006. Traditionally an exporter of undenatured ethanol, mainly to Japan and Korea for use in making alcohol, Chinese exports of fuel

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[16] The construction and operation of pilot plants and demonstration-scale plants precede scale-up to commercial production facilities. According to one industry source, pilot plants have production capacities of about a few thousand gallons of ethanol per year (gpy); demonstration-scale plants, about 1 million gpy; and commercial-scale, upwards of about 100 million gpy (author, pers. comm., April 8 and 9, 2008).

[17] See, GreenCar Congress 2006b and 2006h; Burke 2007; Lauridsen and Peckous 2008, 24; and author, pers. comm., September 16, 2008. State-owned COFCO Limited is working with Novozymes to build a cellulosic ethanol plant in Heilongjiang Province in 2009 with a capacity of 3 million gallons per year. (Lauridsen and Peckous 2008, 24).

[18] See, GreenCar Congress 2006b and 2006h; Burke 2007; Lauridsen and Peckous 2008, 24; and author, pers. comm., September 16, 2008.

ethanol (denatured) increased significantly in 2006 to 12 million gallons from about 950,000 gallons in 2005. During the same period, total Chinese exports of ethanol increased from 42 million gallons to 264 million gallons, reportedly "in reaction to higher world petroleum prices" (Latner, Wagner, and Junyang 2007, 8-9). The United States was the third largest market for China's ethanol exports in 2006, accounting for 16 percent (Latner, Wagner, and Junyang 2007, 8-9; Benjamin 2006).

In 2007, however, reportedly as a result of the elimination of the refund of the 13 percent value-added tax (VAT) on exports, ethanol exports declined by 88 percent to less than 53 million gallons (roughly 2005 levels). The elimination of the rebate, reportedly implemented in an effort "to discourage the expansion of [the] grain-processing sector," is said to have substantially reduced ethanol export profits (Sanchez and Junyang 2008, 10).

Biodiesel

Expansion of China's biodiesel industry has reportedly been limited because much of the progress to date on the national biofuels program has focused on ethanol, even though diesel consumption in China is double that of gasoline because of the increased use of trucks and farm machinery. A lack of standards and regulations has also reportedly hampered the industry's development. A voluntary national biodiesel standard was announced in July 2007 (Sanchez and Junyang 2008, 8).

As with ethanol, food security is a major concern. Vegetable oils are one feedstock for biodiesel. Whereas China is the world's second largest producer of rapeseed after Canada, it uses it mainly to produce edible oils for food use. China supplements such production with imports; it is the largest importer in the world of major edible vegetable oils. Land use is also limited; only 14 percent of land in China is arable. Given the lack of availability of virgin vegetable oils, biodiesel feedstocks are largely waste grease and oils. In July 2008, the NDRC approved three biodiesel pilot projects using jatropha oil, a nongrain feedstock.[19] Three state-owned entities–PetroChina Company Limited, Sinopec, and the China National Offshore Oil Corporation (CNOOC)–will develop the projects, bringing onstream about 51 million gallons of capacity (Zang 2008).

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[19] Jatropha does not compete for acreage with crops as it can be grown on marginal acreage.

Also as with ethanol, in addition to working with domestic research organizations, China is collaborating with foreign entities to develop its biodiesel industry (CORDIS News 2006; *Dow Jones Energy Service* 2006; and BP 2007). For example, D1 Oils PLC (UK), in a joint venture with China's Ministry of Agriculture, is developing *Jatropha curcas* farms with the eventual expectation to build a biodiesel production facility using jatropha as a feedstock. D1 Oils has also entered into a 50-50 joint venture with BP to cultivate jatropha in South East Asia, Southern Africa, Central and South America, and India.

In regard to international trade, official statistics are not available but much of the biodiesel produced is said to be exported to Europe; very little, if any, is said to be imported. Biodiesel exports in 2006 were estimated to amount to about 3 million gallons (Latner, Wagner, and Junyang 2007, 7; Wen 2005; and Li, Jiao 2007). In 2007, one firm was reportedly planning to focus new production capacity towards exports to expand revenues and profit margins to offset an 18 percent increase in the price of waste oil, the company's feedstock (*BiofuelsMarketplace.com* 2007).

Government programs

A draft version of the 11th Five-Year Plan, introduced in 2006 by the NDRC addressed biofuels development in the 2006-10 period and was expected to be implemented in December 2006. At the same time, however, concerns about food security for the country's population of 1.4 billion escalated in combination with increased commodity prices, including grain prices. Given these concerns, the State Council did not approve the initial draft plan; however it did approve a revised version at a later date. The NDRC subsequently published the "Mid- and Long-Term Renewable Energy Development Plan" (Renewable Energy Plan) on September 4, 2007, to guide the development of the biofuels sector through 2020. According to the plan, 670 million gallons of nongrain fuel ethanol and 60 million gallons of biodiesel would be produced by 2010, increasing to 3,349 million gallons of ethanol (from all feedstocks) and 600 million gallons of biodiesel by 2020. The NDRC also sought proposals from private and State-owned entities as of June 2007 for the development of 10-15 pilot plants utilizing nongrain feedstocks (e.g., sweet potato, cassava, sweet sorghum, and oilseeds) with resulting funding tied to meeting specific technology and productivity objectives. One ethanol plant, based in Guangxi Province and using cassava as the feedstock, was approved and started commercial production in April 2008.[20] Another proposal, if accepted by the NDRC, would start construction in 2008 on a 30 million gallon ethanol plant using sweet potato as the feedstock.[21]

China regulates the prices of ethanol, gasoline, and diesel and has reportedly maintained energy prices at levels below those on international markets, providing monetary incentives to domestic petroleum companies to offset the difference between the regulated price in China and increasing world market prices. As noted by Sanchez and Junyang (2008, 4),

> "The government evaluates international oil prices periodically to determine a benchmark price for gasoline and diesel for domestic distribution. The fuel ethanol price is linked to the set government fuel price and then marketed by state designated retailers."

The price of ethanol sold to Sinopec and CNPC is set at 91 percent of the price of unleaded gasoline. China also pegged the retail price of E10 to the price of gasoline (Bilin 2007; Sanchez and Junyang 2008, 4; and Wang et al 2007). After increasing gasoline and diesel prices by almost 10 percent in November 2007 as prices rose on international markets, China announced in January 2008 that it was freezing energy prices in an effort to offset inflation concerns (Yardley 2008, C3; and *Xinhua* 2008a, 2007b, and 2007c). However, in June 2008, China increased fuel prices yet again, boosting gasoline prices to $3.83 per gallon (up 16 percent) and diesel to $3.58 per gallon (up 18 percent) (Benjamin 2006; Bradsher 2008a and 2008b).

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[20] Questions have been raised, however, as to whether the supply of cassava is sufficient to supply such projects. Although Guangxi Province is the source of about 60 percent of China's domestic production of cassava, the Guangxi ethanol project is said to have imported cassava chips from Thailand and Vietnam to meet supply needs. However, as the price of imported cassava doubled in 2007 and early 2008 to around $200 per ton because of speculation that the facility would have to import two-thirds of its annual input, industry sources indicated that the profitability of the project has decreased. The Guangxi Provincial Government is said to be promoting domestic cassava production. Moreover, after peaking at 5.4 million tons in 2006, China's imports of cassava have declined through 2008; imports in the first quarter of 2008 amounted to about 660,000 tons, a decline of about 70 percent compared with the like period in 2007, leading to a projected total for 2008 of about 830,000 tons. (Sanchez and Junyang 2008, 7; and Shuping and Nakanishi 2008).

[21] The information in this paragraph was obtained from various sources, including Sanchez and Junyang 2008, 3, 5, and 7, and Latner, Wagner, and Junyang 2007, 4; author, pers. comm., January 29, 2008; Shuping and Nakanishi 2008; Shuping 2007; and Dehua Liu n.d.

The United Nations (UN; 2008) announced in March 2008 the formation of the International Biofuels Forum, calling it "a joint project" of Brazil, China, India, South Africa, the United States, and the European Commission. The forum, initially expected to meet regularly for 1 year, was intended to increase the production, distribution, and consumption of biofuels by promoting increased interaction between producers and consumers, in turn creating a world market for biofuels. The National Institute of Standards and Technology (2008) announced that a February 2008 report on standards commissioned by three Forum parties–the United States, Brazil, and the EU–concluded that existing standards developed by the parties' national standards organizations "share much common ground and, therefore, impose few impediments to biofuel trade."

As with many other countries, government support plays an important role in promoting China's development of a bio-based economy, particularly in regard to biofuels.[22] Long-term support of industrial biotechnology and related strategic planning are reflected in the country's 11th Five-Year Plan. The Chinese government's approach has been expansive in scope, addressing research and development (R&D) as well as measures supporting supply and demand. The policies are summarized below.

R&D Support

During the mid-1980s, China initiated several R&D programs related to ethanol. R&D on biofuels is continuing today in many of China's research institutes, often funded by the government and increasingly focused on biodiesel. For example, China has initiated and is funding several government research programs related to biodiesel that have, to date, identified technological improvements allowing for feedstock diversification and lower feedstock costs (e.g., the breeding of a rapeseed plant with an oil content that is nearly 2 percent higher than the current highest strain) (Worldwatch Institute 2006 and *Xinhua News Agency* 2006a). The resulting technologies are often adopted by the industry (Cao and Liu 2006 and Chervenak 2006, 175).

Government-sponsored research funding for small enterprises in China and national R&D and commercialization funding for high-technology projects, including liquid biofuels or bio-based projects, is also available (Cao and

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[22] In its report on industrial biotechnology, the Commission (USITC 2008, 4-1) noted that Brazil, Canada, China, the EU, Japan, and the United States have "extensive policies to support industrial biotechnology." Much of the support is focused on liquid biofuels.

Liu 2006). Three such programs are the National High-tech R&D Program, or the "863 program," launched in 1986; the National Program on Key Basic Research Projects, or the "973 program," launched in 1997; and the National Innovation Fund of China. Examples of specific R&D programs related to biofuels that are classified under the 863 or 973 programs include five focusing on feedstock processing, enzymatic modification, and technological processes.[23] It is not clear, however, what percentage of total such R&D spending under these programs is accounted for by projects related to liquid biofuels and bio-based chemicals (Jiayang Li 2007, and author, pers. comm., January 7, 2008). China is also entering into numerous alliances and policy agreements with other countries to increase its supply of biofuels (box 1).

Supply-side policies

China has implemented numerous measures intended to promote the supply of biofuels, including agricultural feedstock support, monetary support to ethanol producers, loan assistance, tax and VAT exemptions, and interest support for loans. China also recently announced it would invest $5.0 billion over the next 10 years in expanding ethanol production capacity, particularly cellulosic ethanol.[24]

Agricultural feedstock policies

China capped the volume of corn that can be used for industrial applications in late 2006, largely limiting the amount available for use by fuel ethanol producers to what is currently used by the existing plants and significantly tightening the conditions firms must meet before being able to start-up production (e.g., approving no new plants using grain feedstocks). Moreover, citing inflation concerns amid rapid increases in food prices and concerns about food security, China moved to decrease grain exports in late 2007 by rescinding the 13-percent VAT rebate on such exports (*People's Daily Online* 2007; author, pers. comm., January 29, 2008; and Eyre 2007).

The Ministry of Agriculture has announced plans for growing sugarcane, sweet sorghum, cassava, and rapeseed for use in the production of ethanol

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[23] The Chinese Academy of Sciences also funds several research projects, including R&D in biobutanol, micro-organisms, and energy crops.

[24] Chervenak 2006, 175; ABARE 2005, 68; Bilin 2007; Kojima, Mitchell, and Ward 2007, 94; and GreenCar Congress 2006h.

Box 1. Examples of China's international agreements and investments related to biofuels

Brazil:	In 2006, China signed a memorandum of understanding (MoU) with Brazil to share information on policies and projects in the mining and energy sectors and to promote joint ventures related to energy, including renewable resources and biofuels.
Indonesia:	China has also been investing in Indonesia. State-owned CNOOC announced in early 2007 that it, in a joint venture with PT Smart Tbk (a producer of palm oil) and Hong Kong Energy Ltd., will invest $5.5 billion over eight years in biodiesel production from palm oil and ethanol production from sugarcane and cassava. Sinopec will invest $5 billion in the cultivation of palm and jatropha and in biodiesel production in Indonesia in a project that will begin in 2008. Many such projects in Indonesia, however, including the CNOOC project, are being re-evaluated because of the high price of palm oil. As of early 2008, the price of palm oil had doubled from the previous year.
Malaysia:	In 2006, China entered into an R&D alliance with Malaysia focusing on technology to manufacture biofuels from biomass, including palm-based biomass. Malaysia, the world's largest producer of palm oil, creates a significant supply of palm-based biomass annually.
The Philippines:	In early 2007, China signed memoranda of agreement (MoA) with the Philippines to not only invest in hybrid rice, hybrid corn, and, eventually, hybrid sorghum (intended for use in ethanol production), but to also increase Philippine ethanol production to be imported by China. About three ethanol production facilities–using sugarcane and cassava as feedstocks– were expected to be established under the MoA.
United States:	In late 2007, the U.S. Department of Agriculture, the U.S. Department of Energy, and the NDRC signed an MoU on biofuels cooperation that addresses biofuel development, production, technical issues, and policy.

Sources: Ali and Suhartono 2007; *BiofuelsDigest.com* 2008; *Checkbiotech.org* 2008; Lane 2008; Soeriaatmadja 2008; Wood and Aglionby 2008; GreenCar Congress 2006a; *Checkbiotech.org* 2007; *BiofuelsBusiness.com* 2007; and USDA 2008, 8.

and biodiesel. China also announced the initiation of large-scale cultivation of bioenergy forests with trees yielding nuts or fruit with high concentrations of oil for use in producing biodiesel. China ultimately intends to cultivate 13 million hectares of bioenergy forests by 2020, much of it in mountainous areas, enough to yield an estimated 1.8 billion gallons of biodiesel (Bloomberg News 2007, Liang 2008, and Jiao 2007).[25]

Tax and investment incentives

Initial government-sponsored financial support provided to companies in the ethanol industry, tendered during the industry's initial years to promote production, has been described as being very generous (Xinhua News Agency 2006b). China appropriated $188 million annually from 2004 to 2006 to support companies producing fuel ethanol. Annual monetary support levels, set at $0.85 per gallon in 2005, $0.72 in 2006, and $0.59 in 2007, have been declining as the companies' profitability has improved. In 2008, however, the government switched to a flexible support program, which is based on performance evaluations for each plant as of November of each year (Latner, O'Kray, and Jiang 2006a and Sanchez and Junyang 2008, 5).

China also recently promulgated new laws (the creation of risk reserves, changes in financial incentives, availability of venture capital,[26] etc.) that are reportedly intended to help the fuel ethanol industry become more economically self-sufficient.[27] For example, in regard to risk reserves, companies are expected to establish internal funds that would cover losses should crude petroleum prices decline significantly; if crude prices remain low, then government compensation would be implemented. Investment sources are also becoming available and more diversified. As of 2006, Cathay Industrial Biotech (Shanghai) began developing bio-based products, including biobutanol, another liquid biofuel, using $78 million invested by companies such as Goldman Sachs (OECD 2008).

[25] Liang (2008) notes three benefits of use of mountainous areas: (1) farmland is not diverted to biofuel crops; (2) mountains have a great deal of unused acreage; and (3) local incomes are likely to be enhanced.

[26] The availability of private equity and venture capital has increased in recent years. Examples cited include investments by Biolux (Austria), Directions-Based Investments (USA), and venture capital raised by Gushan Group (Chervenak 2006, 176).

[27] China maintains an import duty of 30 percent on ethanol imports.

National economic incentives related to biodiesel production include tax benefits;[28] preferential loans, depending on the project; and, as with ethanol, monetary assistance to farmers producing nonfood feedstocks and to companies developing demonstration-scale production of biofuels using nonfood feedstocks (e.g., producing biodiesel from forest products and ethanol from cellulosic sources, sweet sorghum, and cassava) (Dow Jones Energy Service 2006; Jia 2007; *Xinhua* 2007a; and Kojima, Mitchell, and Ward 2007, 94). The projected publication of a national biodiesel standard in 2007 was expected to further spur industry growth. The voluntary standard introduced in July 2007 is for 100 percent biodiesel (Cao and Liu 2006; Chervenak 2006; Graham-Harrison 2007; and Sanchez and Junyang 2008, 8).

Demand-side policies

China has implemented a mandatory use program for ethanol, stimulating demand. In the 2000-2002 timeframe, China started a trial ethanol program in several provinces, expanding the program in 2004 when it proved successful. The provinces, primarily on the eastern coast, are concentrated geographically around the five approved ethanol production sites. Of the ten provinces currently participating in the program, six are using E10 almost exclusively, and four are still expanding E10 consumption (Sanchez and Junyang 2008, 5, and Latner, Wagner, and Junyang 2007, 4; Ke 2006; Kojima, Mitchell, and Ward 2007, 93; and Wang et al. 2007). In 2005, China mandated that ethanol blends would replace conventional gasoline for all vehicles. The share of gasoline consumption accounted for by such blends is expected to increase from 20 percent in 2006 to 50 percent in 2010. According to the NDRC's Renewable Energy Plan, the E10 plan is expected to be implemented on a national basis by 2020 (Speckman 2008).

China also implemented a Renewable Energy Law on January 1, 2006. The law, intended to complement the national biofuels initiative and to promote production and use of liquid biofuels, calls for renewable energy to account for 10 percent of total energy consumption by 2020 versus about 3 percent in 2003. Moreover, the law requires entities selling gas to include liquid biofuels in the gasoline mix; any economic losses to biofuels producers resulting from failure to comply must be compensated by the marketing entity (Mohan, Phillippe, and Shiju 2006, 68; EIA 2006; and ABARE 2005, 68).

[28] For example, as of December 2006, biodiesel derived from animal fat or vegetable oil is not subject to consumption taxes.

Outlook for the Liquid Biofuels Industry?

China is currently transitioning from grain-based fuel ethanol to ethanol based on nonfood crops, such as cassava, sweet sorghum, and sweet potato, and lignocellulosic feedstocks. Annual growth levels appear likely to level off for the short-term, perhaps remaining in single-digits, as supplies of grain for existing production facilities remain capped; lignocellulosic technology becomes technically and economically viable on a commercial basis; and as alternative feedstocks are cultivated and the logistical infrastructure for such crops and other biomass (e.g., agricultural residue) is enhanced. New projects using alternative feedstocks are under development. Questions have arisen, however, as to whether the supply of alternative feedstocks such as cassava is sufficient to supply some of these projects (Shuping and Nakanishi 2008). As shown in box 2, state-owned entities within China are investing significant amounts in renewable energy, liquid biofuels (including cellulosic ethanol), and the production of bio-based chemicals; they have also been acquiring shares in existing state-owned ethanol producers.

Box 2. Examples of Expanding Investment by State-Owned Entities in China's Biofuels Industry

- COFCO Limited announced it would spend renminbi (RMB) 10 billion ($1.3 billion) by about 2010-12 to expand its fuel ethanol production capacity to 104 billion gallons from its current level of 335 million gallons. COFCO purchased CRAC in 2005 and acquired 20-percent stakes in ethanol producers Anhui BBCA Biochemical Co. and Jilin Fuel Ethanol Co., and has since been expanding its production of ethanol and bio-based chemicals.
- CNPC announced in 2007 it would invest RMB 10 billion ($1.34 billion) in renewable energy by 2020; the company also bought a 55 percent stake in Henan ethanol producer Tianguan Group.
- As mentioned earlier in this article, CRAC, COFCO, and Tianguan Group are planning and/or operating demonstration-scale cellulosic plants. PetroChina, Sinopec, and CNOOC will develop three jatropha-based biodiesel projects, bringing onstream about 51 million gallons of capacity.
- Sinopec is said to be the majority investor in an ethanol plant that will use sweet potatoes as its feedstock. PetroChina is also investing in nongrain ethanol.

Sources: Zang 2008; Commission of the State Council n.d.; *EnergyCurrent* 2007; *Chinamining.org*

New laws recently implemented are reportedly intended to help the fuel ethanol industry become more economically self-sufficient (Wang et al. 2006, 80). Investment sources are becoming available and more diversified. Monetary support for ethanol producers is still available from the government but the payments will now be flexible based on annual evaluations. Whereas some believe that such monetary support will eventually be phased out, others suggest that it is likely to remain in place as long as the price of fuel in China remains significantly lower than world prices (Xinhua News Agency 2006b; *Farms.com* 2006; Sanchez and Junyang 2008 and 2006a, 9).

The value of fuel ethanol exports continued to decline in January-July 2008 to $2.4 million versus $11.6 million and $8 million in the like periods in 2006 and 2007, respectively. The continued elimination of the VAT rebate through 2008 will probably continue to temper ethanol exports. More information on the elimination of VAT rebates, as well as other economic changes such as the new labor regulations, is provided later in this article in the section on bio-based chemicals. At the time this article was prepared, it was not clear yet what impact the changes would have on the biofuels industry, given the high level of state ownership combined with an official projection in June 2008 of a probable gradual slowing in economic growth in China, the decline in energy prices in the latter part of 2008, and the volatile effects of the economic slowdown that cascaded globally during the latter part of 2008 (Sanchez and Junyang 2008, 10; and Hong'e 2008).

Opinions about the outlook for biodiesel are mixed. The NDRC's Renewable Energy Plan calls for biodiesel production to reach about 600 million gallons by 2020. Whereas some expect biodiesel capacity to increase in coming years as a result of possible national consumption mandates, the likelihood of blending ratios of 5-20 percent, and expected export potential (Latner, O'Kray, and Jiang 2006a, 21; Wen 2005; and Wang et al. 2006,44), others suggest that the lack of feedstocks will delay the initiation of production incentives for biodiesel (Sanchez and Junyang 2008, 9). Concurrent with the increasing government focus on biodiesel, new companies, domestic and foreign, private and state-owned, are entering the industry and several large-scale plants are expected to be brought onstream in the next 3-5 years. Exports are likely to remain limited in the near future.

Bio-based chemical products

Use of industrial biotechnology in the Chinese chemical industry is also rapidly growing, particularly in emerging areas such as biopolymers. As with biofuels, the growth builds upon the country's longstanding use of fermentation. The information presented below largely addresses biopolymers and bio-based chemicals derived from fermentation processes.

Industry Profile

China's production of chemicals increased steadily in value during 1994 to 2004 to $190 billion, registering an increase of almost 300 percent, before climbing to $223 billion in 2005, $310 billion in 2006, and almost $390 billion in 2007. The industry's ranking increased steadily from the world's fourth largest chemical producer in 2004 (after the United States, Japan, and Germany), to third largest in 2005, and second largest in 2006 and 2007 (after the United States).[29] This increase was largely attributed to dynamic growth in consuming industries (e.g., the automotive, construction, textile, and consumer products industries) resulting from the country's increasing economic prosperity. Domestic consumption of petrochemicals and polymers is expected to increase by 6 to 8 percent annually, or by about 50 percent by 2010. Commodity and specialty chemicals are expected to be strong growth sectors with continued increases in production capacity to meet the growing demand (Mergent 2007, 2).

The chemical industry's expanded use of industrial biotechnology to manufacture many chemicals, including enzymes, starches and sweeteners, citric acid, lactic acid, xanthan gum, vitamin C, and bioplastics, with much of the output exported, has created "relatively mature" sectors (Chervenak 2006, 175; also OECD 2008). China's production of enzymes, many critical to industrial biotechnology and themselves fermentation products,[30] increased by almost a quarter during the past decade, reaching about 440,000 tons in 2005 according to Chervenak. About 50 domestic companies are said to produce enzymes; two major multinational enzyme companies–Novozymes and Genencor®, a Danisco Division (both of Denmark)–maintain a significant share of the Chinese market (Chervenak

[29] See, ACC 2005, 53 and 55; 2006; 2007, 43 and 45; and 2008, 43 and 45. These data are likely to include ethanol, particularly food-grade ethanol.

[30] Enzymes are generated from the fermentation of micro-organisms.

2006, 174-175). Royal DSM N.V. (DSM; the Netherlands) is participating in a joint venture to produce lignocellulosic enzymes (Jiang 2008, 17).

Production of bio-based chemicals is expanding beyond traditional fermentation products. Cathay Industrial Biotech (Shanghai) began developing bio-based products such as dibasic fatty acids, biobutanol, biopolymers, and specialty chemicals in 2006 (OECD 2008, 13). Research is also underway in China on the use of biocatalysis, according to a sampling of papers published in recent years; one focus of this research is the production of pharmaceuticals (H. Li, 2006; Zheng 2007; and Yan 2007).[31] Ethanol producers, particularly those focusing on cellulosic inputs, are developing production of value-added bio-based chemicals as co-products (Lauridsen 2008, 25).

Chinese production of bioplastics is also increasing.[32] Pilot-plant production of two biopolymers—polyhydroxyalkenoate (PHA) and polylactic acid (PLA)—currently accounts for the majority of Chinese production of all bioplastics. In June 2006, a representative of the Degradable Plastics Committee of the China Plastics Processing Industry Association stated that 3 companies each produced PLA and PHA, with a combined production capacity of about 1,100 tons for each biopolymer. In late 2007, state-owned COFCO Limited announced it was investing RMB 200 million (about $26 million) in an 11,000 ton per year demonstration facility to produce PLA and plans to construct other PLA facilities. It is projected that there will be at least eight Chinese manufacturers of PLA by 2010. DSM Venturing, a unit of DSM, announced it had invested $20 million in March 2008 in Tianjin Green Bio-Science Co., Ltd., (China) to build an 11,000 ton per year production facility for PHA that was expected to be operational in early 2009 (DSM 2008). Other companies are also starting up R&D and/or production efforts for biopolymers (*BiopackNews* 2007, 7).

Annual sales of bulk fermentation products in China were valued at approximately $2.5 billion in 2003. In 2007, the value of products manufactured utilizing industrial biotechnology was said to exceed $60.5 billion with sales expected to increase by about 10 percent annually. Large, state-owned enterprises account for a significant share of chemical

[31] Several papers address the use of biocatalysis in the manufacture of pharmaceuticals. Moreover, the 973 program covers "Basic Research on Critical Problems in Biocatalysis and Biotransformation." (National Basic Research Program of China.)

[32] The information in this section was obtained from various sources including Chervenak 2006, 175; *Bioplastics World* 2006a; Weng 2006; G. G.-Q. Chen 2007; and *China Chemical Reporter* 2007.

production in China. The expanding presence of domestic companies utilizing industrial biotechnology, however, is complemented by the growing activity of foreign companies (Cao and Liu 2006; *People's Daily Online* 2008; and Chervenak 2006, 175-176).[33]

China's trade flows also increased during 1995-2007. China's chemical imports increased during the period from about $18 billion to about $120 billion, or by over 550 percent. Export growth, however, outpaced that of imports in 2007, reducing the sector deficit (*Chemical & Engineering News* 2008). China's chemical exports increased in value from $9 billion in 1995 to $36 billion in 2005, or by 300 percent, before increasing to almost $61 billion in 2007. The two largest categories, bulk organic chemicals and plastics–Harmonized System (HS) Chapters 29 and 39, respectively–together accounted for more than 50 percent of the total value of chemical exports in 2006 and 2007. Plastics accounted for almost 18 percent of the total, versus 10 percent or less in the years prior to 2003. These chapters also include many of the bio-based chemicals currently produced commercially.[34]

Examples of major bio-based organic chemicals exported from China and their approximate annual export volumes in 2005 include citric acid (about 704,000 tons, or about 80 percent of domestic production); vitamin C (about 52,800 tons, or about 80 percent of production); and glutamic acid (about 110,000 tons, or 8 percent of production) (Chervenak 2006, 175, and Cao and Liu, 2006).[35] Industry sources note that most of the biopolymers produced in China are currently exported, given a limited domestic market, the relatively high prices of products made from the biopolymers, a limited recycling and composting infrastructure in China, and a lack of national standards for biodegradable plastic products (Embassy of the United States

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[33] Values were converted from RMB using IMF exchange rates.

[34] Trade data were obtained from the World Trade Atlas based on the 2007 HS-Standard International Trade Classification (SITC), rev. 4, concordance for Section 5, "Chemicals and Related Products, n.e.s." Miscellaneous plastics products are excluded from the totals shown for Chapter 39. The chemicals classified in Chapter 29 range from commodity chemicals (low-value, high-volume products) to specialty and end-product bulk chemicals such as pharmaceuticals and their intermediates (high-value, low-volume products). The HS classifications do not differentiate by production process. Individual chemicals are classified together whether produced using conventional chemical processes or new technologies such as biotechnology or nanotechnology.

[35] The two-step fermentation process developed in China in the 1908s to produce Vitamin C is said to have allowed it to become the leading world producer of Vitamin C (Jiang 2008, 12).

of America, Beijing, China, 2006; author, pers. comms., December 7, 2007, and January 3 and 10 and February 6, 2008).

HS 3907, the heading under which biopolymers such as PLA and PHA and certain other plastics are exported, accounted for almost 30 percent by value annually of China's total exports of plastics (excluding miscellaneous plastics products) during 2005-07 (versus 10 percent in 1996). According to data from the World Trade Atlas, the value of exports classified in this heading doubled during this period, climbing from $1.5 billion to $3 billion.

Business strategies

As with biofuels, much of the technology used in the production of bio-based chemicals has been obtained either from Chinese research institutes or imported from overseas. Much of the Chinese production and marketing of bio-based chemical products is open to foreign firms, and significant levels of sector-specific foreign investment are entering the country. Total investment by the U.S. chemical industry in China increased from $329 million in 1998 to $2.6 billion in 2006, or by 690 percent (ACC 2008, 83). Several new facilities are located at industrial parks established by the government. Companies that have made large investments in R&D and/or production facilities in China include Archer Daniels Midland Company (United States), BASF SE (Germany), Cargill, Incorporated (United States), The Dow Chemical Company (Dow; United States), DSM, E. I. du Pont de Nemours and Company (DuPont; United States), Genencor, NatureWorks LLC (United States), and Novozymes (Chervenak 2006, 176; *Plastics News* 2006; and Mergent 2007, 2).

Several projects address bio-based chemicals. For example, Dow Epoxy, a Dow business group, is building two plants at the Shanghai Chemical Industry Park that are expected to start-up in 2010-11. One will produce 165,000 tons per year of bio-based epichlorohydrin (it will be the first commercial-scale facility to utilize Dow's proprietary technology using glycerin from biodiesel production as the feedstock) and the second will produce 110,000 tons per year of liquid epoxy resins (LER). Epichlorohydrin is a key input for LER; about 40 percent of the epichlorohydrin produced at the site will be used as an input for the neighboring LER plant (Dow 2007 and n.d.; and author, pers. comm., July 17, 2008). Dow announced on September 2, 2008, that China's Ministry of Environmental Protection had approved the project's environmental impact assessments, a step said to be required of all chemical plants in China before initiating construction. The company stated that its use of its proprietary technology to produce epichlorohydrin will reduce chlorine consumption by 50 percent and will "produce 10 times less waste water, while also improving process efficiency and product quality" (Dow 2008).

DuPont, in partnership with Zhangjiagang Glory Chemical Industry Co., Ltd., is initiating commercial production and distribution of its renewably-sourced Sorona® biopolymer in China "so that the entire supply chain–from polymer to fabric–will be in Asia" (DuPont 2008.). DuPont will ship the feedstock, bio-based 1,3-propanediol, derived from corn sugar via its proprietary process, from the DuPont Tate & Lyle Bio Products LLC production site in Loudon, TN (DuPont 2006).[36] Licensees are reportedly testing material made at the 33,000 ton per year plant and commercial production is expected to start in late 2008 (Patton 2008). DuPont also produces Sorona® in the United States in Kinston, NC.

Government Programs

As with biofuels, long-term support of industrial biotechnology and related strategic planning are reflected in the country's 11th Five-Year Plan. Such measures address R&D as well as supply and demand. Although many of the policies enacted to date are focused on biofuels, numerous policies also address bio-based chemicals. For example, in addition to providing incentives to profitable companies displaying production efficiency, China also provides tax and investment incentives for emerging industries in "bio-chemistry" that show promise (author, pers. comm., December 18, 2006).

R&D Support

R&D programs related to bio-based chemicals, many funded by the government, are underway in many of China's research institutes, generating technology often adopted by the industry (Cao and Liu 2006; and Chervenak 2006, 175). Industrial parks focusing on chemicals have also been established, reportedly to increase investment by domestic and foreign firms and to provide economic stimulus (Mergent 2007, 2).

Government-sponsored research funding programs mentioned earlier (e.g., the 863 program, the 973 program, and the National Innovation Fund of China) also apply to bio-based chemicals (Cao and Liu 2006). For example,

[36] DuPont Tate & Lyle Bio Products LLC is a joint venture formed between DuPont and Tate & Lyle plc to manufacture and distribute the bio-based 1,3-propanediol.

