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8 Taxes, Technology Transfer, and the R&D Activities of Multinational Firms

James R. Hines, Jr.

8.1 Introduction

Many governments encourage the development and use of new technologies within the borders of their countries. It is not difficult to understand why they do so. It is widely believed that the positive correlation between local economic affluence and the presence of technologically advanced industries implies that the use of new technologies enhances overall productivity. More direct evidence generally supports the conclusion that the economic benefits of research and development (R&D) activity extend to local firms other than those undertaking the R&D.[1] Since there are reasons to expect that externality-generating R&D activities may be underprovided by markets in which developers of new technologies do not capture all of the economic benefits that the technologies provide, various governments offer R&D-related tax subsidies.[2] Governments that do not offer R&D tax subsidies are often concerned that

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1. See Griliches (1991) and Nadiri (1993) for surveys of empirical measures of productivity spillovers from R&D activities.

2. In theory, the welfare consequences of subsidizing R&D are ambiguous because competitive pressures might generate too much R&D in certain industries in the absence of a subsidy and because foreign competitors may benefit from domestic subsidies (or in other ways influence the domestic market). See Dixit (1988) and Reinganum (1989) for surveys of the theory. The United States introduced the research and experimentation tax credit, and increased the tax deductibility of the R&D expenses of certain multinational corporations, in the Economic Recovery Tax Act of 1981. This legislation appears to have been motivated by consideration of economic externalities, though the focus of congressional sentiment as described in U.S. Joint Committee on Taxation (1981) is on comparisons of U.S. research intensity with the research intensities of other countries.

perhaps they should. There are, however, many open questions about the impact of tax policy on the level of R&D.

Tax systems influence the level and content of R&D activity through a variety of channels. This paper focuses on R&D by multinational firms, and on the impact of one particular set of taxes: withholding taxes on cross-border royalty payments. Firms that develop new technologies in their home countries and use the technologies in foreign locations are required to pay royalties from foreign affiliates to domestic parent companies. Governments tax these royalty payments. High tax rates make royalties, and the technology imports that they accompany, more expensive for the foreign affiliates that pay the taxes.

In theory, higher costs of imported technology might encourage or discourage local R&D by affiliates of multinational corporations. If local R&D is complementary with imported technology, then high royalty tax rates should discourage local R&D, while if local R&D is a substitute for imported technology, then high royalty tax rates should encourage local R&D.

This paper has two objectives. The first is to identify the degree to which R&D activity by multinational firms is sensitive to local tax conditions. The second objective is to determine whether imported technology and local R&D are complements or substitutes.

The results suggest that R&D responds significantly to local tax rates, and that local R&D is a substitute for imported technology. These results appear both in the behavior of American investors in other countries and in the behavior of foreign investors in the United States. Firms appear to react to high royalty tax rates by paying fewer royalties and performing additional R&D locally. To the extent that royalty payments reflect actual technology transfer (rather than adept accounting practices), the behavior of multinational firms implies that local R&D is a substitute for imported technology.

Section 8.2 of the paper briefly describes the tax treatment of multinational firms, paying particular attention to technology-related issues. Section 8.3 describes a simple model of firm behavior that traces the link between taxation and the degree of complementarity or substitutability of local R&D and imported technology. Section 8.4 describes the data that serve as the basis of the empirical work. Section 8.5 presents evidence on the relationship between royalty tax rates in foreign countries and the R&D intensities of local affiliates of American multinational firms. Section 8.6 examines the same relationship for foreign firms investing in the United States. Section 8.7 is the conclusion.

8.2 Multinational Firms, Taxation, and International Technology Transfer

This section examines the role of multinational firms in international technology transfer and reviews the tax treatment of R&D expenditures and royalty receipts by multinational firms.

8.2.1 International Technology Transfer

There is considerable interest in understanding the role that multinational firms play in transferring technologies across borders. There are two methods by which multinational firms provide new technologies to the countries in which they invest. The first method is to develop new technologies locally, through R&D or other similar types of activity. The second method is to import technologies produced elsewhere.

The foreign affiliates of American firms use both methods to bring technologies to the countries in which they operate, and there exists sufficient information to assess quantitatively the relative significance of each method. Direct information on the R&D activities of the foreign affiliates of U.S. firms is reported in surveys conducted by the U.S. Commerce Department. Information on technology imports by these affiliates is considerably sketchier. One can, however, infer the approximate magnitude of technology imports from royalties paid by the affiliates to U.S. parent firms and third parties in other countries, since royalty payments should, in principle, reflect the values of imported technologies.

Table 8.1 reports detailed information about the aggregate technology-related behavior of the foreign affiliates of U.S. firms in 1982 and 1989. It is noteworthy that these affiliates paid more in royalties to their parent firms ($9.8 billion in 1989) than they spent on R&D ($7.9 billion in 1989), though, as the table indicates, there was extensive use of both methods of technology acquisition. The survey distinguishes two categories of R&D expenditure: R&D by affiliates for themselves and R&D by affiliates for others (the latter of which is R&D performed on a contract basis). R&D by affiliates for themselves constitutes roughly 80 percent of their total R&D expenditures.

American firms spend a considerable amount of money on R&D performed in foreign countries, but in recent years, foreign-owned firms in the United States have spent even more than that on R&D performed here. Figure 8.1 illustrates the R&D expenditure levels of foreign affiliates of U.S. firms and foreign-owned firms in the United States over the 1977–90 period. Due to the R&D intensity of the U.S. economy relative to the rest of the world, and the strength of foreign direct investment into the United States since 1973, foreign firms have spent more on R&D inside the United States than American firms have spent on R&D outside the United States in every year since 1982, and the gap between the two expenditure levels is widening (see fig. 8.1).[3]

There is considerable interest in the role of multinational firms in transfer-

3. Exchange rate fluctuations can confound the interpretation of fig. 8.1 since changes in the value of the dollar relative to foreign currencies affect the dollar-denominated relative magnitudes of R&D performed in the United States and abroad, even if nominal expenditures are unchanged. This consideration is not significant in this case, however, since a simple adjustment for the changing value of the dollar relative to a trade-weighted average of foreign currencies produces a figure that very closely resembles fig. 8.1.

