

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

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Francisco Moris  
U.S. National Science Foundation  
Arlington, VA

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F. MORIS - NSF**

**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.

The paper then explores methodological issues on R&D expenditures and international R&D transactions. In particular, after reviewing selected international statistical manuals, the paper develops a trade-based definition for “R&D exports and imports”, in contrast with funding and FDI-based measures used elsewhere. We then develop a framework that characterizes R&D expenditures and flows by systematically incorporating performance, funding, and trade perspectives. The framework allows examining different R&D aggregates and flows and the scenarios where each of them may be a sensible indicator for the analytical objective at hand. Lastly, the paper explores the relationship of existing data with the terminology reviewed and developed here using 2003 U.S. business data.

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## 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 develops a definition for “R&D exports and imports” after reviewing the literature from international statistical manuals on R&D, national accounts, balance of payments, and services trade. Lastly, the paper explores the relationship of existing data with the terminology reviewed and developed here. Indicators on technology linkages and transactions 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**). In terms of geographic diversification of activities through foreign direct investment, U.S. parents companies are increasing their R&D activities overseas, even though U.S. MNCs still perform the majority of their R&D at home. 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 trends, as recognized by the **OECD Handbook on Economic Globalization Indicators (OECD 2005a)**. In addition to analyzing 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 have contributed to 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 parent companies of U.S. multinational corporations (MNCs) but by relatively large exports by U.S. affiliates of

foreign MNCs, at least since 2001.<sup>1</sup> 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 (or cross-border trade) 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, cross-border trade among entities within and outside MNCs 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.

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<sup>1</sup> An affiliate is a business that is located in one country but it is owned or controlled by a parent company located in another country. U.S. multinational corporations (MNCs) comprise U.S. parent companies and their foreign affiliates. Foreign MNCs are multinationals whose parent companies are located outside the U.S.

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 or entities (1992-2004) are collected by BEA's surveys of selected services; RDT trade with affiliated persons (2001-2004) and other affiliate data are collected by BEA's balance of payments surveys.<sup>2</sup>

### *Services trade flows*

The U.S. has had annual positive trade balances or trade surpluses<sup>3</sup> of at least \$60 billion since the early 1990s in overall private services, including a surplus of \$65.3 billion in 2004, according to international transactions data from BEA (see **Nephew et al. 2005**). Business, professional, and technical services and royalties and license fees had the largest trade surpluses within private services in 2004 (\$30.2 billion and \$28.7 billion, respectively). In terms of trade volume (exports plus imports), travel services constituted the largest sector.

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<sup>2</sup> 2001 is the first year in which affiliated trade data for RDT services are separately 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.

<sup>3</sup> The trade balance is defined as exports minus imports. Services exports are measured by receipts or sales. Services imports are payments or purchases.

From 2001 to 2004, RDT services represented between 6 and 8% of the trade surplus in overall private services and between 15 and 18% of the surplus within BPT (**figure 1**).

From 2001 to 2004, total exports (affiliated and unaffiliated) of RDT services increased from \$6.7 billion to \$9.8 billion, compared with total annual imports under \$5 billion, for trade surpluses up to \$5.1 billion within this period (**table 1**). Within BPT, RDT services had the 3<sup>rd</sup> largest surplus in 2004, behind the miscellaneous category and operational leasing.

#### *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 RDT services the reverse is true: affiliated exports and imports are larger than unaffiliated exports and imports.

For *unaffiliated* RDT services trade, imports have been growing faster than exports after 2001, resulting in trade deficits in 2003 and 2004 (**table 1 and figure 2**). Growth in unaffiliated RDT imports was notable for services from the United Kingdom, almost doubling from \$382 million in 2003 to \$734 million in 2004 (**table 2**). On the other hand, *affiliated trade* in RDT services is both larger than unaffiliated trade and has recorded substantial trade surpluses since 2001 (**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.

*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.<sup>4</sup>

From 2001 to 2004, annual exports of RDT services from U.S. parents to their foreign affiliates fluctuated narrowly around \$2 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 \$1.5 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) increased from \$3.5 billion