Tianan Biologic Material Co. Ltd., a developer of bioplastics, receives funding from both the 863 program and the National Innovation Fund. It is not clear, however, what percentage of total such R&D spending under these programs is accounted for by projects related to liquid biofuels and bio-based chemicals (MOST 2007b; Grace 2007; and Lunt 2007). Morever, in line with its increasing focus on innovation and, according to Adams (2008), on "high-value-added production," the Chinese government announced on September 27, 2007, that it would expand financial support to high-technology capacity building in its 11th Five-Year Plan period and would encourage investment in high-technology industries by organizations such as banks and investment firms (Sanger 2008, 4, and Linton 2008).

Policies Addressing Supply and Demand

Bioplastics are one area of focus within bio-based chemicals. Several government organizations are responsible for policies, regulations, and funding of bioplastics, including the Ministry of Science and Technology, the State Environmental Protection Administration, the Standardization Administration, and the NDRC. To offset China's growing consumption of plastic, estimated to amount to 25 to 30 million tons in 2005, the government is implementing several measures. In January 2008, the Chinese government announced that, as of June 1, 2008, it would ban the production and use of ultra-thin plastic bags and prohibit stores from giving free plastic bags to customers. The government also is said to have established a program in 2005 to promote the production and consumption of PLA with a goal of boosting demand to 9-11 million tons by 2020. The 11th Five-Year Plan is said to call for annual production of 330,000 tons of bioplastics, equivalent to1 percent of the Chinese plastics market, by 2010. Under the Plan, a partnership is reportedly being developed between a unit of the Chinese Academy of Sciences and private sector companies to develop R&D and production facilities for polybutylene succinate polyester, funded by an initial RMB 100 million (about $13 million) (*BiopackNews* 2007, 7; *Bioplastics World* 2006a, 3; *Xinhua* 2008b; DECHEMA e.V. 2007, 4; and Jiang 2008, 8).

Moreover, production and consumption of bioplastics in China was expected to be spurred by the decision by the Beijing Olympics Organization Committee, as noted in the Olympic Science and Technology (2008) Action Plan, to use "environmentally friendly products," including those made from bioplastics (e.g., utensils, food containers, packaging, beverage bottles, home furnishings, and apparel), during the 2008

Olympics as part of its commitment to host a "Green Olympics" (Cargill 2006; *Bioplastics World* 2006b; 3, *Plastics News* 2006; and H.S. Chen 2007). The use of bioplastics in the 2008 Olympics was also promoted by the United Nations' International Center for Science and High Technology as part of the organization's program related to biodegradable plastics. In cooperation with the UN, the organizing committee sought to promote widespread use of biopolymers during the games, as well as promoting the development of "green" products within China, such as those derived from biopolymers (*Bioplastics World* 2006c, 3, and H.S. Chen 2007). The use of such products is also expected to be a focus of the 2010 Shanghai World Expo (Guangming 2007).

Outlook for the Chemical Industry?

The market conditions facing many ongoing and prospective ventures in the chemical industry, however, including projects relating to bio-based chemicals, are changing as a result of the combined impact of factors, including the strength of the Chinese currency, new labor regulations, tax changes, and volatile energy prices. These factors are expected to affect manufacturing and transportation costs, as well as export levels and prices. Many bio-based chemicals produced in China, including biopolymers, are exported. Although China is a net importer of chemicals, mainly to satisfy growing domestic demand, China is a major world supplier of many commodity chemicals, including those produced using industrial biotechnology. Exports have been characterized by Scimo and Bjacek (2008) as "the ultimate demand drivers" for the Chinese chemical industry.

The strength of the renminbi against the U.S. dollar, however, eroded export growth in major sectors, including chemicals, in the first seven months of 2008[37] (World Trade Atlas[38] and *C&E News* 2008). Moreover, in mid-2007, China reduced or eliminated the VAT refund to Chinese exporters of certain chemicals and other products, reportedly focusing on chemicals and products that have a negative environmental impact (i.e., whose manufacture consumes significant amounts of energy, products that are highly polluting, and products that use scarce natural resources) and goods deemed likely to cause international trade disputes. The refund on plastics resins and products, for example, was reduced to 5 percent from

[37] According to IMF data, after the RMB strengthened versus the U.S. dollar over the past few years and during the first half of 2008, the relative positions of the two currencies stabilized as of mid-2008.

[38] Trade data from the World Trade Atlas based on the 2007 HS-SITC, rev. 4, concordance for Section 5, "Chemicals and Related Products, n.e.s."

11 percent, reportedly resulting in tighter profit margins (PriceWaterhouseCoopers 2007; Ho and Gong 2007; Hautekeete 2008; and Sung 2007). As of late 2008, however, the refunds for some chemicals were reportedly increased to stimulate economic growth (China Briefing 2008).

The increase in energy costs through the first half of 2008 compounded the impact on companies. Despite inflation concerns, the Chinese government raised fuel prices in June 2008, increasing gasoline prices to about $3.83 per gallon (up 16 percent) and diesel to about $3.58 per gallon (up 18 percent), after having frozen them in January 2008 (Benjamin 2006; Bradsher 2008a and 2008b). Higher international energy costs increased transportation costs for companies worldwide, including those exporting product from China, resulting in many companies "tightening" their global supply chains–in some cases reducing the geographical reach of portions of their supply chains–to reduce fuel and energy consumption and emissions (Rohter 2008).[39] The higher energy costs were also expected to prompt companies to increasingly implement "green" policies, potentially including utilizing bioprocesses common to industrial biotechnology, particularly if energy costs increase over the long term. Energy costs declined significantly in the latter part of 2008 but potentially remain volatile.

Companies are also contending with increasing labor costs, largely because of new labor regulations implemented as of January 1, 2008, that, according to Batson and Fong (2007), provide "the most significant overhaul of China's workplace rules in a decade."[40] The regulations provide increased protection for employees by calling for, among other things, written employee contracts that are signed; more ways for employees to seek redress; higher hourly rates for overtime and holiday work; limits on overtime; and for companies to pay a higher share of social costs (Adams 2008 and Sung 2008). According to official Chinese statistics, the average annual wage of staff and workers for all manufacturing increased from RMB 12,496 ($1,510) in 2003 to RMB 17,966 ($2,253) in 2006, or by about 12-14 percent annually; the average annual wage of staff and workers in the

[39] Rohter (2008) cites a May 2008 study published by CIBC World Markets (Canada) that found that the increased shipping costs were, on average, equal to the imposition of a 9 percent rate of duty. He notes, though, that transportation costs "are only one factor" of many considered when companies make investment and sourcing decisions.

[40] Batson and Fong (2007) note that the Chinese Government, in an effort perceived at increasing transparency in the formulation of legislation, sought public comments on the draft version of the law (first presented in December 2005) and received almost 200,000 comments, resulting in "substantial changes" to the legislation.

chemical industry increased by 17 percent from RMB 15,585 ($1,902) in 2005 to RMB 18,212 ($2,284) in 2006 (*China Statistical Yearbook* (2004-06 editions)). Kim and Kuijs (2007,12) state that annual increases in nominal wages within the chemical industry fluctuated between 12 and 14 percent during 2002-05. Although Scimo and Bjacek (2008) note that labor costs were still considered "the primary advantage" for the Chinese chemical industry as of early 2008,[41] labor costs are reportedly expected to increase by as much as 25 percent annually; given the strength of the renminbi at the time, the impact was expected to be exacerbated when considered in terms of dollars. Inflation rates of 7-8 percent per year were also expected to intensify such increases (Benjamin 2006; and Bradsher 2008a and 2008b). Companies are also facing an expected gradual slowing in China's economic growth, as projected by the Deputy Director of the National Bureau of Statistics in June 2008 citing a "cyclical adjustment" (Hong'e 2008),[42] as well as the progressive effects of the global economic slowdown that began in the latter part of 2008.

These factors pushed Chinese manufacturing costs and export prices for chemicals closer to those of the United States (Sung 2008; and Kim and Kuijs 2007, 12). The combination of the strengthening currency and the reductions in the VAT refunds alone, for example, was expected by industry sources to temper China's competitive pricing for exported chemicals, including bio-based products such as xanthan gum (Chervenak 2006, 174-175; and *BakeryandSnacks.com* 2005).

Profit margins within the industry are also narrowing.[43] The Chinese chemical industry's profit margins grew annually during 1999-2004, increasing by about 2 percent in 1999 to over 5 percent in 2004; the increases tapered off, however, during 2005-06 to an increase of slightly over 3 percent in 2006 (Kim and Kuijs 2007, 12). Profit margins for Vitamin C, a bio-based fermentation product derived from corn starch, are said to have declined significantly because of inflation and concomittant increases in production costs. At the same time, the product's export price increased as a result of short supplies (purportedly attributed to production shutdowns resulting from factors such as tightened environmental

[41] Another source states that despite the increases, manufacturing costs of Chinese chemicals in mid-2008, including bio-based products, were still considered to be lower than those in the United States (author, pers. comm., 2008).

[42] According to Hong'e (2008), a report published a week earlier by the People's Bank of China attributed the slowing growth to "the U.S. credit crunch, a spate of tightening measures ad natural disasters."

[43] See, Sung 2008; and Kim and Kuijs 2007, 12.

standards) and the currency situation (A. Liu 2008).[44] Citric acid, a product produced by Chinese companies via fermentation since the 1980s, has reportedly been the subject of numerous unfair import investigations in various countries over the years, most recently in 2008 in the EU and the United States. EchinaChem Trading Marketplace (2008) states that "According to experts, the worldwide antidumping actions against citric acid producers, the increasing prices of raw materials and the appreciation of Renminbi with respect to U.S. dollars, will all cause the exports of citric acid to fall in 2008, with export growth slowing."

The cumulative impact of the changing market environment is still unfolding, particularly given the volatile economic situation resulting from the global economic slowdown. Anecdotal reports mention higher Chinese manufacturing costs and export prices, citing larger increases in feedstock prices and energy costs in the first half of 2008 than in previous years, coupled with higher labor costs and the strength of the renminbi versus the U.S. dollar (author, pers. comm., July 2 and September 5, 2008). One preliminary indicator of future trends could be shifts in export levels and unit values during the first seven months of 2008, although such shifts could also be attributed to factors other than those listed above (e.g., changes in the product mix).

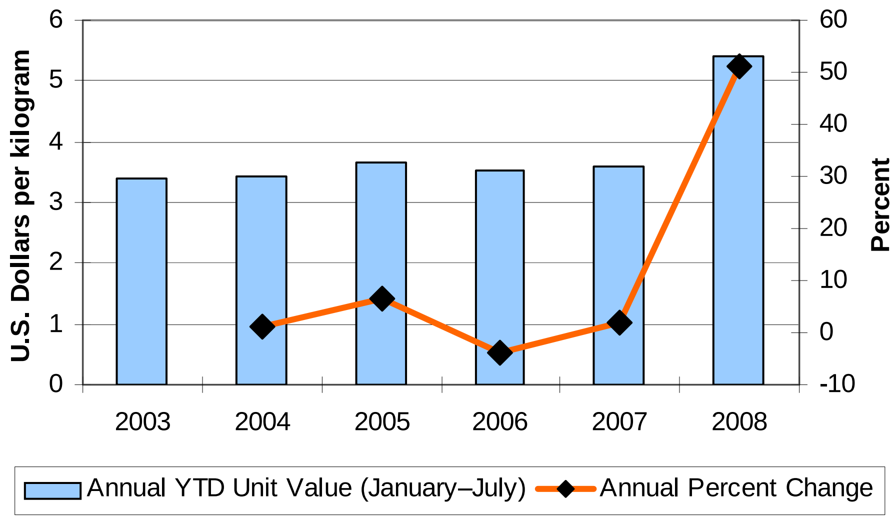
During January-July 2008, the value of Chinese chemical exports totaled $48 billion, an increase of 47 percent over the like period in 2007. Quantity data are not readily comparable for total exports given the mix of units in the products considered. For HS Chapter 29 alone (organic chemicals in bulk form), however, the value of exports increased by 59 percent to $18 billion during the seven-month period versus the same period in 2007, while growth in the quantity of exports slowed, increasing by only 10 percent. The average unit value increased significantly during the first seven months of 2008, climbing to $3.71 per kilogram (up by 43 percent) from $2.59 per kilogram and $2.67 per kilogram for the like periods in 2007 and 2006, respectively.[45]

The unit value of such exports to most markets increased substantially during January-July 2008. For example, as shown in Figure 1, the unit value

[44] Liu cites increased costs associated with feedstocks, energy, labor, and transportation. Inflation is also said to have played a role (A. Liu 2008).

[45] Trade data from the World Trade Atlas based on the 2007 HS-SITC concordance for Section 5, "Chemicals and Related Products, n.e.s." In comparison, the year-on-year increases in the value and quantity of exports of Chapter 29 during January-July 2007 increased by 34 percent and 38 percent, respectively, versus the like period in 2006.

Figure 1 Chinese Exports under HS Chapter 29 to the United States, January–July 2003-08



of exports to the United States increased by 50 percent to $5.42 per kilogram after remaining relatively constant between $3.40 and $3.70 per kilogram during the like periods in 2003-07. Of about 150 export markets worldwide for which unit values increased, almost half increased by as much as 50-400 percent. Another third increased by between 20 to 50 percent.[46]

Exports classified in HS 3907 (plastics) were valued at $2 billion in January-July 2008, an increase of 22 percent versus the like period in 2007; the quantity of such exports, however, increased by only 11 percent. The unit values also increased, but at a more measured pace than those for HS Chapter 29, increasing steadily from $1.21 per kilogram in January-July 2003 to $1.87 per kilogram in the like period in 2008.[47]

Industry sources indicated in mid-2008 that whereas companies still considered the Chinese chemical industry/market attractive given its size, breadth, and potential, some companies were also adding new capacity

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[46] Trade data from the World Trade Atlas based on the 2007 HS-SITC concordance for Section 5, "Chemicals and Related Products, n.e.s." The unit values of exports to about 20 countries decreased by up to 100 percent during the 2008 period.
[47] Trade data from the World Trade Atlas. In comparison, the year-on-year increases in the value and quantity of exports of this product grouping for January-July 2007 were 47 percent and 43 percent, respectively, versus the like period in 2006.

and/or expanding existing operations within other Asian countries, including Vietnam, to offset some of the changes (Bradsher 2008a and Sung 2007). Within China, continued productivity gains, such as those enabled by industrial biotechnology, have been suggested as one way to potentially mitigate some portion of the impact (Benjamin 2006). Kim and Kuijs (2007, 13-14) note that despite increased prices for raw materials and higher labor costs, the Chinese chemical industry maintained annual productivity gains in every year during 2002-06 except 2005; the industry's gains of 35-36 percent in 2002-03 declined to a low of -2 percent in 2005 before increasing again to 15 percent in 2006, short of the 2004 level of 20 percent. As Kim and Kuijs concluded in late 2007 (2007, 17), " . . . the ability of China's industry to offset rising raw material prices by increasing efficiency has so far remained undiminished."

Conclusion

China's use of industrial biotechnology in its biofuels and chemical industries has enhanced its positioning as the world's third-largest producer of ethanol and second-largest producer of chemicals and has corresponded with concurrent export growth in chemicals. The country's continued use of bioprocesses and renewable resources is reflected in both its rigorous efforts to develop nongrain biofuels, including cellulosic ethanol, and its ongoing research into biocatalytic processes, particularly for use in the chemical industry. The strength of these industries has encouraged expanded domestic and foreign investment, including investment in bio-based projects and generated related gains in exports, particularly in the chemical industry. However, the market conditions facing many of the ongoing and prospective ventures in the two industries are in flux because of changes such as China's implementation of new labor laws, the reduction or elimination of VAT refunds to Chinese exporters in many industry segments, the strength of the Chinese renminbi versus the U.S. dollar, and higher domestic energy prices through the first half of 2008. Moreover, the June 2008 projection of slowing domestic economic growth has been exacerbated by the impact of the global economic slowdown that cascaded globally during the latter part of 2008. Although the magnitude of the impact is likely to vary by sector and the economic situation remained volatile as of the end of 2008 (e.g., energy prices declined significantly in the latter part of the year), the changing market conditions appear to have tempered export gains and related profits in the liquid biofuels and chemical industries in the first seven months of 2008.[48] Within the chemical industry, industry sources cited higher increases in manufacturing costs (e.g., higher feedstock and energy prices) and lower profit margins in the first half of 2008 than in previous years. Continued productivity gains, such as those enabled by industrial biotechnology, have been suggested as one way to potentially mitigate some portion of the impact of the abovementioned factors.

[48] The November 2008 decline in China's exports was the largest since 1999 (Jacobs and Barboza 2008). Several sources state that the sectors experiencing the largest impact–furniture, toys, and apparel–are those with lower infrastructure investments and narrower price margins. In comparison, the chemical industry incurs significant capital investment and many of its products (e.g., specialty chemicals and end products such as pharmaceuticals) have higher profit margins and significant value-added components.

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Challenges to Foreign Investment in High-Tech Semiconductor Production in China

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Abstract

This article seeks to explain the limited level of high-tech semiconductor production by foreign investors in China. First, the article briefly summarizes the evolution and current state of China's policy efforts to promote foreign investment in its semiconductor industry. Second, the article shows that foreign front-end semiconductor production in China remains relatively small, despite the lure of the government's promotional policies and the fact that China is the world's largest market. The article concludes by identifying two major factors discouraging foreign front-end semiconductor production in China: (1) China's uncertain business environment for front-end semiconductor production, punctuated by lax intellectual property rights (IPR) protection and enforcement; and (2) restrictive investment and export control policies by foreign governments.

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Introduction

Two developments over the past several years contributed to the expectation that foreign high-tech semiconductor wafer fabrication production, known as front-end production, would soar in China, commensurate with the rapid development of other high-tech sectors.[2] First, in 2000 the Chinese government dramatically reoriented promotional policies and incentives for its semiconductor industry to attract foreign semiconductor investment, recognizing that foreign investment and relocation are vital to the development of China's domestic high-tech semiconductor industry. Second, in 2005 China became the world's largest single-country semiconductor market.

Despite these two developments, foreign front-end semiconductor production in China still accounts for a very small share of global production. In 2008, foreign front-end firms in China represented only around $1 billion of the $227 billion total in global integrated circuit (IC) production (McClean, Matas, and Yancey 2009, 2-54).[3] In addition, within China, domestic semiconductor firms, not foreign firms, continue to represent the majority of front-end semiconductor production, with domestic firms accounting for, on average, over 80 percent of China's annual semiconductor production from 2003 to 2008 (McClean, Matas, and Yancey 2009, 2-54). By the end of 2007, only two foreign semiconductor firms had established front-end production in China (SEMI 2008a, 2-4).[4]

[2] Production growth in China's advanced technology sectors is explained in Preeg 2005. Preeg argues that China is rapidly becoming an "advanced technology superstate." Sigurdson 2005 also argues that China's technological power will continue to rapidly increase.

[3] Semiconductors are commonly referred to as integrated circuits (ICs), microchips, or simply "chips." This article uses these terms interchangeably. Technically, the semiconductor market comprises two major subsets, the IC market and the optoelectronics, sensor, and discretes (O-S-D) market. Since ICs represent the larger share of the semiconductor market (84 percent in 2008) and comprise semiconductors that are harder to manufacture, more advanced, and more expensive, IC production is often used as a proxy for semiconductor production. Based on data availability, this article uses both semiconductor and IC production data.

[4] However, China continues to be a leading location for foreign firms to establish low value-added, labor intensive "back-end" semiconductor production. When comparing the total (i.e. foreign plus domestic) number of front-end and back-end production facilities in China, back-end facilities far outnumber front-end. Currently, an estimated 200 back-end facilities are operating in China compared with an estimated 30 front-end fabs (SEMI 2008a, 2-4; and McClean, Matas, and Yancey 2009, 15-4).

The lack of foreign front-end production investment has helped to keep China from its stated goal of becoming one of the major semiconductor production centers in the world (State Council Circular 18 2000).[5] Becoming a leading location of the more high-end, capital- and knowledge-intensive front-end production process would establish China as a major force in the global industry (along with the EU, Japan, Taiwan, and the United States).[6] Clearly, such a change would have significant implications for the balance of economic and high-tech power throughout the world, as well as for trade flows.

This article seeks to highlight some factors limiting the level of foreign front-end semiconductor production in China. First, the article briefly summarizes the evolution and current state of China's policy efforts to promote its semiconductor industry. Second, the article describes China's evolving role in the global semiconductor manufacturing process over the past few years. Investment, production, and trade data demonstrate that, despite growth in certain segments of China's semiconductor industry (e.g., foreign and domestic back-end and domestic front-end production), foreign front-end semiconductor investment and production in China remain relatively small. Finally, the article identifies factors influencing foreign investment. Despite the draw of government incentives and the size of China's market, foreign firms face two major obstacles that have discouraged investment: (1) China's uncertain business environment for front-end semiconductor production, punctuated by lax intellectual property rights (IPR) protection and enforcement; and (2) restrictive investment and export control policies by foreign governments. Based on their behavior over the past several years, the majority of foreign firms seem to have determined that the potential risk associated with these two factors outweighs the potential reward of locating their front-end production in China.

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[5] In 2000, the stated goal of the Chinese government for its semiconductor industry was to become one of the major semiconductor production centers in the world, meet most domestic demand, and export in large quantities within 5 to 10 years (State Council Circular 18 2000). These goals are far from being met.

[6] China's ambition for its semiconductor industry is typical of most semiconductor-producing countries; it seeks progressive development up the high-tech production chain, from engaging in labor intensive back-end production to more capital and knowledge intensive front-end production and design. For China, this ambition is strengthened by its desire to supply its vast domestic market rather than to rely on foreign imports.

Evolution of Policies to Attract Foreign Investment

The Chinese government's efforts to develop its semiconductor industry have evolved to feature foreign investment as a cornerstone for developing the industry. By contrast, earlier government promotional plans restricted foreign investment and allowed the government to actively manage the industry (table 1). Prior to 2000, semiconductor firms in China were either state-owned enterprises or joint ventures in which the Chinese partner was a government entity.

Several factors prompted the central government to develop this new promotional model. First, the government realized that the previous set of policies were not effective. Most notably, the Chinese government's "command-economy" model, in which the state directed the industry and

TABLE 1 Changes in China's promotional policy model for its semiconductor industry

Policy	Pre–2000	2000–Forward
Corporate structure	State-owned enterprise	Private; government holds passive minority share
Foreign direct investment	Heavily restricted	Liberalized
Promotion of IC design industry	Emphasis on state-owned research institutes	Privatization of government research institutes; financial assistance to private companies
Government as direct investor in leading firms	100 percent government ownership of semiconductor enterprises	Government passive minority equity stake
Tariffs on semiconductors	6–30 percent	0
Industrial parks	Over 100 "high-tech parks" scattered throughout the country	Bigger, more concentrated clusters. 1 flagship park (Zhangjiang), 2–3 others emerging (Suzhou, Beijing)
Major financial incentives to individuals	None	Major tax benefits
Government controls enterprise decision-making	Yes	No
Government promotion of venture capital sector	No	Yes

Source: Reprinted in part from Howell et al. 2003, figure 11.

controlled major enterprises, proved a bad fit with the semiconductor industry, which flourishes in an innovative and entrepreneurial environment often associated with private enterprise (Howell et al. 2003, 22–23). Despite much investment over several decades and the implementation of several long range plans with specific goals, by the end of the 1990s the semiconductor industry in China significantly lagged behind those of the leading global producers (United States, EU, and Japan) in both production quantity and technology advancement. The Chinese industry was several technological generations behind the global leading edge, was not a major presence in foreign markets, and only supplied around 15 percent of its own market (Howell et al. 2003, 27). [7]

Second, the Chinese government learned how the Taiwanese government successfully implemented promotional policies in the 1980s and 1990s that made its industry a global leader by the end of the 1990s. One expert describes the divergent paths taken by the two governments.

> Chinese planners built their industry on a foundation of state-owned enterprises, laboratories and research institutes, withpervasive control over decisionmaking by government ministries. By contrast, the government of Taiwan utilized incentive policies intended to create and strengthen a vibrantprivate sector and did not attempt to exert influence over individual enterprise management. China sought to control inward foreign investment to such a degree that most foreign semiconductor producers were deterred altogether from major investments in China; Taiwan welcomed inward foreign investment with relatively few restrictions (Howell et al. 2003, 30).

To a large degree, the Chinese government's current policies are modeled after Taiwan's, aiming to achieve similar success.

Third, China's entry into the World Trade Organization (WTO) in 2001 forced the government to bring their methods for promoting industry into compliance with WTO rules. For example, prior to WTO entry, the Chinese government engaged in a development strategy of "trading markets for technology," in which foreign firms were permitted to invest in China and sell into the Chinese market in exchange for technology transfer and other

[7] For more information on the development of the Chinese semiconductor industry prior to 2000, see Chase, Pollpeter, and Mulvenon 2004, 101–103.

benefits (Howell et al. 2003, 39). Since WTO rules prohibit such promotional strategies, China developed new promotional policies in line with those of other WTO member countries, such as subsidies, tax incentives, and science, education and training programs (Howell et al. 2003, 39).

Current Policies and Incentives

Circular 18 and the 10th Five-Year Plan. The Chinese central government designated the semiconductor industry as an encouraged industry, promulgating a full menu of policies to promote its growth. State Council Circular 18, "Some Policies for Encouraging the Development of the Software and the Integrated Circuit Industry," is the principal document that defines the central government's policy for the semiconductor industry.[8] Issued in June 2000, Circular 18 implements the broad vision of the development of the semiconductor industry in China as part of the government's 10th Five-Year Plan. Circular 18 specifically lays out the goal of making China a leading design and manufacturing center for ICs by 2010, which includes ensuring that ICs produced in China will "match most demands from the domestic market and be exported in large quantities" (Circular 18 2000, art. 2). Circular 18 also outlines specific promotional policies for the IC industry (box 1). These policies are available to both foreign and domestically owned firms that qualify (Circular 18 2000, art. 52). By promoting greater foreign investment through FDI liberalization, tax incentives, and easing of government ownership requirements (among other things), the promotional policies for the semiconductor industry envisioned in the 10th Five-Year Plan and articulated in Circular 18 mark a major departure from Chinese government promotional policies of the past.[9]

[8] Other policies exist for the development of high-technology industry in China, but Circular 18 is the only directive that specifically targets the semiconductor industry. For a full discussion of policies aimed at high-technology industry and R&D development, see USITC 2007a. Notably, semiconductors is one of only two sector-specific industries in China provided its own policy documents by the government (the other being the automobile industry) (Howell et al. 2003, 45; industry official, interview by Commission staff, Shanghai, China, January 15, 2008).

[9] Since the 1950s, the Chinese government has sought to develop a semiconductor industry, but with limited success. For a detailed description of China's various policies and programs to promote the semiconductor industry (and the high-tech, R&D, and electronics sectors, in general), see Howell et al. 2003, 22–27; Sigurdson 2005, chaps. 2 and 3; and USITC 2007a, 103–117.

BOX 1 Major Promotional Policies in Circular 18

The major promotional policies in Circular 18 include:

- Tax holidays and reductions—eligible IC manufacturers can receive a five-year tax holiday from corporate income tax starting on the first year that a firm earns a profit. The five-year tax holiday is followed by five additional years in which the corporate tax rate is halved.
- VAT exemptions on imported equipment and machinery—IC manufacturers are exempt from paying the 17 percent value-added tax applied on imports of machinery and equipment.
- Import duty exemption on equipment and machinery—IC manufacturers are exempt from import duties on IC production equipment. In joining the WTO in 2001, China agreed to eventually eliminate tariffs on these goods.
- Exemption on import duties and VAT on raw materials—IC manufacturers are exempt from import duties on "raw materials and consumables for their own use."
- Capital construction/infrastructure investment—Under article 3(2), "some direct budgetary funds for the capital construction shall be allocated to provide the financial supports for the infrastructure construction and industrialization of IC industries." According to one observer, however, in practice the vast majority of infrastructure support is provided to firms by local governments at the local level (Howell et al. 2003, 46).
- Facilitated customs clearance—IC manufacturers shall be granted an "easier customs clearance."
- Foreign currency retention—Under article 45, "In an aim to evade the exchange rate risks, [IC manufacturers] are allowed to deposit the after-tax profits in the special accounts in the form of foreign currency if the profits are to be used for reinvestment in China."
- Capital—Under articles 3(1) and 51, "the State shall provide the generous assistance for establishing the risk investment [venture capital] companies and setting up the risk investment [venture capital] funds."

Source: State Council Circular 18 2000.

Regional and Local Policies and Practices. While Circular 18 is often cited as the definitive roadmap set forth by the central government for the development of the industry, implementation is left up to provincial and local governments (Howell et al. 2003, 47).[10] Given the number of provincial and local governments in China and limited data, comprehensive details about how these governments have implemented the State Council's vision, communicated via Circular 18, for the semiconductor industry remain elusive.

[10] According to Howell et al., most of the provisions in Circular 18 are not self-implementing; thus, full implementation depends on (1) provincial and local authorities' implementing regulations, and (2) clarifications from the state level.

Some provincial and local governments have devised strategies of their own as well. For example, starting in 2005, provincial and local governments have adopted a new strategy not specifically outlined in local policies and regulations for attracting investment in front-end fabrication. The strategy, known as a "virtual fab" strategy, entails a local government largely or fully funding the construction of a fabrication plant (fab) for a semiconductor firm to manage. Under this arrangement, the local government owns the fab while the contracted semiconductor firm manages it for a fee and a share of the profits. Two regional governments reportedly adopted this strategy—the Wuhan local government, which began construction of a 300 mm fab in 2006, and the Chengdu municipal government, which set up a 200 mm fab in 2005. Both fabs are managed by Semiconductor Manufacturing International Corporation (SMIC), the largest China-headquartered semiconductor firm according to 2008 IC sales (LaPedus 2008).[11]

Semiconductor Production in China

Summary

- Semiconductor production in China represented less than 2 percent of world production in 2008.
- From 2003 to 2008, foreign firms accounted for less than 20 percent of front-end production annually in China, while domestic firms accounted for over 80 percent.
- By the end of 2008, two foreign firms had established front-end production in China, while many more had established the more labor-intensive and less capital-intensive back-end semiconductor production.

Despite China's promotional incentives and its status as the world's largest semiconductor market (box 2), semiconductor production in China still accounts for a very small share of the global total. In 2008, total IC production in China accounted for less than 2 percent of total worldwide IC production, and foreign-based IC production in China accounted for 25 percent of

[11] Because this strategy is not based on a written policy, it is unclear whether both foreign and domestic firms can participate. Thus far only SMIC has participated in the strategy.

total IC production in China (figure 1). For perspective, each of the top 19 global IC companies in 2008 had a greater share of the world market than all Chinese-based IC companies combined, and production by the world's leading IC company, U.S.-headquartered Intel Corporation (Intel), accounted for more than eight times that of all Chinese-based IC companies (McClean, Matas, and Yancey 2009, 3-2). The average annual growth rate of Chinese-based production from 2004 to 2008, however, exceeded that of overall global production (36 percent compared with 9 percent, respectively),[12] principally due to the growth of Chinese-owned firms, and not foreign-invested firms (McClean, Matas, and Yancey 2009, 2-54).

Semiconductor production in China has historically involved labor-intensive processes. For example, China's participation in the three stages of semiconductor production—design; front-end fabrication; and back-end testing, assembly, and packaging—has tilted more toward the back-end stage, which requires more labor and less capital and knowledge than front-end production and chip design (table 2).[13] Compared to the other stages of production, back-end production in China is well-established and robust.[14] Also, China's large market provides a convenient location for back-end production, because once chips finish back-end production they are ready for consumption by the numerous downstream semiconductor consumers located in China.

Currently, an estimated 200 back-end assembly and test companies exist in China (McClean, Matas, and Yancey 2009, 15-4). Several major foreign firms operate back-end facilities in China, including the world's largest semicon-

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[12] It should be noted that the higher average annual growth rate for Chinese-based production likely reflected a catch-up to production leaders and the fact that Chinese-based production started from such a small base. The faster growth of Chinese-based semiconductor production during this period increased China's share of global production from 1.17 percent in 2004 to 1.81 percent in 2008 (McClean, Matas, and Yancey 2009, 2-54).