Table 8.1 R&D and Royalty Activity of Foreign Affiliates of U.S. Multinationals

Activity	1982	1989
R&D expenditures, total	3,851	7,922
By affiliate for itself	3,073	6,307
By affiliate for others	778	1,615
Royalty receipts, total	435	1,461
From U.S. parents	36	54
From other foreign affiliates	193	656
From unaffiliated Americans	26	97
From unaffiliated foreigners	180	654
Royalty payments, total	4,308	12,472
To U.S. parents	3,663	9,839
To other foreign affiliates	354	1,488
To unaffiliated Americans	102	660
To unaffiliated foreigners	189	485

Source: U.S. Department of Commerce (1985, 1992).

Note: Amounts are millions of current dollars. Data cover majority-owned foreign affiliates of U.S. multinational firms.

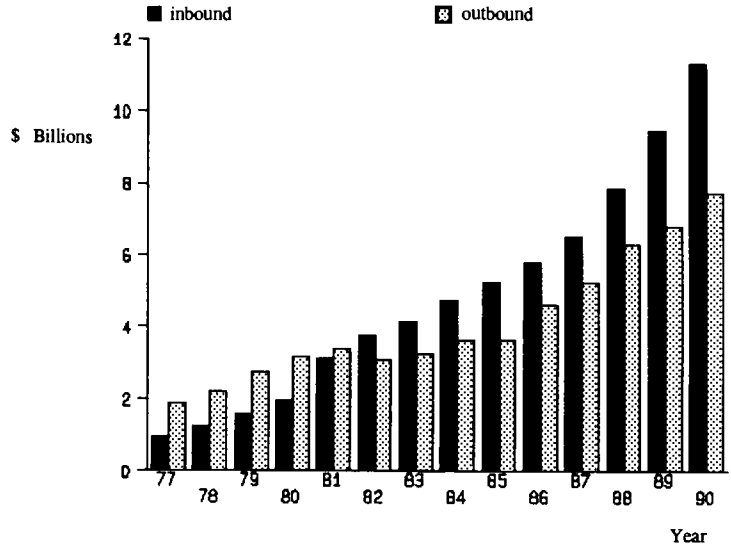

Fig. 8.1 R&D by foreign firms in the United States and by American firms abroad, 1977–90

Sources: U.S. Department of Commerce (various issues); National Science Foundation (1993).

Note: The vertical scale measures billions of current dollars of annual R&D expenditures. Darkly shaded bars represent total R&D expenditures of foreign-owned firms in the United States. Lightly shaded bars represent total R&D expenditures of foreign affiliates of American firms.

ring technology across borders, and the impact that government policy can have on the rate and direction of technology transfer. Though these issues have been extensively studied,[4] one of the open questions is the degree to which imported technology is a substitute or complement for local R&D.

8.2.2 U.S. Taxation of Foreign Income[5]

The United States taxes income on a "residence" basis, meaning that American corporations and individuals owe taxes to the U.S. government on all of their worldwide income, whether earned in the United States or not. The top U.S. corporate tax rate is now 35 percent. Since foreign profits are usually taxed in host countries, U.S. law provides a foreign tax credit for income taxes (and related taxes) paid to foreign governments, in order not to subject American multinationals to double taxation. The foreign tax credit mechanism provides that an American corporation earning $100 in a foreign country with a 12 percent tax rate (and a foreign tax obligation of $12) pays only $23 to the U.S. government, since its U.S. corporate tax liability of $35 (35 percent of $100) is reduced to $23 by the foreign tax credit of $12. The foreign tax credit is, however, limited to U.S. tax liability on foreign income; if, in the example, the foreign tax rate were 50 percent, then the firm pays $50 to the foreign government but its U.S. foreign tax credit is limited to $35. Hence, an American firm receives full tax credits for its foreign taxes paid only when it is in a "deficit credit" position, i.e., when its average foreign tax rate is less than its tax rate on domestic operations. A firm has "excess credits" if its available foreign tax credits exceed U.S. tax liability on its foreign income. Firms average together their taxable incomes and taxes paid in all of their foreign operations in calculating their foreign tax credits and the foreign tax credit limit.[6]

Deferral of U.S. taxation of certain foreign earnings is another important feature of the U.S. international tax system. An American parent firm is taxed on its subsidiaries' foreign income only when returned ("repatriated") to the

4. See, e.g., Teece (1976), Germidis (1977), Mansfield, Teece, and Romeo (1979), Mansfield and Romeo (1980), Davidson and McFetridge (1984), Lipsey, Blomstrom, and Kravis (1990), Zejan (1990), Blomstrom (1991), Ethier and Markusen (1991), Wang and Blomstrom (1992), and Blomstrom and Kokko (1993). These studies together consider the effect of a large number of variables on technology transfer and R&D activity, though they do not consider the effect of royalty tax rates on local R&D intensities.

5. Parts of this brief description of the tax system are excerpted from Hines (1991).

6. In order to qualify for the foreign tax credit, firms must own at least 10 percent of a foreign affiliate, and only those taxes that qualify as income taxes are creditable. Furthermore, income is broken into different functional "baskets" in the calculation of applicable credits and limits. Income earned and taxes paid in the conduct of most types of active foreign business operations are grouped in one basket; petroleum industry income is grouped in a separate basket; and there are separate baskets for items such as passive income earned abroad. The basket distinctions imply that a firm might simultaneously have excess foreign tax credits in the petroleum basket (which is common, since foreign tax rates on oil income are typically quite high) and deficit foreign tax credits in the active income basket. Such a firm would have to pay some U.S. tax on its active foreign income, even though it has excess foreign tax credits on its petroleum income.

parent corporation. This type of deferral is available only to foreign operations that are separately incorporated in foreign countries ("subsidiaries" of the parent) and not to consolidated ("branch") operations. The U.S. government taxes branch profits as they are earned, just as it would profits earned within the United States.

The deferral of U.S. taxation may create incentives for firms with lightly taxed foreign earnings to delay repatriating dividends from their foreign subsidiaries.[7] This incentive arises in those cases in which firms expect never to repatriate their foreign earnings, or in which they anticipate that future years will be more attractive for repatriation (either because domestic tax rates will be lower or because future sources of foreign income will generate excess foreign tax credits that can be used to offset U.S. tax liability on the dividends).[8] It appears that, in practice, American multinationals tend to pay dividends out of their more heavily taxed foreign earnings first.[9] Consequently, the average tax rate that firms face on their foreign income need not exactly equal the average foreign tax rate faced by their branches and subsidiaries abroad.