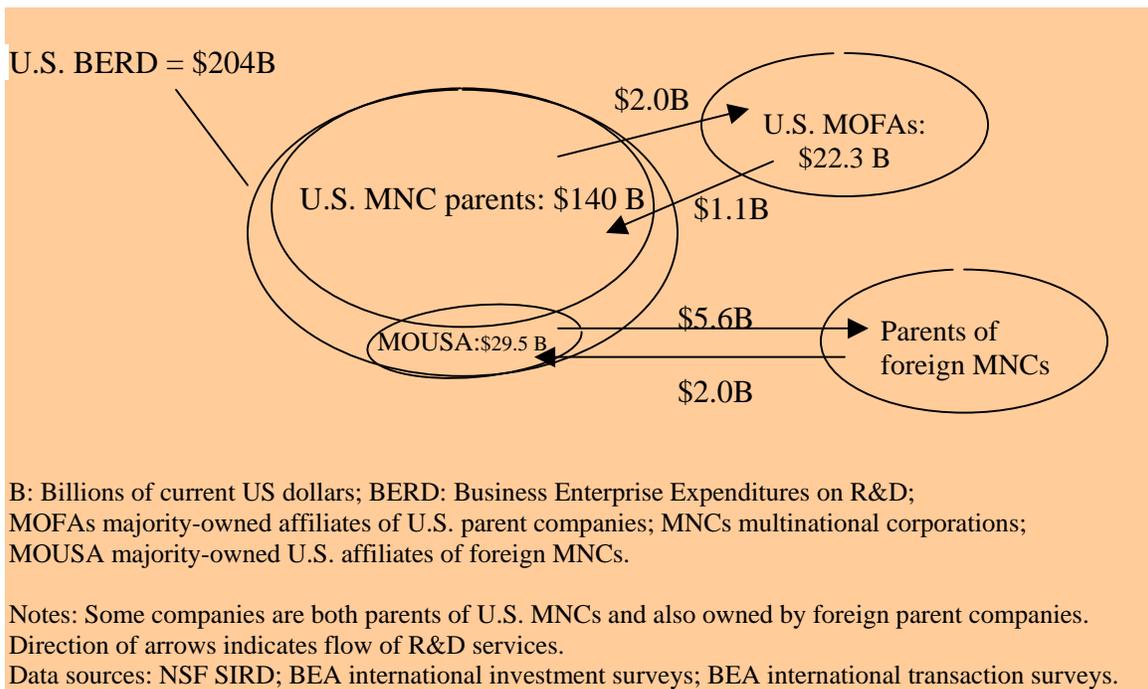
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<sup>4</sup> Data on an ownership basis for major categories of the U.S. current account have been available since 1992 (**Lowe 2005**).

in 2001 to \$6.7 billion in 2004. On the other hand, annual imports fluctuated between \$1 and \$2 billion, resulting in growing trade surpluses *within foreign MNCs*, reaching \$5 billion in 2004 (**last column in table 3**). In short, the largest component in U.S. RDT trade is the exports from U.S. affiliates of foreign MNCs (**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 (2004 NSF, BEA R&D are NA)



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

The discussion above suggests 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 \$5.6 billion from U.S. affiliates of foreign MNCs to their foreign parents in 2003 was the equivalent of 19.0% of their \$29.5 billion in R&D expenditures, according to BEA and NSF data.<sup>5 6</sup>

For their part, parents of U.S. MNCs performed a larger proportion of U.S. industrial R&D – 69%, or \$140.1 billion of \$204.0 billion in total U.S. industrial R&D in 2003 – according to NSF and BEA data.<sup>7</sup> However, parents' \$2.0 billion in RDT services exports to all their overseas affiliates was the equivalent of only 1.4% of their R&D expenditures.

Comparisons between R&D-related trade and R&D expenditures data should be treated with caution. 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

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<sup>5</sup> 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.

<sup>6</sup> 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>.

<sup>7</sup> NSF Survey of Industrial R&D and **Mataloni (2005)**.

levels across countries or MNCs underline in part trade balances in R&D-related services.

### III. R&D transactions and R&D expenditures

Across OECD member countries, 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 – Proposed Standard Practice for Surveys on Research and Experimental Development* (hereafter Frascati or FM). 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 and imports, are not explicitly defined in the 2002 version of FM, the Technology Balance of Payments Manual (**OECD 1990**), or in the recently released Handbook for Economic Globalisation (**OECD 2005a**).

International R&D transactions are critical not only as indicators of globalization, diffusion, and spillovers of R&D and other technological inputs, but also to appropriately measure domestic stocks of R&D subject to capitalization in the National Accounts (**OECD 2005c**).

The Frascati manual is devoted to measuring R&D “inputs” (FM 14). The basic measure is “intramural expenditures”, i.e. all expenditures for R&D performed within a statistical unit or sector of the economy (FM 34). The manual recognizes that “R&D is an activity for which there are significant transfers of resources among units, organisations, and sectors, especially between government and other performers....[thus] it is important ...

to know who finances R&D and who performs it” (FM 35). Further, Frascati takes “the globalization process into account by suggesting more detailed breakdowns of sources of funds for R&D and extramural R&D for transactions with units abroad”.

In short, FM focuses on R&D performance and funding (or R&D production and financing). Transactions are not a focal point of the Manual, and are covered in terms of financing sources, a somewhat idiosyncratic view of international transactions, compared with the material reviewed below.

The focus on R&D performed and used internally follows the history of R&D activities in industrial economies, along with the received wisdom of the economics of R&D. That is, R&D is mostly performed for own account given the public goods characteristics of knowledge and information, namely non-rivalry and appropriability issues. These characteristics limit open market transactions and often the full exploitation of technological innovation (**Teece 1986**). Even today geographically dispersed companies such as multinational corporations have kept the largest shares of their R&D activities at home. Further, for an outside (or even an internal) customer, R&D is typically user-specific and prone to technical uncertainties and failures, so that projects may not get started before funds and guidance are provided.

