U.S. INTERNATIONAL TRADE IN R&D-RELATED SERVICES AND A TRANSACTIONS-BASED PROFILE OF BUSINESS R&D

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Abstract

International trade in research, development, and testing (RDT) services accounts for a substantial share of the U.S. trade surplus in business services according to BEA data. Since 2001, when data for affiliated RDT trade became available, the surplus in these services was driven not by U.S. MNC parents but by large exports of U.S. affiliates of foreign MNCs, revealing previously unknown patterns in R&D-related services. Secondly, the paper develops a transactions-based profile of business R&D that systematically incorporates performance, funding, and trade perspectives. The model differentiates between two measures of international flows in the literature of official R&D accounting, namely funding and trade-based measures of R&D exchanges. The paper ends with an illustration of the model with 2003 U.S. business data.

I. Introduction

This paper analyzes U.S. international transactions in research and development (R&D) services based on Bureau of Economic Analysis (BEA) data, including recently available details on affiliated trade, in the context of R&D by multinational corporations (MNCs). Secondly, the paper explores the relationship of existing data with still-emerging concepts of R&D exports and imports, which are necessary for a better account of how industrial R&D is diffused, used, and exploited in an increasingly global environment for technology sourcing and innovation.

Increasingly, industrial innovation involves a combination of R&D performed internally and a host of activities with external partners (**Adams 2005, pp 131–3; Adams and Marcu 2004; Chesbrough 2003**). Technology activities or transactions with external partners (such as contract R&D and technology alliances) may reduce costs, expedite projects, or complement internal capabilities, but they may also present strategic and management challenges compared to in-house R&D (**Cassiman and Veugelers 2002**). For their part, even though U.S. MNCs still perform the majority of their R&D at home, U.S. parents companies are increasing their R&D activities overseas. At the same time foreign MNCs are associated with larger R&D expenditures in the U.S. (**NSB 2006b**), This scenario has enhanced the role of international R&D transactions within a global science and technology (S&T) enterprise (see sidebar below).

From the perspective of official statistics, indicators on R&D transactions embedded across economic surveys are emerging as complements of R&D performance and funding surveys, as recognized by the **OECD Handbook on Economic Globalization Indicators (OECD 2005)**. In this spirit, in addition to analyzing trends in one such indicator, services trade statistics (Section II), this paper explores a multifaceted characterization of R&D transactions (Section III) based on the interface of three official R&D accounting perspectives, namely performer, funder, and user-based data. Section IV concludes. An appendix covers data notes.

Sample of global S&T indicators in an open innovation system

Performance linkages – intra-MNC R&D; international joint ventures and alliances; triadic patents granted

Funding linkages – parent-affiliate funding flows; contract R&D; corporate venture funding/spinoffs

R&D-user transactions – trade in research, development, and testing services

II. U.S. trade in research, development, and testing services

International trade in *research, development, and testing services* accounts for a substantial share of the U.S. trade surplus in *business services* according to BEA data. Further, according to newly available data on affiliated trade, the U.S. trade surplus in research, development, and testing services has been driven not by U.S. parent companies but by relatively large exports by U.S. affiliates of foreign multinational corporations, at least since 2001. This is consistent with these affiliates' growing share in U.S. industrial

R&D. On the other hand, the unaffiliated trade surplus in these services has been trending down since 1992, due to import growth. Knowledge flows through trade in services represent the convergence of two recent trends in U.S. industrial S&T: an increase in R&D performance in the service sector and an increase in external and overseas links in innovation activities. R&D-related data in international services trade discussed below represent a new indicator on international industrial technology flows, along with high-technology goods trade, patent royalties and license fees, and foreign direct investment (FDI) published elsewhere (**NSB 2006a, 2006b**).

An international transaction is a transaction between a U.S. resident and a foreign resident, regardless of ownership considerations. Thus, affiliates of multinational companies are regarded as residents of the countries where they are located rather than of the countries of their owners. Separately, however, the ownership of the U.S.-located business and of its trading partner can be identified, allowing a profile of trade statistics in terms of intra-company or *affiliated* trade and cross-company or *unaffiliated* trade. Research, development, and testing services (RDT) is a component of business, professional, and technical services (BPT), a major category of private services, along with other categories such as financial services, travel services, telecommunications, and royalties and licensing fees.

BEA services trade data presented in this paper are published by type of service, not by industry of the respondent, and cover private services, which exclude government transactions. Further, unaffiliated and affiliated trade data are available with different

details: the former by country of trading partner, the latter by ownership categories. Data on international trade in RDT services with unaffiliated persons (1992-2003) are collected by BEA's surveys of selected services; RDT trade with affiliated persons (2001-2003) and other affiliate data are collected by BEA's balance of payments surveys on affiliates.[1]

A. Services trade flows

The U.S. has had annual positive trade balances or trade surpluses[2] of at least $50 billion since the early 1990s in overall private services, including a surplus of $65.9 billion in 2003, according to international transactions data from BEA (see **Borga and Mann 2004**). Business, professional, and technical services and royalties and license fees had the largest trade surpluses within private services in 2003 ($28.9 billion and $28.1 billion, respectively). In terms of trade volume (exports plus imports), travel services constituted the largest sector.

From 2001 to 2003, RDT services represented between 6-7% of the trade surplus in overall private services and between 14-17% of the surplus within BPT (**figure 1**). From 2001 to 2003, total exports (affiliated and unaffiliated) of RDT services fluctuated annually around $7 billion, compared with total annual imports under $3 billion, for trade

[1] 2001 is the first year in which affiliated trade data for RDT services are available. The definition of RDT services in unaffiliated and affiliated trade from these surveys is essentially the same (the definition within unaffiliated transactions contains additional information on exclusions/inclusions). See appendix.
[2] The trade balance is defined as exports minus imports. Services exports are measured by receipts or sales. Services imports are payments or purchases.

surpluses up to $4.8 billion within this period (**table 1**). Within BPT, RDT services had the 3rd largest surplus in 2003, behind the miscellaneous category and operational leasing.

B. Affiliated vs. unaffiliated trade

As noted earlier, international trade data in private services are available for two major categories of customers or suppliers: unrelated or unaffiliated companies, and affiliates of the same company. For overall private services, the unaffiliated portion of exports and imports has been larger than affiliated trade since at least 1992. For business, professional, and technical (BPT) services as well as for its subcomponent of RDT services the reverse is true: affiliated exports and imports are larger than unaffiliated exports and imports. For RDT services, unaffiliated trade balance is not only smaller but is declining in contrast with affiliated trade, as discussed next.