Branch earnings and dividends from subsidiaries represent only two forms of foreign income for U.S. income tax purposes. Interest received from foreign sources also represents foreign income, though foreign interest receipts are often classified within their own basket and hence are not averaged with other income in calculating the foreign tax credit. Royalty income received from foreigners, including foreign affiliates of U.S. firms, is also foreign-source income. Foreign governments often impose moderate taxes on dividend, interest, and royalty payments from foreign affiliates to their American parent companies; these withholding[10] taxes are fully creditable against an American taxpayer's U.S. tax liability on foreign income.

7. The incentive to defer repatriation of lightly taxed subsidiary earnings is attenuated by the Subpart F provisions, introduced into U.S. law in 1962, that treat a subsidiary's passive income, and income invested in U.S. property, as if it were distributed to its American owners, thereby subjecting it to immediate U.S. taxation. The Subpart F rules apply to controlled foreign corporations, which are foreign corporations owned at least 50 percent by American persons holding stakes of at least 10 percent each. Controlled foreign corporations that reinvest their foreign earnings in active businesses can continue to defer their U.S. tax liability on those earnings. See Hines (1994a), Hines and Rice (1994), and Scholes and Wolfson (1992) for the behavioral implications of these rules.

8. It is interesting to note that the deferral of U.S. tax liability does not itself create an incentive to delay paying dividends from foreign subsidiaries since the U.S. tax must be paid eventually. See Hartman (1985).

9. See the evidence presented in Hines and Hubbard (1990).

10. Taxes on cross-border flows, such as dividends, interest, and royalties, are known as "withholding" taxes because of some of the specifics of their administration. Strictly speaking, these taxes represent obligations of the recipients of the cross-border flows and not the payors; this arrangement permits immediate full crediting of withholding taxes by recipients who are eligible to claim foreign tax credits. The taxes are called "withholding" taxes because the local payor is the withholding agent for the tax and is therefore liable to its host government for full payment of the taxes.

8.2.3 The Tax Treatment of R&D Expenditures and Royalty Receipts

American multinational firms that perform R&D in the United States intending to use the resulting technology both in the United States and abroad face a complex tax treatment of their transactions. Since passage of the Tax Reform Act of 1986, American multinationals are no longer allowed to deduct 100 percent of their U.S. R&D expenses against their U.S. tax liabilities. Instead, U.S. law requires American firms to allocate R&D expenses between U.S. and foreign source based on the fraction of a firm's sales that are foreign.[11] The practical importance of this system is that firms with excess foreign tax credits receive usable tax deductions for only a fraction (equal to the ratio of domestic sales to total worldwide sales) of their U.S. R&D expenses. This system is based on the idea that multinational firms performing R&D in the United States use only a fraction of the output of their R&D activities to enhance their sales in the United States and, consequently, that only a fraction of their R&D costs should be deductible against U.S.-source income.

Royalties received by American parent firms for R&D used abroad represent taxable foreign-source income of the American firms. American firms with deficit foreign tax credits must pay U.S. income tax on these royalty receipts, while firms with excess foreign tax credits can apply the excess credits against U.S. taxes due on the royalties, thereby eliminating the U.S. tax liability created by the royalty receipts.

Most of the world's governments impose withholding taxes on cross-border royalty payments from affiliates located within their countries. These royalty tax rates are frequently reduced according to the terms of bilateral tax treaties. For example, the United States imposes a 30 percent tax on royalties paid to foreign corporations, but this tax rate is often reduced, in some cases to zero, when recipients of royalty payments are located in countries with whom the United States has a tax treaty in force.

8.3 Framework for Analysis

This section analyzes the implications of systems of international taxation for the R&D behavior of multinational firms.

Consider a multinational firm that establishes a foreign affiliate to produce and sell goods in the foreign country in which the affiliate is located.[12] The affiliate generates sales using local inputs of capital, labor, and intermediate products; in addition, the affiliate uses technology from its parent and the technology it generates on its own to produce goods for sale. The reduced-form

11. See Hines (1993, 1994b) for descriptions of the precise formulas used and quantitative assessments of their impact on R&D spending levels.

12. This analysis abstracts from the possibility that the activities of a foreign affiliate directly enhance the sales of its domestic parent firm. One of the practical difficulties that American firms encounter in such situations is that royalties paid by U.S. parents to their foreign affiliates are severely tax disadvantaged. See Hines (1994b) for a discussion of this issue.

function that describes the impact of technologies on the affiliate's sales can be formalized as $S(R, R^*, \phi)$, in which S denotes sales in the local (foreign) market, R is technology provided by the parent firm to the affiliate in this market, R^* is the technology that the affiliate generates on its own, and ϕ denotes other features of the local market (as well as the affiliate's profit-maximizing employment of local factors).

American tax law and the tax laws of most other countries[13] require that foreign affiliates pay rents or royalties to their parent firms for the fair market value of technologies transferred from the parent firms to the affiliates. Of course, in practice it is frequently difficult to establish the fair market value of technology transferred from one party to another within a controlled group since there may exist no market prices for the types of technology in question. In such circumstances, tax-avoiding firms that transfer technology from the parent to its foreign affiliates often have incentives to select royalty payments that transfer taxable income out of high-tax jurisdictions and into low-tax jurisdictions. Governments are aware of this incentive and try to use their enforcement power to prevent royalties from deviating too greatly from reasonable values.[14]

One way to describe government enforcement efforts is to introduce an additional cost that firms bear when royalties deviate from market values. The cost includes the cost that firms incur in justifying their royalty declarations to tax authorities. If this adjustment cost rises sufficiently with the size of the deviation of reported royalties from market values, it will ultimately limit the degree to which firms modify royalty payments simply for tax purposes.

A quadratic model of adjustment costs provides a convenient framework to use in analyzing the impact of government enforcement efforts. One can distinguish R, the true value of transferred technology, from r, the royalty paid to the parent firm by the affiliate receiving the technology. If the rate of adjustment cost is quadratic in the deviation of declared royalties from the technology's market value, then adjustment costs equal $\alpha[(R - r)^2/R^2]$ for each unit of technology transferred. The parameter α is taken to be constant. Total adjustment costs equal the product of R and this term, or $\alpha(R - r)^2/R$.