However, even though the vast majority of R&D is still performed at home by developed-country MNCs for internal company consumption, R&D is increasingly performed globally and collaboratively, driven by market and costs factors (**NSF 2006**).

Further, increased and more dispersed FDI in R&D-intensive industries (**NSF 2006**, **UNCTAD 2005**) have provided opportunities for global R&D and technology exchanges (**Arora et al. 2004**) within and outside companies, as shown by the data discussed above. Given the interest in these international activities, the need to focus on “R&D exports and imports” has come to the fore. However, these terms have been applied with a variety of meanings by statistical officials, including FDI-based definitions (that is, R&D performed by foreign-owned companies in the national territory) and funding-based definitions (R&D funded by overseas sources regardless of ownership considerations), both of which rely essentially on R&D costs as prescribed in the Frascati Manual. See **Mandler and Peleg 2003** and **de Haan and van Rooijen–Horsten 2004**. In contrast, **Robbins (2005)** implicitly uses a trade-based definition by using the data on trade in private R&D services featured in the first part of this paper. This paper justifies the latter approach by formally defining R&D exports/imports. The paper also develops a three-way characterization of expenditures and transactions on R&D incorporating concepts from the Frascati Manual, the Systems of National Accounts Manual (SNA, CEC et al. 1993), and the Manual on Statistics of International Trade in Services (MSITS) by distinguishing between R&D production, funding, and use/exchange.

#### *International transactions and R&D exports/imports*

As discussed above, FM focuses on cost-based measures, namely, production and financing of R&D. But a full account of international R&D transactions should incorporate trade-based measures:

- cost-based and market-based measures of R&D differ on the inclusion of operating surplus in the latter;<sup>8</sup>
- cost-based measures include transfer funds or grants that do not require an exchange of R&D results. In contrast, transfers are typically excluded from data on private services trade. Common transfers sources include domestic government units, international organizations, and overseas parents;<sup>9</sup>
- completed vs. ongoing R&D: Much like inventories create a wedge between production and trade for tangible goods, there are usually long lags between initial R&D funding and project completion. R&D costs include both ongoing and completed R&D projects, but trade-based data are recorded when services are rendered, implying completed R&D projects.

Both the Manual on Statistics of International Trade in Services (MSITS) and the IMF's Balance of Payments Manual (BPM5) define international trade as transactions between residents and non-residents of an economy (MSITS Box 1). Further, “[a] transaction itself is defined as an economic flow that reflects the creation, transformation, exchange, transfer or extinction of economic value and involves changes in ownership of goods and/or financial assets, the provision of services or the provision of labour or capital” (MSITS 2.31). For its part, residency requires both having a center of interest (i.e., participation in economic activities) and residing in the country for one year or more.

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<sup>8</sup> In practice, data from these different basis may be closer to each other: R&D surveys include items on contract R&D while intra-MNC exchanges may not fully reflect market values.

<sup>9</sup> Of course, parent companies also engage in fee-based R&D transactions with their affiliates as discussed above with U.S. data.

This “concept of residence... is identical to that used in BPM5 and the 1993 SNA [and]...it is not based on nationality or legal criteria...” (MSITS 3.3).

Note that considerations on ownership of the provider or financing of the exchanged product (good or service) are outside the scope of these definitions. Traded products are assumed to be available for any willing buyer, inside or outside the company, regardless of how, when, or where the products were designed, developed, produced, or financed.

Lastly, MSITS recognizes four modes of international delivery of services. Two of them are particularly relevant for business technical services such as R&D. The first mode refers to transactions between residents and non-residents --int’l trade in conventional sense as defined above. The other mode of interest is the provision of services through foreign affiliates (mode 3 in MSITS). Notably, the manual indicates that *only* mode 1 transactions (between residents and non-residents) should be labeled exports and imports. Separately, the manual recognizes that mode 1 may be detailed in terms of transactions between related parties, and transactions between unrelated parties (in this paper, affiliated and unaffiliated trade, respectively) (MSITS 3.36).

The discussion above on MSITS terminology suggests that *R&D exports and imports* can be defined in terms of cross-border exchanges, or transactions between residents and non-residents (of course, the direction of payments [or services] determines the designation of exports vs imports). In FM terms, residents may be partitioned between R&D performers

and non-R&D performers. Thus, transactions involve resident and non-resident R&D performers and non-performers.

*Official R&D Accounting and A New Transactions-based Profile of Business R&D*

We now develop an integrated framework for R&D expenditures and transactions putting together three official accounting approaches. The framework is based on a little noticed insight in the Frascati Manual on the separate identities of performer, funder, and user of R&D. According to Frascati, for a given R&D project, the performer, funder, and user fulfill different economic 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).<sup>10</sup>

In effect, Frascati identifies three distinct approaches for the collection and analysis of R&D data. Data based on R&D performers avoids potential double counting of the same activity when funds flow across several sectors. R&D performance reflects technological capabilities of companies, whereas R&D funding reflects financial capabilities or policy priorities. R&D performance underlines gross domestic expenditures on R&D (GERD) and business enterprise expenditures on R&D (BERD), whereas funding is used to compile gross national expenditures on R&D (NGERD). See **sidebar below**.