Unaffiliated exports and imports in RDT services each reached up to $1.3 billion annually from 2001 to 2003, resulting in relatively small trade surpluses (**table 1**). Indeed, the unaffiliated trade surplus in RDT services has been trending down since 1992, due to strong import growth (**figure 2**). Further, when Japan is excluded from unaffiliated trade, small trade surpluses turn into small deficits in 2002 and 2003 (**table 2**). Companies in the U.S. received the largest shares of their unaffiliated receipts (exports) from companies located in Japan in 2001-2003, compared with growing unaffiliated payments (imports) from the United Kingdom and Canada.

On the other hand, *affiliated trade* in RDT services is both larger than unaffiliated trade and has recorded relatively large trade surpluses: annual exports around $6 billion coupled with under $2 billion in annual imports resulted in trade surpluses between $4-5 billion in 2001 to 2003 (**table 1**).

Affiliated trade in business services, particularly R&D-related services, may reflect advantages of internally managing, exploiting, and protecting complex or strategic transactions involving proprietary technical information (**Caves 1996; McEvily et. al 2004**). Secondly, the prominence of affiliated trade in advanced economies is tied to well-known FDI trends (**Markusen 2004)**. For the U.S., the large relative size of affiliated trade in RDT is consistent with stronger U.S. FDI activity generally (**Mataloni 2005**), increasing the number of potential affiliated trading partners, and more specifically, consistent with expanded MNC R&D activity (**NSB 2006b**), increasing opportunities for intra-company knowledge flows.

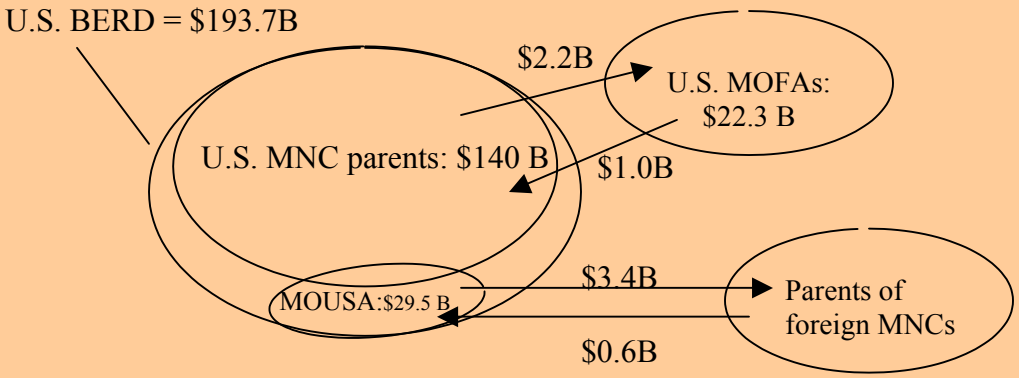
C. Affiliated trade within multinational corporations

Table 3 disaggregates the last column of table 1 (affiliated trade in RDT services) in terms of the identity of the U.S.-located company (parent of U.S. MNC vs. U.S. affiliate of a foreign MNC) and the trading partner (foreign affiliate of a U.S. parent vs. foreign parent of a U.S. affiliate), thus, making possible an examination of intra-MNC trade.[3]

[3] Data on an ownership basis for major categories of the U.S. current account have been available since 1992 **(Lowe 2005)**.

From 2001 to 2003, annual exports of RDT services from U.S. parents to their foreign affiliates fluctuated narrowly around $2.1 billion, compared to up to one billion dollars in annual imports from their overseas affiliates, resulting in trade surpluses *within U.S. MNCs* of up to $1.6 billion over this period (**second data column in table 3**). Over the same period, RDT services exports by affiliates of foreign MNCs in the U.S. to their foreign parents (and other foreign members of the company) were larger –more than $3 billion annually– with annual imports up to $1.1 billion, resulting in trade surpluses *within foreign MNCs* between $2.2 and $3.2 billion (**last column in table 3**). In short, these estimates show that in recent years U.S. trade surpluses in research, development, and testing services within U.S. MNCs have been smaller than within foreign MNCs with activities in the United States (**figure 3**).

Figure 3.
U.S. affiliated RDT services trade flows (*data along arrows*) and industrial R&D expenditures (*U.S. BERD and data inside circles*): 2003



B: Billions of current US dollars; BERD: Business Enterprise Expenditures on R&D;
MOFAs majority-owned affiliates of U.S. parent companies; MNCs multinational corporations;
MOUSA majority-owned U.S. affiliates of foreign MNCs.

Notes: Some companies are both parents of U.S. MNCs and also owned by foreign parent companies.
Direction of arrows indicates flow of R&D services.
Data sources: NSF SIRD; BEA international investment surveys; BEA international transaction surveys.

D. Affiliated trade and U.S. industrial R&D

The discussion above indicates that the U.S. trade surplus in RDT services is driven by the relatively large exports by U.S. affiliates of foreign MNCs. This consistent with their growing share in U.S. R&D (**NSB 2006b**), although they still perform under 15% of U.S. industrial R&D. However, a substantial share of R&D-related activities is apparently aimed at services for their foreign parents (and other foreign members of the company). In particular, RDT services exports of $3.4 billion from U.S. affiliates of foreign MNCs to their foreign parents in 2003 was the equivalent of 11.4% of their $29.5 billion in R&D expenditures, according to BEA and NSF data.[4] [5]

For their part, parents of U.S. MNCs performed a larger proportion of U.S. industrial R&D – 72%, or $140.1 billion of $193.7.0 billion in total U.S. industrial R&D in 2003 – according to NSF and BEA data.[6] However, parents' $2.2 billion in RDT services exports to all their overseas affiliates was the equivalent of only 1.5% of their R&D expenditures.

[4] U.S. industry R&D data are from the NSF Survey of Industrial R&D (SIRD). BEA data from **Zeile (2005)** are for majority-owned affiliates of foreign MNCs; R&D by all affiliates is not available for 2003. Since R&D by all affiliates is by definition a larger amount, the desired comparison would be lower than the 11.4 % reported in the text. Majority-owned affiliates R&D represented an increasing share of all U.S. affiliates R&D reaching about 90% in the late 1990s. Applying the later ratio to the 2003 data, the ratio reported in the text would be lower by one percentage point.