[13] Semiconductor design is the first and most R&D-intensive stage of semiconductor production. Because this article focuses on the location of the front-end fabrication, it does not address semiconductor design in detail. In general, around 500 design firms (or "fabless" firms) currently exist in China, although their capabilities are limited and their output is small vis-à-vis their U.S.- and Taiwanese-based competitors. Of the top 50 global semiconductor suppliers in 2007, none was a Chinese-based firm. There are very few foreign-based design firms operating in China (Industry official, interview by Commission staff, Beijing, China, January 14, 2008; McClean, Matas, and Yancey 2009, 3-5–3-7).

[14] According to one Chinese industry official, back-end testing and assembly semiconductor activities in China account for 40–50 percent of total current semiconductor production in China (Industry official, interview by Commission staff, Beijing, China, January 14, 2008).

BOX 2 Semiconductors: Uses, Global Industry, and Market

Semiconductors, the building blocks of the Information Age, are found in virtually all electronic products today. They perform a wide range of functions in a variety of end-use products, from simple children's toys to sophisticated computers. In 2008, the most common end uses for semiconductors were estimated to be personal computers, consumer electronics, cell phones, industrial/military applications, automotive applications, and wired communications.

The global semiconductor industry had total worldwide sales of $249 billion in 2008. Over the long term, the industry has grown tremendously, registering a compound annual growth rate of 10.2 percent from 1987 to 2008, fueled by demand from a growing and increasingly diverse market. For most of its history, the industry has experienced distinct boom/bust cycles occurring on average every four years, though the industry's recent performance has bucked this trend with positive growth from 2002 to 2007.

Semiconductors are consumed in all major regions of the world, though Asia-Pacific (excluding Japan) is by far the largest regional market, accounting for 51 percent of the global IC market. China is the largest country market in the world, accounting for 25 percent of the global IC market. The Asia-Pacific region's status as the world's largest semiconductor market stems from the vast majority of semiconductor consumers—electronic systems producers—that have production located there.

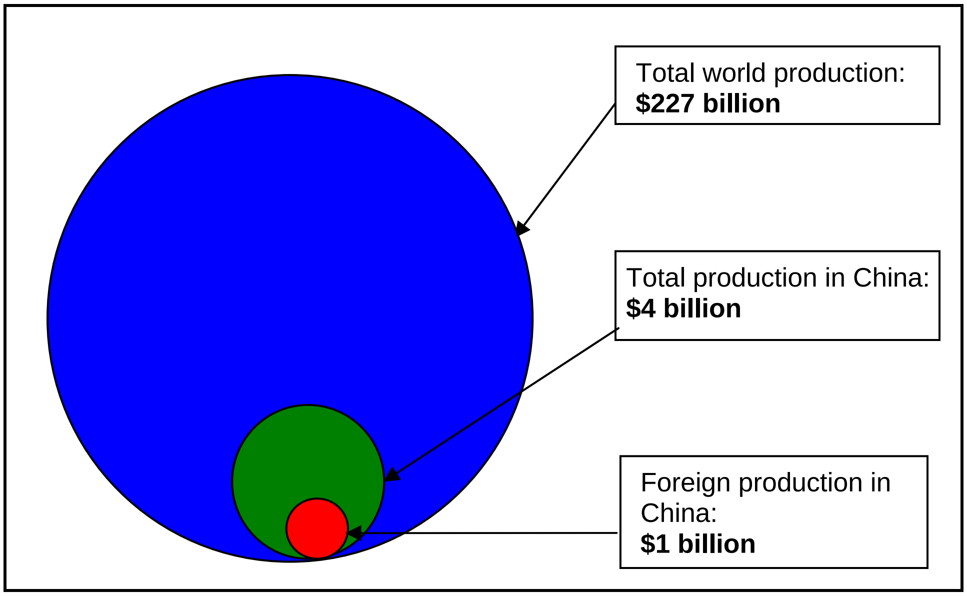
The majority of leading semiconductor producers are headquartered in five countries: the United States, the EU, Japan, Korea, and Taiwan. Many firms, however, maintain production in several countries. With the emergence in recent years of the Asia-Pacific region as the world's largest market, many semiconductor firms headquartered in other parts of the world have increased their presence (in some cases, shifting or establishing some level of production) in the region, including in China.

Sources: Montevirgen 2008, 17; SIA 2008; McClean, Matas, and Yancey 2009.

ductor firm, Intel (Intel Corp. 2008, 20). In addition, many Chinese and foreign-owned firms that focus exclusively on back-end production (also known as open-market assembly and test (OSAT) service providers, or simply back-end contract manufacturers) operate in China (table 3). For example, one of the world's biggest OSAT service providers, U.S.-headquartered Amkor Technology Inc., has its largest facility (based on factory floor square footage) in Shanghai (Amkor Technology Inc. 2008, 27). Furthermore, in recent years, many notable foreign companies, both integrated device manufacturers (IDMs)[15] as well as OSATs, have established or increased back-end production in China (table 4).

[15] IDMs are semiconductor firms that operate in all three stages of semiconductor production. As the three stages of production have become more specialized, three other types of firms have developed in the industry: design or "fabless" firms which operate exclusively in the design stage; pure-play foundries, which operate exclusively in the front-end stage; and OSATs, which operate exclusively in the back-end stage.

FIGURE 1 Foreign IC production in China, total IC production in China, and total world IC production, 2008



Source: McClean, Matas, and Yancey 2009, 2-54.

TABLE 2 Three stages of semiconductor production and the extent of China's participation

Stage	Description of activity	Characteristics	Leading locations
Design	Design of the semiconductor	- R&D intensive - Abundant high-skilled labor - Strong IPR environment	United States, Taiwan **China's participation: limited**
Front-end fabrication	Construction of semiconductors on silicon wafers using highly sophisticated machinery	- Capital intensive, very expensive - Some low-skilled labor - Strong IPR environment	United States, Korea, Japan, EU, Taiwan **China's particpation: limited**
Back-end testing, assembly, and packaging	Testing, assembling, and packaging of semiconductors for final sale to end customers	- Less capital intensive and expensive than front-end fabrication - More labor intensive than front-end fabrication	China, Singapore, Malaysia, Taiwan, the Philippines **China's participation: established and robust**

Source: Compiled by author.

TABLE 3 Types of semiconductor firms by production stages and description of their presence in China

Design	Front-end fabrication	Back-end testing, assembly, and packaging
Fabless Firms Leading firms have yet to emerge in China. Chinese domestic firms exist but are not major producers.	**Pure-Play Foundries** These firms account for the majority of front-end production in China. Most firms are Chinese domestic firms.	**Back-end Contract Manufacturers (or OSATs)** These firms have an established presence in China.
Integrated Device Manufacturers (IDMs) These firms operate in all three stages of production. Most maintain a presence in China, usually in the form of back-end operations or sales offices, but they have been reluctant to locate front-end production in China.		

Source: Compiled by author.

Front-end fabrication, the most capital- and technology-intensive stage of semiconductor production is done in China by Chinese-owned foundries and foreign-owned IDMs. Chinese domestic firms, not foreign firms, are the leading source of front-end semiconductor production in China (table 5). From 2003 to 2008, Chinese domestic production accounted for an annual average of at least 83 percent of total semiconductor production in China (McClean, Matas, and Yancey 2009, 2-54).[16] Of Chinese-owned foundries, SMIC is by far the leading producer, accounting for 33 percent of total Chinese-based IC production in 2008 (McClean, Matas, and Yancey 2009, 2-54).

The establishment of front-end semiconductor fabrication in China by foreign firms in recent years has occurred sparingly. Of the roughly 180, 200 mm fabs in operation worldwide in 2008, only one foreign-owned facility existed in China, a plant operated by Taiwan Semiconductor Manufacturing Company (TSMC) of Taiwan (McClean, Matas, and Yancey 2009, 14-69). Of the 70 more advanced 300 mm fabs in operation worldwide in 2008, one foreign-owned facility existed in China, a joint venture between Hynix Corporation of Korea and STMicroelectronics NV of the EU (Hynix-STMicro JV)

[16] Though specific data for foreign-based production in China are not available, Chinese domestic production accounted for at least 80 percent of total production in 2003 and at least 70 percent in 2008. For most of the intervening years, Chinese domestic production was greater than 80 percent (McClean, Matas, and Yancey 2009, 2-54).

TABLE 4 Selected foreign IDM and OSAT firms establishing back-end assembly and test facilities in China, 2001–08

Selected Foreign IDMs		
Company	*Headquarters*	*Year Established*
AMD	USA	2004
Fairchild	USA	2003
Hynix	Korea	2005
Intel	USA	2004
Qimonda	EU	2004
International Rectifier	USA	2005
Micron	USA	2005
National	USA	2004
Renesas	Japan	2004
Samsung	Korea	2003
STMicroelectronics	EU	2008
Toshiba	Japan	2005
Selected Foreign OSATs		
Company	*Headquarters*	*Year Established*
Amkor	USA	2001
ASE	Taiwan	2004
Carsem	Malaysia	2004
SPIL	Taiwan	2002
UTAC	Singapore	2004

Source: McClean, Matas, and Yancey 2008, 15-5.

Note: Intel and STMicroelectronics had also established back-end facilities in China prior to the years noted above.

(McClean, Matas, and Yancey 2009, 14-69).[17] By the end of 2007 two other foreign IDMs, Intel of the United States and ProMOS Technologies of Taiwan, were constructing fabs (Intel 300 mm, ProMOS 200 mm) in China,[18] and one other firm, PowerChip of Taiwan, was planning to construct a

[17] In 2006, sales from STMicro/Hynix's facility were $305 million, while sales from TSMC's facility were $160 million (SEMI 2008a, 2, 40, and 42).

[18] Intel has begun construction on a fab in Dalian that is expected to begin production in 2010 (Intel Corp. 2008, 20; SEMI 2008a, 4).

TABLE 5 Domestic and foreign IC production in China, 2003–08

	Sales in millions $					
	2003	2004	2005	2006	2007	2008
Total Chinese IC production	1,046	2,248	2,431	3,201	3,800	4,110
Estimated production from domestic firms	843	2,019	2,183	2,761	3,005	2,910
Share of total	81%	90%	90%	86%	79%	71%
Estimated production from foreign firms	203	229	248	440	795	1,200
Share of total	19%	10%	10%	14%	21%	29%

Source: McClean, Matas, and Yancey 2009, 2-54.

TABLE 6 Foreign semiconductor firms with front-end semiconductor activity in China, 2007

Company	*Headquarters*	*Status of Fab*
Hynix-STMicro JV	Korea and EU	Began production in 2006
TSMC	Taiwan	Began production in 2004
Intel	USA	Under construction
ProMOS	Taiwan	Under construction
PowerChip	Taiwan	Planning

Source: SEMI 2008a, 2–4.

(200 mm) fab in China (table 6) (SEMI 2008a, 4). The noticeable increase in foreign production from 2006 to 2008 (table 5) is attributed mainly to the ramping up of production from the Hynix-STMicro JV plant, rather than an increase in the number of foreign firms establishing production in China.[19]

Though advances in production efficiencies vary widely, the majority of fabs in China use outdated process technologies to manufacture their

[19] The Hynix-STMicro JV plant began production in June of 2006, and ended the year with $305 million in sales (SEMI 2008a, 40). Sales from the plant in 2007 and 2008 would likely be much higher, because they would include: 1) 12 months of production instead of 6 months, and 2) the ramping up of production capacity as well as a capacity expansion which occurred in 2007 (STMicroelectronics N.V. 2008, 88).

semiconductors.[20] Indeed, all but one of the major indigenous Chinese semiconductor firms currently use process technology that was considered leading edge 10–15 years ago in terms of linewidth and wafer size (SEMI 2008a, 38–42; GAO 2008, 11–12). SMIC, which produces mainly for foreign-based consumers, is the exception.[21] Regarding the two foreign firms with front-end production in China, TSMC's fab does not employ leading-edge technology (180–350 nanometer linewidths on 200 mm wafers), and while the Hynix-STMicro JV uses more advanced process technologies (90–100 nanometer linewidths on 300 mm wafers), it still does not operate at the leading- edge (SEMI 2008a, 40–42). Intel's future fab in Dalian, to be completed in 2010, will produce 300 mm wafers using 90 nanometer linewidths, which is estimated to be at least three generations behind the leading edge (LaPedus 2007).

Trade Patterns

The long-established production-sharing pattern of firms maintaining front-end production in the United States while using China as a leading location for back-end production is evident in U.S.-China bilateral trade data (box 3 and figure 2). For example, in 2006, at least 84 percent of all U.S. semiconductor exports to China consisted of unfinished semiconductors in the form of chips, dice, and wafers.[22] Semiconductors in this form have undergone front-end production but have yet to undergo back-end production. These data strongly suggest that a majority of semiconductors exported from the United States to China in 2006 underwent front-end production in the United States, and were subsequently shipped to China for final back-end production. By contrast, only 5 percent of Chinese exports of semiconductors to the United States in 2006 consisted of unfinished semiconductor chips, dice, and wafers; the vast majority consisted

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[20] Semiconductor process technology is measured by linewidth and wafer size. Smaller linewidths and larger wafer sizes equate to more advanced process technology. In 2008, the most advanced process technologies achieved in the industry were linewidths of 45 nanometers and wafer sizes of 300 mm.

[21] By the end of 2007, SMIC reported in financial documents that it had three 300 mm fabs in Beijing (one operating, two constructed) and one in Shanghai (constructed) (SMIC 2008, 27–28; and SMIC 2007c). In terms of linewidth, by mid–2008 SMIC was producing semiconductors at the 65 nanometer node, which was one generation from the most advanced level at that time.

[22] Changes to the Harmonized Tariff Schedule of the United States (HTS) in 2006 eliminated HTS provisions for semiconductors by "unfinished semiconductor chips, dice, and wafers." Therefore, after 2006, it is difficult to use trade data to determine the production stage of semiconductors that are traded (USITC Dataweb; GAO 2006, 28).

BOX 3 The Global Nature of Semiconductor Production-Sharing

Semiconductor production is global in nature; the three stages of production often occur in different countries. Asia has historically been a popular location for back-end production, though in recent periods, some design and front-end fabrication have also occurred in the region. In the 1960s and 1970s, when back-end testing, assembly, and packaging was more labor intensive than today, many IDMs either offshored this production stage to Asia to keep costs low by taking advantage of lower labor rates, or contracted it out to Asian firms that exclusively focused on this stage of production. In the 1980s and early 1990s, as competition in the industry intensified and costs of designing and fabricating chips increased, many firms decided to specialize in either the design stage or the production stage, thus developing a new production model known as the fabless/foundry model. Most semiconductor design work tended to remain in the United States, which has long been a base and magnet for semiconductor engineering talent, while the first foundries were established in Taiwan. Today, although the majority of semiconductor design still occurs in the United States, small design clusters have developed recently in Taiwan and China.

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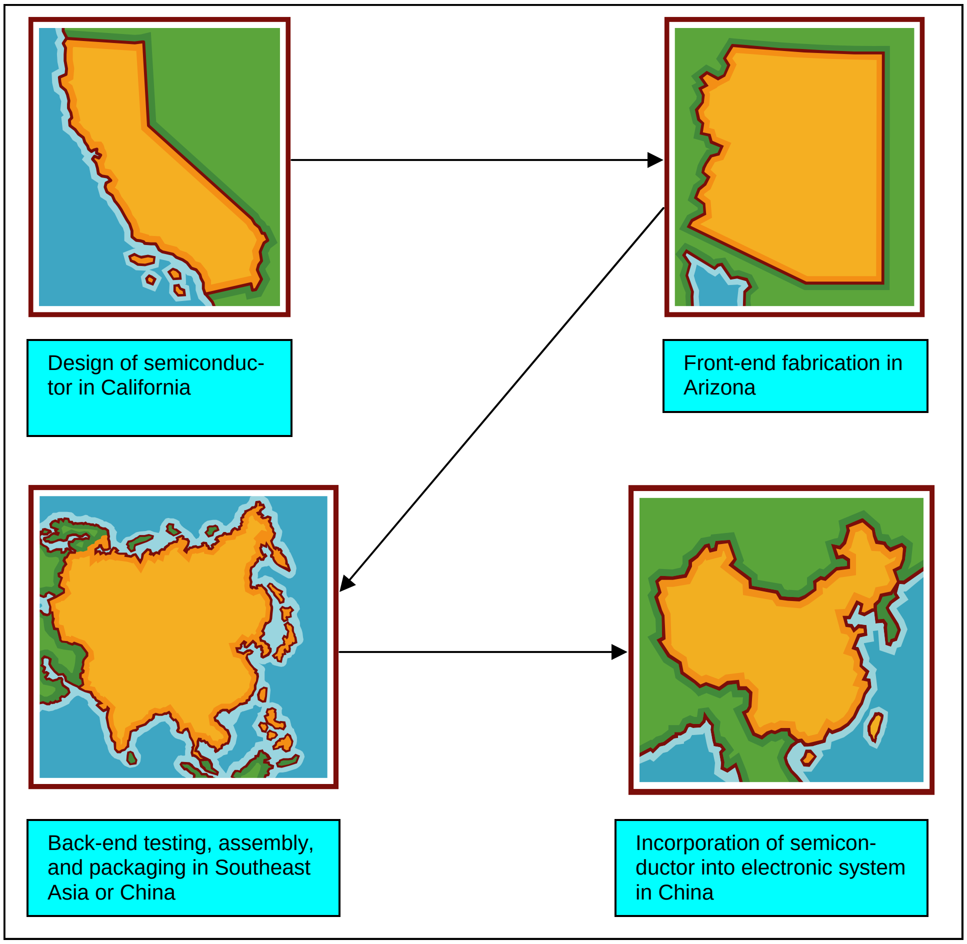
Sources: McClean, Matas, and Yancey 2009, 3-7, 16-10; industry official, interview by Commission staff, Beijing, China, January 14, 2008.

Notes: 1) One of the factors driving the development of the fabless/foundry model was the increasing cost of constructing a fab. From 1980 to 1995, the cost had risen from $100 million to $1 billion. Many firms, especially new ones, discovered that this cost was prohibitive, thus forcing them to specialize in chip design only and adopt the fabless business model. 2) It is estimated that roughly 500 semiconductor design firms currently exist in China; however, given that in 2008, 31 of the top 50 fabless suppliers were U.S.-based firms and no Chinese-based firm was in the top 50, it is likely that the vast majority of design firms in China are small suppliers.

of finished semiconductors (USITC, Dataweb). Presumably, a large number of these finished semiconductors imported from China were those sent there as unfinished semiconductor chips, dice, and wafers from the United States—and other leading front-end semiconductor producing countries—for final back-end production.

Because the location of front-end semiconductor production has remained relatively stable in recent years, U.S.-China bilateral semiconductor trade trends have remained largely unchanged. The United States maintained a surplus in semiconductor trade with China every year from 2001 to 2008, reaching a high of $3.3 billion in 2008 (USITC, Dataweb). The leading destinations for U.S. exports of semiconductors in 2008 were Malaysia, China, Taiwan, the Philippines, Korea, and Singapore (USITC, Dataweb); all of these countries except Korea are leading locations of back-end production.

FIGURE 2 Current typical global production-sharing pattern of a U.S.-based IDM



Source: Compiled by author.

Foreign Investment Environment for Front-End Semiconductor Production in China

Summary

- Two realities discourage foreign investment of front-end semiconductor production in China:
  - An uncertain business environment marked by lax IPR protection and enforcement
  - Restrictive investment and export control policies by foreign governments
- Two incentives for foreign front-end semiconductor investment in China exist but have yet to significantly increase foreign investment:
  - Chinese government policies and practices to promote foreign semiconductor investment
  - Establishing production in the world's largest semiconductor market

Why have so few foreign firms established front-end semiconductor production in China, given its market size and the available incentives? Over the past several years, the deterrents to moving front-end production to China proved stronger than the incentives. Two factors in particular have proven effective detractors: (1) China's uncertain business environment marked most notably by lax IPR protection and enforcement, and (2) restrictive investment and export control policies by foreign governments. The strength of these two challenges has outweighed the two major incentives encouraging foreign investment in China: (1) Chinese government policies and practices to promote foreign semiconductor investment, and (2) foreign firms' desire to establish production in the world's largest semiconductor market.

China's Uncertain Business Environment

Weak IPR Enforcement

China's weak IPR protection and enforcement is recognized by the U.S. government and U.S. industry. In its 2005 "Special 301" out-of-cycle review of China's implementation of its IP protection commitments, the

United States Trade Representative (USTR) determined that IP infringement was "unacceptably high," and that China's inadequate IPR enforcement was "resulting in infringement levels at 90 percent or above for virtually every form of intellectual property" (USTR 2005, 2). In 2005, the USTR elevated China to its "Priority Watch List" of countries that do not provide an adequate level of IPR protection and enforcement, where it remains to date.[23] In addition, the USTR's 2008 report to Congress on China's WTO Compliance reported that counterfeiting and piracy in China "remain at unacceptably high levels and continue to cause serious harm to U.S. businesses across many sectors of the economy" (USTR 2008a, 5).

The U.S. semiconductor industry has also voiced concerns over China's lack of IPR protection and enforcement. The Semiconductor Industry Association (SIA) described IPR enforcement in China as "woefully inadequate in some local regions," adding that "the central government has been unable to turn its [IPR] policy objectives into action on the ground in all regions" (SIA 2005, 31). In its 2005 annual report, SIA described improving IP protection in China as a "high priority" (SIA 2005, 31).[24] SIA further notes that China "has the substantive intellectual property law required under the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), but enforcement remains an issue" (SIA 2004, 3).

One example of China's weak IPR environment is the existence of semiconductor counterfeiting in China. According to SIA, "counterfeiting of semiconductors is a growing problem, and China is the source of many of the counterfeits" (Dewey & LeBoeuf LLP 2007, 13). A recent two-month joint operation between the EU and U.S. Customs resulted in the seizure of over 360,000 fake computer components (including highly-valuable central processing chips), most of which originated in China (Kirwin 2008). The common counterfeiting practice with semiconductors is for counterfeiters to scrape off the label on the plastic package encasing the semiconductor, remark it with a different brand, speed, and/or part number, and sell it outside of authorized channels (Dewey & LeBoeuf LLP 2007, 13).

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[23] The USTR's most recent Special 301 Report continued to characterize overall counterfeiting and piracy levels in China as "unacceptably high" and continued to put China on its Priority Watch List (USTR 2008b, 20).

[24] For more information on SIA's view of the importance of IP protection in China, see http://www.sia-online.org/cs/issues/china and http://www.sia-online.org/cs/issues/free_fair_trade.

According to SIA, the Chinese government has taken some steps to address counterfeiting of semiconductors; however, it believes enforcement measures should be tougher (Dewey & LeBoeuf LLP 2007, 13).[25] Counterfeiting of semiconductors reinforces the notion of a business environment in China that presents investment challenges for foreign semiconductor firms, particularly on advanced front-end production. Because the semiconductor industry is highly R&D intensive, semiconductor firms' IP is their most important asset, and firms guard their IP zealously, most foreign firms have hesitated to establish front-end production in China.

Going forward, China's new Antimonopoly Law (AML) may also contribute to uncertain business risks for foreign semiconductor firms desiring to establish front-end production in China. SIA has expressed concerns that the new law, which became effective on August 1, 2008, could potentially compromise a foreign semiconductor firm's proprietary technology. According to SIA, the law may leave open the potential for highly-advanced firms to be exposed to "discriminatory and unwarranted enforcement" (Dewey & LeBoeuf LLP 2007, 10–11). It argues that under article 47 of the law,[26] foreign firms that are found to have abused a dominant position by withholding proprietary technology might confront cease-and- desist orders "directing them to transfer IPR and technology to Chinese competitors" (Dewey & LeBoeuf LLP 2007, 10–11). Such risk contributes to foreign firms' wariness about locating highly-valuable and advanced front-end production in China.

Foreign Governments' Investment Restraints and Export Controls

Two of the world's largest semiconductor-producing countries, the United States and Taiwan, maintain policies that preclude the sale or transfer of sensitive and state-of-the-art semiconductor products and technology to China, because they are considered dual-use items (products that potentially have both commercial and military uses). Similar to the effect of

[25] According to SIA, the Chinese government currently takes criminal enforcement actions on counterfeiters only when the amount of counterfeited goods exceeds a certain threshold. This enforcement practice is, in the view of the SIA, "effectively giving a safe harbor for counterfeiting below the threshold amount."

[26] Article 47 of the law states: "Where any business operator abuses its dominant market status in violation of this Law, it shall be ordered to cease doing so. The anti-monopoly authority shall confiscate its illegal gains and impose thereupon a fine of 1% up to 10% of the sales revenue in the previous year." (Antimonopoly Law 2008).

China's uncertain business environment, these policies have ostensibly limited the movement of foreign front-end production to China.

U.S. Export Controls

U.S. semiconductor manufacturing equipment and material exports to China are chiefly controlled for national security and antiterrorism purposes.[27] The U.S. government requires a license to export certain equipment and materials to China, and for these items, it generally is the policy to approve exports for civilian end uses and deny exports having the potential for a significant and direct contribution to Chinese military capabilities (GAO 2008, 9).[28]

According to some experts, the U.S. government generally allows semiconductor technology transfers to China if the technology is at least three generations older than the current technology in the United States (U.S.-Taiwan Business Council 2008, 10).[29] U.S. industry groups have argued that "export controls should not apply to mass market semiconductor products, or to equipment and materials available from competitors who do not share [U.S.] views on export controls." [30]

Some industry officials believe that U.S. export controls, particularly on semiconductor equipment, have slowed the growth of the semiconductor industry in China by inhibiting investment by foreign firms and technology advancement of Chinese-owned firms.[31] In 2007, the U.S. Department of Commerce (DOC) announced the creation of a new program that removes individual export license requirements for certain authorized customers in China (DOC 2007).[32] Three firms have qualified for eased U.S. export procedures for semiconductor equipment and materials under the program: Applied Materials China, Ltd., SMIC, and Shanghai Hua Hong NEC Corporation (GAO 2008, 17). A recent U.S. Government Accountability Office report found that the program has not been used as frequently as DOC had

[27] The Export Administration Regulations (EAR) (15 C.F.R pts. 730–774) contain the requirements for export controls for dual-use items.

[28] For a list of the specific items, see GAO, "Export Controls," September 2008, app. III.

[29] On a case-by-case basis, the United States may also look into investment or technology transfer transactions.

[30] SEMI and SIA, "Joint Statement on Policy Priorities," http://dom.semi.org/web/winitiatives.nsf/0d191b3930beb33b882565ed0058880e/90a1e571d2da50b78825660c0069868e?OpenDocument (accessed March 13, 2008).

[31] Industry officials, interview by Commission staff, Beijing, China, January 14, 2008.

[32] The program is called the Validated End-User program.

anticipated. For example, after the program had been in existence for approximately one year, roughly 6 percent of the total exports of semiconductor manufacturing equipment to China occurred under the program, while 94 percent occurred using an export license. Furthermore, as of June 2008, the report found that only one of the three of the validated end-users authorized to receive semiconductor equipment and materials under the program had received any items (GAO 2008, 22–23).

Taiwanese Regulations on Investments in China

The Taiwan government regulates the type of investment Taiwan-headquartered semiconductor firms can make in China.[33] One of the main objectives of this policy is to slow the pace of investment in China and to guarantee new investments in Taiwan (U.S.-Taiwan Business Council 2008, 6). For example, Taiwanese firms are required to construct and ramp up to mass production a state-of-the-art 300 mm fab in Taiwan before constructing a less-advanced 200 mm fab in China (U.S.-Taiwan Business Council 2008, 6). Another regulation limits Taiwanese firms in China to employing 250 nanometer process technology (or apply to use 180 nanometer technology); these process technologies are several generations behind the most advanced technology. Consequently, only one Taiwanese-owned front-end fab was operating in China as of April 2008, TSMC's 200 mm facility in Shanghai (U.S.-Taiwan Business Council 2008, 8).

Foreign Firms Take Advantage of Incentives

While government incentives are not the "make or break" factor for foreign firms to establish front-end production in China as IPR concerns are, once a foreign firm decides to establish front-end production in China, it likely takes advantage of explicit or negotiated promotional policies and practices. Regarding foreign-owned firms that presently have or plan to have front-end fabs in China, press reports indicate that these projects benefited or will benefit from Chinese government incentives. For example, press reports indicate that Intel received up to $1 billion in incentives from the Chinese government to build its new front-end fab in Dalian, which is scheduled to begin production in 2010 (Nystedt 2007). Intel's CEO indicated that Chinese government support played a major role in the firm's decision to build the fab, though Intel has not disclosed the specifics of the support (Nystedt 2007). The only foreign-owned, cutting-edge fab currently

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[33] Technically, the regulations expired in 2005, though new rules have yet to be written (U.S.-Taiwan Business Council 2008, 6).

operating in China, the Hynix-STMicro JV in Wuxi, reportedly was constructed with support from the Chinese government (Electronics.ca Research Network 2006), though specifics of the reported support are not mentioned in publicly available company financial information.

Importing a Viable Alternative to Production in China

Foreign firms reluctant to establish front-end production in China can still competitively supply the market from abroad, thus sidestepping the IPR risk associated with front-end production in China. First and foremost, Chinese import tariffs on semiconductors are currently zero. By joining the WTO in 2001 and becoming a signatory to the Information Technology Agreement (ITA), China agreed to reduce to zero its tariffs on all ITA products, including semiconductors. On January 1, 2005, China eliminated all tariffs on ITA products (USTR 2008a, 27). Also, due to their small size, semiconductors are relatively inexpensive and easy to transport. Finally, because of the global nature of the semiconductor production chain, foreign semiconductor firms have extensive knowledge and experience to draw upon in operating in a global production environment. An import strategy has proven viable for most foreign firms under the current competitive conditions in China. And although almost no foreign firms have front-end production in China, most have established at least some sort of "presence" in China, allowing proximity to the market.

Conclusion

Foreign front-end semiconductor production in China over the past few years can be characterized as conspicuous by its absence. Despite attractive government investment incentives, coupled with the advantages of operating in the world's largest semiconductor market, the majority of foreign semiconductor firms have not established front-end production in China.

Investment, production, and trade data show that, despite growth in certain parts of China's semiconductor industry in recent years, foreign front-end semiconductor investment and production in China remain relatively small. Thus, the current picture of China's semiconductor industry seems to be that foreign and domestic back-end production continues to grow, while domestic foundries have led the way in China's front-end production development, without significant foreign investment in front-end production.

Despite the draw of government incentives and proximity to China's market, foreign firms face two major obstacles that have discouraged investment: (1) China's uncertain business environment for front-end semiconductor production, punctuated by lax IPR protection and enforcement; and (2) restrictive investment and export control policies by foreign governments. While some increase in foreign front-end production occurred in recent years, the majority of global firms determined that the potential risk presented by these two factors continues to outweigh the advantages of locating production in China. Until these risks are mitigated or the lure of the Chinese market and policy incentives prevail, major shifts in global semiconductor production and trade patterns are unlikely.

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The Antigua-United States Online Gambling Dispute

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Abstract

During the last decade, online gambling grew in popularity while complex and overlapping gambling laws in the United States left its legal status ambiguous. The United States' efforts to prosecute foreign-based suppliers of online gambling services prompted Antigua to file a complaint in the WTO, in which it claimed that the United States had violated its GATS commitment to free trade in recreational services. The WTO ultimately ruled in favor of Antigua and awarded Antigua the right to suspend $21 million annually in intellectual property rights held by U.S. firms. This dispute exemplifies the potential for market access commitments to have unexpected and undesirable consequences. The potential for suspending intellectual property rights as a retaliatory measure may increase the leverage of small countries in trade disputes with large countries, but the implementation and management of such a suspension may be difficult and costly.

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Overview

The online gambling dispute between Antigua and the United States illustrates key issues in international trade, including the relationship between domestic legislation and international agreements, the potential for trade commitments to have unintended consequences, and the challenges facing small countries in disputes with large countries. And it has culminated in an intriguing and unintuitive decision: the World Trade Organization empowered Antigua to suspend intellectual property rights held by U.S. firms. In this article I survey the relevant background, outline the sequence of events in the online gambling dispute, and discuss some of the issues raised by this case.

Background

Antigua and Barbuda are tropical Caribbean islands covering 443 square miles (about 2.5 times the size of Washington, D.C.) (CIA 2008). The two islands are organized as a single political entity, hereafter "Antigua." Antigua's 2007 population was 69,500 persons, and its gross domestic product (GDP) adjusted for purchasing power parity (PPP) was $1.2 billion, giving it a high GDP per capita by Caribbean standards (CIA 2008). More than half of its GDP is generated by tourism, with one third of its tourists coming from the United States (CIA 2008).