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<sup>10</sup> 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.

Lastly, R&D users subsequently produce new or improved products or processes, realizing profits through commercialization (OSLO Manual, **OECD 2005b**).<sup>11</sup> For its part, the SNA states that “goods and services are used when institutional units make use of them in a process of production or for the direct satisfaction of human needs or wants” (SNA 9.35). In practice, for services “the distinction between acquisition and use may not be relevant” (SNA 9.37). Indeed the definition of services implies that for many services production, delivery, and use may be indistinguishable (SNA 6.8). SNA terminology is also used to define market and non-market R&D and own account R&D. See **Robins (2005)** and sidebar below.

For the purposes of this paper, we distinguish between i) funding, ii) production, and iii) use/exchange of R&D. Each approach may not only be the subject of different economic surveys, but is also associated with different impacts in the economy:

- 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.

#### 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).

<sup>11</sup> 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).

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).

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.

The following matrix 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], where [2] + [3] = total R&D sales; [4] + [5] = total R&D purchases).

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<sup>th</sup> region corresponds to the area encircling the three circles. The regions formed by the intersections are nonempty. Below is a list of R&D profiles and examples of organizations (numbers inside ‘[]’ indicate lines in either **table 4** or sectors in the Venn diagram of **figure 4**):

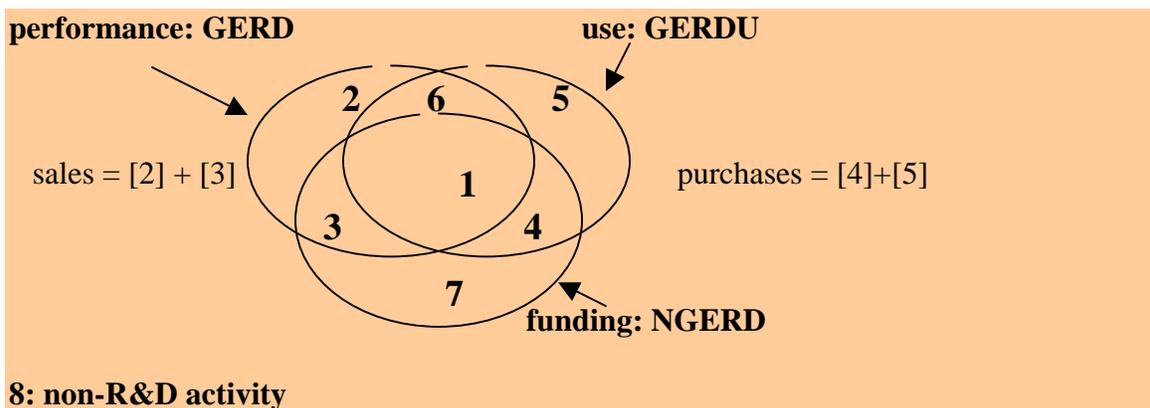
- [1] Own account, company-funded, R&D: high-tech manufacturer
- [2] Custom R&D services supply: DOD contractor
- [3] Open market R&D services supply: IBM
- [4] Purchase of custom R&D: DOD
- [5] Purchase of open market R&D: financial services company
- [6] Transfers for R&D (externally-funded own account R&D): Federal grantee
- [7] Transfers supply: State or local government funder
- [8] Non R&D-players (the vast majority of economic agents)

Notice that R&D profile [5] is out of scope of FM-based R&D surveys, including NSF R&D surveys, but it is within scope of services trade surveys. R&D profile [7] is out of scope of private services trade, but within scope of FM-based R&D surveys.

The following are key combinations of R&D profiles:

- R&D sales (domestic sales + exports): [2] + [3]
- R&D purchases (domestic purchases + imports): [5] + [4]

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



*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 in 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 framework the proposed term ‘*gross expenditures on R&D used*’ is an accounting term that does not measure long-term diffusion, value, or benefits but rather the short-term allocation or deployment of R&D at the end of its production period, assuming no inventories or ‘waste’.

Further, in this closed economy: [2]=[4]; [3]=[5]; and [6]=[7]. This is consistent with intra-country trade equilibrium, which requires: domestic R&D sales ([2]+[3]) = domestic R&D purchases ([5] + [4]).