[5] Results from a NSF/Census-BEA interagency feasibility project aimed at developing a methodology to link NSF Survey of Industry R&D data with R&D data from BEA FDI surveys suggest both caveats and insights regarding Figure 3 and accompanying text. First, the agencies found discrepancies in reported R&D to the NSF and BEA surveys by linked MNC parent companies (1999 data) and by linked U.S. affiliates of foreign MNCs (1997 data). Therefore, ratios based on expenditure estimates from these separate surveys may not reflect the true proportion of the international component of U.S. R&D – the subject of future inter-agency research. At the same time, using NSF data for linked companies on the composition of R&D in terms of basic research, applied research, and development, it was found that U.S. affiliates of foreign MNCs devoted a larger share of their R&D to basic research compared to the aggregated of all U.S. R&D-performing companies. If further research confirms these findings, along with the new indicators on intra-MNC services trade discussed in this paper, a better picture may be obtained on how MNCs organize, fund, *and* distribute their R&D globally, including the U.S. role as a magnet for these activities. For the full report from this first link project see http://www.bea.gov/bea/di/FinalReportpublic.pdf.

[6] NSF Survey of Industrial R&D and **Mataloni (2005)**.

Comparisons between R&D-related trade and R&D expenditures data should be taken with care. As discussed more fully below, conceptually and statistically, RDT services and R&D expenditures are related but distinct terms. Nevertheless, R&D performance is of course a precursor for many RDT services exports. Thus, relative R&D performance levels across countries or MNCs underline in part trade balances in R&D-related services.

III. R&D transactions and R&D expenditures

Across the OECD, R&D expenditures are collected on a performance and funding basis by national statistical offices based on definitions and prescriptions of the OECD's Frascati Manual 2002 (hereafter FM; see sidebar below). R&D expenditures and trade in R&D-related services trade are linked by the concept of "R&D transactions". However, R&D transactions, and more specifically R&D exports/imports, are not explicitly defined in the 2002 version of FM. Within the official statistics literature, there are two different ways of characterizing R&D exports/imports. One approach is based on cross-border funding flows (**Mandler and Peleg 2003; de Haan and van Rooijen–Horsten 2004)** the other is based on trade in R&D services (**Robbins 2005**). The latter approach is based on the concept of the R&D "user" consistent with the UN's Systems of National Accounts 1993 (CEC et al. 1993) (hereafter, SNA).

The remainder of this paper develops a transactions-based profile of business R&D expenditures built upon existing but separate accounting approaches within official R&D statistics, and examines the relationship between the trade-based R&D exports/imports vs. funding flows, showing that in general these are not equivalent even abstracting from data collection issues.[7]

Terms in official R&D statistics

FM-based terms:

Business Enterprise Expenditures on R&D (BERD) – portion of GERD performed by the business or industrial sector. This is the same as 'industrial R&D' in this paper.

Gross domestic expenditure on R&D (GERD) – total intramural expenditures on R&D performed on the national territory during a given period (FM 423). Includes R&D performed within a country and funded from abroad but excludes payments for R&D performed abroad (FM 424).

Gross national expenditure on R&D (NGERD) – total expenditures on R&D financed by a country's institutions during a given period. It includes R&D performed abroad but financed by national institutions or residents; it excludes R&D performed within a country but funded from abroad (FM 426).

R&D funder – organization that is source of funding for R&D. R&D funding is the basis for NGERD defined above.

R&D performer – organization that engages in R&D. This is the same as 'R&D producer' in SNA terms. R&D performance is the basis for GERD and BERD defined above.

SNA-based terms:

Market R&D – R&D produced for sale at an economically significant price (Robbins 2005).

[7] For example, a difference between R&D expenditures and R&D services trade data as collected by NSF and BEA, respectively, is that trade data include testing services beyond R&D-based testing activities (which are limited to non-routine and pre-production activities). More fundamentally, data on R&D services traded in the open market reflect operating surplus, unlike cost-based R&D expenditures. In practice, data from R&D and trade surveys may be closer to each other for some segments of R&D exchanges: R&D surveys include contract R&D funds whereas intra-MNC exchanges may not fully reflect market values. The proposed transaction/expenditure matrix and exchange model below abstract from these issues.

Non-market R&D – R&D distributed for free or at non-economically significant prices (Robbins 2005).

Own account R&D – R&D both performed and used internally, regardless of funding source (also in Frascati Manual 1993: Annex 11, paragraph 58). Own account R&D in the business sector of advanced economies is funded mostly internally, plus funds from transfers receipts.

R&D producer – same as R&D performer

R&D user – organization that exploits results or knowledge from R&D. R&D used could be produced internally or acquired from an external provider.

A working definition for *market R&D transactions* is the following: monetary exchanges for the use of R&D performed by another party. Of course, R&D exports/imports are the subset of these flows for transactions that involve cross-border parties. These transactions include those among R&D performers and between R&D performers and non-performers. The user-based definition of R&D transactions allows differentiating between transfer funds and user or contract fees. Transfer funds for R&D are given as grants and do not require an exchange of R&D. These funds are properly included in R&D funding but are in principle excluded from trade-based data. Common transfers sources include domestic government units, international organizations, and overseas parents[8].

[8] Of course, parent companies also engage in fee-based R&D transactions with their affiliates as discussed above with U.S. data.

For a given R&D project, the performer, funder, and user fulfill different functions, possibly performed by three different organizations:

"The [Frascati] Manual distinguishes between performers and funders of R&D. The SNA distinguishes between the producers and users of R&D services (expenditure account). The unit which 'performs' the R&D also 'produces' it. The 'funder' unit is usually, but not always, the SNA 'user'." (2002 Frascati Manual Annex 3, Paragraph 28).[9]

These R&D functions are the basis of three accounting approaches for data collection or analysis. Data based on R&D performers avoids potential double counting of the same activity when funds flow across several sectors. Further, R&D performance reflects technological capabilities of companies, whereas R&D funding reflects financial capabilities or policy priorities. Lastly, R&D users subsequently produce new or improved products or processes, realizing profits through commercialization. Given the exploratory and uncertain nature of R&D activities, "R&D use" can also include learning from completed but 'unsuccessful' R&D, where the latter is defined either technically or in business terms (completed projects that did not yield expected results or whose results are not commercially viable or relevant).

These three accounting approaches are not only well defined but also are associated with different impacts in the economy (see sidebar below).

[9] R&D and technology users are also contemplated by the OECD (1997) Oslo Manual on innovation indicators (chapter 5, section 5) in the context of diffusion of innovations.