Since the late 1990s, companies based in Antigua have used Antigua's high-quality international fiber-optic cable connections to provide gambling services over the Internet (Krebs 2003). The online gambling industry is the second-largest employer in Antigua after tourism; in 2001, there were 93 licensed gambling organizations in Antigua employing 1,900 persons (Antiguan Directorate of Gaming n.d.). Antigua's annual online gambling revenue peaked at $90 million in 1999 (Hansen 2006). There are conflicting estimates of how much of this revenue came from gamblers in the United States, but Bear Stearns estimated that 60 percent of worldwide online gambling revenues came from U.S. customers in 2003.[2]

Online gambling is a relatively recent phenomenon (the first Internet casino was launched in 1995) facilitated by the expansion and improvement of communications technology.[3] Internet betting parlors offer a nearly

[2] Cited in Kanigher, 2003.
[3] The Gaming Club, http://www.thegamingclub.com, was the first online casino.

unlimited volume of gambling services at very high speeds to customers around the world. Gamblers typically upload funds to the online gambling Web sites via electronic payment services or wire transfers, play games either with each other (poker, sports betting) or against the house (blackjack, roulette), and withdraw any winnings by check or online payment service. Online casinos have many competitive advantages over traditional brick-and-mortar casinos: U.S. resort casinos incur construction costs of up to $300 million and generally operate with profit margins between 8 percent and 16 percent, while one representative online casino (Internet Casinos Inc.) was developed for $1.5 million, employs 17 persons, and averages a 24 percent profit margin (Kyros n.d.).

U.S. policymakers have several concerns about online gambling. Some object to gambling in general, based on the need to protect the public from addictive behaviors that create negative externalities (such as bankruptcy) (Leach and Carruthers 2006). These objections are heightened with respect to online gambling, which is believed to be dangerously available to children, as users often can place bets with only a credit card number. Online gambling has become popular on college campuses, and the National Council on Problem Gambling estimates that 7 percent of college students who gamble online become addicted (Hogan 2007). There are also concerns specific to offshore online gambling, including the prospect of criminal organizations and terrorists using gambling Web sites to launder money (Leach and Carruthers 2006).[4]

Many countries, including the United States, have laws to control or prohibit online gambling (GAO 2002, 45). However, the borderlessness and anonymity of online gambling make it inherently difficult to regulate. For example, Internet gambling sites can prevent banks from recognizing transactions as gambling by disguising credit card transactions or using online payment providers as intermediaries (GAO 2002, 21). Most online gambling companies are based in small countries (Antigua, Costa Rica, Malta, the Isle of Man, etc.) with limited ability or inclination to supervise the industry.

[4] However, gambling websites keep detailed records of every bet and some have expressed willingness to share their records with U.S. regulators; see Kanigher.

Ambiguity in U.S. Gambling Laws

The complexity of U.S. gambling laws adds to the difficulty of managing online gambling. For one, there are overlapping federal and state regulations. States determine whether individuals are permitted to gamble, and whether gambling businesses are permitted to operate, within their borders (GAO 2002, 3). (As of 2006, 8 states—Illinois, Indiana, Louisiana, Nevada, New Jersey, Oregon, South Dakota, and Wisconsin—had specifically prohibited internet gambling (Friedman and Cheng 2006).) On the other hand, federal authorities are responsible for regulating interstate commerce, which is often interpreted to include online gambling (GAO 2002, 12). As an example of the tension between state and federal authorities, in 2001 Nevada Governor Kenny Guinn signed a bill establishing a legal framework for internet betting parlors, giving the Nevada Gaming Commission power to "adopt regulations governing the licensing and operation of interactive [online] gaming"(Richtel 2001). The Commission, however, has never used this power, because the Department of Justice (DOJ) takes the position that all online gambling is illegal, regardless of the laws of the state in which it takes place (Kanigher 2003).

The basis of the DOJ's position is the 1961 Wire Act, the federal statute most directly relevant to online gambling.[5] This law prohibits the transmission of certain types of bets via wire-based communication networks (such as telephones). The view of the DOJ (as articulated in 2002 by then- Assistant U.S. Attorney General Michael Chertoff) is that the Wire Act "prohibits gambling over the Internet, including casino-style gambling" and covers jurisdictions both "where the bettor is located and the state or foreign country where the gambling business is located," as opposed to applying only where bets are received (Kanigher 2003). However, the Wire Act predates the internet, and there are different interpretations of its application to online gambling. A 2002 federal ruling in Louisiana, later upheld by the 5th U.S. Circuit Court of Appeals, determined that the Wire Act only applies to bets placed on sporting events.[6] Additionally, some court decisions have affirmed that interstate gambling does not violate the Wire Act if gambling is legal both where the bet originates and where it is received.[7] This brings up the jurisdictional problem of defining location when electronic signals

[5] Sporting Events – Transmission of Bets, Wagers, and Related Information Act, Pub. L. No. 87-216, § 2, 75 Stat. 491, 552-553 (1961).

[6] Thompson v. Mastercard International (2002), cited in Kanigher.

[7] United States v. Kaczowski (2000) and Missouri v. Coeur D'Alene Tribe (1999), cited in GAO.

are routed through telecommunications networks: an online bet could be made by a user in a gambling-friendly state, on the website of an internet betting parlor based in a gambling-friendly country, but comprise information routed through places where gambling is illegal.

The unresolved status of online horseracing wagers compounds these legal ambiguities. In 1978 Congress passed the Interstate Horseracing Act, 15 U.S.C. § 1978 (IHA), which allows the electronic transmission of interstate wagers on state-licensed horse races, so long as the relevant racing commissions and associations approve the transaction. Over the objections of the DOJ, Congress amended this Act in 2000 specifically to allow wagers placed over the internet (Rodefer 2005). The availability of online betting on horse races has helped the horseracing industry; in 2005, off-track and online betting on horse races generated $3 billion in revenue, and online betting has been described as the source of "the only growth in the horseracing industry today" (Vlahos 2005). Despite this amendment, the DOJ testified in 2000 that it still believes internet bets on horseracing violate the Wire Act, pointing out that the IHA is a civil statute (allowing states, associations, and race tracks to bring civil actions against establishments that violate it) and thus does not override a criminal statute like the Wire Act (GAO 2002, 43). Nevertheless, the DOJ has never brought a case against a state-licensed entity offering online wagering on horse races. Representative Barney Frank, who sponsored a bill to legalize online gambling, recently said "you can't get a straight answer if [online betting on] horse racing is illegal. It's total hypocrisy and mishmash" (Gaul 2008b).

Chronology of the Dispute

The United States started cracking down on foreign-based internet betting parlors in 1998, when federal prosecutors charged 21 U.S. citizens connected to offshore internet gambling with violations of the Wire Act (Hansen 2006). Among them was Jay Cohen, an American citizen and former stock trader who had been operating the Antigua-based World Sports Exchange (which had 10,000 customers that year) (Kanigher 2003). Twenty of the indicted persons entered guilty pleas, had their cases dropped, or remained outside the United States as fugitives, but Cohen returned to the United States to contest his case in court (Brunker 2001). He lost in 2000 and was sentenced to 21 months in prison and fined $5,000, becoming the first person convicted in the United States for operating an offshore internet gambling website (Hansen 2006).

Cohen's case was brought to the attention of Mark Mendel, an attorney based in El Paso, Texas. After researching World Trade Organization (WTO) documents Mendel came to believe that the United States had violated the General Agreement on Trade in Services (GATS). He outlined his case in a memo sent to the government of Antigua, and Antigua's prime minister hired Mendel to file suit against the United States at the WTO (*Gaming Law Review* 2006).

In March 2003, Antigua initiated the dispute resolution process of the WTO to challenge the United States' prohibition on the cross-border supply of online gambling services. A Dispute Panel ("Panel"), formed in June 2003, determined that the United States had made a commitment to free trade in online gambling services in GATS Section 10.D, "Other Recreational Services, Excluding Sporting."[8] The Panel found that three U.S. federal laws, including the Wire Act, contravened this commitment (the other two were the Travel Act, 18 U.S.C. § 1952, and the Illegal Gambling Business Act (IGBA), 18 U.S.C. § 1955). State laws in Louisiana, Massachusetts, South Dakota, and Utah were also found to obstruct free trade in online gambling services. The Panel determined that the cumulative effect of these laws was inconsistent with the United States' commitments under GATS, and made a confidential ruling in favor of Antigua in March 2004. The Panel's report was released publicly in November 2004 after unsuccessful negotiations between the parties.

In January 2005, the United States appealed this ruling to the WTO's Appellate Body ("Body"). Antigua filed a cross-appeal shortly thereafter, and both countries made oral arguments before the Body. In April 2005, the Body issued a report that generally upheld the Panel's findings. It affirmed that the United States had committed to free trade in online gambling services and ruled that the three federal laws violated these commitments (although it did not refer to other state and federal laws that Antigua had sought to include). It also ruled that the United States, which maintained that these trade restrictions were necessary to promote moral goals, had not met the criteria of the "moral defense" permitted by GATS Article XIV under certain conditions. (This defense, for example, is invoked by some countries with large Muslim populations to restrict trade in alcoholic beverages.) The Body found that the federal laws were necessary to protect public morals or maintain public order, but the United States had not met the

[8] All findings in this and the following two paragraphs are from WTO (2008a).

“chapeau” condition that regulations not discriminate between countries, noting that some U.S. companies are allowed to offer internet gambling services by accepting online wagers on horseracing.[9]

A WTO Arbitrator determined that a deadline of April 2006 would give the United States enough time to change its laws to comply with its commitments. The United States did not alter the laws in question by that deadline, but did issue a status report stating that its current laws prohibit the interstate transmission of bets and wagers; that it was investigating possible violations of these laws by U.S. companies; and that, in light of this, it was in compliance with the WTO’s rulings (i.e., it was able to successfully meet the chapeau condition of a moral defense). Antigua held that the United States was not observing the Body’s ruling and requested the establishment of a Compliance Panel. In March 2007 the Compliance Panel ruled in favor of Antigua.

In May 2007, the United States responded by invoking procedures under GATS Article XXI to modify its schedule of commitments, specifically excluding online gambling from its recreational services commitments. This is the first time a WTO member has withdrawn a commitment in response to a WTO ruling (*Gambling 911.com* n.d.). A condition of withdrawing from a GATS commitment is that the withdrawing country must compensate any affected WTO members, and after the United States’ announcement, Australia, Canada, Costa Rica, the European Union (EU), India, Japan and Macao all filed claims for compensation, arguing that they would be negatively impacted by the modification (*Associated Press* 2007). The United States negotiated settlements with Australia, Canada, the EU, and Japan, making commitments to maintain liberalized markets in the following U.S. industries: postal services, research and development services, technical testing services, and warehousing (*Online Casino City* 2008). Negotiations with Costa Rica, India, and Macao are ongoing.

In 2007, Antigua requested permission to retaliate against the United States by suspending some of its obligations under the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (WTO 2008a). Antigua asked for the right to suspend $3.4 billion worth of U.S. intellectual property (IP) rights (which comprise copyrights, patents, and trademarks)

[9] “We find . . . that the Wire Act, Travel Act, and IGBA . . . satisfy the ‘necessity’ requirement [under Article XIV] . . . but [the United States] has not shown, in the light of the IHA, that the prohibitions embodied in these measures are applied to both foreign and domestic service suppliers of remote betting services for horseracing.”

annually, arguing that this was the value of Antigua-United States online gambling services trade that would have taken place had the United States complied with the initial WTO ruling (Kanter and Rivlin 2007). The United States challenged Antigua's estimate, claiming the true value would have been $500,000. The WTO agreed to authorize the suspension and settled on a figure of $21 million annually, their counterfactual estimate of Antigua's average 2001-2006 annual revenues from horseracing gambling services exports to the United States, adjusted for the impact of competing suppliers and for developments in US demand (WTO 2008a).[10] Antigua's domestic laws currently provide IP protections in accordance with TRIPS protocols, and at the time of writing legislation that would allow the suspension of IP rights held by U.S. firms has not yet been introduced (Antigua and Barbuda Ministry of Legal Affairs n.d.).

Consequences of Trade Commitments

The Office of the United States Trade Representative (USTR) argues that it never intended its original GATS commitment to cover online gambling services, referring to their inclusion as an "unintended consequence of imprecision" in the 1994 draft (Office of USTR 2007). The United States made this point forcefully before the WTO Panel, arguing that it would have been "incomprehensible" for the United States to make this commitment, "given the over-riding policy concerns surrounding these services, which are re-

[10] The WTO used two methods to estimate the average annual revenue loss for Antigua caused by US measures: data (provided by the private gambling consulting group Global Betting and Gaming Consultants) on the difference between Antigua's total remote gambling revenues in 2001 and in 2002-2006, which yielded a figure of $304 million, and data (provided by seven publicly-listed companies) on remote gambling firms' average revenues per employee, multiplied by the difference between the number of such employees in Antigua in 2001 and in 2002-2006, which yielded a figure of $196 million. The WTO adjusted these figures based on the almost 50-percent decline from 2001-2006 in Antigua's contribution to the Central American, South American, and Caribbean region's share of the global remote gambling market, resulting in figures of $164 million and $128 million. In restricting its award to only the share of revenue from gambling on horseracing, the WTO relied on the fact that horseracing had an average 11-percent share in all gambling activities from 2001-2006, yielding adjusted figures of $18 million and $14 million, and to account for the possible growth in the horseracing segment of the US remote gambling market in the absence of US measures, the WTO applied the 5-percent average annual growth rate from 2001-2006 in net receipts in the horseracing segment of the non-remote gambling market, yielding final figures of $23 million and $18 million for Antigua's average annual revenue losses. The WTO then took the average of these numbers and rounded up to the nearest million.

flected in the extremely strict limitations and regulations of these services" (Raghavan 2004).

The WTO Panel conceded this point, acknowledging that "the [U.S.] legislation at issue in this dispute predates by decades, not only the GATS itself, but even the notion of 'trade in services.' We have therefore some sympathy with the United States' point in this regard." But the Panel continued:

> The scope of a specific commitment cannot depend upon what a Member intended or did not intend to do at the time of the negotiations. The purpose of treaty interpretation… is to ascertain the common intentions of the parties. These common intentions cannot be ascertained on the basis of subjective and unilaterally determined 'expectations' of one of the parties to a treaty… There are no provisions in the WTO Agreement that would allow a Member's intentions to be probed and determined, except as reflected in the treaty language.[11]

The WTO's decision underscores the general point that trade commitments can have unpredictable consequences. International trade agreements inherently impact national sovereignty inasmuch as signatories agree to choose only policies that do not reduce market access from negotiated levels (Bagwell and Staiger 2001, 545). This can affect regulatory flexibility in a wide array of behind-the-border policy areas, including import licensing procedures, customs valuation, sanitary and phytosanitary measures, and labor and environmental standards (Srinivasan 2002, 5). Trade agreements are incomplete contracts in that they cannot anticipate all future conditions, so industry trends, technological changes, exchange rate shocks, political realignments, or other contingencies can leave signatories with limited policy options (Mahlstein and Schropp 2007, 1).[12] Governments that make trade commitments freely accept these risks in exchange for anticipated market access gains and other benefits. However, the tension between national regulatory efforts and international trade agreements has surfaced repeatedly, in the EU's ban on U.S. exports of hormone-treated beef (WTO 1997a), the United States' ban on certain shrimp imports stemming from its 1973 Endangered Species Act (WTO 1998), and numerous other disputes.

[11] Quoted in Raghavan 2004.

[12] Trade agreements can also create legitimacy problems if governments are perceived to be putting foreign obligations ahead of domestic ones; see the discussion of Argentina's 2001 economic crisis in Rodrik, "Feasible Globalizations," (2002), 15-6.

Trade in services agreements may involve unique uncertainties and risks, as developments in services can be especially difficult to predict. Services are intangible, non-storable, subject to rapid innovation, and are deliverable not only through cross-border transactions but also through the movement of consumers (consumption abroad), firms (commercial presence), and labor (temporary movement of people). Additionally, many research agencies are only now developing a robust set of trade-in-services statistics and analyses. The risks inherent in services trade commitments were emphasized in 1998 by former WTO Director General Renato Ruggiero, who argued that the GATS extends “into areas never before recognized as trade policy” (Ruggiero 1998). Countries try to anticipate future developments when making services trade commitments, but even the United States with its expertise and resources did not predict when it agreed to free trade in recreational services that this might one day be interpreted to include online gambling (a service that did not exist in 1994 when such commitments were scheduled).

There are ways to deal with the risk of unintended consequences. Many trade agreements have provisions allowing signatories to renegotiate or rebalance commitments, such as GATS Article XXI, invoked by the United States in the online gambling dispute, which lets countries compensate for the modification or withdrawal of existing market access commitments by making new ones. Trade agreements can also incorporate emergency safeguard measures: escape clauses that exempt specific products from liberalization commitments in order to provide temporary relief to domestic industries that are seriously and unexpectedly harmed. Article XIX of the General Agreement on Tariffs and Trade (GATT) regulates emergency safeguard measures for goods, and GATS Article X calls for discussions about similar safeguards for services. (Clogstoun, Trewin, and Bosworth 2006)[13] Safeguards can provide policy flexibility and increase domestic political support for liberalization agreements; it is plausible that the promise of eventual services safeguard measures helped countries make more and deeper services commitments in the Uruguay Round than they would have done otherwise (Sauvé 2002, 314). But safety valves can impede liberalization and limit the impact of trade agreements, as many of the benefits of liberalization come from credibly locking in policies and establishing high barriers to future backpedaling. Even trade commitments that go no further than confirming on-the-ground levels of liberalization can encourage investment when investors know that the rules are no longer subject to an-

[13] Originally there was a 1997 target date for the establishment of such provisions, but in the absence of agreement that deadline has been repeatedly extended.

nual legislative renewal or other political conditions. The Antigua-United States dispute illustrates the balancing act demanded in international trade agreements: liberalization requires that countries be discouraged from unilaterally altering or withdrawing from commitments just because unpopular consequences arise, but countries are less likely to make commitments in the first place if it is too costly to deal with unanticipated online gambling-like developments.

Intellectual Property Rights and Cross-Retaliation

The WTO generally grants aggrieved countries the right to suspend concessions and other obligations when partners violate their trade commitments, but these remedies are usually narrow, specific adjustments to bilateral trade, aimed at prohibiting an amount of offending-country exports equal in value to the damage caused by the offense (often through the imposition of *ad valorem* tariffs) (Chang 2004). In Article 22.3 of its Dispute Settlement Understanding, the WTO states that suspensions should be confined to the same sector where the violation occurred if possible (WTO n.d.). However, when no same-sector retaliation options would provide adequate compensation, the WTO has been willing to authorize cross-retaliation. Antigua successfully argued that raising duties on U.S. services imports would harm its economy without significantly affecting the United States. About 49 percent of Antigua's total goods and services imports come from the United States, but this amounts to less than 0.02 percent of total U.S. exports (Basheer 2007, 1).

TRIPS-based cross-retaliation was authorized by the WTO once before. In an Ecuador-EU dispute over bananas, the WTO gave Ecuador permission to suspend $202 million annually in IP rights held by EU firms (WTO 1997b). Ecuador used this leverage to resolve the dispute in 2001, before enacting suspensions, on terms that incorporated many of its core demands (Smith 2006). Additionally, in 2005 the WTO Appellate Body ruled in favor of Brazil in a dispute with the United States over cotton, and Brazil has requested the right to suspend IP obligations in retaliation, arguing that increasing duties on U.S. goods imports would create inflation and harm industries in Brazil (WTO 2008b). At the time of writing, a WTO Arbitrator is preparing to rule on Brazil's request to impose annual retaliation of $2.3 billion and a one-time retaliation of $350 million in the withdrawal of IP rights and services commitments, equal to Brazil's estimate of the worldwide impact of U.S. cotton subsidies (Wasson 2009).[14] Ironically, cross-retaliation originated as a way to protect the interests of developed countries, who wanted the ability to penalize developing countries that violated IP rights (Bassheer 2007, 24). IP-based retaliation would have limited effectiveness in such cases because developing countries produce little IP, so developed countries sought means of imposing tariffs on other goods and services exports from offenders (Basheer 2007, 4).

No country has actually suspended IP rights in accordance with a WTO ruling, so the online gambling dispute is in uncharted territory. Antigua could ignore U.S. copyrights on software, movies, and music owned by U.S. companies, and sell up to $21 million worth of these media annually in domestic markets.[15] Antigua could also grant compulsory licenses and produce U.S.-patented products such as pharmaceuticals. However, while it is inexpensive to reproduce most copyrighted materials, many patented goods need to be manufactured, and Antigua's potential gains from patent suspension are limited by its lack of capacity to produce goods such as pharmaceuticals. And getting rid of trademarks, which identify the producer of a product and inform consumers where to seek recourse if the product fails, could erode the quality and safety of consumer goods (Fink and Smarzynska 2002, 404).

It is doubtful that suspending U.S. copyrights could increase domestic retail sales of U.S. copyrighted goods in Antigua by $21 million annually, as this would require average new expenditures of $300 per person in a country with a GDP PPP per capita of $17,000 (CIA 2008). Antigua might consider exporting to reach the permitted level of retaliation, but the WTO Panel in the Ecuador-EU case noted that even when IP rights are suspended by one country, other WTO members are still obligated to follow TRIPS with respect to their imports (WTO 1997b). However, Antigua could export goods to countries where IP protections are not in place; for example, Antigua could theoretically suspend patents for HIV / AIDS medicines, manufacture

[14] Notably, Brazil is arguing that the size and form of its cross-retaliation should be governed by the Agreement on Subsidies and Countervailing Measures, and not the Dispute Settlement Understanding. The former has vaguer language (countermeasures need only be "appropriate" and "commensurate with the degree and nature" of violations) whereas the latter requires stronger proof that same-sector retaliation is not practicable or effective. If Brazil's interpretation is upheld, it may lower the hurdles for cross-retaliation in future disputes.

[15] Palmer (2008) asks, "Would you go into a store [in Antigua] and see a 'real' version of Harry Potter for $14.95 and a packaged, legally pirated copy for $9.95 or even $4.95? Would the legal pirates experience so much competition from each other that the price would drop to just enough money to cover the cost of the disc, duplication, distribution and retail profit, say $3.00?"

them, and export them to countries where they are not under patent (Ruse-Khan 2008, 6).

It would be difficult to manage the suspension of IP rights to meet any specific monetary target. For many goods and services, there is no robust method for estimating the value added purely by intellectual content, so the exact value of any act of IP suspension by Antigua could be subject to challenge. In different contexts IP is valued based on the cost of research and development inputs, the anticipated future revenue streams derived from ownership of the IP right, or market prices for similar IP in third-party transactions, but these numbers can be subjective and highly variable (Hoi 2001). (IP-producing companies measure their performance in part by how much profit and revenue they can generate from a given amount of IP.) One of the guiding principles of the WTO is that the negative effect of retaliation on countries must be equivalent to the harm caused by their non-compliance, so difficulties in quantifying the impact could make IP-based retaliation unworkable (WTO n.d.).

Other considerations include the fact that Antigua is obligated to respect U.S. IP rights under separate agreements. The Caribbean Basin Economic Recovery Act (CBERA) gives Antigua preferential access to U.S. markets, but grants the United States the right to alter the terms of the initiative unilaterally and without consequence if Antigua disregards U.S. IP rights.[16] In 2007 only 1.6 percent of Antigua's exports to the United States entered under CBERA preferences, but the potential loss of preferential access to U.S. markets is nevertheless a disincentive to retaliation (USITC 2008, 2-21). The Berne Convention and the Paris Convention are other multilateral agreements that provide IP protections, and the issue of whether WTO rulings supersede these treaties is complicated.[17] Finally, the suspension of IP obli-

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[16] CBERA was enacted August 15, 1983, as Pub. L. 98-67, Title II; 97 Stat. 384, 19 U.S.C. 2701 et seq., and became effective January 1, 1984 (Proclamation No. 5133, 48 Fed. Reg. 54453, November 30, 1983).

[17] According to Subramanian and Watal, (2000), 411: "Two observations are relevant here. First, Article 2.2 of TRIPS, which upholds the existing obligations that WTO Members have to each other under other IPR conventions and treaties, does not extend to the dispute settlement provisions of TRIPS. Second, to the extent that the WTO's dispute settlement rules provide for or allow TRIPS commitments to be withdrawn, the possibility of conflict always existed . . . [This] conflict would, under customary rules of interpretation of international law as laid out in the 1969 Verne Convention on the Law of Treaties, have to be decided in favor of TRIPS, which is the later treaty." On the other hand, see Basheer, (2007), 34: "[Article 2.2] states that nothing in TRIPS shall derogate from obligations of members states under either Paris or Berne. In other words, obligations under Paris and Berne are to subsist independently even after the advent of TRIPS… Illustratively, Article 6*bis* of the Berne Convention [which confers "moral rights" on authors of IP] has not made it into TRIPS. In so far as provisions such as Article 6*bis* are concerned, the Berne provisions continue to subsist."

gations may harm Antigua's reputation and discourage foreign investment if companies fear their intellectual assets will not be protected. Antigua had $207 million in foreign direct investment inflows in 2006, which accounted for 46 percent of its gross fixed capital formation (UNCTAD 2007).

These considerations may persuade Antigua not to suspend IP rights. But the WTO aims to give all member countries effective recourse in trade disputes, and IP suspension is one of the few methods by which small developing countries can inflict economic damage on large developed countries. The WTO has faced criticism in the past for providing insufficient protections for developing countries in trade disputes in the face of information and resource asymmetries;[18] one study of GATT/WTO disputes found that 50 percent of the complaints brought by developing countries in the WTO resulted in the complainants gaining full concessions, while the figure for developed countries was 74 percent (Busch and Reinhart 2003).[19] More powerful retaliatory measures will not alter the fundamentals of enforcement, and suspending IP rights may be too costly or difficult for many countries, but the option of suspending IP rights can increase the leverage of developing countries in trade disputes and give IP-producing countries stronger incentives to change their policies if they are in violation of trade rules.[20]

As Antigua weighs the costs and benefits of retaliation, a final point is that a socially optimal IP regime balances the goals of protection and access. IP producers have incentives to stake out the maximum territory covered by their claims, using IP rights as legal weapons to collect royalties, establish monopolies, and block new market entrants. On the other hand, consumers and second-generation innovators have incentives to minimize IP protections, which lowers their costs and increases their access to new technologies even as it reduces compensation for first-generation research and

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[18] See Steinberg (2002). Also see UNCTAD (1999), 40: "the special and differential treatment which the Uruguay Round accorded [developing countries] has been inadequate . . . [and] insufficient human and financial resources and weak institutional capacities have restricted the ability of many developing countries to exploit the opportunities open to them under the WTO system . . ."

[19] However, developing countries might achieve even fewer concessions if they attempt to resolve disputes with developed countries through bilateral negotiations. For example, Peru won a 1999 sardine-labeling case against the E.U. using the WTO's dispute resolution process, while Vietnam, in a similar 2002 catfish-labeling case, was unable to successfully challenge the United States through bilateral means. (Vietnam was not a WTO member at the time.) Davis (2006).

[20] See Smith (2006).

development. Ideally, IP protections should be strong enough to encourage creators and let them recoup their investments, but not so strong as to inhibit fair access and further innovation. Antigua may agree with critics of TRIPS that the treaty's IP protections are too strong, and anticipate that the suspension of IP rights will stimulate domestic innovation (Yu 2006). For example, nascent Antiguan industries such as pharmaceuticals or agriculture could use valuable inputs, such as patented technology or copyrighted scientific material, at lower costs in the absence of IP protections (Yu 2006). Firms, however, might be reluctant to invest in new, suspension-based capacities given that IP rights could be restored as soon as the United States enters into compliance. And harm done to legal and social norms of IP protection may discourage creative industries, and perhaps damage the rule of law, in Antigua.

Conclusion

This dispute has captured the attention of U.S. movie, music, software, and pharmaceutical industries, which have a stake in preventing a precedent-setting act of IP rights suspension (Rivlin 2007). The United States produces and exports a large amount of IP—in 2005, U.S. firms received $57.4 billion in IP licensing fees alone (NSB 2008)—and IP-producing firms may pressure the United States to negotiate a settlement with Antigua, or to pass legislation that legalizes online gambling or prohibits online horseracing wagers and thereby brings the United States into compliance with the WTO's rulings. In the Ecuador-EU dispute, after Ecuador won the right to suspend IP rights, the European Confederation of Spirits Producers immediately began lobbying EU officials to settle with Ecuador in order to prevent the enactment of retaliatory measures (Smith 2006).

The United States continues to face challenges in preventing its citizens from gambling online. Virtual betting parlors are available to anyone with a computer and a credit card. In 2005, there were at least 2,300 internet gambling websites generating $12 billion in worldwide revenues, with at least $6 billion of that originating in the United States (House Committee on the Judiciary 2006). The lack of regulation and oversight leaves players vulnerable to abuse, as in recent cheating scandals at AbsolutePoker and UltimateBet (Gaul 2008a). But in some respects online gambling exhibits behavior typical of legitimate industries: the internet facilitates information exchanges that drive dishonest casinos out of business, and online gambling websites compete on the basis of reputation, availability of customer service hotlines, variety of games offered, and other features (Gambling

Forum n.d.). The FAQ page of one popular online casino is candid about the industry's strange legal status: "Is it legal to bet online? It depends a great deal on where you are living. There are no records of anyone getting into trouble because they have gambled online even though it was illegal to do so in the state or country where they live " (Gambling Forum n.d.).

The Antigua-United States online gambling dispute resulted from a combination of U.S. legislative processes that struggled to balance competing interests and U.S. services trade commitments made in a sector that developed unexpectedly. As the online gambling industry grew, U.S. laws governing online gambling were stuck in a state of ambiguity, and in the eyes of the WTO the United States failed to resolve this ambiguity in a way that complied with its trade commitments. But suspending IP rights is a thorny means of retaliation. If Antigua chooses to do so, it may set a precedent that provides small countries with useful leverage in trade disputes; but the difficulties of implementation and the harm done to Antigua's reputation might overwhelm and outlast the economic benefits.

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Inbound and Outbound U.S. Foreign Direct Investment, 2000-2007

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Abstract

This article examines U.S. inbound and outbound foreign direct investment (FDI) during 2000–2007. Both inbound and outbound U.S. investment showed steady increases between 2000 and 2007, with outbound FDI remaining larger than inbound FDI throughout the period. Even though substantial media attention in recent years has focused on U.S. investment links with emerging markets, particularly China, Europe remains by far the largest regional U.S. investment partner, and the United Kingdom is the largest single country U.S. investment partner. U.S. outbound investment is growing most rapidly to Russia, Austria, and India, while inbound investment from India, the United Arab Emirates, and Venezuela has recorded the fastest growth. The article examines FDI trends and compares inbound and outbound investment in the aggregate, by geographical region, and by major countries within each region. Within countries, the article identifies some of the largest U.S. company investors abroad, and foreign company investors in the United States.

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Introduction

This article identifies the major U.S. investment partners for both inbound and outbound foreign direct investment (FDI), and the most important industries and companies involved. Both U.S. direct investment abroad (USDIA, or outbound investment) and foreign direct investment in the United States (FDIUS, or inbound investment) have showed steady increases in recent years, with outbound FDI remaining larger than inbound FDI throughout the period. U.S. outbound investment to Russia and India has exhibited particularly rapid growth, along with U.S. investment in the United Arab Emirates and Egypt, although total USDIA in the latter two countries remains very small. U.S. outbound investment in holding companies has also increased rapidly since 2000, driving above average growth in Austria, Luxembourg, Singapore, and the Netherlands. India recorded the fastest growth in inbound FDI to the United States, followed by the UAE and Venezuela, and China ranked fifth. Overall investment from all of these emerging market countries was comparatively quite small, with Venezuela, the largest, holding an investment position of just over $6 billion in 2007. By contrast, Spain and South Korea also registered annual growth rates in FDIUS of over 20 percent during 2000-07, with comparatively larger investment positions. In 2007, Europe remained by far the largest regional U.S. investment partner in absolute terms. The United Kingdom was both the largest single country investor in the United States and the largest recipient of U.S. foreign direct investment.

The article surveys FDI trends and compares inbound and outbound investment from 2000 through 2007, using the most recent data available from BEA for direct investment position and capital flows.[2] We closely examine the U.S. direct investment relationship by region for both outbound and inbound investment, and briefly discuss the U.S. investment relationship with the most prominent countries within each region. Within each section, we identify some of the leading companies responsible for the trends, and where possible, discuss the reasons behind the trends.

[2] Unless noted otherwise, FDI position and capital flows data in this article are official U.S. government data sourced from the U.S. Department of Commerce (USDOC), Bureau of Economic Analysis (BEA). Data is available for download at http://www.bea.gov/international/index.htm#iip.