*R&D transactions in a two-country system* – **Figure 5** shows international R&D exchanges involving 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

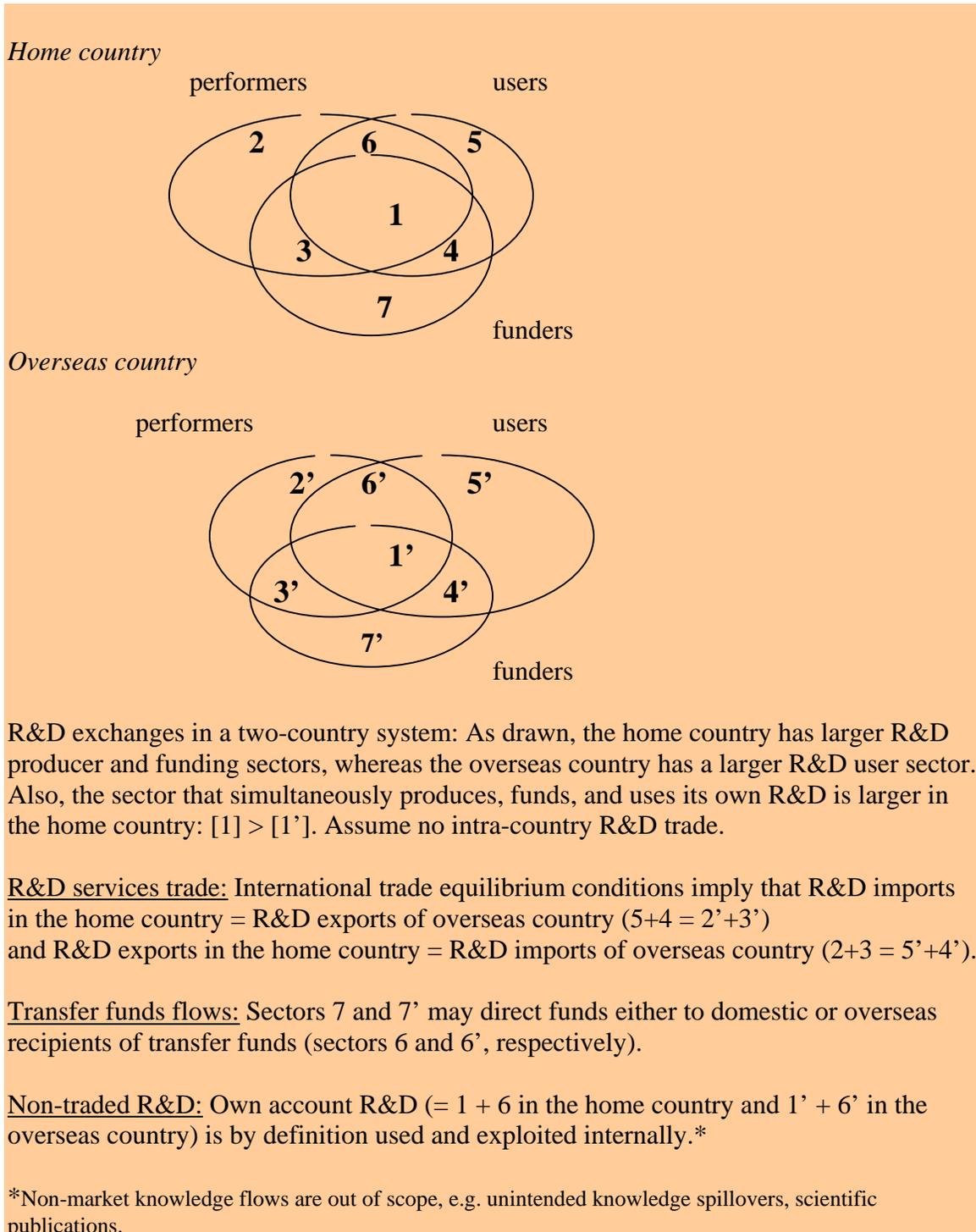
$$5+4 = 2' + 3'$$

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'). Typically, these transfer flows are excluded from estimates on private services trade.

Figure 5  
**R&D flows in an open economy**



### *Discussion*

The framework presented in Table 4 and Figures 4/5 characterizes R&D transactions and expenditures by systematically incorporating performance, funding, and trade perspectives. In particular, this integrated framework clearly distinguishes between 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.

*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. 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):

$NGERD \equiv GERD - \text{funding from abroad} + \text{funding funded abroad.}$

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, these data have already proved useful in accounting for the external sector of business R&D in an ongoing update of the U.S. R&D satellite account, 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:

$GERDU \equiv GERD - R\&D \text{ exports} + R\&D \text{ imports.}$

By using the fact that GERD is also equal to *own account R&D* plus R&D exports (Frascati Manual, OECD 1993) we also have:

$GERDU = \text{own account R\&D} + R\&D \text{ imports.}$

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

$$\begin{aligned} \text{BERDU} &\equiv \text{BERD} - \text{industrial R\&D exports} + \text{industrial R\&D imports} \\ &= \text{industry own account R\&D} + \text{industrial R\&D imports}. \end{aligned}$$