Economic and policy relevance of official R&D accounting:

* Performer-based data – R&D employment; productivity (learning by doing)
* Funder-based data – public budget accountability; R&D incentives; rates of return
* User-based data – non-R&D high-tech employment; productivity (learning by using); production of new or improved goods, processes, or services.

A. Business R&D Transactions and Official R&D Accounting

In most research on official R&D statistics, authors often focus on any two of these approaches according to their particular objective at hand. The following matrix, however, explores what we can learn about R&D expenditures and transactions by considering the interaction of the three different accounting bases defined above.

Table 4 below summarizes all possible combinations of these R&D functions resulting in 8 non-overlapping R&D profiles, associated with non-overlapping monetary amounts. Of course, a given organization may satisfy multiple R&D profiles as described by the rows of the table, e.g., a company may perform company-funded own account R&D and also contract out R&D, satisfying profiles 1 and 4. Note that market-based R&D transactions comprise profiles [2]-[5].

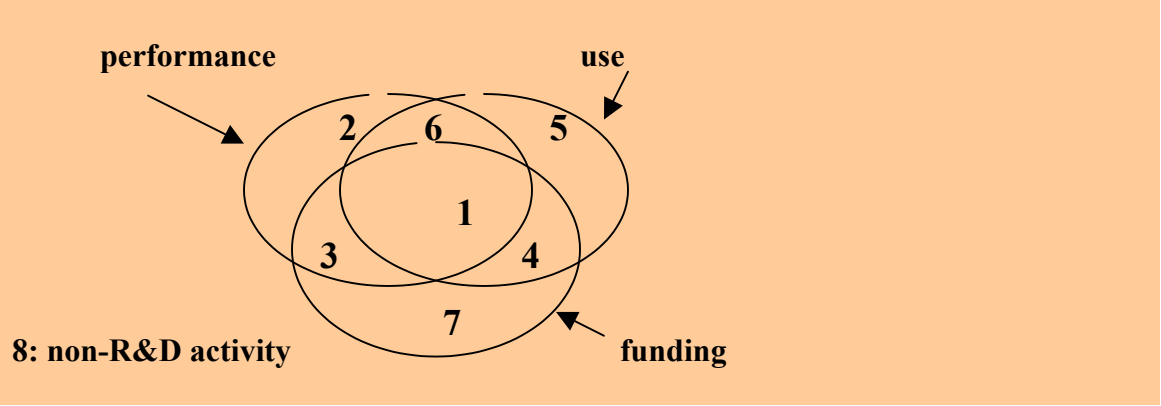
Table 4. A New Transactions-based Profile of Business R&D

R&D profiles	R&D functions: FM funder	SNA, FM producer/ performer	SNA user	
1 performer of company-funded own account R&D	yes	yes	yes	
2 seller of externally-funded R&D (custom R&D contractor)	no	yes	no	Market R&D transactions
3 seller of internally-funded/off-the-shelf R&D (open market sale)	yes	yes	no	
4 purchaser of custom R&D (contract R&D payer: R&D funder)	yes	no	yes	
5 purchaser of internally-funded R&D (open market buy: not R&D funder)	no	no	yes	
6 transfer/grants recipient (externally funded own account R&D)	no	yes	yes	
7 transfer/grants source (R&D funder)	yes	no	no	
8 outside R&D statistics	no	no	no	

These R&D profiles can also be depicted as an n-Venn diagram where n=3 intersecting sets or curves correspond to dollar amounts associated with performance, funding, and user activities (**figure 4**). With 3 curves there are exactly $2^n = 8$ regions that partitions the space of expenditures, one for each R&D profile in Table 4. The 8^{th} region corresponds to the area encircling the three circles. The regions formed by the intersections are nonempty. The list below shows examples of organizations satisfying a given R&D profile (numbers inside '[]' indicate lines in either **table 4** or sectors in the Venn diagram of **figure 4**):

[1] High-tech manufacturer (own account company-funded R&D)
[2] "Custom R&D" services company – e.g., Federal defense contractor
[3] "Open market" services company
[4] Federal agency (purchaser of custom R&D)
[5] Financial services company (purchaser of open market R&D)
[6] Federal grantee (own account externally funded R&D)
[7] State or local government funder
[8] Non R&D-players (the vast majority of economic agents)

Figure 4. The relationship among R&D functions underlying official R&D accounting.



The following are possible combinations of R&D functions:

- R&D funder but no user: [3] + [7]
- R&D user but no funder: [6] + [5]
- R&D user but no performer nor funder: [5] – out of scope of FM-based R&D surveys, including NSF surveys; within scope of services trade surveys and innovation surveys

- R&D performer but no funder: [2] + [6]
- R&D funder but no performer: [4] + [7]
- R&D funder but no user or performer: [7] – source of grants/transfers; out of scope of private services trade; within scope of FM-based R&D surveys

- R&D performer but no user: [2] + [3] = R&D sales = domestic sales + exports
- R&D user but no performer: [5] + [4] = R&D purchases = domestic purchases + imports
- R&D performer but no user or funder: [2]

- R&D funder, performer, user – own account *company-funded* R&D: [1]
- Total own account R&D: [1] + [6]

R&D in a closed economy – In a closed economy, each "pie" in **figure 4** would be a different cut of the same total R&D expenditures for a given period:

- performer pie: Gross domestic expenditure on R&D (GERD): total industrial R&D performed in country: 1+ 6+ 2 +3
- funder pie: Gross national expenditure on R&D (NGERD): total industrial R&D funded by country: 1 + 3 +4 + 7
- user pie: "Gross domestic expenditures on R&D used": 1 + 6 + 4 +5

where GERD = NGERD = Gross domestic expenditures on R&D used.

The last accounting equality abstracts from long-term multiple uses and/or users, and from R&D lags, incomplete R&D, and R&D inventories; and assumes that 'uses' of

R&D include learning from completed but unsuccessful R&D, as discussed earlier. Thus, in this model 'gross expenditures on R&D used' is an accounting term that does not measure long-term diffusion, value, or benefits but rather the immediate or short-term allocation of R&D expenditures at the end of its production period, assuming no inventories or 'waste'.

Note that in this closed economy intra-country trade equilibrium implies that domestic R&D sales (= [2] + [3]) equal domestic R&D purchases (= [5] + [4]). Further: [2]=[4]; [3]=[5]; and [6]=[7].