The affiliate's technology-related taxable income represents the difference between sales revenue generated by the technology and the affiliate's costs. These costs include the affiliate's own R&D expenditures, the royalties it pays to the parent firm, and the adjustment cost.[15] The parent firm receives a royalty

13. Of the 25 industrialized countries surveyed by Lawlor (1985), 24 apply the arm's-length principle to the taxation of related-party transactions; Hong Kong is the lone exception.

14. For evidence on the overall effectiveness of transfer price enforcement, see Kopits (1976), Grubert and Mutti (1991), Harris et al. (1993), and Hines and Rice (1994).

15. This treatment of the foreign affiliate abstracts from its activities that are unaffected by R&D activities or technology imports. The affiliate, and not the parent firm, is assumed to bear the adjustment cost because doing so simplifies the algebra that follows. A more general treatment that allocates adjustment costs between affiliates and parent firms yields qualitatively similar results. See e.g., the treatment of adjustment costs in Hines and Rice (1994).

from its affiliate and may incur a cost of producing the technology that it transfers to the affiliate. In order to fix ideas for the analysis that follows, the model describes the behavior of a multinational firm that has excess foreign tax credits and that values on a one-for-one basis its after-tax profits in foreign subsidiaries.[16] The multinational firm maximizes after-tax profits, π:

$$\pi = (1 - \tau^*)[S(R, R^*, \phi) - R^* - r - \alpha(R - r)^2/R] + (1 - w^*)r - cR, \tag{1}$$

in which τ^* is the foreign statutory tax rate, w^* is the withholding tax rate imposed by the foreign government on outgoing royalty payments, and c is the per unit cost incurred by the parent firm to develop and/or transfer the technology represented by R. The first term in expression (1) represents the after-foreign-tax profits earned by the affiliate; the second term is the parent firm's after-withholding-tax royalty receipts; and the third term is the parent firm's cost of developing the technology that it transfers to the affiliate. In some cases, parent firms costlessly transfer to their subsidiaries technologies developed for other purposes, so it is possible that $c = 0$.

The first-order condition describing the firm's optimal choice of r is

$$(1 - \tau^*)[2\alpha(R - r)/R - 1] + (1 - w^*) = 0, \tag{2}$$

which yields

$$r = R\{1 + (\tau^* - w^*)/[2\alpha(1 - \tau^*)]\}. \tag{3}$$

The first-order condition describing the firm's optimal choice of R is

$$(1 - \tau^*)[\partial S/\partial R - \alpha(R - r)(R + r)/R^2] - c = 0. \tag{4}$$

Imposing equation (3) and simplfying yields

$$\partial S/\partial R = c/(1 - \tau^*) + (w^* - \tau^*)/(1 - \tau^*) - (w^* - \tau^*)^2/[4\alpha(1 - \tau^*)^2]. \tag{5}$$

The first-order condition describing the firm's optimal choice of R^* is considerably simpler:

$$\partial S/\partial R^* = 1. \tag{6}$$

16. A firm values its subsidiaries' profits on a one-for-basis either if there is no tax due upon repatriation or if the firm can use deferral strategies of the type described in Hines and Rice (1994) to reduce the present value of repatriation taxes. A firm with deficit foreign tax credits maximizes an expression that is similar to equation (1), with the difference that the terms $1 - \tau^*$ and $1 - w^*$ are replaced by $1 - \tau$, in which τ is the home country tax rate. The first-order conditions describing the behavior of such a firm imply that the firm sets $r = R$, and that, in this static setting, host country tax rates do not influence its behavior. In practice, the behavior of American multinational firms should reflect some kind of average of these two extremes. The analysis that follows assumes that all American firms have excess foreign tax credits, so, to the extent that many firms do not, the empirical estimates *understate* the responsiveness of the affected group to local tax conditions. The home countries of foreign investors in the United States have tax systems that differ considerably in their treatments of R&D expenditures and royalty and dividend income from foreign sources. The empirical work in this paper distinguishes home-country tax systems only by whether firms are permitted to claim foreign tax credits, which omits some more subtle distinctions and may, thereby, introduce measurement error in the tax variables.

The conditions (3), (5), and (6) characterize the multinational firm's optimal interior choices of R, R^*, and r. Inspection of equations (5) and (6) indicates that taxation does not affect the required marginal productivity of R&D performed in the foreign location, while taxation does affect the required marginal productivity of R&D performed in the home country. Consequently, as long as tax rates are set in a manner that is exogenous to the unobservable factors that determine R&D intensity, it is possible to use the tax variables that appear on the right-hand side of equation (5) to estimate the extent to which domestic technology is a substitute or complement for foreign R&D.

8.4 Data

There are two available sources of detailed information on the R&D activities of multinational firms located in a large number of countries. The first source is the 1989 Benchmark Survey of the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. This survey, the results of which are reported in U.S. Department of Commerce (1992), is the most recent comprehensive survey of the activities of the foreign affiliates of American multinational firms. The survey covers activities during 1989. In order to protect the confidentiality of survey respondents, BEA does not divulge the responses of individual firms and reports country aggregates only for those countries in which there are sufficient numbers of U.S. firms with sizable activities that aggregate figures do not reveal information about individual firms. Useful R&D and royalty data are available for affiliates in 43 foreign countries for 1989.

The second source of information is the 1987 survey of foreign direct investment in the United States, reported in U.S. Department of Commerce (1990). This survey describes the activities of foreign-owned firms in the United States during 1987. Because of data suppressions and other limitations, useful data are available on investors from 27 different countries during 1987.