The FDI data presented here primarily rely on official U.S. government data for direct investment position[3] and capital flows, published by the U.S. Department of Commerce, Bureau of Economic Analysis.[4] Direct investment position data reflect the cumulative value of parent companies' investment in their affiliates, while capital flows data reflect cross-border transfers of capital during a given time period. Data on FDI position and capital flows are a component of U.S. Balance of Payments calculations. Data for direct investment comprises capital flows for companies where U.S. equity ownership in a foreign company (for capital outflows) or foreign equity ownership in a U.S. company (for capital inflows) comprises at least 10 percent of total equity. Capital flows for equity ownership below 10 percent are classified as portfolio investment, rather than direct investment. To illustrate the trends, the article supplements the BEA data with information from private-sector databases, individual company information, and press reports.

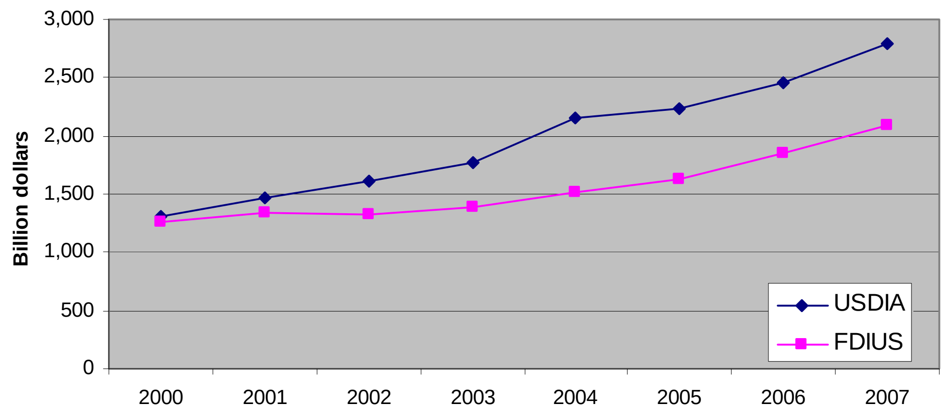
Aggregate Trends in U.S. Inbound and Outbound FDI Position and Capital Flows

The USDIA position measures the cumulative value over time of U.S. equity ownership in, plus net outstanding loans to, foreign affiliates of U.S. firms. Similarly, the FDIUS position measures the cumulative value of foreign equity ownership in, plus net outstanding loans to their U.S. affiliates (USDOC, BEA, 2008, 37). Both the USDIA and FDIUS positions have steadily increased since 2000, illustrating the continually increasing interconnections between the United States and the global economy. In every year, USDIA has exceeded FDIUS (figure 1), although the gap between the two has been wider in some years, depending on economic conditions. Preliminary data for 2007 show the total USDIA position at $2.8 trillion, compared with an FDIUS position of $2.1 trillion, continuing the sharp upward trend of recent years. For 2000-07, the compound annual growth rate (CAGR) was 11 percent for USDIA and 8 percent for FDIUS, visible in the widening difference between the two trend lines in the figure.

[3] In other contexts, investment position may be referred to as investment stock. These terms are interchangeable, but in this article we employ the terminology used by the Bureau of Economic Analysis.

[4] BEA data is available free of charge at http://www.bea.gov.

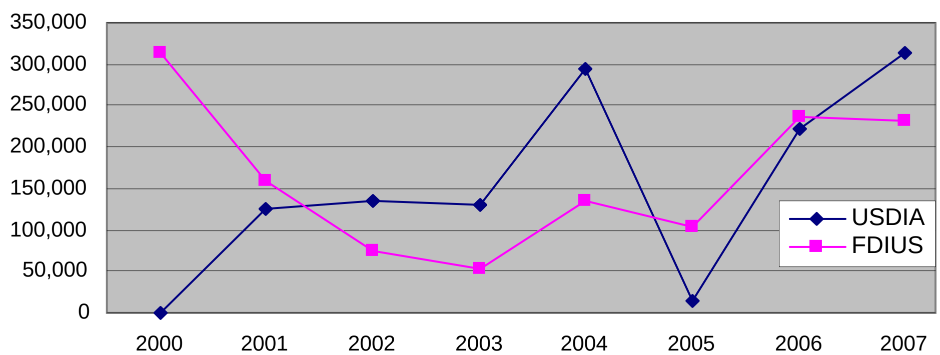
Figure 1 USDIA and FDIUS position, 2000-2007



Source: USDOC, BEA.

Figure 2 illustrates annual capital inflows and outflows, compared to the cumulative investment position shown in figure 1. Annual capital flows fluctuate to a much greater degree than investment position, depending on short term economic conditions, exchange rate movements, and particular large mergers, acquisitions, or investment decisions by individual multinational corporations. This article is more concerned with longer term trends, so the data presented here primarily reflects direct investment position, rather than annual capital flows.

Figure 2 U.S. capital inflows and outflows, 2000–2007



Source: USDOC, BEA.

The data for USDIA and FDIUS position and capital flows used throughout most of this article present calculations on a historical-cost basis, which reflects the value of equity at the time of investment. No adjustments are made for inflation, current value of invested assets, or change in market value of the companies. This represents the original cost of the assets to investors, but may not give a good indication of current value, as assets tend to increase in value over time. To provide a comparison, table 1 presents BEA estimates of the direct investment position for inbound and outbound FDI position using two additional valuation methods: current-cost and market-value. The current cost estimate reflects the estimated current values of "U.S. and foreign parents' share of their affiliates' investment in plant and equipment, land, and inventories." The market value method estimates the "value of the equity portion of direct investment, using indexes of stock market prices" (USDOC, BEA, 2006, 21). At the end of 2007, both the current cost and market value estimates were significantly higher than the estimate based on historical cost, and are likely a closer approximation of the aggregate value reflected on company balance sheets. These alternate valuation estimates are not available for the country and industry breakdowns that are the focus of this article, so the remaining data in this article reflect historical cost valuations.[5]

Whereas FDI position measures cumulative investment, annual FDI capital inflows and outflows measure the new investment that takes place during a specific calendar year. In contrast to the steady upward trend for both USDIA and FDIUS positions shown in figure 1, trends for capital flows exhibit much greater fluctuation, without any consistent relationship between U.S. capital outflows (USDIA) and inflows (FDIUS) (figure 2). This fluctuation reflects annual variation in economic conditions, and may be greatly influenced by one-time events such as particularly large cross-

TABLE 1 Alternative estimates of U.S. direct investment position, 2007 (million dollars)

	USDIA	FDIUS
Historical cost	2,791,269	2,093,049
Current cost	3,332,828	2,422,796
Market value	5,147,952	3,523,600

Source: USDOC, BEA.

[5] For a discussion of issues regarding the deflation of direct investment data, see USDOC, BEA (2002).

border mergers and acquisitions, or by market conditions in particularly countries.

Capital outflows and inflows consist of three components: new equity capital infusions, reinvested earnings, and intercompany loans. Because reinvested earnings from existing investments make up a substantial share of overall capital flows, past investments have a strong influence on the sources of new capital flows (table 2). For example, reinvested earnings as a share of total capital outflows (USDIA) averaged 63 percent from 2000-2007, but varied between 42 percent and 96 percent.[6] For this reason, even as a growing share of U.S. equity capital outflows is directed toward Asia, overall U.S. capital outflows will continue to reflect reinvested earnings and intercompany loans from established, U.S.-owned businesses in Europe. For FDIUS, reinvested earnings averaged a much smaller share of total capital inflows—11 percent during 2000–07; in several years, reinvested

TABLE 2 Components of capital inflows and outflows, 2000–07 (million dollars)

	2000	2001	2002	2003	2004	2005	2006	2007
USDIA								
Capital outflows without current-cost adjustment (inflows (–))	142,627	124,873	134,946	129,352	294,905	15,369	221,664	313,787
Equity capital	78,041	60,942	42,707	35,484	133,277	61,937	32,306	87,969
Reinvested earnings	77,018	52,307	65,756	100,478	141,589	-31,182	211,985	243,827
Intercompany debt	-12,431	11,624	26,483	-6,609	20,039	-15,386	-22,627	-18,008
FDIUS								
Capital inflows without current-cost adjustment (flows (–))	314,007	159,461	74,457	53,146	135,826	104,773	236,701	232,839
Equity capital	259,641	140,901	105,343	93,420	92,905	70,725	117,771	147,432
Reinvested earnings	-7,529	-41,410	-5,331	3,683	39,389	33,869	63,584	63,825
Intercompany debt	61,895	59,969	-22,555	-43,957	3,532	180	55,346	21,581

Source: USDOC, BEA.

Note: Data for 2005 is an anomaly. U.S. legislation permitted a one-time tax benefit for repatriating profits from overseas during 2005, encouraging unusual capital inflows that year.

[6] The decline in U.S. capital outflows in 2005 was largely due to the American Jobs Creation Act of 2004, which offered a one-time tax incentive to U.S. firms to repatriate profits from overseas operations back to the United States. For further detail on the effects of the American Jobs Creation Act, see USDOC, BEA, 2006, 24.

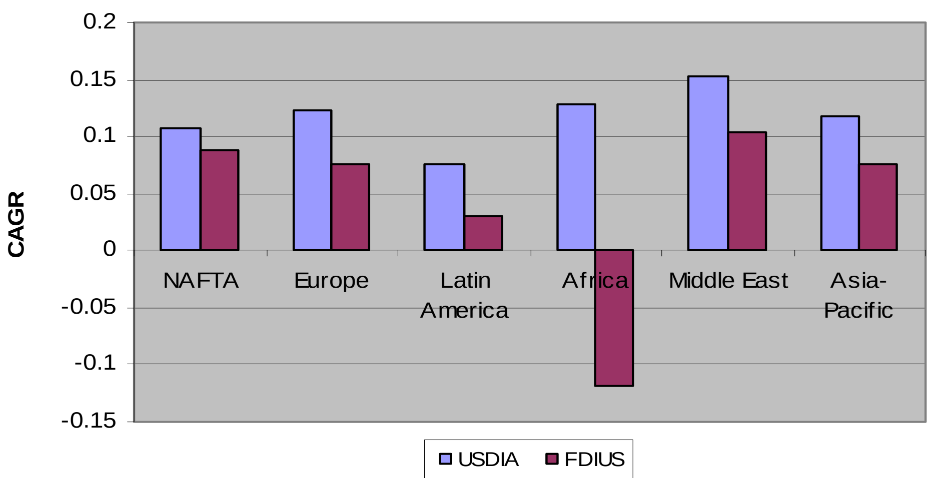
earnings were negative. The majority of the USDIA position is invested in other developed economies, with Europe accounting for 56 percent of the 2007 total. Europe accounts for an even greater share of the FDIUS position (71 percent), confirming the strong connection between the economies of the United States and Europe.

Growth Rates of Inbound and Outbound FDI

The CAGR rates of inbound and outbound investment position vary by region, and by direction of investment. Higher growth rates do not necessarily reflect the regions with the highest levels of FDI position. Between 2000 and 2007, the growth of USDIA position was fastest in the Middle East (15 percent), followed by Africa (13 percent). The growth of U.S. outbound investment in Europe (12.3 percent) was faster than the growth of U.S. investment in Asia-Pacific (11.9 percent) (figure 3).

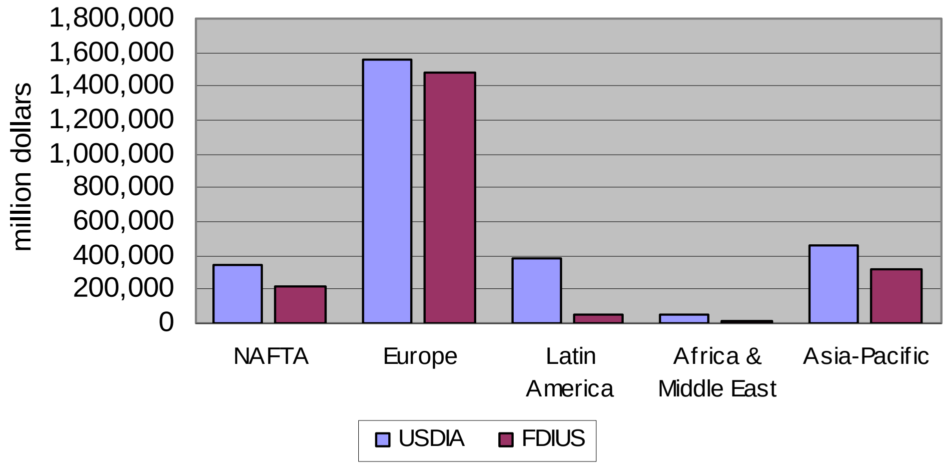
For inbound investment, the Middle East recorded the most rapid growth, followed by the NAFTA countries. Growth of investment from Europe and Asia-Pacific was essentially the same (7.6 percent and 7.5 percent, respectively). The overall decline in inbound investment from Africa

Figure 3 CAGR of USDIA and FDIUS position, by region, 2000-2007



Source: USDOC, BEA.

Figure 4 U.S. inbound and outbound FDI position, by region, 2007



Source: USDOC, BEA.

represents declines from both South Africa and other African countries in a fairly steady trend throughout the period.[7]

Focusing on growth rates tends to obscure the differences in absolute investment levels between regions, since the rate of growth is magnified when the base level of investment is small. For comparison, figure 4 shows the 2007 FDI position by region, for both inbound and outbound investment. As the figure illustrates, even though growth is higher for U.S. investment in Africa and the Middle East, overall inbound and outbound FDI remains dominated by Europe.

Table 3 lists the top 15 countries for which inbound and outbound U.S. investment showed the highest growth rates during 2000-07. U.S. outbound investment grew fastest in Russia, followed by Austria and India. Almost three-fourths of U.S. FDI in Russia is in the mining sector, which includes the petroleum industry, with another 13 percent in manufacturing industries, primarily chemicals and food. U.S. investment in Russia's mining sector includes very large investment projects by Exxon-Mobil and ConocoPhillips, among others (FDIMarkets and Zephyr databases, accessed July 1, 2009). However, there are concerns that Russia's efforts to regulate FDI, particularly in strategic sectors such as oil and gas, may

[7] Further details on particular industries and countries within Africa are not available from BEA.

TABLE 3 Fastest growing U.S. investment partners, inbound and outbound investment position, 2000–2007

USDIA position, all industries			
	2000	**2007**	**CAGR**
All countries	**1,316,247**	**2,791,269**	11.3%
Russia	1,147	12,986	41.4%
Austria	2,872	20,490	32.4%
India	2,379	13,633	28.3%
United Arab Emirates	683	3,846	28.0%
Luxembourg	27,849	113,611	22.2%
Egypt	1,998	7,513	20.8%
Singapore	24,133	82,623	19.2%
Netherlands	115,429	370,160	18.1%
Czech Republic	1,228	3,782	17.4%
Belgium	17,973	54,464	17.2%
South Korea	8,968	27,151	17.1%
U.K. Islands, Caribbean	33,451	90,803	15.3%
Israel	3,735	10,119	15.3%
Turkey	1,826	4,905	15.2%
Norway	4,379	11,650	15.0%

FDIUS position, all industries			
	2000	**2007**	**CAGR**
All countries	**1,256,867**	**2,093,049**	7.6%
India	227	2,957	67.1%
United Arab Emirates	64	862	45.0%
Venezuela	792	6,059	33.7%
Spain	5,068	27,606	27.4%
China	385	1,091	23.2%
South Korea	3,110	13,057	22.7%
New Zealand	395	1,481	20.8%
Panama	3,819	12,903	19.0%
Norway	2,665	7,952	16.9%
Australia	18,775	49,100	14.7%
Switzerland	64,719	155,696	13.4%
Italy	6,576	15,482	13.0%
Luxembourg	58,930	134,310	12.5%
U.K. Islands, Caribbean	15,191	32,807	11.6%
Hong Kong	1,493	3,209	11.6%

Source: USDOC, BEA, and calculations by the author.

moderate the growth of FDI going forward (See, e.g., Liuhto, 2008). In Austria, slightly more than half of outbound U.S. investment is destined for holding companies, and 20 percent goes to manufacturing. U.S. investment in India is more varied, as described below.[8]

Luxembourg, Singapore, the Netherlands, and the U.K. Islands in the Caribbean also exhibited very fast growth in U.S. outbound investment, primarily due to investment in holding companies. Much of this FDI is ultimately destined for investment in other operating industries in third countries (see box 1). Readers may be surprised not to see China among the fastest growth countries for outbound U.S. investment. Among all countries for which data are reported, China ranked 19th in terms of annual growth, with a CAGR of 14.2 percent, compared with 11.2 percent for overall outbound investment to all countries. It is likely that a significant share of U.S. direct investment in holding companies, which has also been growing rapidly, is ultimately destined for operating companies in China, but data do not permit tracking onward investment through holding companies. For inbound U.S. investment, the fastest growing country was India, for which 70 percent of total investment in the United States was directed to professional, scientific, and technical services, including computer systems design services. The United Arab Emirates and Venezuela ranked second and third; China ranked fifth.[9] Spain and South Korea registered the fastest growth among countries with larger existing levels of investment in the United States. The total investment positions from Spain and South Korea were $27.6 billion and $13.1 billion in 2007, respectively, compared with total investment of $3.0 billion from India and $862 million from the United Arab Emirates. The majority of Spanish investment in the United States (65 percent) was directed to depository institutions. Spanish companies have also been active in the renewable energy sector, which is classified within the Other Industries category. Leading Spanish electric power companies including Abengoa, Iberdrola, and Acciona have invested billions of dollars in wind, solar, and biofuels

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[8] The latter category includes computer systems design, engineering, legal, and accounting services. A further breakdown for U.S. investment in India is not available, however, for total U.S. FDI in this area, computer systems design accounts for 54 percent of all professional, scientific, and technical services.

[9] Industry detail for U.S. investment from the United Arab Emirates and Venezuela are not available. According to press reports, however, UAE investors made several large investments in U.S. financial institutions in 2007. Venezuela's U.S. investments are mostly likely tied to the petroleum industry, particularly the Citgo Petroleum Corp. which is wholly owned by Petroleos de Venezuela, the Venezuelan state-owned oil company (data accessed June 30, 2009 from Bureau van Dijk, Zephyr database).

power in the United States since 2000 (FDIMarkets database, accessed July 2, 2009). For South Korea, 72 percent of U.S. investment was in the wholesale trade industry. This is consistent with strong Korean exports of manufactured goods including automobiles and electronic equipment, and corresponding investment by South Korean manufacturers in U.S. distribution systems. China's growth rate of FDIUS ranked fifth, but overall FDI from China remained comparatively quite small in 2007. Like South Korea, the largest share of Chinese investment in the United States was in wholesale trade.

Europe

Even though Asia-Pacific has attracted an increasing share of U.S. investment in recent years, and U.S. direct investment in Asia has received extensive press coverage, 47-68 percent of new annual capital outflows since 2000 have been directed to Europe, except for the anomaly year of 2005 (figure 5). As noted, Europe accounted for the majority of both U.S. outbound investment position ($1.6 trillion) and inbound investment position ($1.5 trillion) in 2007. For U.S. companies, the United Kingdom is both the largest source and the largest destination for FDI both within Europe and globally. The Netherlands is in second place (figure 6).

In 2007, the largest European destination for USDIA position was holding companies, with 39 percent of the total (table 4). Holding companies are designed primarily for tax purposes, to channel funds to operating companies in other industries. Those operating companies are often located in a different country than the holding company (box 1). USDIA investment in European holding companies was greatest in the Netherlands ($254.5 billion), followed by Luxembourg ($83.6 billion), the United Kingdom ($80.7 billion), and Switzerland ($59.7 billion).[10] Other industries with significant USDIA positions in Europe are manufacturing, particularly of chemicals, and financial services.

Inbound investment from European countries into the United States is smaller, with manufacturing holding 38 percent of the total FDIUS position

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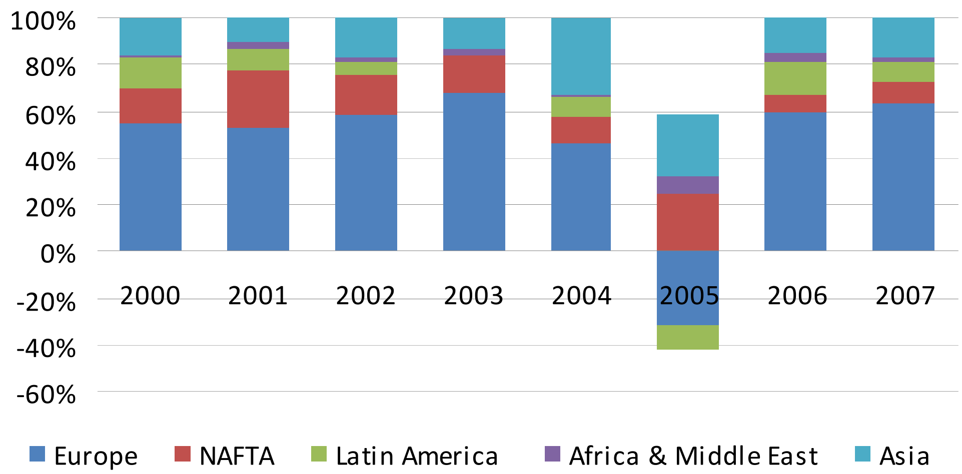
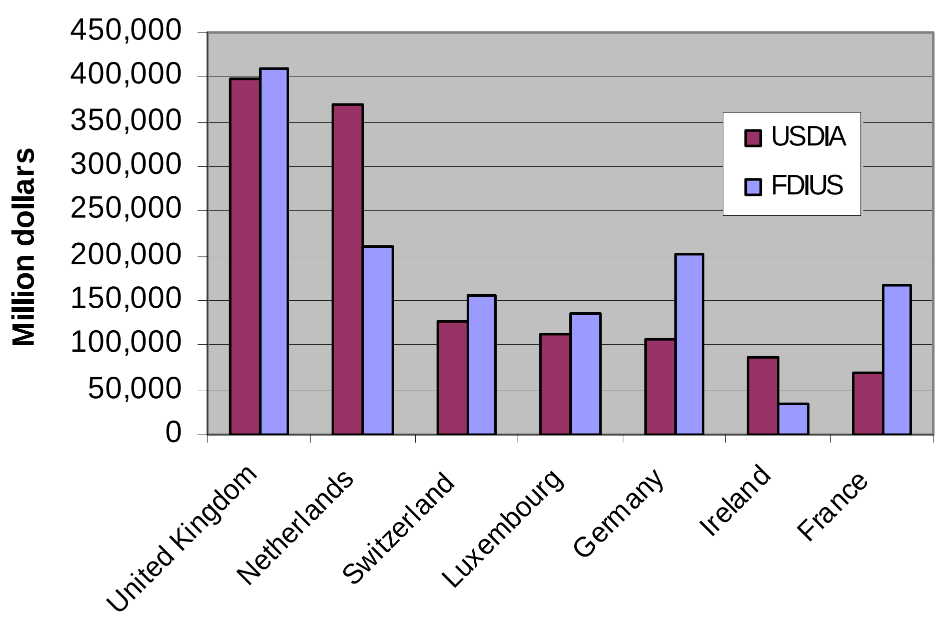
[10] Comparable data are not available for 2000, when BEA included holding companies in the Other Industries category. However, in 2000, that category was the largest industry destination for USDIA to the United Kingdom and Switzerland. Data for USDIA in Other Industries was suppressed in 2000 for Luxembourg and the Netherlands.

Figure 5 Shares of total U.S. capital outflows by region, 2000-2007



Source: USDOC, BEA.

Figure 6 Selected European countries, USDIA and FDIUS position, 2007



Source: USDOC, BEA.

in 2007, close to the 41 percent share of manufacturing in 2000. Within this sector, most European investment is directed to chemicals, which includes the pharmaceuticals industry. Data for European investment in the pharmaceuticals industry are not available, but pharmaceuticals have accounted for roughly one-half of global FDIUS in the U.S. chemicals manufacturing industry in recent years (USDOC, BEA, 2008, 117). Global pharmaceutical companies based in Europe have a strong presence in the U.S. market, including Bayer (Germany), Sanofi-Aventis (France), Novartis (Switzerland), and AstraZeneca (United Kingdom).[11] Financial services are the second largest destination for European FDIUS position. Of the European countries with the largest FDIUS positions in U.S. financial services, investors from the United Kingdom and Spain were concentrated more heavily in banks, and investors based in France, Germany, the Netherlands, and Switzerland were more heavily invested in the insurance and securities segments of the industry.

United Kingdom

As noted, the United Kingdom is the United States' largest investment partner, both for inbound and for outbound investment. British investors accounted for 14 percent of total USDIA position in 2007 and 20 percent of FDIUS position, illustrating the historically close economic relationship between the two countries. The British share of overall U.S. direct investment declined during 2000-07, however, for both inbound and outbound investment (table 5).

Inbound and outbound FDI are concentrated in different industries, as illustrated above in table 3. Financial services accounts for the largest share of USDIA in the United Kingdom (33 percent), consistent with the central role of London's financial markets in the global financial system. Table 6 shows the leading U.S.-owned financial services in the United Kingdom, as ranked by operating revenue.[12]

Manufacturing ranks second to financial services for U.S. investors in the United Kingdom, with chemicals manufacturing accounting for the largest share (figure 7). Leading U.S.-owned manufacturing companies include

[11] One database lists a total of 45 Europe-based pharmaceutical companies with affiliates operating in the United States (data accessed April 1, 2009 from Bureau van Dijk, Orbis database).

[12] However, the ownership of these firms may have changed hands since the onset of the global financial crisis in September 2008, and reported operating revenue in 2007 may not reflect 2009 market conditions.

TABLE 4 USDIA and FDIUS position, selected European countries and industries, 2007 (million dollars)

	All industries	Total mfg	Chemicals	Machinery	Computers and electronic products
USDIA					
Europe	1,551,165	257,397	69,326	19,482	26,375
Belgium	54,464	17,538	9,151	236	45
France	68,454	25,099	3,138	1,694	2,203
Germany	107,351	25,593	4,706	3,301	5,074
Ireland[a]	87,023	19,180	6,202	340	5,330
Luxembourg	113,611	7,585	([b])	-1	([b])
Netherlands	370,160	27,404	8,015	1,404	1,415
Spain	55,894	13,196	4,206	10	380
Switzerland	127,709	11,273	5,975	2,126	716
United Kingdom	398,836	70,083	16,777	6,273	5,241
European Union (27)[a]	1,376,926	239,409	62,186	15,766	25,741
FDIUS					
Europe	1,482,978	557,115	197,269	67,978	41,048
Belgium[a]	19,520	9,369	([b])	30	([c])
France	168,576	79,636	21,163	([b])	18,062
Germany	202,648	61,901	25,003	12,243	1,115
Ireland[a]	33,557	15,742	4,745	4	-1
Luxembourg	134,310	61,886	23,638	21,990	305
Netherlands[a]	209,449	94,998	44,666	([b])	2,344
Spain	27,606	3,357	256	-3	([b])
Sweden	31,857	12,878	([b])	([b])	([b])
Switzerland[a]	155,696	98,672	31,552	1,172	402
United Kingdom	410,787	92,682	31,860	2,799	14,850
European Union (27)[a]	1,301,813	455,232	165,073	65,459	40,231

Source: USDOC, BEA.

[a] Financial services data reflects finance and insurance only. Data for depository institutions was suppressed to avoid disclosing individual company information.

[b] Data suppressed to avoid disclosure of individual company information.

[c] Less than $500,000.

[d] The Bureau of Economic Analysis does not provide FDIUS data for holding companies.

Transportation equipment	Wholesale trade	Information	Financial services	Professional, scientific, and technical services	Holding companies (nonbank)
23,743	109,995	73,170	326,326	37,949	593,837
1,136	5,222	177	24,529	2,479	1,753
1,828	5,868	1,357	8,518	2,342	12,470
2,347	21,385	2,758	16,152	4,649	30,128
11	1,370	16,501	9,886	5,267	6,831
([b])	3,076	1,802	16,554	-24	83,595
-8	17,619	6,694	54,491	3,023	254,500
1,335	3,582	589	8,916	2,132	24,880
248	22,166	1,267	25,689	1,631	59,720
11,210	15,660	36,155	129,985	13,707	80,656
23,040	84,992	71,509	294,348	36,103	531,241
30,440	139,133	133,039	260,522	53,500	([d])
-1	1,881	2	1,248	-42	([d])
3,185	8,999	11,802	46,853	6,663	([d])
11,041	10,772	48,585	50,554	197	([d])
([b])	174	([b])	2,691	-36	([d])
([b])	1,296	7,048	6,884	([b])	([d])
3,075	21,444	16,815	36,766	6,742	([d])
45	132	([b])	19,008	([b])	([d])
4,214	7,442	847	10	54	([d])
([b])	7,865	12,064	29,388	474	([d])
5,959	72,240	22,264	65,141	28,616	([d])
29,061	128,228	116,492	237,221	49,538	([d])

Box 1. USDIA in holding companies

The high level of USDIA in holding companies makes it difficult to determine the final industry destination of U.S. outbound investment. Official U.S. government statistics track capital outflows from U.S. parent firms only to the first foreign affiliate recipient. When a U.S. parent firm invests in a foreign affiliate holding company, which then sends the capital onward to an operating company in another industry and/or another country, U.S. FDI data reflect only the first step of investment in the holding company, not the final industry and/or country destination of these capital outflows. However, it is possible to gain some insight into the final industry destination of FDI by comparing the USDIA position as measured by the industry of the U.S. parent to the USDIA position measured by the industry of the foreign affiliate (table A).

TABLE A USDIA position by industry of affiliate compared to industry of parent, all countries, 2007

Industry	USDIA position by industry of affiliate	USDIA position by industry of US parent	Difference
All industries	2,791,269	2,791,269	0
Holding companies	927,578	35954	891,624
Finance and insurance	531,933	444,603	87,330
Wholesale trade	183,038	100,456	82,582
Mining	147,319	82,700	64,619
Electrical equipment mfg	18,429	24,201	-5,772
Other industries	202,661	212017	-9,356
Primary and fabricated metals mfg	28,685	43,061	-14,376
Machinery mfg	37,063	55,091	-18,028
Information	111,866	146,027	-34,161
Depository institutions	91,768	127,722	-35,954
Prof, scientific, and technical services	63,791	112,605	-48,814
Food mfg	33,766	87,681	-53,915
Computer and electronic products mfg	69,912	189,013	-119,101
Transportation equipment mfg	65,053	275,035	-209,982
Chemicals mfg	117,963	405,292	-287,329
Other mfg	160,444	449,811	-289,367
Total manufacturing	531,315	1,529,185	-997,870

Source: USDOC, BEA, *Survey of Current Business*, September 2008, 85.

Cases in which the USDIA position, as measured by the industry of the parent, differs from the position as measured by the industry of the affiliate, are most likely to be situations in which FDI is directed first to a holding company, and then subsequently reinvested in an operating company. For example, a U.S. manufacturer may invest in a holding company in Bermuda, which then invests in an operating company affiliate such as a factory in India. U.S. FDI data show only the first investment in Bermuda, reported by the industry of the affiliate. When the data are compared by the industry of the parent (manufacturing) vs. the industry of the affiliate (holding companies, included in the service sector), a discrepancy appears. An examination of the data shows that for four industries (holding companies, finance, wholesale trade, and mining), the USDIA position is significantly larger when categorized by the industry of the affiliate, compared to data presented by the industry of the parent. This signifies that many U.S. parent firms have invested in foreign affiliates in an industry different from their own primary industry. By far the largest such discrepancy appears in the category of holding companies. The majority of such funds directed toward holding companies are presumably reinvested in operating companies, probably in third countries.

For 2007, the USDIA position in foreign holding companies was $36.0 billion when measured by the industry of the U.S. parent, compared with $927.6 billion when measured by industry of the affiliate. The reverse is true for manufacturing firms, implying that U.S.-based MNCs engaged primarily in manufacturing industries have invested in foreign affiliates that act as holding companies, and also in affiliates in the wholesale trade, finance, and mining industries. This is particularly true for parent firms that are manufacturers of chemicals, transportation equipment, and computers and electronic equipment. These U.S.-based manufacturing firms have invested in holding companies aimed at onward investment, and also in wholesale trade affiliates used to distribute their products in overseas markets, finance companies likely used to finance the purchase of those finished products, and mining companies, presumably as a source of raw materials for manufacturing operations. In 2007, the USDIA position in manufacturing was $531.3 billion when classified by the industry of the affiliate, but $1,529.2 billion by industry of the parent.

TABLE 5 United Kingdom share of overall U.S. investment position

	USDIA	FDIUS
2000	18%	22%
2007	14%	20%

Source: USDOC, BEA.