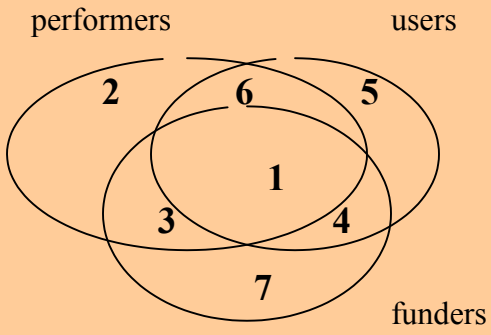
R&D transactions in a two-country system – **Figure 5** shows a simple model of international R&D exchanges involving both R&D services and transfer funds by adding a second country with a similar 3-Venn diagram whose sectors are indicated by (').
Assuming no intra-country R&D trade, international trade equilibrium conditions imply:

R&D imports in the base country = R&D exports of overseas country, or
5+4 = 2' + 3'
and R&D exports in the base country = R&D imports of overseas country, or
2+3 = 5'+4'.

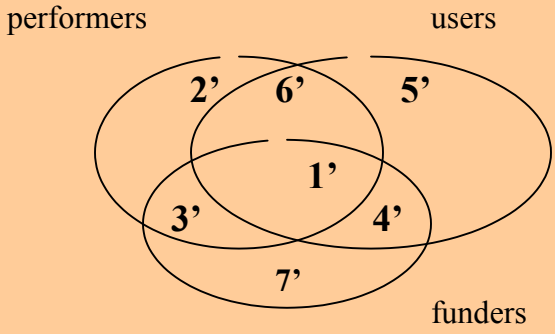
Note that sectors 7 and 7' in **figure 5** are the source of R&D transfer funds. These sectors may direct funds either to domestic or overseas transfer recipients (sectors 6 and 6'). By definition, these transfer flows are outside the scope of R&D trade transactions.

Figure 5
R&D exchanges in an open economy: A simple model of international transactions and funding flows

Home country



Overseas country



R&D exchanges in a two-country system: As drawn, the home country has larger R&D producer and funding sectors, whereas the overseas country has a larger R&D user sector. Also, the sector that simultaneously produces, funds, and uses its own R&D is larger in the home country: [1] > [1']. Assume no intra-country R&D trade.

R&D services trade: International trade equilibrium conditions imply that R&D imports in the home country = R&D exports of overseas country (5+4 = 2'+3')
and R&D exports in the home country = R&D imports of overseas country (2+3 = 5'+4').

Transfer funds flows: Sectors 7 and 7' may direct funds either to domestic or overseas recipients of transfer funds (sectors 6 and 6', respectively).

Non-traded R&D: Own account R&D (= 1 + 6 in the home country and 1' + 6' in the overseas country) is by definition used and exploited internally.*

*Non-market knowledge flows are outside the scope of this model, e.g. unintended knowledge spillovers, scientific publications.

B. Discussion

The model presented in Table 4 and Figures 4/5 characterizes R&D transactions and expenditures by systematically incorporating performance, funding, and trade perspectives. For example, the model accommodates in a single framework two existing but different measures of international flows in the literature of R&D accounting, namely funding flows and trade-based measures of R&D exports/imports.

In particular, *R&D exports* comprise overseas components of [2] (sales of custom R&D) and [3] (sales of open market or "off-the-shelf" R&D). In contrast, *funding from abroad* comprises overseas components of [2] and [6] (transfers received). Similarly, *R&D imports* comprise overseas components of [4] (purchases of custom R&D) and [5] (purchases of open market R&D or "off the shelf R&D"), whereas *funds sent overseas* comprise overseas components of [4] and [7] (transfers sent). BEA RDT services trade data analyzed in Section II above correspond to overseas components of [2+3] (exports) and [4+5] (imports), abstracting from the inclusion in these statistics of non-R&D testing services.

The difference between R&D funding flows and trade-based R&D exports/imports depends on the presence of dedicated R&D services organizations with international sales and on the size of cross-border transfers. Of course, the quantitative and/or economic relevance of these differences is likely to vary, for example, by industry (e.g., pharmaceuticals vs. textiles) and by country.

Furthermore, the particular objective at hand may call for either one of these indicators to describe different aspects of international R&D linkages. For example, when the policy or analytical focus is cross-border R&D funding issues, then the relevant concept is gross national expenditure on R&D (NGERD: FM 426):

NGERD ≡ GERD – funding from abroad + funding funded abroad.

On the other hand, when the focus is on R&D use or knowledge diffusion, trade-based R&D exports and imports are more appropriate, from a source such as BEA's RDT trade statistics. In fact, the data have already proved useful for the business sector component of an ongoing update of the U.S. R&D satellite account for the US, an NSF-funded project conducted by the BEA. The account implies that R&D is capitalized, which further requires the following measurement: "R&D output" – R&D exports + R&D imports, or the domestic R&D stocks available for use in an economy **(Robbins 2005)**. Within expenditures, the corresponding term for this measure is the proposed *"gross domestic expenditures on R&D use (GERDU)",* depicted by the 'user' pie above. The term is defined more formally as:

GERDU ≡ GERD – R&D exports + R&D imports

= own account R&D + R&D imports.[10]

Thus, this formula also allows computing own account R&D.

[10] R&D exports and imports are defined as above, in trade-based terms. The last equality follows from the fact that GERD is also equal to own account R&D plus R&D exports (Frascati Manual, OECD 1993).

The corresponding term for the business sector would be *business enterprise expenditures on R&D use (BERDU)*:

BERDU ≡ BERD – industrial R&D exports + industrial R&D imports

= industry own account R&D + industrial R&D imports.