The goal of the statistical work is to examine the relationship between royalty tax rates and levels of R&D activity, both for American firms investing in foreign countries and for foreign firms investing in the United States. The difficulty that such a study encounters is that R&D levels differ for reasons that have nothing to do with tax rates. One nontax factor that is clearly associated with R&D spending is the degree of R&D intensity in the countries in which multinational firms have operations. The foreign affiliates of American multinationals located in countries whose economies are R&D intensive tend to perform more R&D than do affiliates located in other countries. Similarly, foreign-owned affiliates in the United States tend to invest more in R&D if their parent firms are located in technologically intensive countries.[17]

17. At a first pass, this association is suggestive of a complementary relationship between local R&D and imported technology, since affiliates of multinational firms headquartered in R&D-intensive countries probably face lower real costs of importing technology than do affiliates of firms from other countries. But differences in the technological intensities of parent firms also reflect heterogeneity between affiliates that can invalidate such an inference.

Information is available from the National Science Foundation (1992) on the R&D intensities of a large number of countries. The National Science Foundation constructs indices that reflect national R&D/GNP ratios; because of data limitations, these ratios are not all calculated using data for the same year, though most observations represent the period 1986–88.[18] In the empirical work that follows, the variables that influence R&D demand are interacted with these country-level measures of R&D intensity. This procedure represents a simple, if rather unsubtle, adjustment for heterogeneity among countries in the extent to which their firms undertake R&D. Local R&D intensity can have an important impact on the demand for imported technology as well, so the R&D intensity variable appears in the royalty equations. Since R&D intensity is likely to have a less direct impact on royalties than it does on R&D expenditures, the R&D intensity variable enters the royalty equations independent of the other explanatory variables.

Information on tax systems and tax rates is reported by Price Waterhouse (various issues). In the empirical work that follows, firms are assumed to face effective tax rates on their technology-related activities equal to statutory corporate tax rates in host countries. Tables 8.3 and 8.4 report means and standard deviations of the variables used in the empirical work.

8.5 Foreign Affiliates of American Multinational Corporations

The model described by equations (1)–(6) carries the implication that technology-related royalty payments and R&D spending levels should respond to local tax rates. Specifically, the model predicts that higher withholding taxes on royalties will reduce royalty payments both by discouraging technology transfers and by reducing the ratio of reported royalties to the values of technologies transferred.

The regressions reported in table 8.5 test these implications on the data that describe the behavior of the foreign affiliates of American multinational corporations for the year 1989. Table 8.5 presents estimates of the coefficients that correspond to the implied specification of the royalty demand equation that emerges from equations (3) and (5). The dependent variable is a ratio, the numerator of which is royalties paid by the foreign affiliates of U.S. firms to their parent companies, and the denominator of which is total sales by the affiliates.[19] Data represent country aggregates.

18. R&D/GNP ratios change little from year to year, as evidenced by the time-series data on France, Germany, Japan, the United Kingdom, and the United States presented in table 8.2. These economies, which are among the most R&D intensive in the world, exhibit only gradual movements in R&D intensity relative to each other. This pattern suggests that time-invariant cross-sectional differences in R&D intensity are likely to be much more important than any differences created by the asynchronous nature of the data reported by the National Science Foundation.

19. The equations reported in table 8.5 were all rerun using total royalties paid in place of royalties paid to U.S. parents, with very similar results (and not surprisingly, since, as table 8.1 indicates, 80 percent of all royalties paid by the foreign affiliates of American firms go to the parent companies of the affiliates paying the royalties). The regressions reported in table 8.5 use

Table 8.2 **R&D Expenditure as a Percentage of GNP, 1961–89**

Year	France	West Germany	Japan	United Kingdom	United States
1961	1.4	–	1.4	2.5	2.7
1962	1.5	1.2	1.5	–	2.7
1963	1.6	1.4	1.5	–	2.8
1964	1.8	1.6	1.5	2.3	2.9
1965	2.0	1.7	1.6	–	2.8
1966	2.1	1.8	1.5	2.3	2.8
1967	2.2	2.0	1.6	2.3	2.8
1968	2.1	2.0	1.7	2.2	2.8
1969	2.0	1.8	1.7	2.3	2.7
1970	1.9	2.1	1.9	–	2.6
1971	1.9	2.2	1.9	–	2.4
1972	1.9	2.2	1.9	2.1	2.4
1973	1.8	2.1	2.0	–	2.3
1974	1.8	2.1	2.0	–	2.2
1975	1.8	2.2	2.0	2.1	2.2
1976	1.8	2.1	2.0	–	2.2
1977	1.8	2.1	2.0	–	2.2
1978	1.8	2.2	2.0	2.2	2.1
1979	1.8	2.4	2.1	–	2.2
1980	1.8	2.4	2.2	–	2.3
1981	2.0	2.5	2.3	2.4	2.4
1982	2.1	2.6	2.4	–	2.5
1983	2.1	2.6	2.6	2.2	2.6
1984	2.2	2.6	2.6	–	2.7
1985	2.3	2.8	2.8	2.3	2.8
1986	2.3	2.8	2.8	2.4	2.8
1987	2.3	2.9	2.8	2.3	2.8
1988	2.3	2.9	2.9	2.2	2.7
1989	2.3	2.9	3.0	2.0	2.7

Source: National Science Foundation (1991).

Note: French data are based on gross domestic product (GDP); consequently, percentages may be slightly overstated compared to GNP. Omissions (–) indicate that R&D data are unavilable.

The estimates reported in column (1) of table 8.5 imply that royalty payments respond negatively to royalty tax rates and are close to unaffected by statutory tax rates. The coefficients indicate that, at a statutory tax rate of 35 percent, a 10 percent reduction in the withholding tax rate on royalties stimulates additional royalty payments equal to 0.1 percent of sales. The implied elasticity of royalty payments with respect to the royalty tax rate, calculated using these estimates and mean values of the variables as reported in table 8.3,

royalties paid to parent companies because only for those royalties is it clear at what rate the royalties will be taxed.