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

- BERD (= aggregate of [1] + [6] + [2] + [3]) = \$204.004 billion<sup>12</sup> (NSF SIRD)
- R&D exports (=overseas portion of [2] + [3]) = \$ 8.752 billion (BEA)
- R&D imports (= overseas portion of [4] + [5]) = \$4.427 billion (BEA)
- BERDU  $\equiv$  BERD – industrial R&D exports + industrial R&D imports =  
 $([1] + [6] + [2] + [3]) - ([2] + [3]) + ([4] + [5])$ <sup>13</sup> =  
 $\$204.004 - \$8.752 + \$4.427 = \$199.679$  billion =  
 aggregate of ([1] + [6] + [4] + [5])
- Business own account R&D (= [1] + [6]) = BERD – industrial R&D exports =  
 BERDU - industrial R&D imports = \$199.679 - \$4.427 = \$195.252 billion<sup>14</sup>
- Industrial R&D funding from abroad: Not available.
- Industrial R&D funded abroad = \$ 29.171 billion (NSF SIRD)

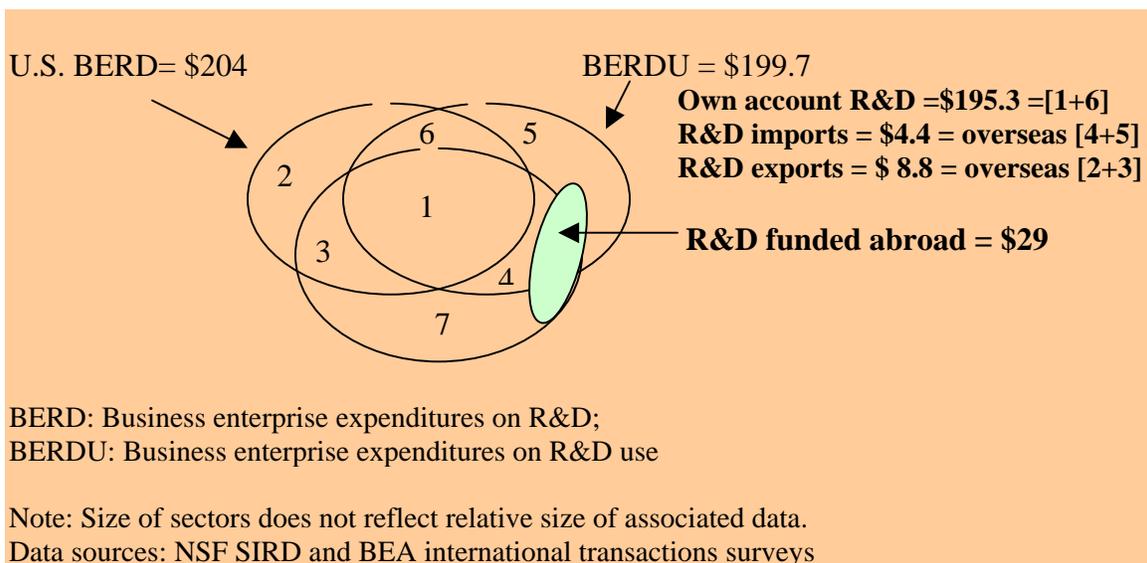
Note: As collected by NSF, and in the language of this paper, industrial R&D funded abroad by (R&D-performing) for-profit U.S. residents is the aggregate of overseas purchases of custom and open market R&D, plus funds transfers sent abroad. Recipients of the funds include overseas affiliates and contractors. 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.

<sup>12</sup> Excludes industry administered FFRDCs.

<sup>13</sup> 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).

<sup>14</sup> 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.

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



#### 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 2004, 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 explicitly defines “R&D exports and imports” consistent with several international statistical manuals and develops a framework that characterizes R&D expenditures and flows by systematically incorporating performance, funding, and trade perspectives. The framework allows examining different R&D aggregates and

flows, and the scenarios where each may be a sensible indicator for the analytical objective at hand.

In particular, the transactions-based matrix identifies a key difference between cost-based and trade-based measures of R&D flows in terms of two non-overlapping sectors: R&D users that are neither performers nor funders [sector 5] and organizations that are exclusively source of R&D transfer funds [sector 7]. The empirical and economic significance of these sectors are likely to vary by industry and country. However, differences in scope and methodology across surveys with information on R&D-related flows and the need for further detail by industry and 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/fddscript.htm> (FDIUS) and <http://www.bea.gov/bea/di/usdscript.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.<sup>15</sup> 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 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

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<sup>15</sup> 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<sup>16</sup>, 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.<sup>17</sup> 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.

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<sup>16</sup> The last benchmark survey was performed in 2001.