TABLE 6 Leading U.S.-owned financial firms in the United Kingdom, by operating revenue, 2007

Affiliate company	Employees	Operating revenue	Global ultimate owner
		Million dollars	
Blackrock Fund Managers	7	20,336.5	Bank of America
Threadneedle Investment Services	57	13,440.5	Ameriprise Financial
Goldman Sachs International	5,489	9,175.2	Goldman Sachs Group
Morgan Stanley & Co. International	363	7,617.4	Morgan Stanley
ML UK Capital Holdings	2,622	-11,323.2	Bank of America
JP Morgan Securities	([a])	4,537.9	JP Morgan Chase
Managed Pension Funds	([a])	4,088.9	State Street Corporation
Citigroup Global Markets Europe	4,385	3,309.6	Citigroup
MBNA Europe Bank	([a])	3,205.0	Bank of America
Citigroup Global Markets	4,385	3,205.0	Citigroup

Source: Bureau van Dijk, Orbis database, accessed December 30, 2008 and April 20, 2009.

Note: Operating revenue reflects latest available year, mostly 2007.

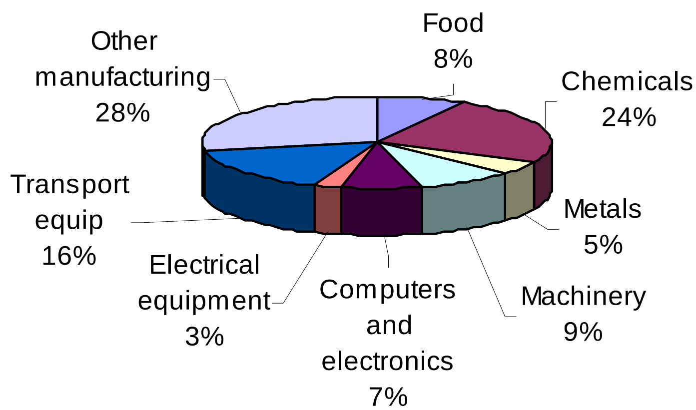
[a] Not available.

affiliates of Altria (tobacco), Chevron (petroleum products), General Motors (automobiles), IBM (computers and computer services), and Hewlett Packard (computers).[13] The U.S.-owned manufacturing company with the highest operating revenue by far ($285.0 billion in 2007) is British Petroleum (BP).[14] By comparison, SABMiller, an affiliate of Altria, reported operating revenue of $22.0 billion, followed by Chevron's British affiliate, with operating revenue of $12.8 billion.[15]

By contrast, a greater share of FDIUS from the United Kingdom is invested in the manufacturing (23 percent) and wholesale trade (18 percent)

[13] Data accessed December 30, 2008, from Bureau van Dijk, Orbis database.
[14] J.P. Morgan Chase, the U.S.-based financial firm, owned 28.5 percent of BP as of 2007 (data accessed December 30, 2009 from Bureau van Dijk, Orbis database).
[15] Data accessed December 30, 2008, from Bureau van Dijk, Orbis database.

Figure 7 USDIA position in the United Kingdom manufacturing sector, 2007



Source: USDOC, BEA.

industries, closely followed by financial services (16 percent). British-owned parents control a number of very large and well-known companies in the United States, and are active in manufacturing industries including chemicals; food, beverage and tobacco; energy; and defense. Leading British-owned manufacturers include AstraZeneca, Shell Petroleum, Chevron Phillips, and Reynolds American (table 7). UK-owned companies are also closely involved in the U.S. defense industry, including BAE Systems, which controls more than 40 separate U.S. affiliates, and Cobham, which operates more than 20 U.S. affiliates.[16]

Netherlands

Holding companies were by far the largest industry destination for U.S. investment in the Netherlands, with U.S. position valued at $245.5 billion in 2007, equal to 69 percent of all USDIA in the Netherlands. Although precise data are not available, given the nature of holding companies as financial vehicles created primarily for tax purposes and the relatively small size of the Dutch economy, it is likely that a significant share of these funds is ultimately reinvested in other countries. Smaller amounts are invested in financial services ($54.5 billion) and manufacturing ($27.4 billion).

[16] Data accessed December 30, 2008, from Bureau van Dijk, Orbis database; Cobham Web site; and BAE Systems Web site.

TABLE 7 Selected United Kingdom-owned manufacturing affiliates in the United States, 2009

Affiliate company	Employees	Operating revenue	Global ultimate owner	Primary business
		Million dollars		
Astrazeneca Limited Partnership	2,500	23,950	Astrazeneca	Pharmaceuticals
Shell Petroleum	26,888	16,300	Royal Dutch Shell	Petroleum
Reynolds American	6,800	8,845	British American Tobacco	Tobacco
Equilon Enterprises	8,600	5,206	Royal Dutch Shell	Petroleum refining
Chevron Phillips Chemical Company	400	3,429	Ineos Group Limited	Petrochemicals and plastics
BAE Systems	34,988	2,961	BAE Systems	Electrical machinery, equipment, and supplies
Tomkins Corporation	29,464	2,627	Tomkins	Electric domestic appliances
BAE Systems Survivability Systems	589	2,400	BAE Systems	Motor vehicle parts
Armor Holdings	8,150	2,361	BAE Systems	Tanks and tank components
Rexam Beverage Can Americas	3,000	2,300	Rexam	Light metal packaging
RB Holdings (USA)	1,600	2,000	Reckitt Benckiser Group	Soaps, detergents, and specialty cleaning preparations

Source: Bureau van Dijk, Orbis database, accessed February 10, 2009.

The FDIUS position from the Netherlands is dominated by manufacturing, which accounts for 45 percent of the total ($95.0 billion), of which almost one-half is directed to the chemicals industry. By far the largest Netherlands-based chemicals manufacturer in the United States is Akzo Nobel, which ranked 455 on the Fortune magazine Global 500 list in 2008. The company reported global revenues of $18.5 billion in 2007, and was ranked ninth of the top 10 global chemical companies (Fortune, 2008). A significant share of total revenues derived from the company's U.S. operations: Akzo Nobel's 32 affiliate companies in the United States reported combined operating revenue of just under $10 billion in their most recent annual reports.[17] Royal DVM, another Netherlands-based

[17] Data from most recent annual report from each affiliate, for either 2006 or 2007, as reported by Bureau van Dijk, Orbis database, accessed December 30, 2008.

chemical company, reported operating revenue of just over $1 billion from 10 U.S. affiliates.

The inbound investment position from the Netherlands in finance and insurance was valued at $36.8 billion in 2007.[18] Several of the world's largest financial services companies are based in the Netherlands, including ING Group (ranked 7th on the Fortune Global 500 List), Aegon (ranked 103rd), and Rabobank (ranked 147th), all of which have extensive operations in the United States.[19]

Germany

In contrast with the United Kingdom and the Netherlands, FDIUS from Germany is substantially larger than USDIA in Germany (see figure 6). The USDIA position in Germany was valued at $107.4 billion in 2007 (4 percent of total USDIA) compared with German direct investment in the United States of $202.6 billion (10 percent of FDIUS). The manufacturing sector represents the largest share of the German FDIUS position, with $61.9 billion (31 percent), primarily in invested chemicals (table 8). Machinery and transportation equipment are also significant destinations for German manufacturing investment. Within the service sector, finance and insurance ($34.1 billion) and banks ($16.4 billion) also represent large shares of total German investment (figure 8).

Most large German financial services companies hold affiliates in the United States. Those that report the highest operating revenues include various affiliates of insurers Hannover Reinsurance, Allianz, and Munich Reinsurance, and of Deutsche Bank.[20] German-based automakers, including Daimler and BMW, also operate finance companies in the United States. German investment in the U.S. information sector[21] was valued at $48.6 billion in 2007. As of February 2009, Deutsche Telekom was the leading German-owned company in the U.S. information sector, operating through several subsidiaries, including Suncom Wireless, Aerial Communications, and Triton[22].

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[18] Does not include depository institutions, for which data were suppressed in 2007 (Bureau van Dijk, Orbis database, accessed December 30, 2008).

[19] Data accessed February 10, 2009 from Bureau van Dijk, Orbis database; Fortune, 2008.

[20] Data accessed February 11, 2009 from Bureau van Dijk, Orbis database.

[21] The information sector is comprised of publishing; motion picture and sound recording industries; broadcasting; telecommunications; and internet, data processing, and other information services.

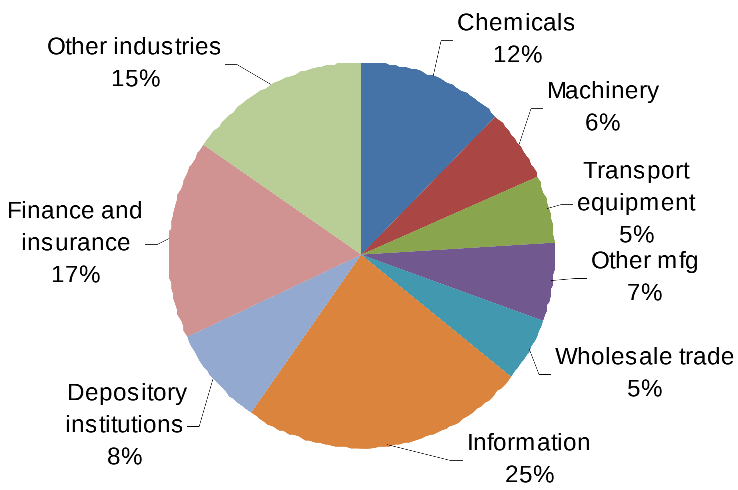
[22] Data accessed February 11, 2009 from Bureau van Dijk, Orbis database.

TABLE 8 Selected German-owned companies invested in chemicals manufacturing in the United States, 2009

Global ultimate owner	Number of U.S. subsidiaries	Combined U.S. operating revenue	Combined U.S. employment	Principal business lines
		Million dollars		
BASF	14	13,108.9	43,077	Oil and gas, plastics, agricultural products and fine chemicals
Bayer	7	8,547.5	35,402	Health care, crop science, materials science, business services, and technology services
Henkel	13	7,848.076	7,036	Laundry and home care, cosmetics and toiletries, and adhesive technologies
Linde	10	4,150.1	10,264	Industrial, medical, and therapeutic gases, and hydrogen, oxygen, and olefin processing plants
Freudenberg & Co. Kommandit-gesellschaft	3	1,381.8	6,317	Seals, nonwovens and filtration, household products, lubricants, and IT services

Sources: Bureau van Dijk, Orbis database, accessed February 11, 2009; and company Web sites.

Figure 8 German FDIUS position, 2007



Source: USDOC, BEA.

Asia Pacific

The U.S. investment relationship with the Asia-Pacific region was the second largest in 2007, accounting for 16 percent of the outbound U.S. investment position ($454.0 billion) and 15 percent of the inbound U.S. investment position ($319.8 billion). The largest share of USDIA position was in manufacturing ($102.7 billion), almost one-third of which reflected investment in manufacturers of computers and electronic products ($31.2 billion). U.S. investors also held an $18.7 billion USDIA position in the region's chemical manufacturing industry, split among several Asian countries (table 9).

Figure 9 shows the largest country destinations for USDIA in the Asian manufacturing sector. Japan is the largest country destination for USDIA in manufacturing, but its share slipped slightly from 21 percent to 19 percent from 2000–07. In contrast, China's share of USDIA in Asia-Pacific manufacturing has increased to 15 percent from 11 percent during the same period, and South Korea's share has increased to 13 percent, from 7 percent.

Holding companies closely followed manufacturing as an industry destination for USDIA, with $102.1 billion, two-thirds of which was invested in the financial centers of Singapore and Hong Kong. As noted, FDI in holding companies is generally reinvested in operating companies in other countries, so it is likely that much of this investment is ultimately destined for investment into Chinese manufacturing companies. If so, actual USDIA in China's manufacturing sector may be significantly larger than reflected in the official U.S. data.

Financial services ranked third for USDIA in the Asia-Pacific region in 2007, at $112.0 billion, of which $22.5 billion was invested in depository institutions. Japan accounts for almost one-half of USDIA in financial services in the region, but investment growth has been significantly faster in the emerging markets, particularly in China, which registered compound annual growth rates for USDIA of more than 50 percent for both banks and other financial services during 2000–2007 (table 10). Even though the domestic economies of Singapore and Hong Kong are small, both serve as regional centers for financial services beyond holding companies. As such, most U.S.-owned banks, securities firms, and many insurance companies active in global markets are likely to maintain an affiliate office in one or both of those locations. It remains to be seen, however, whether the global

TABLE 9 USDIA and FDIUS position, Asia-Pacific region, leading countries and industries, 2007

	All industries	Manufacturing: Total	Chemicals	Computers and electronic products	Transportation equipment
	Million dollars				
USDIA					
Asia and Pacific	453,959	102,677	18,653	31,183	9,677
Australia	79,027	13,883	2,992	564	1,711
China	28,298	15,007	3,263	3,616	2,055
Hong Kong	47,431	3,680	565	1,360	36
India	13,633	2,918	1,014	315	157
Japan	101,607	19,273	3,975	4,686	2,251
Singapore	27,151	10,930	1,532	3,108	1,298
South Korea	82,623	13,748	1,348	8,211	1,397
FDIUS					
Asia and Pacific[a]	319,832	98,040	11,053	22,244	31,051
Australia	49,100	4,656	([b])	-40	-32
China	1,091	-79	89	-7	-173
Hong Kong[a]	3,209	1,530	(D)	734	([b])
India	2,957	136	42	(D)	57
Japan	233,148	79,951	9,589	21,165	31,205
South Korea	13,057	([b])	19	([b])	([b])
Singapore[a]	10,217	([b])	-66	31	10

Source: USDOC, BEA.

[a] Financial services data reflects finance and insurance only. Data for depository institutions was suppressed to avoid disclosing individual company information.

[b] Data suppressed to avoid disclosure of individual company information.

[c] Less than $500,000.

[d] The Bureau of Economic Analysis does not provide FDIUS data for holding companies.

financial crisis that began in September 2008 will lead to a realignment of USDIA in the Asia-Pacific financial services industry.

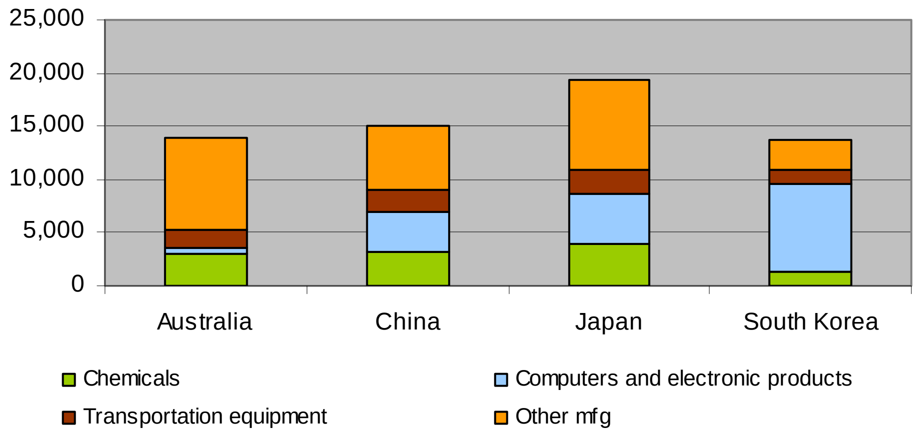
Inbound investment from the Asia-Pacific region in 2007 was concentrated in wholesale trade ($113.9 billion) and manufacturing ($98.0 billion). FDI in wholesale trade tends to reflect investment in distribution services for manufactured goods. Consistent with this, 86 percent of FDIUS in the wholesale trade industry originated in Japan, which has strong manufacturing exports to the United States.

Japan

In 2007, the FDIUS position from Japan ($233.1 billion) was more than twice the country's USDIA position ($101.6 billion). This divergence

Wholesale trade	Information	Financial services	Professional, scientific, and technical services	Holding companies
33,105	24,678	111,999	17,365	102,128
3,702	10,239	13,308	3,822	14,244
3,136	645	1,963	1,287	1,815
7,475	1,197	11,784	3,832	17,648
530	4,132	3,276	1,821	401
8,552	4,554	46,522	1,654	11,494
1,638	721	11,175	1,265	51,690
3,369	2,535	6,882	2,579	140
113,857	(D)	24,916	7,353	([d])
2,349	1,023	6,367	([b])	([d])
847	([c])	([b])	73	([d])
1,059	([b])	413	([b])	([d])
10	101	368	2,071	([d])
97,827	1,821	26,026	4,685	([d])
9,371	([b])	577	-1	([d])
94	14	351	87	([d])

Figure 9 USDIA position in manufacturing, leading Asia-Pacific countries, 2007



Source: USDOC, BEA.

TABLE 10 USDIA position in Asia-Pacific financial services, selected countries, 2000 and 2007

	2000	2007	CAGR	Share of total, 2007
	Million dollars		Percent	
Asia and Pacific	51,390	111,999	11.8	100.0
Australia	5,799	13,308	12.6	11.9
China	107	1,963	51.5	1.8
Hong Kong	9,034	11,784	3.9	10.5
India	632	3,276	26.5	2.9
Japan	23,459	46,522	10.3	41.5
Singapore	3,245	11,175	19.3	10.0
South Korea	1,955	6,882	19.7	6.1

Source: USDOC, BEA.

reflects two separate trends: strong Japanese interest and success in the U.S. market, and the historic difficulties that many U.S. firms have faced in penetrating the Japanese market. The Japanese FDIUS position is particularly strong in the manufacturing and as noted, the wholesale trade sectors. Within manufacturing, the largest industries for Japanese investment are transportation equipment, and computers and electronic products. There are at least 900 Japanese-owned wholesale trade firms in the United States, representing industries including automobiles, metals, apparel, auto parts, agricultural goods, and office equipment (table 11).

In contrast to the pattern for FDIUS, by far the largest share of the USDIA position in Japan in 2007 was invested in financial services, primarily finance and insurance services ($45.8 billion or 45 percent).[23] Many U.S.-based securities and insurance firms have substantial operations in Japan (table12). By comparison, the USDIA position in the Japanese manufacturing sector was valued at a comparatively smaller $19.3 billion. In 2007, the largest recipient manufacturing industries were computers and electronic products ($4.7 billion) and chemicals ($4.0 billion). Wholesale trade ($8.6 billion) and information services ($4.6 billion) were also significant destinations for U.S. direct investment in Japan.

[23] The remainder of the total USDIA position in financial services ($648 million) was invested in banks.

TABLE 11 Leading Japanese-owned wholesale trade companies in the United States, by operating revenue, 2009

Affiliate company	Employees	Operating revenue	Global ultimate owner	Primary business	Latest reporting year
		Million dollars			
American Honda Motor Company	26,000	7,680,900	Honda Motor Company	Automobiles	2007
Sumitomo Corp. of America	175	6,983,834	Sumitomo Corporation	Ferrous and nonferrous metals	2005
Mitsui & Co. (U.S.A.)	2,093	6,811,560	Mitsui & Company	Diversified trading company	2006
Zen-Noh Grain Corporation	([a])	5,719,822	National Federation of Agricultural Cooperative Associations	Grains and seeds	2008
CGB Enterprises	100	4,402,572	Itochu Corporation	Grains	2008
Ikon Office Solutions	25,000	4,168,344	Ricoh Company	Office equipment	2007
Itochu International	([a])	3,917,745	Itochu Corporation	Diversified trading company	2006
Mitsubishi International Corporation	([a])	3,466,693	Mitsubishi Corporation	Diversified trading company	2006
Ricoh Americas Corporation	36,400	3,234,600	Ricoh Company	Office and photographic equipment	2007
Consolidated Grain and Barge Company	15	2,849,410	Itochu Corporation	Grains and seeds	2007
Marubeni America Corporation	([a])	2,532,540	Marubeni Corporation	Diversified trading company	2006
Helena Chemical Company	1,000	2,300,000	Marubeni Corporation	Farm Supplies	2006
Marubeni Itochu Steel America Inc.	1,358	1,907,782	Itochu Corporation	Metals service centers	2006
Makita U.S.A.	140	1,819,000	Makita Corporation	Power-driven hand tools	2004
TBC Corporation	9,400	1,779,400	Sumitomo Corporation	Tires and related automotive products	2007

Source: Bureau van Dijk, Orbis database, accessed April 2, 2009.

[a] Not available.

TABLE 12 Leading U.S.-owned financial services affiliates in Japan, by annual operating revenue, 2008

Affiliate company	Annual operating revenue	Global ultimate owner	Primary business
	Million dollars		
American Life Insurance (ALICO Japan)	14,643	American International Group	Insurance carrier
Hartford Life Insurance	8,246	Hartford Financial Services Group	Insurance carrier
Mitsui Life Insurance	7,999	Manpower	Insurance carrier
Gibraltar Life Insurance	6,489	Prudential Financial	Insurance carrier
Kyoei Life Insurance	5,686	Prudential Financial	Insurance carrier
Prudential Life Insurance	4,587	Prudential Financial	Insurance carrier
AIG Edison Life Insurance	4,069	American International Group	Insurance carrier
AIG Star Life Insurance	2,661	American International Group	Insurance carrier
Goldman Sachs Japan Securities	2,563	Goldman Sachs	Securities and commodity contracts
MassMutual Life Insurance	2,271	Massachusetts Mutual Life Insurance	Insurance carrier
Nikko Cordial Securities	2,177	Citigroup	Short term business credit institutions

Source: Bureau van Dijk, Orbis database, accessed December 30, 2008.

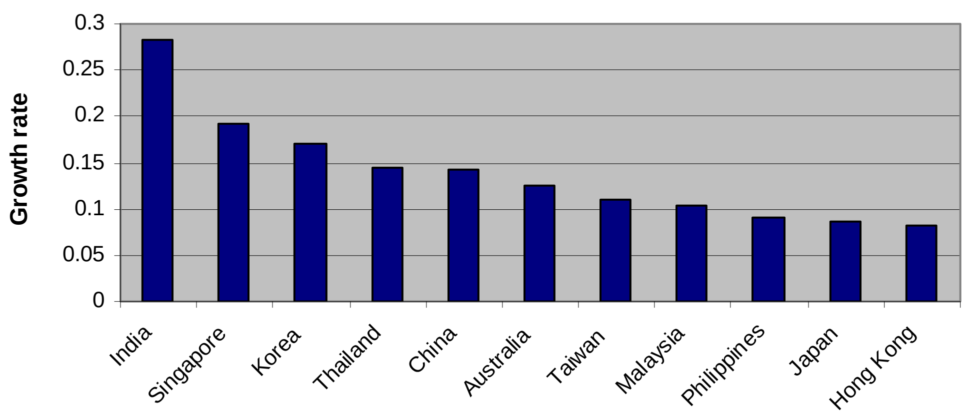
Note: Operating revenue reflects latest reported year for each company.

China

The USDIA position in China reached $28.3 billion in 2007. While this was just 1 percent of total USDIA, investment in China recorded a CAGR of 14 percent during 2000–2007, compared to 11 percent for global USDIA position during the period. Annual USDIA capital outflows of new investment into China increased rapidly, remaining under $2.0 billion during 2000–2003, but increasing to $3.9 billion in 2006 and $5.7 billion in 2007.[24] However, for all the media attention paid to U.S. investment in China, there was significantly faster growth in U.S. outbound investment to several other Asian countries, including India, Singapore, South Korea, and Thailand (figure 10).[25]

Manufacturing accounted for 53 percent ($15.0 billion) of U.S. investment in China in 2007 (figure 11). The largest manufacturing segments were computers and electronic products, chemicals, and transportation equipment. Wholesale trade accounted for 11 percent ($3.1 billion). As is well-known, U.S. corporations have invested heavily in Chinese manufacturing facilities in recent years, often taking advantage of China's relatively low labor costs and integrated distribution infrastructure, and

Figure 10 Compound annual growth rate (CAGR) of USDIA position, selected Asian countries, 2000-2007

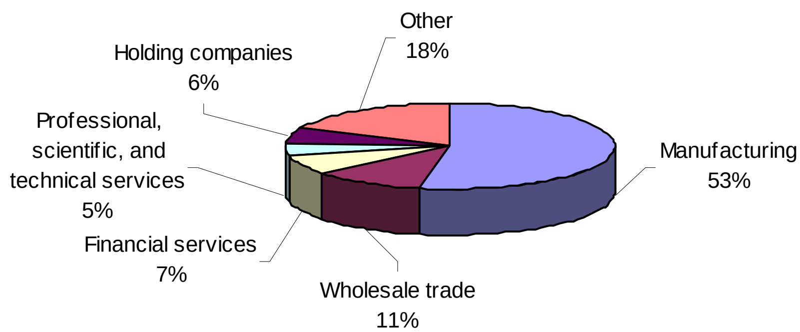


Source: USDOC, BEA.

[24] CAGR rates for capital flows are often misleading, as they ignore the annual fluctuation of capital flows, so the CAGR for capital flows is not presented here. Such fluctuation is significantly more extensive than for FDI positions.

[25] As noted above, however, much of USDIA stock in Singapore and Hong Kong is invested in holding companies. China is the likely final destination of a large share of this investment.

Figure 11 USDIA position in China, by industry, 2007



Source: USDOC, BEA.

seeking to sell their products in China's growing domestic market. As noted, investment in wholesale trade affiliates often supports manufacturing investment. Table 13 illustrates some of the largest U.S.-owned manufacturing and wholesale trade affiliates in China, particularly in the areas of computers, electrical equipment, and consumer products.

Chinese firms have also begun to invest in the United States in recent years. In 2007, China's FDIUS position was $1.1 billion, of which $847 million was classified as wholesale trade. The largest contributor to China's FDIUS in the wholesale trade area is most likely COSCO, the Chinese government-owned shipping company. COSCO had approximately 24 U.S. affiliates in 2007, which together reported over 4,000 U.S. employees, and $429.0 million in operating revenue.[26] As ranked by operating revenue, the largest Chinese-owned manufacturing company in the United States, by a significant margin, was Lenovo USA. Lenovo, a China-based personal computer company, acquired IBM's personal computer business in 2005. Lenovo reported operating revenue of $365.1 million in 2007, with 2,000 U.S. employees (Bureau van Dijk, Orbis database, accessed March 9, 2009).

[26] Data for employment and operating revenue reflect either 2006 or 2007, depending on the affiliate. Data accessed March 9, 2009 from Bureau van Dijk, Orbis database.

TABLE 13 Selected U.S.-owned, manufacturing and wholesale trade affiliates in China, by annual operating revenue, 2009

Affiliate company	Employees	Operating revenue	Global ultimate owner	Primary business
		Million dollars		
Motorola (China) Electronic	14,441	6,536.2	Motorola	Communications equipment
Procter & Gamble (Guangzhou)	3,152	3,207.9	Procter & Gamble	Consumer products
Shanghai HP	4,863	3,205.2	Hewlett-Packard	Computers
Hangzhou Motorola Cellular Equipment	430	3,123.7	Motorola	Telecommunications equipment
RF Micro Devices (Beijing)	1,120	741.3	RF Micro Devices	Integrated circuits
Coca-Cola (China) Beverages	634	568.0	Coca-Cola	Beverages
BP Zhuhai Chemical Company	263	544.5	JP Morgan Chase	Chemicals
Qingling Motors Company	3,030	514.3	General Motors	Automobiles
Delphi Shanghai Dynamics And Propulsion Systems	1,353	456.4	Delphi Corporation	Automotive parts
Colgate-Palmolive (Guangzhou)	521	337.6	Colgate Palmolive	Consumer products
Avon Products (China)	2,190	327.0	Avon Products Inc	Cosmetics
Shanghai Shenmei Beverage Food	1,158	279.9	Coca-Cola	Beverages
Intel Products (Shanghai)	2,752	278.8	Intel Corp	Integrated circuits
Yada Electronics Co.	4,653	273.7	Emerson Electric	Electronic components
Beijing Delphi Wanyuan Engine Management System	365	273.3	Delphi	Automotive parts
MeadJohnson (Guangzhou)	435	218.3	Bristol-Myers Squibb	Milk and dairy production
Agilent Technologies (Shanghai)	233	218.0	Agilent Technologies	Instrument manufacturing

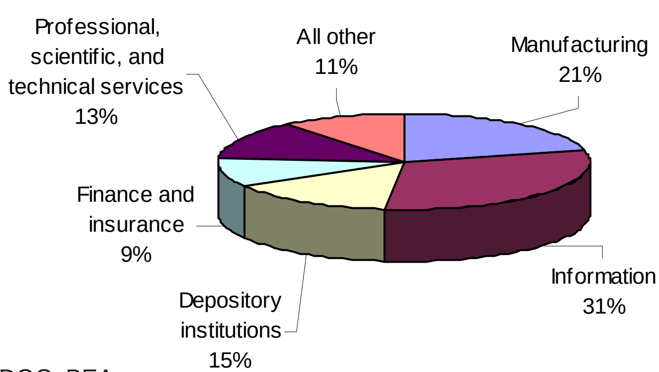
Source: Bureau van Dijk, Orbis database, accessed March 9, 2009.

India

U.S. investment in India increased significantly to $13.6 billion in 2007, up from $2.4 billion in 2000, a CAGR of 28.3 percent, compared with growth of 11 percent for the total USDIA investment position. Although India accounts for only 3 percent of total USDIA position in the Asia-Pacific region, its share is much larger in certain industries: 17 percent of total USDIA in information industries, 12 percent in machinery manufacturing, and 11 percent in professional, scientific, and technical services.

Almost one-third of USDIA in India is directed to the information industry (figure 12), primarily data processing and related services. This reflects U.S. companies' well documented outsourcing of certain technical and customer service functions to India. Prominent U.S. companies with Indian affiliates in the information industry include Oracle, Honeywell, Igate, and Citigroup. Although less well documented, 21 percent of USDIA in India is invested in the manufacturing sector. Of that amount, just over one-third is focused on chemicals, and one-fourth is invested in machinery manufacturing. Major U.S.-owned chemical companies with affiliates in India include Pfizer, Abbott, and Mylan, all global pharmaceutical firms. India is well known for its pharmaceutical research industry, and U.S. firms have actively engaged in the market (Linton and Corrado, 2007). In the machinery industry, Cummins India Ltd., an affiliate of a U.S.-based manufacturer of diesel engines, reported the largest operating revenue among all U.S.-owned affiliates in India ($688.8 million in 2007).[27]

Figure 12 USDIA position in India, by industry, 2007



Source: USDOC, BEA.

[27] Includes affiliates included in the Orbis database. Not all companies publicly report operating revenue. Data accessed June 30, 2009 from Bureau van Dijk, Orbis database.

India's FDIUS position has also registered rapid growth, from $227 million in 2002 to $3.0 billion in 2007. This was a thirteenfold increase but, as is typical for developing countries, inbound investment was much smaller than U.S. outbound investment in India. Over two-thirds of Indian FDIUS was invested in professional, scientific, and technical services. Wipro, Patni Computer Systems, and HCL own several of the largest U.S. affiliates of Indian technology companies, as measured by operating revenue; all offer computer consulting and software development services)Bureau van Dijk, Orbis database).

NAFTA

In 2007, Canada and Mexico together accounted for 13 percent of all outbound U.S. investment and 11 percent of inbound investment. The close economic relationship between the United States, Canada, and Mexico is a result of common borders, shared history, and the NAFTA agreement. The largest share of USDIA goes to manufacturing, most prominently in transportation equipment and chemicals, followed by financial services, holding companies and mining, including petroleum (table 14). For FDIUS, the largest share was represented by financial services, most of which came from Canada, followed by manufacturing.

Canada

Canada accounted for 9 percent of the total USDIA position in 2007, and 10 percent of FDIUS. More than one-third of U.S. FDI in Canada is in the manufacturing sector, with the largest shares in the chemicals and transportation equipment industries. Financial services and mining are also important destinations for U.S. investment. U.S.-owned companies operating in Canada are quite diverse (table 15).

Canadian inbound investment in the United States is concentrated in the financial services sector, which accounts for 44 percent of the total when the banking (depository institutions), finance, and insurance segments are included.[28] The largest Canada-based financial services company operating in the United States is Manulife Financial, which operates 33 U.S. affiliates reporting combined operating revenue of $46.7 billion. As of September 2008, Manulife was the world's third largest insurance company by market

[28] However, banking accounts for only 5 percent of Canada's FDIUS position in financial services.

TABLE 14 USDIA and FDIUS position with NAFTA countries, selected industries, 2007

	Canada	Mexico	NAFTA	NAFTA share of U.S. total
	Million dollars			Percent
USDIA				
All industries	257,058	91,663	348,721	12.5
Mining	32,700	4,463	37,163	25.2
Manufacturing total	93,516	22,802	116,318	21.9
Chemicals	13,280	5,222	18,502	15.7
Transportation equipment	20,474	4,985	25,459	39.1
Wholesale trade	18,241	2,761	21,002	11.5
Financial services[a]	48,426	15,420	63,846	14.8
Holding companies	21,798	16,157	37,955	4.1
FDIUS				
All industries	213,224	5,954	219,178	10.5
Mining	([b])	([b])	([b])	([b])
Manufacturing total	43,118	3,339	46,457	6.5
Chemicals	5,820	128	5,948	2.7
Transportation equipment	3,886		3,886	5.9
Wholesale trade	10,177	1,283	11,460	4.1
Financial services	93,240	1,180	94,420	43.4
Holding companies	([b])	([b])	([b])	([b])

Source: USDOC, BEA.