Table 8.3 **Variable Means and Standard Deviations: Foreign Affiliates of U.S. Corporations, 1989**

Variable	Mean	Standard Deviation	*N*
Parent royalties/Sales	0.00774	0.00693	41
R&D/Labor compensation	0.05370	0.06317	43
R&D for affiliate/Total R&D	0.89466	0.16576	38
R&D/GDP	0.01080	0.00878	41
$w^*/(1 - \tau^*)$	0.42149	0.54876	41
$\tau^*/(1 - \tau^*)$	0.65270	0.29224	41
$(w^* - \tau^*)/1 - \tau^*)$	−0.23121	0.46387	41
$[(w^* - \tau^*)/(1 - \tau^*)]^2$	0.26339	0.27492	41
$1/(1 - \tau^*)$	1.65270	0.29224	41
w^*	0.20784	0.25274	38
τ^*	0.37666	0.09167	38
$[w^*/(1 - \tau^*)]$(R&D/GNP)	0.00263	0.00446	43
$[\tau^*/(1 - \tau^*)]$(R&D/GNP)	0.00737	0.00797	43
$[(w^* - \tau^*)/(1 - \tau^*)]$(R&D/GNP)	−0.00475	0.00752	43
$[(w^* - \tau^*)/(1 - \tau^*)]^2$(R&D/GNP)	0.00388	0.00641	43
$[1/(1 - \tau^*)]$(R&D/GNP)	0.01793	0.01602	43

Note: The regressions reported in tables 8.5–8.7 use these variables. The first three represent country-level aggregate activities of foreign affiliates of U.S. corporations in 1989, as reported in U.S. Department of Commerce (1992). The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable τ^* represents local statutory corporate tax rates, and w^* represents withholding tax rates imposed by foreign countries on royalty payments to the United States. Observations are country-level aggregates of the behavior of all U.S.-owned affiliates.

Table 8.4 **Variable Means and Standard Deviations: Foreign-Owned Affiliates in the United States, 1987**

Variable	Mean	Standard Deviation	*N*
Royalties/Sales	0.00759	0.00936	27
R&D/Labor compensation	0.08749	0.13590	27
R&D/GNP	0.01511	0.00932	27
w	0.12037	0.12805	27
$w(1 - \text{FTC})$	0.06481	0.11752	27
w^2	0.03028	0.03998	27
$w^2(1 - \text{FTC})$	0.01750	0.03532	27
w(R&D/GNP)	0.00120	0.00190	27
$w(1 - \text{FTC})$(R&D/GNP)	0.00068	0.00181	27
w^2(R&D/GNP)	0.00028	0.00056	27
$w^2(1 - \text{FTC})$(R&D/GNP)	0.00017	0.00054	27

Note: The regressions reported in tables 8.8 and 8.9 use these variables. The first two variables represent country-level aggregate activities of foreign-owned affiliates in the United States in 1987, as reported in U.S. Department of Commerce (1990). The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable w represents the withholding tax rate imposed by the United States on royalty payments from the United States. The variable FTC equals unity if an investor's home country taxes worldwide income and grants foreign tax credits to its residents, and equals zero otherwise. Observations are country-level aggregates of the behavior of all U.S.-owned affiliates.

Table 8.5 **Royalty Tax Rates and Royalty Payments by Foreign Affiliates of U.S. Corporations, 1989**

Variable	(1)	(2)	(3)	(4)	(5)
Constant	0.0060	0.0014	0.0142	0.0016	0.0176
	(0.0027)	(0.0014)	(0.0067)	(0.0015)	(0.0078)
R&D/GNP	0.4310	0.4023	0.4310	0.4310	0.4002
	(0.1201)	(0.1215)	(0.1201)	(0.1282)	(0.1240)
$w^*/(1 - \tau^*)$	−0.0068				
	(0.0027)				
$\tau^*/(1 - \tau^*)$	−0.0013				
	(0.0042)				
$(w^* - \tau^*)/(1 - \tau^*)$		−0.0061	−0.0068	−0.0063	−0.0066
		(0.0025)	(0.0027)	(0.0025)	(0.0027)
$[(w^* - \tau^*)/(1 - \tau^*)]^2$				−0.0027	0.0039
				(0.0037)	(0.0046)
$1/(1 - \tau^*)$			−0.0082		−0.0107
			(0.0042)		(0.0052)
$\hat{\sigma}$	0.0053	0.0055	0.0053	0.0055	0.0052
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0006)
log L	125.0988	122.8083	125.0988	123.0681	125.4541
N	41	41	41	41	41

Note: The columns report coefficients from Tobit regressions in which the dependent variable is the ratio of royalties paid by foreign affiliates of U.S. corporations to their parent companies to the affiliates' total sales. The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable τ^* represents local statutory corporate tax rates, and w^* represents withholding tax rates imposed by foreign countries on royalty payments to the United States. Observations are country-level aggregates of the behavior of all U.S.-owned affiliates. Standard errors are in parentheses.

is approximately −0.4.[20] If sales are unaffected by changes in royalty tax rates, then this figure implies that doubling the royalty tax rate reduces royalties by 40 percent, a sizable fraction.

Since sales may respond to tax rate changes, this calculation may understate the responsiveness of royalties, but nevertheless strongly suggests that the true elasticity lies between zero and −1. It is, however, important to note that the aggregate nature of the data may introduce considerable measurement error that biases the estimated coefficient toward zero. The sign of any bias introduced by omitted variables is ambiguous, though the magnitude could be large.

The results presented in column (2) of table 8.5 indicate that royalties also respond significantly to differences between royalty withholding tax rates and statutory tax rates. As predicted, the local R&D/GNP ratio is positively correlated with royalty payments. Alternative specifications reported in columns (3)–(5) of table 8.5 yield similar conclusions: high tax rates on royalties are associated with lower ratios of royalty payments to total sales.

20. Exercises such as this one are fraught with dangers, since variables may exhibit considerable differences between their conditional and unconditional means. The calculation in the text is meant only to be illustrative.

The specifications used to obtain the results described in table 8.5 were changed in a number of ways, in every case generating similar results. One specification issue concerns the appropriate choice of denominator for the dependent variable. Specifications in which labor compensation replaces sales as the denominator of the dependent variable yield results that are almost identical to those reported in table 8.5. Due to the somewhat heterogeneous nature of royalties, it seems most appropriate to scale this variable by sales. In the regressions reported in tables 8.6 and 8.9, the dependent variables that represent R&D expenditures are scaled by labor compensation in manufacturing for somewhat different reasons. Manufacturing affiliates account for approximately 90 percent of the R&D activity of foreign-owned affiliates in the U.S. and of the foreign affiliates of U.S. firms. Labor expenditures share with R&D expenditures the feature of immediate deductibility for tax purposes[21] and are more reasonably thought of as the product of firm choices than are sales, which may be functions of R&D. All of the R&D demand equations in reported in tables 8.6 and 8.9 were rerun scaling the dependent variable by labor expenditures, with results that are very similar to those reported in the tables.