An illustration of transactions-based R&D accounting with 2003 U.S. data (see **Figure 6**):

- BERD (= aggregate of [1] + [6] + [2] +[3]) = $193.7 billion[11] (NSF SIRD)
- R&D imports (= overseas portion of [4] + [5]) = $2.9 billion (BEA)
- R&D exports (=overseas portion of [2] + [3]) = $ 6.9 billion (BEA)

- BERDU ≡ BERD – industrial R&D exports + industrial R&D imports = ([1] + [6] + [2] +[3]) – ([2] + [3]) + ([4] + [5])[12] = $193.7 billion - $6.9 billion + $2.9 billion = $189.8 billion = aggregate of ([1] + [6] + [4] + [5])

- Industrial own account R&D (= [1] + [6]) = BERDU - industrial R&D imports = $189.8 billion - $2.9 billion = $186.9 billion[13]

- Industrial R&D funding from abroad: Not available.
- Industrial R&D funded abroad = $ 29.2 billion (NSF SIRD)

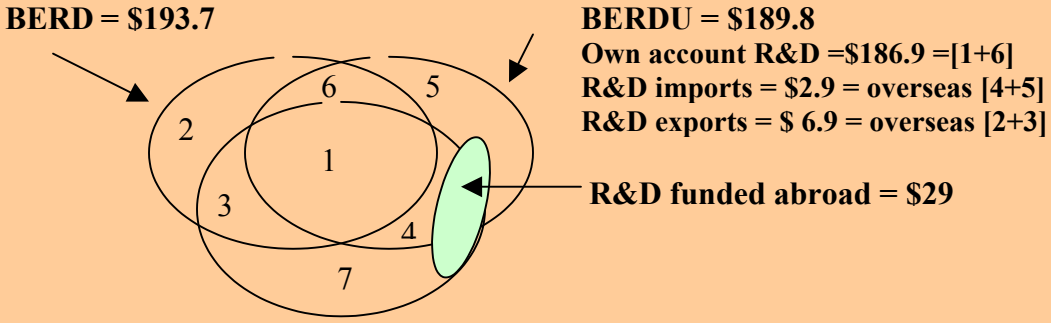
Note: As collected by NSF, and in the language of this paper, industrial R&D funded abroad by (R&D-performing) for-profit U.S. residents is the aggregate of overseas purchases of custom and open market R&D, plus funds transfers sent abroad. Recipients of the funds include overseas affiliates and contractors. Thus, R&D funded abroad straddles the regions corresponding to R&D imports [4 + 5] and transfers/grants source [7]. This statistic is not available for U.S. non-R&D performers that may fund or buy R&D abroad.

[11] Projected value. Excludes industry administered FFRDCs.

[12] Note that intra-country R&D trade cancels out (sales of domestic R&D to domestic companies = purchases of R&D domestic R&D by domestic companies.

[13] Without the BERDU formula, own account R&D cannot be estimated for U.S. industrial R&D. Own account R&D is defined as R&D both performed and used internally (**de Haan and van Rooijen–Horsten 2004; Frascati Manual OECD 1993: Annex 11, paragraph 58, Pho et al. 2005**). Own account R&D in the business sector of advanced economies is funded mostly internally, plus funds from transfers receipts. However, the two major published components of U.S. BERD do not allow to piece together this measure. U.S. BERD is measured by NSF as the sum of "company and other non-Federal funds" (combined) plus "Federal funds". Further, Federally funded R&D is a combination of R&D contracts intended for Federal clients and transfers, which are not separately available.

Figure 6. A profile of U.S. industrial R&D expenditures and transactions (billions of current U.S. dollars): 2003



BERD: Business enterprise expenditures on R&D;
BERDU: Business enterprise expenditures on R&D use

Note: Size of sectors does not reflect relative size of associated data.
Data sources: NSF SIRD and BEA international transactions surveys

IV. Conclusion

Affiliated trade statistics on research, development, and testing (RDT) services explored in this paper represent a welcome addition to the menu on globalization indicators. International trade in RDT services accounts for a substantial share of the U.S. trade surplus in business services according to data from the Bureau of Economic Analysis (BEA). From 2001 to 2003, RDT services represented between 6-7 % of the trade surplus in overall private services and between 14-17% of the surplus within BPT. The surplus in RDT services was concentrated in affiliated trade. More specifically, this surplus was driven not by U.S. MNC parents but by large exports of US affiliates of foreign MNCs, consistent with these affiliates growing share in U.S. industrial R&D, according to NSF and BEA data.

Secondly, this paper developed a model that characterizes R&D transactions and expenditures by systematically incorporating performance, funding, and trade perspectives. In particular, the model accommodates in a single framework two existing but different measures of international R&D flows, identifying a key conceptual

difference between trade-based and FM-based expenditures in terms of two non-overlapping sectors: R&D users that are neither performer nor funders [sector 5] and organizations that are exclusively source of R&D transfer funds [sector 7].

The empirical and economic significance of these differences are likely to vary by industry and country. However, differences across surveys (e.g., non-R&D testing services; cost-based R&D expenditures vs. value-based transactions data) and the need for further detail by industry or trading partner represent both challenges and opportunities for further statistical developments and research in this area.

Appendix – Data Notes

R&D expenditures

Data for U.S. industrial R&D (BERD) were obtained from the NSF Survey of Industrial R&D, a nationally representative sample of all for-profit companies in the 50 U.S. states and the District of Columbia, regardless of ownership status. Estimates are subject to sampling and non-sampling errors. See http://www.nsf.gov/sbe/srs/sird/start.htm for a description of the survey and its methodology.

Estimates on affiliates' and U.S. parents' R&D performance are collected by BEA FDI surveys (along with and other operations data): Survey of Foreign Direct Investment in the United States (FDIUS) and Survey of U.S. Direct Investment Abroad (USDIA). Data are obtained from a combination of census type surveys in benchmark years (every 5 years) and sample-based surveys in nonbenchmark years. Direct investment refers to the ownership of productive assets outside the home country by MNCs and is defined as the ownership or control, directly or indirectly, of 10 percent or more of the voting securities of an incorporated business enterprise (or an equivalent interest in an unincorporated business enterprise). An affiliate is a an entity or company located in one country but owned or controlled by a parent company in another country. For a description of data see http://www.bea.gov/bea/di/fddscrpt.htm (FDIUS) and

http://www.bea.gov/bea/di/usdscrpt.htm (USDIA). For more information see http://www.bea.gov/bea/surveys/diasurv.htm (USDIA) and http://www.bea.gov/bea/surveys/fdiusurv.htm (FDIUS).

International transactions and balance of payments

An international transaction is a transaction between a U.S. resident and a foreign resident, where United States means the 50 U.S. states, the District of Columbia, the Commonwealth of Puerto Rico, and all territories and possessions of the United States (**BEA 1990**). BEA collects data on affiliated and unaffiliated trade from different surveys, and then integrates them into the U.S. international transactions account and the U.S. balance of payments.[14] Trade in private services is a component of services trade, which also includes defense-related and other government services. For full historical tables on international transactions in private services see http://www.bea.gov/bea/di/1001serv/intlserv.htm.

Estimates on international trade in research, development, and testing (RDT) services with unaffiliated persons are obtained from several international accounts BEA surveys. Reporting is mandatory under the International Investment and Trade in Services Survey Act, as amended.