[a] Data for USDIA position in depository institutions in Mexico was suppressed by BEA to avoid disclosing information relevant to individual companies. Therefore, the estimates for the USDIA position in financial services in Mexico and in the NAFTA region are likely underestimated. In 2005 (latest available), the USDIA position in Mexico depository institutions was $17.2 billion.

[b] Not available.

capitalization, and also offers financial services besides insurance. The company operates primarily under the John Hancock brand in the United States, which Manulife acquired in 2003 (Manulife Financial, 2008; and Manulife Financial, 2009). Table 16 shows the Canadian banks active in the United States as of September 2008.

Manufacturing accounts for 20 percent of Canadian FDIUS. Chemicals, computers and electronic products, and transportation equipment are the largest manufacturing segments. Although not all companies report

TABLE 15 Selected U.S.-owned affiliates in Canada, by affiliates' operating revenue, 2009

Affiliate company	Employees	Operating revenue	Global ultimate owner	Primary business
		Million dollars		
3M Canada	2,000	26,296	3M Company	Adhesives and sealants
Imperial Oil	([a])	25,371	Exxon Mobil	Exploration, production, transportation and sale of crude oil, natural gas, and petroleum products
ADM Agri-Industries	24,000	10,340	Archer-Daniels-Midland	Edible fats and oils
Citifinancial Canada	2,460	9,390	Citigroup	Personal credit institutions
Cargill	10,000	6,629	Cargill & Macmillan Families	Grain and field beans
Newmont Mining Corp. of Canada	([a])	5,587	Newmont Mining Corporation	Exploration for and production of gold.
Abitibi-Consolidated Company of Canada	10,000	4,279	Abitibibowater	Paper mills
General Motors of Canada	22,000	4,197	General Motors	Motor vehicles and car bodies
Canadian Ultramar	3,269	3,891	Valero Energy	Fuel oil dealers
Domtar	([a])	3,578	Domtar	Pulp and paper products, and packaging and construction materials
Abitibibowater Canada	([a])	3,547	Abitibibowater	Newsprint, coated and uncoated groundwood papers, bleached kraft pulp and lumber products.
Westcoast Energy	([a])	3,114	Spectra Energy	Integrated natural gas and natural gas liquids company
Citi Financial	5,500	2,843	Citigroup	Short-term business credit
Costco Wholesale Canada	14,500	2,499	Costco Wholesale Corp	Durable goods
Home Depot of Canada	18,000	2,326	Home Depot Inc	Hardware stores
ExxonMobil Canada	1,000	2,311	Exxon Mobil	Crude petroleum and natural gas
ConocoPhillips Canada Resources Corp	1,000	2,312	ConocoPhillips	Crude petroleum and natural gas
Masonite International Inc	10,000	2,201	KKR & Company	Millwork
Union Gas	([a])	2,088	Spectra Energy	Natural gas distribution utility
Devon Canada Corporation	1,000	2,061	Devon Energy	Crude petroleum and natural gas
Best Buy Canada	17,000	2,054	Best Buy	Radio, television, and electronics retail stores

Source: Bureau van Dijk, Orbis database, accessed February 13, 2009.

[a] Not available.

TABLE 16 Canadian-owned banks in the United States, 2008 (million dollars)

Canadian parent bank	Combined assets of U.S. offices
Bank of Montreal	98,562
Bank of Nova Scotia	42,541
Canadian Imperial Bank of Commerce	20,024
La Caisse Central des Jardins du Quebec	334
National Bank of Canada	4,058
Royal Bank of Canada	68,613
Toronto-Dominion Bank	147,176
Total assets	381,308

Source: U.S. Federal Reserve Board, Structure Data for the U.S. Offices of Foreign Banking Organizations, September 30, 2008.

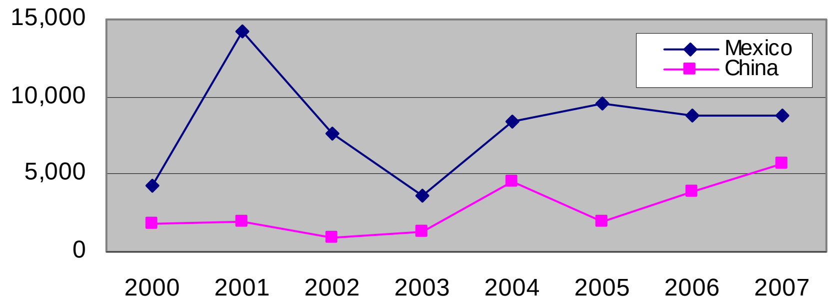
employment figures, the latest estimate for Canadian-owned manufacturing affiliates shows overall employment of more than 138,000 workers (Bureau van Dijk, Orbis database, accessed March 6, 2009). Suncor Energy USA, an affiliate of the Canadian petroleum refining company of the same name, reported operating revenue of $11.1 billion in 2005 (latest available), and employed 625 U.S. workers (Bureau van Dijk, Orbis database, accessed March 6, 2009). Onex Corporation, a diversified holding company manufacturer of electronic components, reports more than 250 U.S. affiliates, with combined operating revenue of $18.7 billion.[29] Onex has interests in a variety of manufacturing industries, including electronic parts, aircraft, and auto parts. The company also has invested in service industries including healthcare, consulting, and financial services (Onex, 2009). Magna International controls approximately 30 U.S. affiliates, mostly in the auto parts industry. Magna's U.S. affiliates reported combined operating revenue of $2.4 billion in the latest reporting year (Bureau van Dijk, Orbis database, accessed March 6, 2009).

Mexico

The USDIA position in Mexico was valued at $91.7 billion in 2007, far more than any other developing country, and increased at a CAGR of 12.8 percent during 2000–2007. Even though many observers of recent FDI trends have remarked on the rapid growth of U.S. FDI in China, it is interesting to note that U.S. capital outflows to Mexico have been consistently higher than outflows to China since 2000 (figure 13). Most U.S. investment in Mexico is concentrated in manufacturing, particularly chemicals and transportation equipment; holding companies; and financial

[29] Actual combined operating revenue for Onex affiliates in the United States is likely to be significantly larger, because many affiliates do not report operating revenue.

Figure 13 USDIA capital outflows to Mexico and China, 2000-2007



Source: USDOC, BEA.

services. However, the fastest growing industries receiving U.S. investment were in the information and mining sectors, due to several large acquisitions by U.S. firms during the period. In mining, by far the largest transaction was Southern Peru Copper Corporation's acquisition of Minera Mexico for $2.9 billion in 2005.[30] In the information sector, several U.S. acquisitions of Mexican firms contributed to the rapid USDIA growth rate (table 17).

TABLE 17 Selected U.S. acquisitions of Mexican information industry companies, 2000–2007

Acquirer	Target	Deal value	Date completed	Description
		Millions		
Onex Corporation	Grupo Cinemex SA de CV	284.7	6/19/2002	Onex (Canada) and Oaktree Capital Mgmt (US) acquired a chain of cinemas
Turner Broadcasting System Inc.	Fashion TV	235.0	10/4/2007	Acquisition of 7 Latin American television channels
American Tower Corporation	NII Holdings Inc.'s 535 communication towers in Mexico	100.0	12/31/2004	Acquisition of 535 communication towers
Time Inc.	Grupo Editorial Expansión	[a]100.0	8/16/2005	Acquisition of Mexican magazine company

Source: Bureau van Dijk, Zephyr database, accessed April 3, 2009.

[a] Estimated value.

[30] In spite of its name, Southern Peru Copper Corp. was established in the United States in 1952. The company changed its name to Southern Copper Corp. (SCC) in 2005, after the Minera acquisition. Since 1999, Grupo Mexico S.A.B. has owned a majority share of SCC (SCC, 2009; and SCC, 2009).

The FDIUS position from Mexico was $6.0 billion in 2007, significantly smaller than from Canada, but higher than for most other developing countries. The largest investment shares are in primary and fabricated metals manufacturing ($1.3 billion), wholesale trade ($1.3 billion), and depository institutions ($1.1 billion). FDIUS in metals primarily reflects a 2005 acquisition of Republic Engineered Products, a producer of special bar quality (SBQ) steel, operating U.S. plants in Ohio, New York, and Indiana.[31] There are a number of Mexico-owned wholesale trade companies in the United States. Prominent among them are several affiliates of Cemex, the Mexican cement company, and Vitro, a Mexican glass manufacturer whose U.S. affiliates are primarily involved in construction-related industries (Bureau van Dijk, Orbis database, accessed March 6, 2009). Two Mexico-owned banks, Banorte and BBVA Bancomer, account for most Mexican FDIUS in the banking industry.[32]

Latin America and the Caribbean[33]

Latin America and the Caribbean accounted for 14 percent of USDIA in 2007 ($380.3 billion), compared with 3 percent of FDIUS ($57.0 billion). The largest industries for USDIA were holding companies and financial services, with $180.8 billion and $123.9 billion, respectively.[34] The USDIA position is concentrated in the British Islands in the Caribbean and in Bermuda, which together accounted for 9 percent of the overall USDIA position. These and other Caribbean countries are significant domiciles for holding companies established by U.S.-based corporations, largely for tax purposes. The majority of the funds invested there are later reinvested in operating affiliates in third countries. Aside from its holding company operations, Bermuda has become an important destination for investment in the insurance industry. Other leading industries for USDIA position in Latin America were manufacturing ($5.7 billion) and mining ($4.7 billion).

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[31] The acquirer was Industrias CH (Industrias CH, 2009; and data accessed March 6, 2009 from Bureau van Dijk, Orbis database.

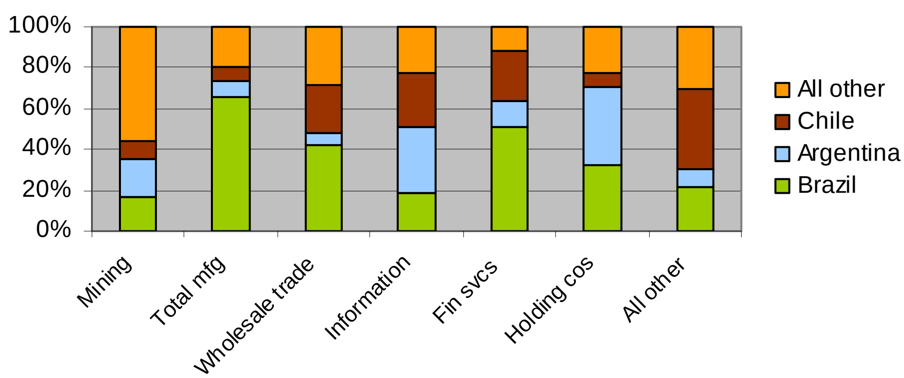
[32] BBVA Bancomer is in turn a subsidiary of BBVA, based in Spain (U.S. Federal Reserve Board, 2008).

[33] Excludes Mexico, which is included with the NAFTA region.

[34] Excludes USDIA in depository institutions (banks), which was suppressed by BEA to avoid disclosure of individual company information.

The three largest destinations for overall U.S. investment in South America were Brazil, Argentina and Chile, with Brazil attracting the largest share of USDIA in most industries (figure 14), although both Chile and Argentina are larger destinations than Brazil for U.S. investment in the information sector.[35] Peru and Colombia accounted for most U.S. investment in the region's mining sector, with $4.7 billion (20 percent) and $2.1 billion (9 percent), respectively. Other mining destinations for U.S. investment in the region include the U.K. Islands in the Caribbean ($3.0 billion), Argentina ($2.9 billion), Brazil ($2.6 billion) and Colombia ($2.1 billion).

Figure 14 USDIA position in leading South American countries, 2007



Source: USDOC, BEA.

In Peru, mining activity by U.S.-owned firms is a mix of gold, other nonferrous metals, non-metallic mining, and petroleum and natural gas activity. In Colombia, U.S. firms are active in coal mining and petroleum. The U.K. Islands, including the Cayman Islands and the British Virgin Islands, are not the center of significant mining industry activity. Instead, they host a number of firms that provide oil and gas field services, or oil exploration services that operate around the world, but are legally based in the islands, presumably for tax purposes. In Argentina, most mining investment is in the petroleum sector. Exxon Mobil's affiliate is the largest U.S. company in Argentina, by operating revenue. In Brazil, U.S. companies are involved in oil and gas production, as well as iron ore, coal, and mining of other metals (Bureau van Dijk, Orbis database, accessed January 8, 2009).

[35] The information sector includes publishing, motion picture and sound recording, broadcasting, telecommunications, and internet and data processing services.

The U.K. Islands and Panama are by far the largest sources of inbound U.S. investment from the region, with FDI positions of $32.8 billion and $12.9 billion, respectively. Venezuela exhibited the fastest growth rate for FDIUS from Latin America, with a CAGR of 34 percent from 2000–2007. There is only limited available information on the industry distribution of FDIUS from the region, as much of the data are suppressed to avoid disclosing information of individual companies. The largest industry recipients of U.S. investment from Latin America are real estate ($9.7 billion), finance and insurance ($7.4 billion), and wholesale trade ($7.4 billion).[36] Separate data regarding the industry distribution of FDIUS from the U.K. Islands, Panama, and Venezuela are not available.

Brazil

After several years of steadily increasing U.S. investment in Brazil, total USDIA was $41.6 billion in 2007. U.S. investment in Brazil is strongest in manufacturing ($22.1 billion), of which the largest share is in the chemicals industry ($5.8 billion). U.S. investors also have an investment position of $8.8 billion in Brazilian financial services firms, including banks. Recent capital flows to Brazil were most prominent in the manufacturing industry, particularly the transportation equipment segment in 2007. Table 18 shows some of the leading U.S.-owned companies in Brazil, by operating revenue, illustrating the diversity of USDIA in that country.

The Brazilian investment position in the United States is comparatively quite small, valued at less than $1.4 billion in 2007. Of this, 36 percent is invested in depository institutions, primarily Banco do Brasil and Banco Bradesco, whose U.S. assets totaled $3.7 million and $2.3 million, respectively, in September 2008 (U.S. Federal Reserve Board, 2008).

Africa and the Middle East

Africa and the Middle East accounted for the smallest shares of both outbound and inbound U.S. investment in 2007, with 1 percent each. For USDIA, the largest industry is mining, including petroleum (figure 15), which was valued in 2007 at $7.0 billion in the Middle East and $12.6 billion in Africa. U.S. investors also held $13.9 billion in the region's manufacturing sector. Of that amount, $10.7 billion was invested in the

[36] FDIUS in real estate includes Mexico, because separate data for Mexico are not available.

TABLE 18 Leading Brazilian affiliates of U.S. parents, 2007

Affiliate company	Employees	Operating revenue	Global ultimate owner	Primary business
		Million dollars		
Cargill Agrícola	24,423	5,314.6	Cargill	Soybean oil mills
Energia Paulista Participacoes	([a])	4,941.1	AES	Energy distribution
AES Elpa	([a])	4,099.5	AES	Security brokers and dealers
Eletropaulo Metropolitana Eletricidade De Sao Paulo	([a])	4,065.9	AES	Electricity production and transmission
Brasiliana Energia	([a])	3,819.5	AES	Electricity production and transmission
Chevron Brasil	940	3,196.8	Chevron	Petroleum products
Whirlpool	([a])	3,154.7	Whirlpool	Manufacture of electronics and home appliances
Brasmotor	([a])	2,164.6	Whirlpool	Manufacture of electronics and home appliances
Banco Citibank	([a])	1,385.0	Citigroup	Commercial Bank
Alcoa Alumínio	4,277	1,272.7	Alcoa	Aluminum production
Dupont Do Brasil	1,070	1,262.5	Dupont	Manufacture of man-made, organic fibers
Seara Alimentos	20,000	1,073.0	Cargill	Meat packing plants
Futuretel and Mem Celular Participacoes	([a])	1,054.2	Citigroup	Security brokers and dealers
White Martins Gases Industriais	6,000	1,041.9	Praxair	Manufacture of industrial gases

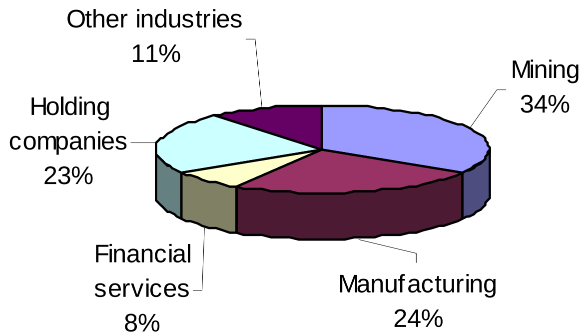
Source: Bureau van Dijk, Orbis database, accessed February 13, 2009.

[a]Not available.

Middle East, of which $6.4 billion was invested in Israel, primarily in the computer and electronics industry. However, the number of U.S. investment projects in Africa's manufacturing sector has been increasing in recent years (figure 16).[37]

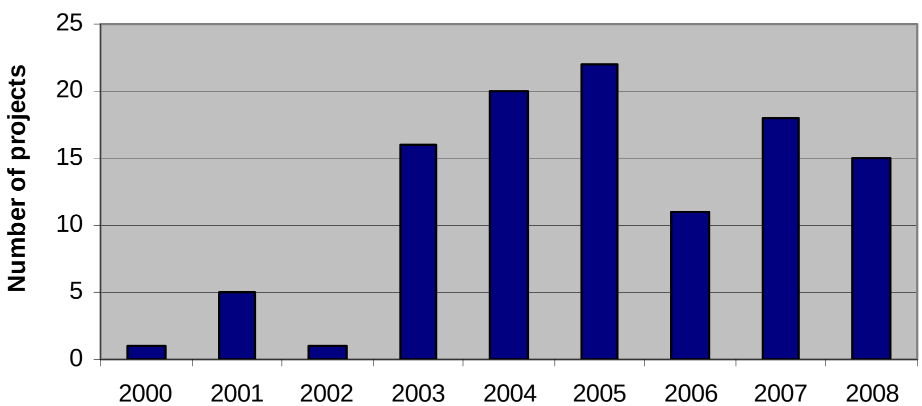
[37] Includes both acquisitions of African companies by U.S. firms and greenfield FDI projects by U.S. companies in Africa. Does not include Middle Eastern countries. Data for 2008 in-

Figure 15 Africa and Middle East, USDIA position by industry, 2007



Source: USDOC, BEA.

Figure 16 U.S. manufacturing investment in Africa, number of greenfield projects and acquisitions, 2000-2007



Source: Bureau van Dijk, Zephyr database, and FDI markets database, accessed September 4, 2008.

The total FDIUS position from Africa and the Middle East was $14.1 billion in 2007. More than one-third ($5.3 billion) originated in Israel, of which $1.9 billion was directed to the U.S. manufacturing sector. In 2006, Africa and the Middle East held an FDIUS position of $1.7 billion in depository institutions, although the data was suppressed for 2007 to avoid disclosing information about particular companies. However, in 2007, investors based in Kuwait and the United Arab Emirates each invested over $800 million in the U.S. banking industry, with data suppressed for Saudi Arabia. Private individuals, corporations, and public investors (through sovereign wealth funds) have all invested large amounts in U.S. banks and securities firms in recent years. For example, the Abu Dhabi Investment Authority invested $7.5 billion in late 2007 to acquire a 4.9 percent equity stake in Citigroup, following three separate investments in 2002 from Saudi Arabia in the same bank, totaling $1.5 billion. Including the Citigroup deal, investors from the UAE acquired equity stakes valued at more than $12.5 billion in U.S. financial services companies between 2006 and August 2008 (Bureau van Dijk, Zephyr database).

Key FDI Terms

- **Direct investment**: Investment in which a resident of one country obtains a lasting interest in, and a degree of influence over the management of a business enterprise in another country, defined as ownership of at least 10 percent of the voting securities of an incorporated foreign business enterprise or the equivalent in an unincorporated foreign business enterprise.

- **Direct investment capital flows** arise from transactions in financial claims and liabilities between U.S. parents and their foreign affiliates, or between U.S. affiliates and their foreign parents. For outward direct investment, capital flows include the funds that U.S. direct investors pay to unaffiliated foreign parties when affiliates are acquired from them and the funds that U.S. investors receive from them when their affiliates are sold. Similarly, inward direct investment capital flows include the funds that foreign investors pay to unaffiliated U.S. residents when affiliates are acquired from them and the funds that foreign investors receive from them when their affiliates are sold. Direct investment capital flows consist of equity capital investment, intercompany debt investment, and reinvested earnings. (Add the definitions for these components here?)

- **Foreign affiliate** – A foreign business enterprise in which a single U.S. investor (a U.S. parent) directly or indirectly owns at least 10 percent of the voting securities, or the equivalent.

- **U.S. affiliate** – A U.S. business enterprise in which a single foreign investor (a foreign parent) owns at least 10 percent of the voting securities, or the equivalent.

- **Direct investment position (stock)** – The value of direct investors' equity in, and net outstanding loans to, their affiliates.

- **U.S. Direct Investment Abroad (USDIA or outward direct investment)** – The ownership or control, directly or indirectly, by one foreign resident of at least 10 percent of voting securities of an incorporated foreign business enterprise or the equivalent.

- **Foreign Direct Investment in the United States (FDIUS or inward direct investment)** – The ownership or control, directly or indirectly, by one foreign resident of at least 10 percent of the voting securities of an incorporated U.S. business enterprise or the equivalent interest in an unincorporated U.S. business enterprise.

Source: USDOC, BEA, Survey of Current Business, July 2008, 27.

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Developments in the Sourcing of Raw Materials for the Production of Paper

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Abstract

During the past decade, there have been major changes in the trade flows of the raw materials (pulp logs, wood chips, pulp, and recovered paper) used to make paper. These changes have been driven primarily by the growth of the paper industry in China, the emergence of new suppliers of wood raw materials, and the increased importance of recovered paper as a raw material for the production of paper. China's paper industry has grown rapidly in the past 10 years, and its output now trails only that of the United States. China, however, lacks the raw materials to support much of its papermaking capacity and thus has become increasingly dependent upon imports of wood pulp, recovered paper, and wood chips. New suppliers of pulp, wood chips, and pulp logs have emerged in recent years as paper producers have looked for cheaper sources of fiber. These new suppliers, Brazil, Chile, Indonesia, Australia, Vietnam, and Russia, have become increasingly important exporters of wood raw materials. Recovered paper that is repulped and made into new paper has become an important complement to virgin fiber for papermakers throughout the world; consequently, recycling rates for recovered paper have risen in many developed countries. Some of the significant changes in the trade flows of the raw materials used to make paper include large increases in Chinese imports of recovered paper and pulp, increased exports of wood chips from Australia, Brazil, and Vietnam, and rising Russian exports of wood chips and pulp logs to Scandinavia.

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Introduction

Over the past decade, there have been some significant changes in the international flows of the raw materials (pulp logs, wood chips, pulp, and recovered paper) used to make paper. These changes have been driven primarily by the growth of the paper industry in China, the emergence of new suppliers of wood raw materials, and the increased importance of recovered paper as a raw material for the production of paper.

This article will briefly describe recent trends in regional paper production and consumption to help the reader better understand the global environment within which these changes in trade flows of raw materials have occurred. The article then describes the development of a large and modern paper industry in China and the industry's consequent dependence upon imported raw materials. The next section covers new country suppliers of wood raw materials, followed by a discussion about the paper industry's increased use of recovered paper. Then, changes in the international flows of the raw materials used to make paper caused by these three developments are described. The article concludes with a discussion of the effect of the global recession on these trends and the outlook for the future.

Recent Trends in Regional Paper Production and Consumption

North America and Europe have traditionally been the major centers for the production and consumption of paper products such as newsprint, printing and writing papers, tissue, linerboard and corrugating medium (to make corrugated containers), and cartonboard (to make folding cartons).[2]

[2] Pulp logs, wood chips, pulp, and recovered paper are the raw materials used to make these paper products. Pulp logs are wood destined to be made into pulp. To make paper, trees are harvested, debarked, and chipped. At a pulp mill, the wood chips are converted into pulp, the intermediate product in the production of paper, by a chemical or mechanical process. Pulp (virgin fiber) is then processed into paper on a paper machine. Sawmills generate large amounts of residual wood chips in the production of lumber. These residual wood chips are also used to make pulp. Recovered paper, which typically consists of old newspapers, magazines, and catalogues, mixed office wastepaper, corrugated containers, and folding cartons, can be repulped (secondary fiber) and used to make new paper.

However, their predominance, particularly that of North America, has been eroded in recent years by the rapid growth in paper production and demand in other regions of the world, particularly in Asia. Fast-growing economies in these areas stimulated domestic demand for all the major grades of paper, and significant papermaking capacity was built within these areas to supply this demand (Stora Enso 2006, 6, 8, and 14–15). Between 1997 and 2007, production of paper in Asia increased by 76 percent and Asia's share of world paper production rose from 29 percent to 38 percent. Paper production in Latin America grew by 40 percent between 1997 and 2007, although the region's share of world paper production was unchanged at 5 percent. By contrast, production of paper in North America declined by 4 percent during the period, and the region's share of world paper production fell from 35 percent to 26 percent. Similar trends in the consumption of paper occurred during this period (Pulp & Paper International 1998; RISI, Inc. 2008).

Growth of the Paper Industry in China and Its Increasing Dependence Upon Imported Raw Materials

Traditionally, China's paper industry consisted of thousands of paper mills, typically integrated with pulp production, scattered about the country. The fiber to make the paper came mostly from domestic agricultural residues such as wheat straw, bagasse, and reed rather than from wood, which is the source of fiber for papermaking in most countries. The capacity of many of these mills was very small, the paper-making equipment outdated, and the quality of paper poor. Although China's aggregate paper production was sizeable, it was intended primarily for the domestic market. Lacking wastewater treatment facilities, these mills were also major contributors to the pollution of rivers, lakes, and bays (He and Barr 2004, 262; USITC 1999, 5–44).

Within the past two decades, however, major changes have occurred in China's paper industry. The Chinese government closed thousands of state-owned paper mills (and adjoining pulp mills), reportedly to reduce water pollution. Chinese provinces also took steps in this regard. For example, the provinces of Shandong, Henan, Jiangsu, and Hunan shut down hundreds of mills (RISI 2007). Many other mills shut down due to competitive pressures from imported paper and from growing domestic demand for higher quality paper (White et al. 2006, 4). Nonetheless, many of these older paper mills remain in business and continue to account for a sizeable portion of China's aggregate paper production. Their output serves primarily low-end domestic demand.

Concurrent with the decline in capacity of the old paper mills has been rapid and significant growth in new papermaking capacity, driven by the desire of the Chinese government to modernize the paper industry as well as by foreign investment by paper companies eager to participate in China's expanding market for paper.[3] This new capacity consists principally of mills with large, modern papermaking machines using wood fiber, rather than fibers from agricultural residues. Many of these machines are among the fastest and most technologically advanced in the world, and their output serves high-end domestic demand and export markets (Flynn 2006).[4] Within the past six years, China has accounted for more than one-half of all the new orders placed worldwide for paper machines (Metso 2006, 30).[5] The paper industry in China thus consists of a mix of small, old mills and new, modern mills. In some paper mills, old paper machines make paper alongside new paper machines (Rooks 2005, 25–27). Annual output from the new paper machines has likely surpassed that from the old paper machines.

The growth in China's paper capacity and production over the past decade, and particularly within the past several years, has been remarkable. This growth is even more noteworthy given the closure of so many paper mills during the same period. The magnitude of these increases, on both an absolute and relative basis, can be gauged by a comparison with the changes in capacity and production for other major paper producers and worldwide (tables 1 and 2). Between 2002 and 2007, China's paper capacity rose by 78 percent (35 million metric tons) compared with an increase in paper capacity for the rest of the world of just 3 percent (9.5 million metric tons). As a percent of world paper capacity, China's capacity rose from 12 percent to 19 percent.[6] By contrast, the United States and

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[3] China's booming economy created strong demand for paper. Chinese paper consumption rose rapidly during the past decade, and in 2007 China lagged only the United States in paper consumption (RISI, Inc. 2008).

[4] The world's largest coated mechanical paper machine and three of the world's five largest coated freesheet paper machines are located in China. Coated mechanical and coated freesheet are major grades of printing and writing paper (RISI, Inc. 2006, 205).

[5] By contrast, in the United States, there have been very few orders for new paper machines in the past six years.

[6] The growth in China's wood pulp capacity has lagged the growth of its paper capacity during the past decade (*Pulp & Paper International* 1998; RISI, Inc. 2008).

TABLE 1 Paper: Capacity for selected countries and the world, 2002 and 2007

Country	2002	2007	% change, 2002–07	% share of world total	
				2002	2007
	Thousand metric tons				
United States	93,577	88,044	–6	24	21
China	45,000	80,000	78	12	19
Japan	34,296	33,809	–1	9	8
Germany	20,634	24,014	16	5	6
Canada	21,377	18,800	–12	6	4
Finland	14,870	15,215	2	4	4
All countries, except China	338,431	347,972	3	88	81
World	383,431	427,972	12	100	100

Sources: *Pulp & Paper International* 2003; RISI, Inc. 2008.

Japan experienced declines in capacity in absolute and relative terms during this same period. China's paper production almost doubled between 2002 and 2007, while production in the rest of the world rose by only 10 percent. Within a few years, China will likely surpass the United States to become the world's largest paper producer.

China's demand for imported fiber has historically been very small because, as mentioned earlier, its paper industry relied upon domestically produced pulp made from agricultural residues such as wheat straw and reed (nonwood pulp) and, to a lesser extent, the repulping of domestic recovered paper. However, China's modern paper capacity is designed to run on pulp made from wood and recovered paper, not from agricultural residues, and consequently the composition of the fiber consumed by China's paper industry has changed over the past several years. The percentage share of total fiber consumed that is accounted for by domestically produced nonwood pulp and domestic recovered paper has fallen, while the percentage share of imported wood pulp, imported recovered paper and imported wood has risen sharply (Stafford 2007, 18).

TABLE 2 Paper: Production for selected countries and the world, 2002 and 2007

Country	2002	2007	% change, 2002–07	% share of world total 2002	% share of world total 2007
	Thousand metric tons				
United States	80,871	83,559	3	25	21
China	37,800	73,500	94	11	19
Japan	30,674	31,266	2	9	8
Germany	18,526	23,180	25	6	6
Canada	20,078	17,371	–13	6	4
Finland	12,776	14,335	12	4	4
All countries, except China	292,904	320,760	10	89	81
World	330,704	394,260	19	100	100

Sources: Pulp & Paper International 2003; RISI, Inc. 2008.

The shift in these shares signifies that China's paper producers have become increasingly dependent upon imports of the raw materials used to make paper.[7]

New Suppliers of Wood Chips, Pulp Logs, and Pulp

New suppliers of wood chips, pulp logs, and pulp have emerged in recent years as paper producers in developed countries have looked for alternative and cheaper sources of fiber. China's growing demand for fiber has also stimulated the development of new sources of fiber. A few countries took advantage of their natural forests to expand their exports of

[7] To reduce its dependence on imported wood fiber, China has established fast-growing tree plantations in four regions of the country. By 2015, these plantations are planned to cover almost 6 million hectares of land. The wood from these plantations supplies several large wood pulp mills that have been built in China in the past several years. However, problems involved in the development of these plantations, including insufficient productive land, rising labor costs, and antiquated infrastructure, suggest that the goal of 6 million hectares is unattainable and that the relatively high cost of the wood from these plantations may place the Chinese wood pulp mills at a competitive disadvantage compared with imported pulp (Barr and Cossalter 2006).

wood chips, pulp logs, and pulp. In most cases though, new country suppliers developed vast tree plantations, the fiber from which is intended primarily for export markets in the form of wood chips and/or pulp. The development of tree plantations became a way for countries with plentiful land and a climate conducive to fast-growing tree species to become competitive suppliers of fiber. Harvesting tree plantations, rather than harvesting natural forests, also lessened the environmental pressures associated with forestry activities.