8.5.1 A First Approach to Estimating the Impact of Taxes on R&D

The results reported in table 8.5 indicate that royalty payments by the foreign affiliates of U.S. multinational firms respond to tax rates in the predicted manner. The model described in equations (1)–(6) does not, however, carry a prediction about the sign of the effect of tax rates on R&D expenditure levels, and the object of the regressions reported in tables 8.6 and 8.7 is to measure the sign of any effect that may be present. The regressions reported in tables 8.6 and 8.7 address this measurement problem using very different methodologies—though, as it happens, the results point to conclusions that are quite similar.

Table 8.6 presents regressions that estimate of the impact of the tax treatment of royalties on the R&D intensities of foreign affiliates of U.S. firms, using specifications drawn from the model described in equations (1)–(6). The dependent variable is the ratio of R&D expenditures in 1989 to manufacturing labor compensation in 1989. The results in the table are strongly suggestive of an important impact of royalty taxes on R&D activity, but not all of the estimated coefficients in the table are significant. The strongest and most parsimonious specification is presented in column (2) of table 8.6, and here the estimated coefficients suggest that an unfavorable tax climate for royalties is associated with greater R&D activity. Imported technology and local R&D appear to be substitutes.

21. Of course, some countries (including the United States) offer tax credits and other inducements to firms that perform R&D (and in some cases to firms that hire labor). A brief survey of country practices indicates, however, that sizable R&D subsidies are rare (e.g., see Hall 1993 for an analysis of the magnitude of the marginal subsidy provided R&D in the United States by the research and experimentation tax credit), and that the primary subsidy comes from the immediate deductibility of R&D expenses that almost all industrialized countries provide.

Table 8.6 **Local Tax Rates and R&D Intensities of Foreign Affiliates of U.S. Corporations, 1989**

Variable	(1)	(2)	(3)	(4)	(5)
Constant	−0.0260	−0.0274	−0.0260	−0.0208	−0.0209
	(0.0146)	(0.0150)	(0.0146)	(0.0146)	(0.0147)
R&D/GNP	10.0631	8.8330	12.7071	8.0861	8.5018
	(2.0237)	(1.8161)	(3.4801)	(1.7744)	(4.7042)
$[w^*/(1 - \tau^*)] \cdot$ (R&D/GNP)	3.1769				
	(2.1870)				
$[\tau^*/(1 - \tau^*)] \cdot$ (R&D/GNP)	−5.8209				
	(2.3508)				
$[(w^* - \tau^*)/(1 - \tau^*)] \cdot$ (R&D/GNP)		4.2941	3.1769	0.3143	0.3981
		(2.0724)	(2.1870)	(2.9011)	(3.0308)
$[(w^* - \tau^*)/(1 - \tau^*)]^2 \cdot$ (R&D/GNP)				−4.4628	−4.2460
				(2.4171)	(3.3159)
$[1/(1 - \tau^*)] \cdot$ (R&D/GNP)			−2.6440		−2.2590
			(2.0200)		(2.7136)
$\hat{\sigma}$	0.0497	0.0509	0.0497	0.0487	0.0487
	(0.0062)	(0.0063)	(0.0062)	(0.0060)	(0.0060)
log L	47.1507	46.3131	47.1507	47.9522	47.9568
N	43	43	43	43	43

Note: The columns report coefficients from Tobit regressions in which the dependent variable is the ratio of R&D expenditures by foreign affiliates of U.S. corporations to the affiliates' expenditures on labor compensation in manufcturing. The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable τ^* represents local statutory corporate tax rates, and w^* represents withholding tax rates imposed by foreign countries on royalty payments to the United States. Observations are country-level aggregates of the behavior of all U.S.-owned affiliates. Standard errors are in parentheses.

Columns (3)–(5) of table 8.6 report the results of alternative specifications of the model. Two aspects of these results are noteworthy. The first is that the estimated coefficients on the variable $[1/(1 - \tau^*)] \cdot$ (R&D/GNP) are always insignificant. This variable appears as one part of the first term on the right-hand side of equation (5), and the estimated coefficient captures the effect of c, the cost of developing technology at home to transfer to affiliates abroad. The insignificance of the estimated coefficient implies either that firms transfer nonrival technologies to their affiliates, so $c = 0$, or that the estimating methodology is not powerful enough to identify an important effect. The second noteworthy aspect of the results is that the specifications that include quadratic tax terms generate insignificant results. These results may reflect the limited ability of the estimators to distinguish the effects of collinear variables in a small sample.

Using the coefficient estimate from the equation presented in column (1) of table 8.6, the implied elasticity of R&D activity with respect to the withholding tax rate on royalties (evaluating all variables at their sample means) is approximately 0.16. This figure is smaller than the implied royalty elasticity calculated

from table 8.5, which is reassuring because own-price elasticities are usually stronger than cross-price elasticities. This estimated elasticity suggests that local R&D is a mild substitute for imported technology, but it is helpful to consider additional evidence before drawing any conclusions.

8.5.2 A Second Approach to Estimating the Impact of Taxes on R&D

One difficulty that arises in estimating the impact of royalty tax rates on local R&D levels is that many omitted variables influence R&D spending. It is possible that these variables are correlated with royalty withholding tax rates in a way that biases the estimated tax rate coefficients and generates a misleading conclusion concerning the substitutability of R&D for imported technology. The regressions reported in table 8.6 control for local technological environments simply by interacting the tax variables with the R&D/GNP measure.

An alternative approach is to use available information that distinguishes the R&D activity of foreign affiliates of American firms for their own purposes from R&D activity that they undertake on behalf of others. Both types of R&D activity are likely to be influenced by local economic and technological conditions. It is, however, possible that the latter type of contract-style R&D performed for others is generally unaffected by the availability of technology imports from parent firms. If not, then R&D performed for others serves as a control group with which to compare R&D performed by affiliates for their own purposes. Under the hypothesis that R&D performed for others is unaffected by technology imports, the fraction of an affiliate's total R&D activity undertaken for itself is a positive function of royalty taxes if local R&D and imported technology are substitutes, and a negative function of royalty taxes if local R&D and imported technology are complements.