Affiliated RDT trade

Data on affiliated services trade are collected by BEA's quarterly balance of payments surveys on affiliates: Transaction of U.S. Affiliates, Except a U.S. Banking Affiliates, with Foreign Parent (survey form BE-605) covers affiliates of foreign MNCs in the U.S.; Direct Transactions of U.S. Reporter with Foreign Affiliate (survey form BE-577) covers U.S. MNCs. In these affiliates' surveys, RDT services are defined as "Commercial and noncommercial research, product development services, and testing services." Affiliated

[14] International transactions cover four major categories: goods or merchandise, services and income, capital flows, and transfers. The balance of payments groups these categories into three accounts following a redesign in 1999: current account (goods, services, income, and unilateral current transfers), financial account (capital flows), and the capital account (capital transfers).

trade data in RDT services, a component of business, professional, and technical services (BPT), have been available since 2001. BPT affiliated trade data have been available since 1997. Before then, these components were included in the overall trade figures but were not separately available.

Unaffiliated RDT trade

Data on unaffiliated trade in RDT services are collected by BEA's surveys on transactions with unaffiliated foreign persons, along with other business, professional, and technical services (**BEA 1998**). These surveys are the Benchmark Survey of Selected Services Transactions With Unaffiliated Foreign Persons (survey form BE-20), conducted every 5 years[15], and the Quarterly Survey of Transactions Between U.S. and Unaffiliated Foreign Persons in Selected Services and in Intangible Assets (survey form BE-25) for non-benchmark years. These surveys for unaffiliated transactions define RDT services as "Commercial and noncommercial research, product development services, and testing services. Includes fees for the conduct of experiments or performance of research and development activities aboard spacecrafts. Excludes medical and dental laboratory services." For more information see http://www.bea.gov/bea/surveys/iussurv.htm .

Services sold to, or purchased from, unaffiliated foreign persons are reported regardless of whether the services were performed in the United States or abroad. Transactions for RDT services are reported on an accrual basis, gross of U.S. or foreign taxes.[16] Purchases of services are included without regard to whether they are charged as an expense on the income statement, capitalized, or charged to inventories. Data is on consolidated enterprise basis for all U.S. reporters. The fully consolidated U.S. domestic enterprise excludes foreign branches and other foreign affiliates.

[15] The last benchmark survey was performed in 2001.
[16] Accounting data on an accrual basis refer to revenues and expenses recognized in the period in which they are earned (products are delivered or services provided). Cash may or may not be received or paid during this period.

The classification of services is based on the IMF's Balance of Payments Manual, the United Nations' Manual on Statistics of International Trade in Services (which in turn draw guidance from the UN's System of National Accounts), and the International Surveys Industry classifications developed by BEA.

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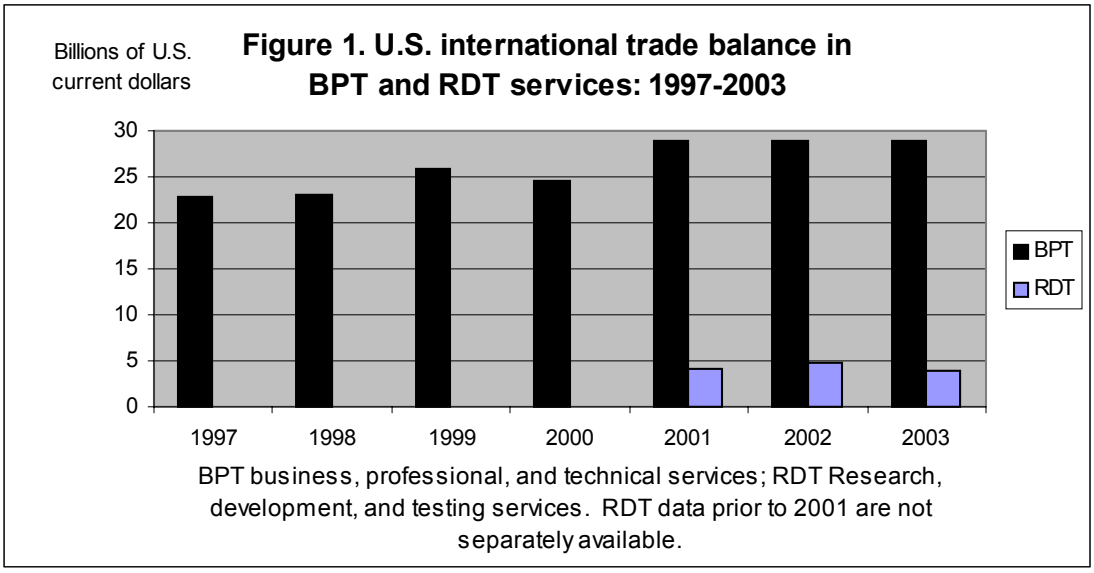

Source: Based on U.S. International Services: Cross-border trade, Table 1,
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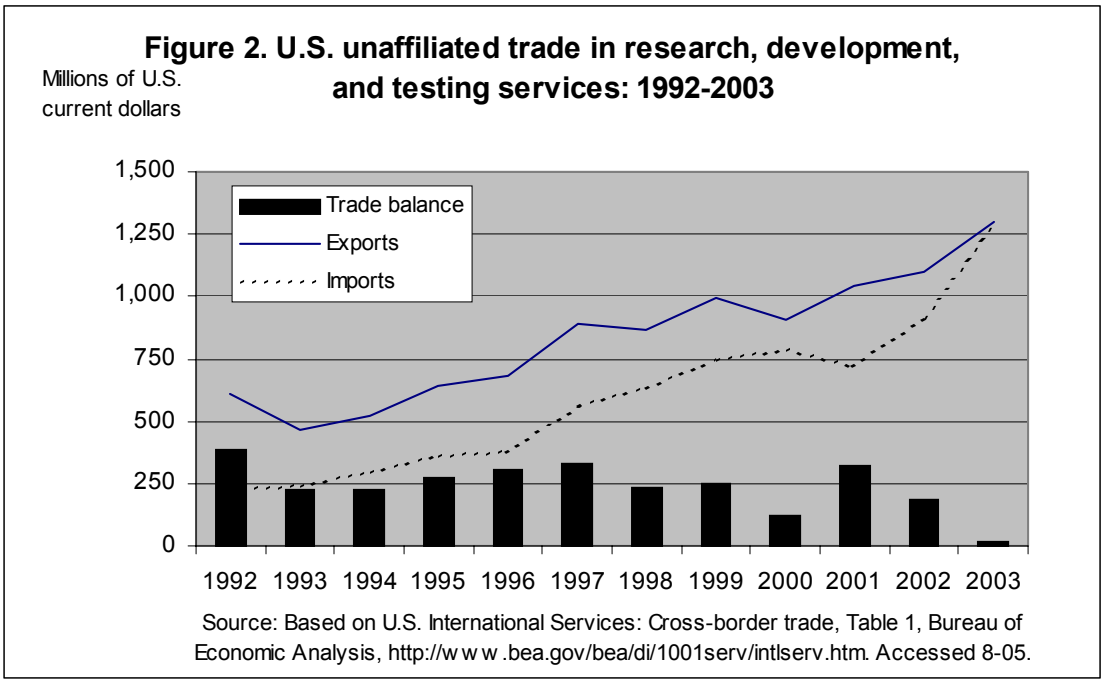