Brazil

With abundant land and an ideal climate, Brazil has developed large eucalyptus plantations and become a major exporter of pulp and, to a lesser extent, wood chips. Although eucalyptus farming began in Brazil in the early 20th century, up until the 1960s, the amount of land planted with eucalyptus was small and the wood was used for purposes other than pulp and paper.[8] In the mid-1960s, eucalyptus planting expanded rapidly due to Brazilian government tax incentives and increased awareness that eucalyptus was well suited for pulp and paper (Suzano Pulp and Paper 2009). Currently, eucalyptus plantations occupy approximately 3.9 million hectares and are located principally in the south and southeastern regions of the country (USDA 2007d, 3).[9] Annually, 500,000 hectares of eucalyptus are planted in Brazil (Patrick 2008, 15). Growth rates, and hence the productivity, of eucalyptus in Brazil far surpasses that of trees in many other areas of the world. For example, Brazilian eucalyptus grows roughly seven times faster than trees in Scandinavia (Stora Enso 2007, 65). It also grows much faster than the native species in Brazil (Aracruz Celulose 2009). Eucalyptus pulp imparts certain beneficial characteristics to paper that make it especially well suited for the production of printing and writing papers and tissue.

There are several large producers of eucalyptus pulp in Brazil. Their pulp mills are sizeable and rival or surpass pulp mills in North America and Europe, and most of their pulp output is exported. These producers source their eucalyptus primarily from their own eucalyptus plantations, which are immense and located in various Brazilian states. One firm has 231,000 hectares of eucalyptus plantations, and another has 286,000 hectares. These pulp producers also source some eucalyptus from small independent

[8] Eucalyptus is native to Australia; it was brought to Brazil in 1825 as an ornamental plant (Suzano Pulp & Paper 2009).

[9] A large volume of eucalyptus from plantations continues to be used by various forest products industries in Brazil.

landowners who have contracted to grow eucalyptus on their land (Aracruz Celulose 2009; Suzano Pulp and Paper 2009; Votorantim Group 2009).

Foreign paper producers have invested in eucalyptus plantations and pulp mills in Brazil to access this fast-growing fiber. Stora Enso, a large Nordic pulp and paper producer, has a joint venture with a Brazilian pulp producer that involves a 50 percent ownership of a pulp mill and ownership of eucalyptus plantations (Stora Enso 2007, 61). Oji Paper Company, a Japanese pulp and paper producer, has an ownership interest in Brazilian eucalyptus plantations and a pulp mill (Oji Paper Co., Ltd. 2009).

Brazil's pulp capacity and production have grown rapidly in the past decade. Pulp production almost doubled during this period, from 6.3 million metric tons in 1997 to 12.1 million metric tons in 2007 (*Pulp & Paper International* 1998; RISI, Inc. 2008). By virtue of this growth, Brazil has become an increasingly important global supplier of market pulp.[10]

To enhance this position in the future, Brazilian pulp firms have ambitious plans to continue to expand their production capacity and associated eucalyptus plantations.[11]

Chile

Chile's development into a sizeable pulp and wood chip exporter has similarities to that of Brazil, albeit on a smaller scale. Chile also has plentiful land and a climate conducive to fast-growing tree species. Originally, radiata pine plantations were developed because radiata pine grows much quicker in Chile than in northern hemisphere countries. Radiata pine matures in Chile within 20–24 years, compared with 30 years in Australia and 40–60 years in North America and Europe. On average, 70,000 hectares of radiata pine are planted each year. In the late 1980s, eucalyptus plantations were started in Chile as the Chilean climate and soil are also very conducive to this tree species. In the past few years, planting of eucalyptus has surpassed that of radiata pine. In Chile, eucalyptus can be harvested within 10 to 15 years. As of year end 2006, Chile had 2 million hectares of plantations in various regions of the country, consisting of 1.4

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[10] Roughly one-quarter of global wood pulp production is sold in the open market (market pulp); the remainder is consumed by producing firms in the production of their own paper (RISI, Inc. 2006, 89).

[11] Over the past decade, Brazil has also grown its eucalyptus wood chip industry and increased its exports of eucalyptus wood chips, primarily to pulp mills in Japan.

million hectares of radiata pine and 600,000 hectares of eucalyptus (USDA 2007c, 4; CMPC 2009).

Chile has two major pulp producers, each with multiple pulp mills. These mills are large and produce pulp from radiata pine and eucalyptus. Most of the pulp production is exported. The two firms source their wood primarily from their own radiata pine and eucalyptus plantations but also from the plantations of smaller landowners. One firm has 722,000 hectares of radiata pine and eucalyptus plantations in Chile; the other has 449,000 hectares of plantations. One of the producers also has plantations in Argentina, while the other producer maintains plantations in Argentina, Brazil, and Uruguay (CMPC 2009; Arauco 2009).

Chilean pulp capacity and production have expanded during the past decade. Pulp production more than doubled, from 2 million metric tons in 1997 to 4.7 million metric tons in 2007 (*Pulp & Paper International* 1998; RISI, Inc. 2008). This growth has enabled Chile to become a more important supplier of pulp to foreign markets such as China, Italy, South Korea, and the Netherlands. Both of the major Chilean pulp producers have the potential to increase pulp capacity and production in the coming years.

Chile's plantations are a source of wood chips not only for Chilean pulp mills, but also for export. Chile's wood chip production from radiata pine and eucalyptus has increased steadily over the past decade, and in 2006 nearly half of this production was exported. Chile has numerous wood chipping facilities, primarily located in the central part of the country. More than 90 percent of wood chip exports are eucalyptus, and virtually all wood chip exports go to Japan as raw material for pulp mills (USDA 2007c, 11). One large Japanese pulp and paper producer has invested in tree plantations in Chile as a means to procure wood chips for its mills (Nippon Paper Group 2009).[12]

[12] Uruguay has begun to follow a path similar to that of Brazil and Chile. Fast-growing eucalyptus plantations have been developed in Uruguay, including plantations developed by Nordic pulp and paper producers. Some of the eucalyptus is exported in the form of wood chips. In late 2007, a new pulp mill with an annual capacity of 1 million tons of eucalyptus pulp began operations. Built at a cost of $1.2 billion by a Finnish pulp producer, the mill sources eucalyptus from its own plantations and that of independent Uruguayan landowners. The mill's output is exported (Botnia 2009; Flynn 2008, 6).

Indonesia

With vast natural forests and the development of tree plantations, Indonesia has become an increasingly important supplier of pulp and wood chips, particularly to other Asian countries. Mixed tropical hardwoods logged in Indonesia's natural forests traditionally had been the source for this wood fiber. In the past three decades, however, these forests have come under tremendous pressure from illegal logging, excessive logging by legitimate companies, and the conversion of forested areas into oil palm tree plantations. Deforestation occurred at an estimated rate of 1.6 to 2.0 million hectares per year (Barr 2007). In response, the Indonesian government, among other things, took steps to encourage the development of fast-growing tree plantations and thus reduce the pressure on the natural forests. Acacia, a hardwood species that matures in seven years, is the principal species on the plantations developed for pulp logs, though eucalyptus was also planted. The Indonesian government's plantation efforts have reportedly had some success. In October 2006, the Indonesian Ministry of Forestry announced that tree plantations for pulp logs covered an area of 1.8 million hectares. There is, however, some evidence suggesting that the actual commercial area of these plantations is considerably smaller (Barr 2007).

Indonesia has several major pulp producers with almost all of their pulp mills located on the island of Sumatra. Two of these producers account for more than 75 percent of total Indonesian pulp capacity (Barr 2007). Indonesian producers obtain their wood from government-granted land concessions, which consist of natural forests and plantations that the producers have developed on formerly forested land. They also obtain wood from joint ventures with other landowners (APRIL 2009). Indonesia's two largest pulp producers have increased pulp capacity faster than plantation development. Consequently, although they hope to eventually source all of their wood from plantations, they currently obtain much of it from natural forests (Barr 2007).

Pulp capacity and production in Indonesia have experienced strong growth during the past decade; pulp production almost doubled, from 3 million metric tons in 1997 to 5.8 million metric tons in 2007 (*Pulp & Paper International* 1998; RISI, Inc. 2008). Pulp is consumed domestically in the production of paper and also exported, principally to Asian countries.

Indonesia has recently expanded its capacity to export wood chips. In late 2008, a new export facility for acacia wood chips opened on the east coast of the province of Kalimantan (Flynn 2008, 6). Although the volume of

Indonesia's wood chip exports is considerably smaller than the wood chip exports of Chile and Australia, Indonesia's exports have increased in importance in some Asian countries. One large Japanese firm has invested in both acacia plantations and a pulp mill in Indonesia to take advantage of the country's forest resources (Marubeni Corporation 2009).

Australia

By virtue of its large areas of natural forest and expanding tree plantations, Australia is the world's largest exporter of wood chips for pulp and papermaking. Unlike Brazil, Chile, and Indonesia, however, Australia has not developed a large export-oriented pulp industry. Australia has an estimated 163 million hectares of natural forest, over one half of which are located in the state of Queensland and the Northern Territory. Three quarters of the natural forest is on public land and one quarter is on private land. Three-quarters of the natural forest consists of eucalyptus (Australian Bureau of Statistics 2009).

The amount of land dedicated to tree plantations has risen steadily over the past three decades, and, at year end 2006, totaled 1.8 million hectares. Softwood trees, primarily radiata pine, accounted for 55 percent of this total; hardwood trees, primarily eucalyptus, comprised the remainder. The composition of these plantations has changed over time, with very little growth in softwood plantations over the past decade but a rapid increase in the land planted with hardwood trees. In 1999, the area of publicly-owned plantations and the area of privately-owned plantations were roughly equal. Since then, most of the investment in new plantations, particularly in hardwood plantations, was from the private sector. Although wood chips are obtained from both natural forest and plantations, the proportion sourced from plantations has increased in the past several years (Australian Bureau of Statistics 2009).

Japan's two largest paper producers, heavily dependent upon imported wood chips for their pulp mills, have turned to Australia as an important supplier. One of these producers obtains roughly one half of its hardwood and softwood chips from Australia. Both Japanese firms procure wood chips in Australia from unrelated wood chip suppliers and from their own plantations. One firm developed three tree plantations totaling 34,000 hectares, while the other developed several tree plantations totaling 78,000 hectares. Both producers have plans to expand their tree plantations in Australia (Oji Paper Co., Ltd. 2009; Nippon Paper Group 2009).

The pulp industry in Australia is small and its output is primarily for the country's own paper producers. Between 1997 and 2007, Australia's pulp production rose from 914,000 metric tons to 1.2 million metric tons, a gain of only 280,000 metric tons (*Pulp & Paper International* 1998; RISI, Inc. 2008). Although there have been some industry announcements of large new pulp mills planned for Australia in the past few years, none of these projects has moved beyond the planning stage. So for the immediate future, Australia's wood chips will continue to flow largely into export markets (Flynn 2008, 6).

Vietnam

Vietnam has emerged as an important producer of wood chips in the past several years. The country's pulp industry, though, is small, and consequently most of the wood chips are exported, primarily to Japan and China. The growth in exports was facilitated by the construction of wood chipping plants and port infrastructure (RISI, Inc. 2006, 86). Vietnam's natural forest area increased steadily between 2002 and 2006, from 9.9 million hectares to 10.4 million hectares; tree plantations grew at a faster pace during this period, from 1.9 million hectares to 2.5 million hectares. Tree plantations consist principally of acacia and eucalyptus. The Vietnamese government limits harvesting in the natural forest so plantations are the primary source for wood chips. In 2007, the government began to implement its Forestry Development Strategy, which envisions, among other goals, the continued development of tree plantations (USDA 2007b, 3, 10). Foreign investment in tree plantations in Vietnam may also occur in the future. One Japanese paper producer has developed a 10,000 hectare tree plantation in the country (Oji Paper Co., Ltd. 2009).

Russia

In recent years, Russia has taken greater advantage of its vast forest resources by increasing its exports of pulp logs, wood chips, and pulp. With a total forest area of approximately 850 million hectares, Russian forests account for one-fifth of the world's forested area; however, much of the forested area is in inaccessible regions of the country. Russian forests contain many species of both softwood and hardwood trees. Although the annual volume of logging in Russia is large, it is still considerably below the government's total allowable annual volume of logging (USDA 2007a, 3).

Russia has expanded its exports of pulp logs and wood chips in the past decade to Scandinavia, the location of many pulp mills. These exports consisted primarily of pulp logs, which were processed into wood chips after importation. Two Finnish pulp and paper producers lease and manage forested areas in Russia from which they source wood. One of the producers leases/manages 669,000 hectares of forest, while the other leases/manages 184,000 hectares (Stora Enso 2007, 61; UPM-Kymmene Corporation 2007, 33).

Russian pulp capacity and production have also risen during the past decade. Russian pulp production almost doubled between 1997 and 2007, from 3.9 million metric tons to 7.4 million metric tons (*Pulp & Paper International* 1998; RISI, Inc. 2008). Increased pulp production was exported and also consumed domestically by Russian paper mills. A U.S. pulp and paper producer recently expanded the pulp capacity at its existing mill in Russia, and two Finnish pulp and paper producers announced plans to invest in pulp capacity in Russia (International Paper 2007; Stora Enso 2009; UPM-Kymmene Corporation 2009).

In an effort to stimulate greater domestic and foreign investment in wood processing facilities in Russia, the Russian government in early 2007 announced export tax increases on softwood and hardwood logs. The export tax on softwood logs rose to 20 percent on July 1, 2007, to 25 percent on April 1, 2008, and was scheduled to increase again to 80 percent on January 1, 2009. Export taxes on certain hardwood logs were also scheduled to increase to 80 percent on January 1, 2009 (Van Leeuwen 2007, 1, 4-5). However, in November 2008, the Russian government, noting the global economic crisis and pressure from Scandinavian countries dependent on Russian log exports, announced that the scheduled export tax hike to 80 percent would be postponed for nine to 12 months. Industry observers speculated that the postponement was also due to the inability of the Russian wood processing sector to expand rapidly enough to process all the logs that would become available when the 80 percent export tax took effect (Random Lengths International 2008, 1). These export tax increases raised the cost of Russian pulp logs, and Scandinavian pulp and paper producers responded by sourcing more of their pulp logs domestically and from other countries (Stora Enso 2007, 8; UPM-Kymmene Corporation 2007, 32).

Increased Use of Recovered Paper in the Production of Paper

In recent years, recovered paper that is repulped and made into new paper has become an important complement to virgin fiber for many papermakers throughout the world. Increasingly, paper is made from a combination of virgin fiber and secondary fiber or from secondary fiber alone. Many of the new paper machines built in Asia and Europe use at least some secondary fiber in the production of paper. Economic, political, and social developments have driven this trend, including greater environmental concern about harvesting trees, particularly in the developed countries, pressure to reduce the amount of material going into landfills, and governmental laws and regulations mandating a certain recycled fiber content in particular paper grades. Technological advances in repulping and deinking (removing the ink from the paper) have improved the quality of the secondary fiber. In many instances, secondary fiber is cheaper than virgin fiber, and secondary fiber is well suited for the production of major paper grades such as newsprint, tissue, linerboard and corrugating medium, and cartonboard. Finally, China's steadily growing demand for recovered paper has stimulated investment in the infrastructure to collect and process paper in many countries. Paper that heretofore would have ended up in a landfill is now being collected, processed, and exported to China (RISI, Inc. 2006, 119–121; Stafford 2007, 5–7).

The amount of paper collected and returned to paper mills to be repulped and made into new paper has risen significantly in many countries. In the United States, the volume of recovered paper has almost tripled in the past two decades, from 17.4 million metric tons to 49.3 million metric tons. Old corrugated containers (cardboard boxes) accounted for roughly one-half of this tonnage. Old newspapers and magazines and mixed papers accounted for most of the remainder (American Forest & Paper Association 2008, 50–51).[13] In 2007, 56 percent of the paper consumed in the United States was recovered for recycling (American Forest & Paper Association 2008, 1).

Recycling rates are also high in Canada, Europe, and Japan. The amount of recovered paper in Canada, the world's fifth largest paper producer, has more than doubled in the last two decades (RISI, Inc. 2006, 127). The

[13] AbitibiBowater Inc., a large North American producer of newsprint and coated printing and writing papers, alone purchases or collects 2.4 million metric tons of old newspapers and magazines annually to repulp and make into new paper (AbitibiBowater Inc. 2007, 8).

European paper industry has set aggressive targets for paper recycling and in 2007 recovered 60 million metric tons of paper, almost double the amount recovered in 1995. The recycling rate in Europe rose to 64.5 percent in 2007 (European Recovered Paper Council 2007, 3). Japan has one of the highest recycling rates in the world and uses a large volume of recovered paper in its production of new paper (Japan Paper Association 2009).

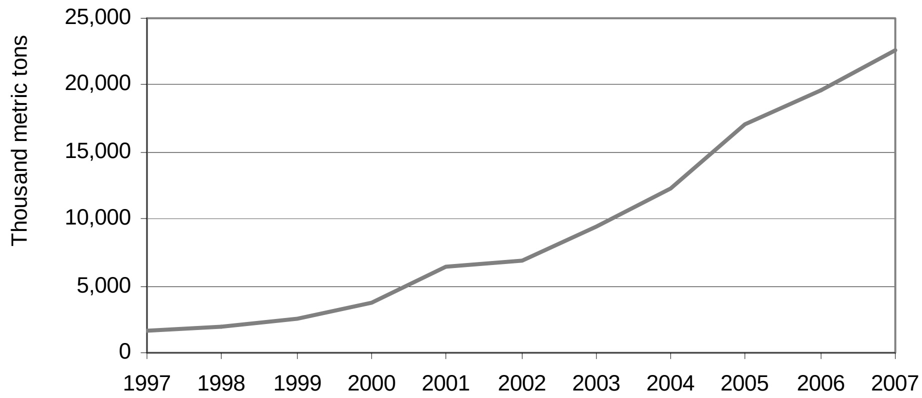
Trends in Trade Flows of Raw Materials for the Production of Paper

Recovered Paper

With much of the papermaking capacity installed in China in the past decade dependent upon recovered paper as raw material, China has become the driving force in global recovered paper trade. Not only has the volume of this trade expanded significantly, most of it is directed toward China. China's imports of recovered paper have grown significantly, from 1.6 million metric tons in 1997 to 22.6 million metric tons in 2007, a fourteenfold increase (figure 1). China's demand for recovered paper is such that much of the increase in recovered paper in the developed world was exported to China rather than being consumed domestically. For example, in the United States in the past decade, virtually all of the increase in recovered paper has been exported, principally to China, rather than used by domestic paper mills. Even many countries not traditionally considered exporters of recovered paper have now become sources of supply for China.

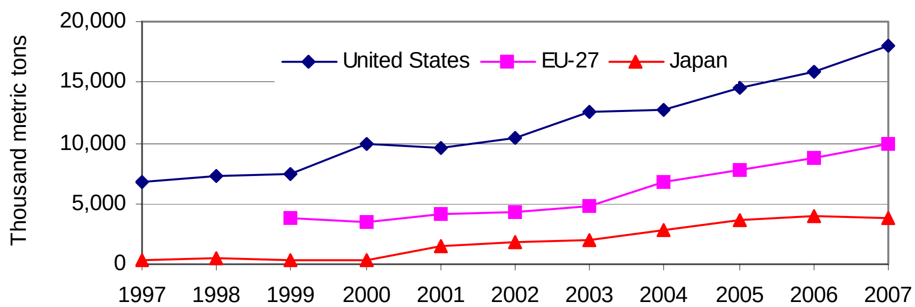
The United States, the EU-27, and Japan are the most important suppliers of recovered paper, accounting for the vast majority of global recovered paper exports. The growth in their recovered paper exports is shown in figure 2. Between 1997 and 2007, U.S. exports of recovered paper almost tripled from 6.8 million metric tons to 18.1 million metric tons, while Japan's exports increased by more than twelve times. The EU-27's exports of recovered paper more than doubled between 1999 and 2007. Exports of recovered paper to China rose even faster over the period, and China became the dominant export market for the United States, the EU-27, and Japan (figure 3).

FIGURE 1 China: Imports of recovered paper, 1997–2007



Source: Global Trade Atlas 2009.

FIGURE 2 Total recovered paper exports of the United States, the EU-27, and Japan, 1997–2007



Sources: Global Trade Atlas 2009; compiled from official statistics of the U.S. Department of Commerce.

Note: Data for 1997–1998 for the EU-27 are not available.

A multitude of other countries have also become suppliers of recovered paper to China. In 1997, China imported recovered paper (24,000 metric tons) from only 13 countries other than the United States, the EU-27, and Japan. In 2007, imports had grown to nearly 2 million metric tons from 35 countries (Global Trade Atlas 2009).

Pulp

The pulp exports of Brazil, Chile, Indonesia, and Russia have grown rapidly during the past decade. Brazilian, Chilean, and Indonesian exports more than doubled over this period, while Russian exports increased by 86 percent (figure 4).[14] On a quantity basis, the share of global exports of pulp accounted for by the pulp exports of these four countries increased from 21 percent in 1999 to 30 percent in 2007 (Global Trade Atlas 2009). Demand from China drove much of this growth.

Lacking sufficient wood pulp capacity, many of China's paper producers must source pulp for their new paper machines from overseas suppliers. Consequently, China has become a significant importer of pulp over the past decade. Chinese pulp imports increased by more than five times between 1997 and 2007, from 1.5 million metric tons to 8.5 million metric tons (figure 5). In 2007, six major pulp exporting countries accounted for 86 percent of China's total pulp imports, with no one country accounting for more than 26 percent (figure 6). Canada was the largest supplier to China in 2007, followed by Indonesia and then Chile. Although these six countries export pulp to many other countries, China's importance as an export market has increased. Between 1997 and 2007, pulp exports to China as a percent of total pulp exports rose for each of the six countries, in some instances by a significant amount (table 3). These increases ranged from 9.8 percentage points for Brazil to 34.5 percentage points for Russia. By virtue of these increases, China became the largest pulp export market for the United States, Chile, Indonesia, and Russia, the second largest pulp export market for Canada, and the third largest for Brazil.

Besides China, Brazil, Chile, and Indonesia have developed additional export markets, which lack sufficient pulp capacity and/or are attracted to these new sources of high quality, cost competitive pulp. Russia, on the other hand, has seen almost all of the increase in its pulp exports accounted for by China. Major export markets for Brazilian pulp, other than China, include the United States and certain European countries. Other than China, Chile has important pulp markets in Europe and Asia, and Indonesia exports pulp principally to India, Italy, Japan, South Korea, and Taiwan (table 4).

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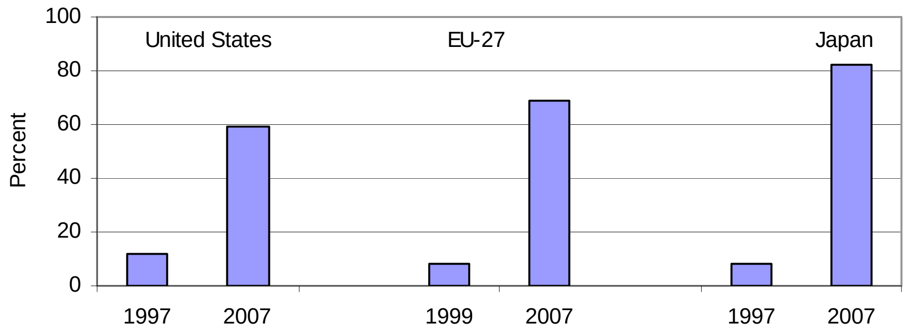
[14] By contrast, pulp exports of the United States and Canada, longtime pulp exporters, have been flat since 1997.

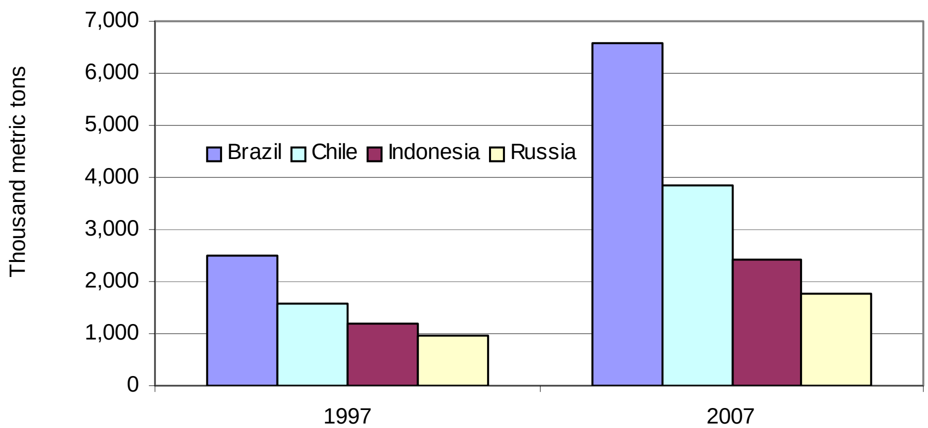
FIGURE 3 Recovered paper: Exports to China as a percent of total exports for the United States, the EU-27, and Japan, 1997 and 2007



Sources: Global Trade Atlas 2009; compiled from official statistics of the U.S. Department of Commerce.

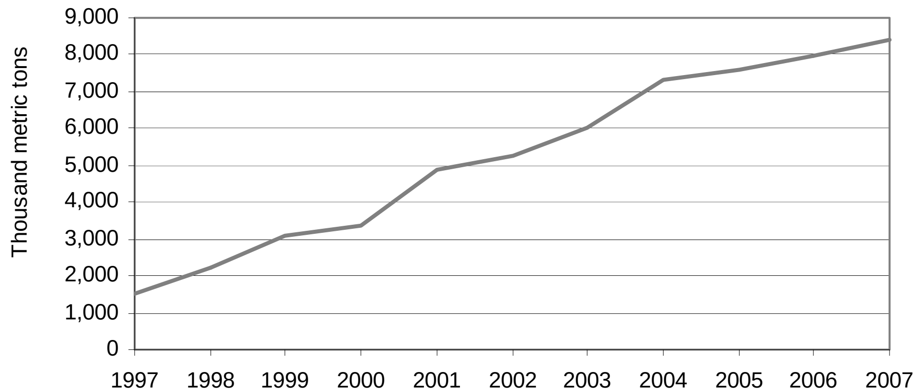
Note: Data for 1997–1998 for the EU-27 are not available.

FIGURE 4 Brazil, Chile, Indonesia, and Russia: Total pulp exports, 1997 and 2007



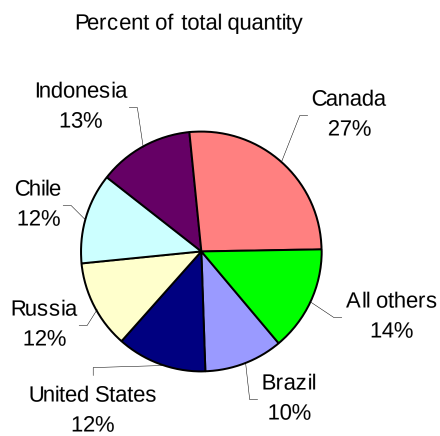
Source: Global Trade Atlas 2009.

FIGURE 5 China: Imports of pulp, 1997–2007



Source: Global Trade Atlas 2009.

FIGURE 6 China: Imports of pulp from major suppliers as a percent of total imports, 2007



Source: Global Trade Atlas 2009.

TABLE 3 Major pulp-exporting countries: Quantity of pulp exports to China as a percent of total pulp exports in 1997 and 2007 (%)

Source	1997	2007
United States	3.1	15.1
Canada	4.2	20.2
Brazil	3.7	13.5
Chile	9.3	29.1
Indonesia	32.3	45.2
Russia	17.5	52.0

Sources: Global Trade Atlas 2009; compiled from official statistics of the U.S. Department of Commerce.

TABLE 4 Pulp exports of Brazil, Chile, Indonesia, and Russia to major countries other than China, 1997 and 2007

Sources	1997	2007	% change 1997–2007
	Thousand metric tons		
Brazil exports to:			
Belgium	367	677	84.5
Italy	135	717	431.1
Netherlands	([a])	1,284	([b])
Switzerland	0	365	([c])
United States	605	1,381	128.3
Chile exports to:			
Belgium	232	180	–22.4
Italy	178	485	172.5
South Korea	83	337	306.0
Netherlands	0	278	([c])
Taiwan	169	199	17.8
Indonesia exports to:			
India	76	158	107.9
Italy	92	162	76.1
Japan	51	134	162.7
South Korea	236	480	103.4
Taiwan	73	105	43.8
Russia exports to:			
Germany	19	40	110.5
Hungary	109	71	-34.9
Indonesia	5	54	980.0
Poland	84	73	-13.1
Ukraine	10	67	570.0

Source: Global Trade Atlas 2009.

[a] Less than 1,000 metric tons.

[b] More than 1,000 percent.

[c] Not calculable.

Wood Chips and Pulp Logs

Australia, Brazil, Chile, Indonesia, Russia, and Vietnam have expanded their exports of wood chips since 1997, with some of these countries enjoying triple digit percentage gains. Wood chip exports from Australia, the largest exporter, increased by 57 percent during the period, while wood chips from Chile, the second largest supplier, grew by 9 percent (table 5). The primary markets for these wood chips were Japan, China, and Finland.

Japan has traditionally been the world's largest importer of wood chips, which are used as raw material for its pulp mills. Although Japan's imports of wood chips have been relatively stable over the past decade, imports from Australia, Brazil, Chile, and Vietnam have increased, thus displacing imports from other countries. The share of Japan's total imports of wood chips, by quantity, accounted for by imports from Australia, Brazil, Chile, and Vietnam rose from 43 percent in 1997 to 65 percent in 2007. In 2007, Japan accounted for 90 percent of Australia's wood chip exports on a quantity basis, 76 percent of Brazil's wood chip exports, 99 percent of

TABLE 5 Wood chips: Exports by Australia, Brazil, Chile, Indonesia, and Russia, 1997 and 2007[a]

Sources	1997	2007	% change 1997-2007
	Thousand metric tons		
Australia	3,856	6,052	57.0
Brazil	352	1,419	303.1
Chile	2,779	3,030	9.0
Indonesia	32	486	([b])
Russia	358	850	137.4

Source: Global Trade Atlas 2009.

[a] Trade data for Vietnam are not available from Global Trade Atlas. A gauge of Vietnam's growth as an exporter of wood chips can be seen in the import statistics of wood chips for Japan and China, believed to be Vietnam's two largest export markets for wood chips. Between 1997 and 2007, Japan's imports of wood chips from Vietnam rose from 155,000 metric tons to 903,000 metric tons, and China's imports of wood chips from Vietnam increased from zero to 684,000 metric tons.

[b] More than 1,000 percent.

Chile's exports, and a significant portion of Vietnam's exports (Global Trade Atlas 2009).

China has rapidly developed into a sizeable importer of wood chips during the past decade, although its demand remains considerably smaller than that of Japan. Between 1997 and 2007, China's imports of wood chips jumped from only 2,000 metric tons to 1.1 million metric tons. Large pulp mills constructed in China, which lack a sufficient source of domestic wood chips, accounted for this import growth (Stafford 2007, 13). Vietnam and Indonesia became the primary sources of these wood chips, accounting for 60 percent and 32 percent, respectively, of total Chinese imports of wood chips, by quantity, in 2007 (Global Trade Atlas 2009).

Russia has become an important supplier of wood chips and pulp logs to Scandinavia, particularly Finland. Finland is a major pulp producer and has looked to Russian wood to supplement its domestic wood. The quantity of Russia's exports of wood chips to Finland more than tripled between 1997 and 2007, and Russia was the largest supplier of wood chips to Finland during this period (Global Trade Atlas 2009). The quantity of Russia's exports of pulp logs to Finland has also increased during the past decade, and Russia was by far the largest supplier of pulp logs to Finland (Global Trade Atlas 2009).[15]

Global Financial Crisis and Recession

The financial crisis that began in the United States in the fall of 2008 and the subsequent worldwide economic downturn have led to a sharp drop in demand for paper. Production and shipments of paper have declined, and many paper mills have curtailed production or ceased operations temporarily or permanently. Demand for pulp, recovered paper, and wood chips and pulp logs has likewise fallen. Some pulp mills have cut production and suspended operations, and some pulp mill capacity expansion plans have been put on hold. Moreover, recovered paper has piled up in warehouses and ports. Nevertheless, the developments

[15] Pulp logs are not specifically broken out in the published trade data for Russia and Finland. Nevertheless, an analysis of the various Harmonized System numbers which comprise softwood logs and hardwood logs for these two countries indicates that certain of these numbers are likely to consist primarily of pulp logs, rather than other types of logs, and consequently can serve as a reasonable approximation of trade in pulp logs.

discussed above—China's expanding paper industry and increased need for imported fiber, the availability of fiber from tree plantations, and the advantages of recovered paper—will likely not be fundamentally altered in the long run by the worldwide recession. When economic recovery occurs and paper demand picks up, these developments, and the trade patterns discussed above, will likely intensify. One exception to this may be the Russian export tax on logs. If the tax does increase to 80 percent at some point in the future, the flow of pulp logs from Russia would likely be severely constrained.

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