<sup>17</sup> 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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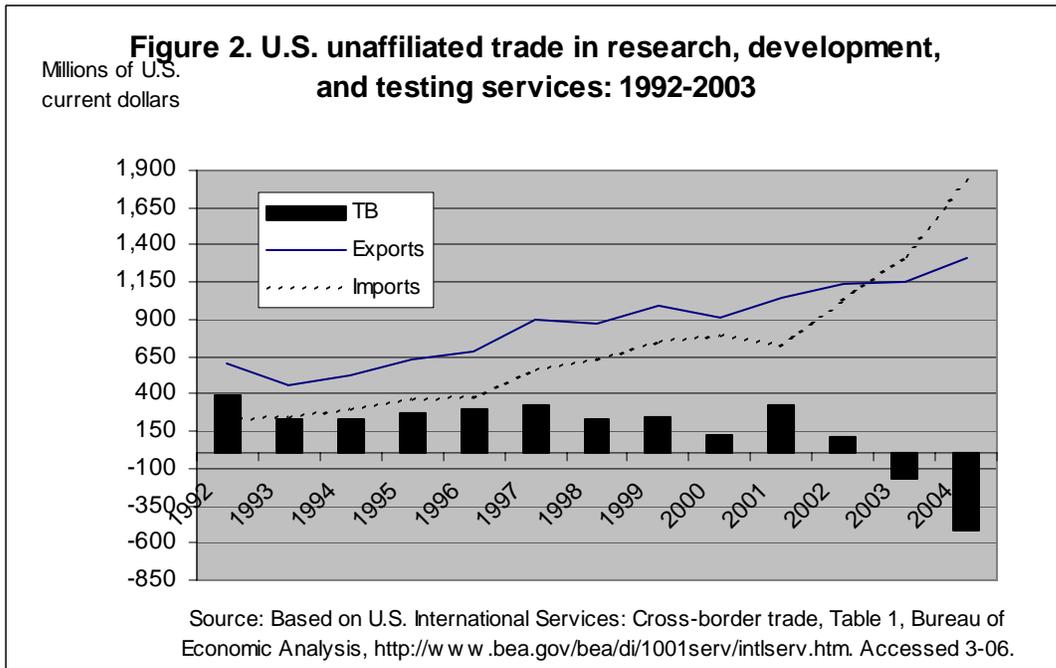
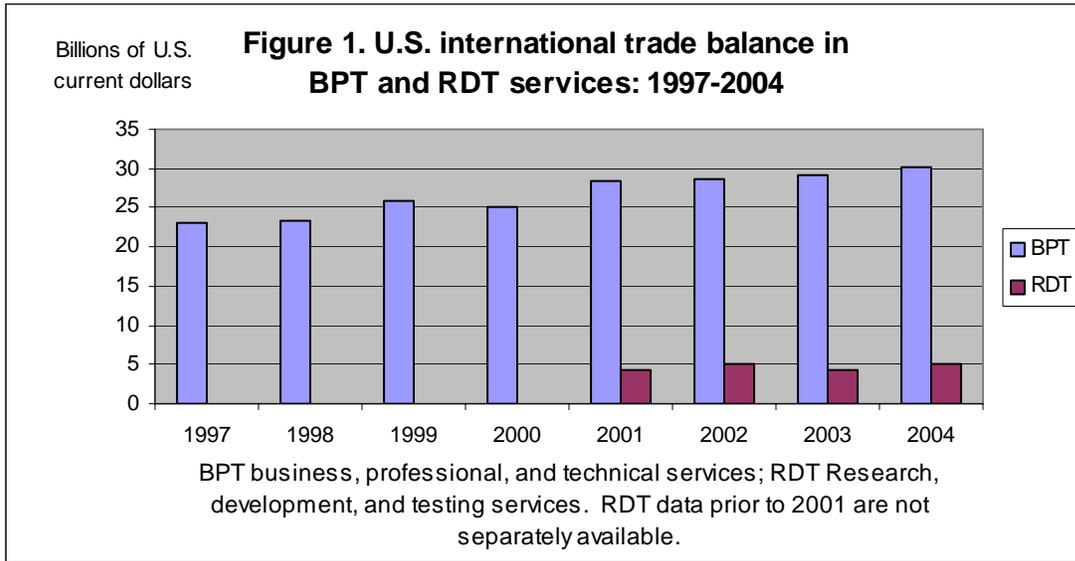
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**Table 1. U.S. trade in research, development, and testing services: 2001-2004**

Billions of current U.S. dollars

	Unaffiliated	Affiliated	
Exports			
2001	6,746	1,046	5,700
2002	7,642	1,142	6,500
2003	8,752	1,152	7,600
2004	9,807	1,307	8,500
Imports			
2001	2,425	725	1,700
2002	2,628	1,028	1,600
2003	4,427	1,327	3,100
2004	4,727	1,827	2,900
Trade balance			
2001	4,321	321	4,000
2002	5,014	114	4,900
2003	4,325	-175	4,500
2004	5,080	-520	5,600

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 March 2006.

Table 2. U.S. trade in RDT services: 2001-2004 -- Millions of current U.S. dollars