Table 1. U.S. trade in research, development, and testing services: 2001-2003
Billions of current U.S. dollars

		Unaffiliated	Affiliated
	Exports		
2001	6.5	1.0	5.5
2002	7.2	1.1	6.1
2003	6.9	1.3	5.6
	Imports		
2001	2.4	0.7	1.7
2002	2.4	0.9	1.5
2003	2.9	1.3	1.6
	Trade balance		
2001	4.1	0.3	3.8
2002	4.8	0.2	4.6
2003	4.0	0.02	4.0

Source: Based on U.S. International Services: Cross-border trade, Table 1,
Bureau of Economic Analysis, http://www.bea.gov/bea/di/1001serv/intlserv.htm. Accessed August 2005.

Table 2. U.S. trade in research, development, and testing services: unaffiliated trade by region/country: 2001-2003

Millions of current U.S. dollars

	2001			2002			2003		
	Exports	Imports	Trade balance	Exports	Imports	Trade balance	Exports	Imports	Trade balance
Total	6,546	2,425	4,121	7,199	2,411	4,788	6,801	2,885	3,916
Affiliated	5,500	1,700	3,800	6,100	1,500	4,600	5,500	1,600	3,900
Unaffiliated	1,046	725	321	1,099	911	188	1,301	1,285	16
Unaffiliated by region/country:									
Canada	82	91	-9	93	118	-25	108	175	-67
Europe	461	419	42	560	555	5	702	788	-86
Belgium-Luxembourg	22	16	6	22	11	11	18	21	-3
France	59	30	29	61	38	23	55	43	12
Germany	102	42	60	115	84	31	158	130	28
Italy	9	6	3	9	14	-5	13	15	-2
Netherlands	14	10	4	15	19	-4	16	28	-12
Norway	4	3	1	3	3	0	4	9	-5
Spain	7	6	1	6	3	3	10	3	7
Sweden	15	14	1	15	19	-4	19	20	-1
Switzerland	79	42	37	127	40	87	137	59	78
United Kingdom	98	187	-89	139	254	-115	203	358	-155
Latin America and Other Western Hemisphere	54	37	17	49	31	18	55	95	-40
Argentina	7	7	0	2	7	-5	4	17	-13
Bermuda	13	9	4	(D)	3	NA	12	3	9
Brazil	7	6	1	11	6	5	6	32	-26
Chile	1	2	-1	1	1	0	1	3	-2
Mexico	13	3	10	10	5	5	18	22	-4
Venezuela	4	1	3	4	(*)	NA	3	1	2
Africa	60	60	0	29	49	-20	21	59	-38
South Africa	42	32	10	9	15	-6	11	9	2
Middle East	44	28	16	38	8	30	48	14	34
Israel	12	23	-11	11	7	4	15	11	4
Saudi Arabia	19	4	15	13	(*)	NA	14	(*)	NA
Asia and Pacific	338	91	247	323	150	173	359	154	205
Australia	19	11	8	17	12	5	16	21	-5
China	12	9	3	13	5	8	10	4	6
Hong Kong	3	1	2	3	4	-1	3	3	0
India	8	16	-8	4	14	-10	9	24	-15
Indonesia	5	3	2	5	5	0	4	9	-5
Japan	235	22	213	240	20	220	273	32	241
Korea, Republic of	27	3	24	15	3	12	20	3	17
Malaysia	2	(*)	NA	1	1	0	2	1	1
New Zealand	1	(*)	NA	1	(*)	NA	1	7	-6
Philippines	2	1	1	2	1	1	2	1	1
Singapore	5	14	-9	4	(D)	NA	4	17	-13
Taiwan	12	4	8	9	13	-4	7	15	-8
Thailand	4	2	2	6	3	3	7	5	2

Addenda:									
Unaffiliated excluding Japan	811	703	108	859	891	-32	1,028	1,253	-225
European Union	358	333	25	410	472	-62	531	677	-146
Eastern Europe	18	34	-16	15	36	-21	18	41	-23
Asia excluding Japan	103	69	34	83	130	-47	86	122	-36

(*) Less than $500,000; D Suppressed to avoid disclosure of data of individual companies; NA not available
Source: Based on U.S. International Services: Cross-border trade, Table 7,
Bureau of Economic Analysis, http://www.bea.gov/bea/di/1001serv/intlserv.htm. Accessed August 2005.

Table 3. U.S. affiliated trade in research, development, and testing services disaggregated by U.S. and foreign MNCs: 2001-2003
Billions of current U.S. dollars

		Within US MNCs	Within foreign MNCs
	Exports	From U.S. parents to their foreign affiliates:	From U.S. affiliates of foreign MNCs to their foreign parents:*
2001	5.5	2.2	3.3
2002	6.1	2.1	4.0
2003	5.6	2.2	3.4
	Imports	From foreign affiliates of US MNCs to their US parents	From foreign MNC parents to their US affiliates*
2001	1.7	0.6	1.1
2002	1.5	0.7	0.8
2003	1.6	1.0	0.6
	Trade balance		
2001	3.8	1.6	2.2
2002	4.6	1.4	3.2
2003	4.0	1.2	2.8

* U.S. affiliate's transactions within foreign MNCs also include transactions with other foreign members of the MNC.

MNCs multinational corporations
Source: Based on U.S. International Services: Cross-border trade, Table E,
Bureau of Economic Analysis, http://www.bea.gov/bea/di/1001serv/intlserv.htm. Accessed August 2005.