	2001			2002		Trade balance
	Exports	Imports	Trade balance	Exports	Imports	
Total.....	6,746	2,425	4,321	7,642	2,628	5,014
Affiliated.....	5,700	1,700	4,000	6,500	1,600	4,900
Unaffiliated.....	1,046	725	321	1,142	1,028	114
Unaffiliated by Country:						
Canada.....	82	91	-9	93	141	-48
European Union.....	358	333	25	427	544	-117
Europe.....	461	419	42	571	640	-69
Belgium-Luxembourg.....	22	16	6	28	13	15
France.....	59	30	29	61	42	19
Germany.....	102	42	60	120	96	24
Italy.....	9	6	3	9	15	-6
Netherlands.....	14	10	4	15	23	-8
Norway.....	4	3	1	3	3	0
Spain.....	7	6	1	7	3	4
Sweden.....	15	14	1	15	19	-4
Switzerland.....	79	42	37	127	52	75
United Kingdom.....	98	187	-89	142	290	-148
Latin America & OWH	54	37	17	48	32	16
Argentina.....	7	7	0	2	7	-5
Brazil.....	7	6	1	11	6	5
Chile.....	1	2	-1	1	1	0
Mexico.....	13	3	10	10	6	4
Venezuela.....	4	1	3	4	1	3
Africa.....	60	60	0	21	48	-27
South Africa.....	42	32	10	3	16	-13
Middle East.....	44	28	16	57	9	48
Israel.....	12	23	-11	11	8	3
Saudi Arabia.....	19	4	15	33	(*)	NA
Asia and Pacific.....	338	91	247	344	158	186
Australia.....	19	11	8	17	12	5
China.....	12	9	3	14	5	9
Hong Kong.....	3	1	2	3	5	-2
India.....	8	16	-8	4	15	-11
Indonesia.....	5	3	2	2	5	-3
Japan.....	235	22	213	263	23	240
Korea, Republic of.....	27	3	24	15	4	11
Malaysia.....	2	(*)	NA	1	1	0
New Zealand.....	1	(*)	NA	1	3	-2
Philippines.....	2	1	1	1	2	-1
Singapore.....	5	14	-9	4	(D)	NA
Taiwan.....	12	4	8	9	13	-4
Thailand.....	4	2	2	6	2	4

Table 2. U.S. trade in RDT services: 2001-2004 -- Millions of current U.S. dollars

	2003			2004		
	Trade			Trade		
	Exports	Imports	balance	Exports	Imports	balance
Total.....	8,752	4,427	4,325	9,807	4,727	5,080
Affiliated.....	7,600	3,100	4,500	8,500	2,900	5,600
Unaffiliated.....	1,152	1,327	-175	1,307	1,827	-520
Unaffiliated by Country:						
Canada.....	100	185	-85	85	172	-87
European Union.....	487	705	-218	504	1,173	-669
Europe.....	637	809	-172	691	1,274	-583
Belgium-Luxembourg.....	16	23	-7	20	24	-4
France.....	47	46	1	60	40	20
Germany.....	149	128	21	136	149	-13
Italy.....	11	14	-3	10	31	-21
Netherlands.....	15	29	-14	19	78	-59
Norway.....	4	10	-6	4	10	-6
Spain.....	9	3	6	11	5	6
Sweden.....	18	20	-2	17	34	-17
Switzerland.....	118	48	70	160	52	108
United Kingdom.....	188	382	-194	194	734	-540
Latin America & OWH	44	96	-52	63	91	-28
Argentina.....	3	18	-15	10	9	1
Brazil.....	5	31	-26	5	26	-21
Chile.....	1	3	-2	(*)	3	NA
Mexico.....	16	24	-8	18	29	-11
Venezuela.....	2	1	1	18	(*)	NA
Africa.....	11	58	-47	24	80	-56
South Africa.....	2	8	-6	14	9	5
Middle East.....	35	16	19	69	13	56
Israel.....	16	14	2	12	11	1
Saudi Arabia.....	2	(*)	NA	19	(*)	NA
Asia and Pacific.....	316	163	153	355	198	157
Australia.....	13	22	-9	18	23	-5
China.....	14	7	7	14	17	-3
Hong Kong.....	2	14	-12	2	2	0
India.....	7	18	-11	20	47	-27
Indonesia.....	(*)	(D)	NA	5	7	-2
Japan.....	236	33	203	236	36	200
Korea, Republic of.....	25	4	21	31	9	22
Malaysia.....	2	(*)	NA	1	2	-1
New Zealand.....	(*)	7	NA	2	8	-6
Philippines.....	1	1	0	3	2	1
Singapore.....	3	16	-13	5	8	-3
Taiwan.....	10	15	-5	10	19	-9
Thailand.....	2	4	-2	9	(D)	NA

(\*) Less than \$500,000; D Suppressed to avoid disclosure of data of individual companies;

NA not available; OWH Other Western Hemisphere

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	
	From U.S. parents to their foreign affiliates:		From U.S. affiliates of foreign MNCs to their foreign parents:*	
<b>Exports</b>				
2001.....	5.7	2.2	3.5	
2002.....	6.5	1.9	4.6	
2003.....	7.6	2.0	5.6	
2004.....	8.5	1.8	6.7	
<b>Imports</b>				
	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.....	1.6	0.8	0.8	
2003.....	3.1	1.1	2.0	
2004.....	2.9	1.2	1.8	
<b>Trade balance</b>				
	By U.S. parents to their foreign affiliates:		By U.S. affiliates to their foreign parents:*	
2001.....	3.9	1.5	2.4	
2002.....	4.9	1.2	3.7	
2003.....	4.5	0.9	3.6	
2004.....	5.6	0.6	5.0	

\* 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 March 2006.