There are 38 countries in the sample for which the BEA data distinguish R&D performed by affiliates for themselves from R&D performed by affiliates for others. Table 8.7 presents estimated coefficients from regressions in which the dependent variable is the ratio of R&D performed by affiliates for themselves to total R&D by affiliates. The results once again suggest that local R&D is a substitute for imported technology. In the regression reported in column (1) of table 8.7, the estimated coefficient on royalty withholding tax rates is positive and significant; the same is true of the coefficient on the difference between withholding and statutory tax rates reported in column (2). The coefficient estimates reported in column (2) indicate that a 10 percent change in the difference between foreign withholding and statutory tax rates (normalized by one minus the foreign statutory tax rate) is associated with a 2.6 percent change in the intensity of R&D activity by affiliates for themselves.

Columns (3)–(5) of table 8.7 report the results of alternative specifications of the R&D demand equation. The coefficient estimates from these specifications are consistent with those reported in columns (1) and (2) and are also consistent with the results reported in table 8.6. In particular, the estimated

Table 8.7 **Local Tax Rates and the Own-Intensity of R&D by Foreign Affiliates of U.S. Corporations, 1989**

Variable	(1)	(2)	(3)	(4)	(5)
Constant	0.9644	0.9294	0.9750	0.9447	0.8776
	(0.1273)	(0.0685)	(0.3608)	(0.2065)	(0.4103)
$w^*/(1 - \tau^*)$	0.2654				
	(0.1333)				
$\tau^*/(1 - \tau^*)$	−0.2048				
	(0.2028)				
$(w^* - \tau^*)/(1 - \tau^*)$		0.2562	0.2654		0.2362
		(0.1256)	(0.1333)		(0.1509)
w^*				0.4378	
				(0.2333)	
τ^*				−0.3872	
				(0.5543)	
$[(w^* - \tau^*)/(1 - \tau^*)]^2$					−0.1071
					(0.2982)
$1/(1 - \tau^*)$			0.0606		0.1311
			(0.1923)		(0.2766)
$\hat{\sigma}$	0.2527	0.2527	0.2527	0.2550	0.2525
	(0.0435)	(0.0434)	(0.0435)	(0.0439)	(0.0434)
log L	−12.1006	−12.1524	−12.1006	−12.5287	−12.0370
N	38	38	38	38	38

Note: The columns report coefficients from Tobit regressions in which the dependent variable is the ratio of R&D expenditures by foreign affiliates of U.S. corporations for their own use to the affiliates' total R&D expenditures. The variable τ^* represents local statutory corporate tax rates, and w^* represents withholding tax rates imposed by foreign countries on royalty payments to the United States. Observations are country-level aggregates of the behavior of all U.S.-owned affiliates. Standard errors are in parentheses.

coefficient of the variable $1/(1 - \tau^*)$ is again insignificant. The estimates reported in column (1) of table 8.7 imply that the elasticity of R&D spending with respect to royalty withholding taxes (evaluating all variables at their sample means) is approximately 0.11, which resembles the elasticity calculated from estimates reported in table 8.6.

The regressions reported in tables 8.6 and 8.7 offer consistent evidence that the aggregate behavior of the foreign affiliates of American multinational firms exhibits substitution of local R&D for imported technology. It is important to note, however, that there can be more than one interpretation of this pattern at the level of individual firms. One possibility is that tax differences influence the behavior of firms located in different countries. A second possibility is that tax differences encourage specific firms to locate in certain countries and not in others, *without* influencing the R&D intensities of individual firms.[22] A third,

22. Lipsey et al. (1990) examine the impact of host country characteristics on the attributes—particularly R&D intensities—of multinational firms choosing to locate within the country. They do not, however, consider the impact of tax policies.

and perhaps the most likely, possibility represents some combination of the first two. The use of aggregate data makes it impossible to use the observed pattern of behavior to distinguish these explanations; however, for many purposes, it may not be necessary to distinguish them.

8.6 Foreign-Owned Affiliates in the United States

The behavior of foreign-owned affiliates in the United States offers additional evidence on the responsiveness of R&D activity to royalty tax rates. This evidence must, however, be interpreted with caution, owing to heterogeneous circumstances of foreign firms that invest in the United States and the small sample size of 27 foreign countries for which sufficient data are available.

Home country tax treatments of foreign multinational firms that invest in the United States differ according to individual circumstances and national law. There are two dimensions along which the variation between investors is most important. The home governments of some foreign investors tax the worldwide incomes of their residents while granting credits for foreign taxes paid, while other governments exempt all foreign-source income from tax.[23] A second dimension along which tax systems differ concerns the degree of integration of personal and corporate taxes. For some countries, their corporation taxes largely represent advanced withholding taxes against personal tax liabilities.

The specification of royalty equations corresponding to the system described by equations (1)–(6) is somewhat different in the case of foreign investors in the United States than it is in the regressions reported in table 8.5. To start, the tax rate τ^* is the U.S. tax rate, which is the same for all foreign investors. The value of c, the cost of producing technology for export, need not be similar for different foreign investors and is captured in the estimating equations by the inclusion of R&D/GNP as an explanatory variable. And there may be important differences between the incentives facing investors from foreign tax credit countries and those facing investors from countries that do not grant foreign tax credits.

Table 8.8 presents estimates of the determinants of royalty payments by foreign-owned affiliates in the United States in 1987. The coefficient on the withholding tax rate in the regression presented in the column (2) of table 8.8 implies that raising the tax rate by 10 percent reduces the royalty/sales ratio by 0.74 percent. The estimated coefficient lies just at the margin of statistical significance. To understand its magnitude in a different way, the implied elasticity of royalties/sales, evaluating all variables at their population means, is approximately -0.12. If sales are unaffected by changes in royalty tax rates, then this figure implies that doubling the royalty tax rates reduces royalties by 12 percent.

23. Of course, this dichotomous breakdown greatly oversimplifies the many distinctions and subtleties that foreign tax systems exhibit.

Table 8.8 **Royalty Tax Rates and Royalty Payments by Foreign-Owned Affiliates in the United States, 1987**

Variable	(1)	(2)	(3)	(4)	(5)
Constant	−0.0012	0.0005	−0.0004	0.0007	−0.0003
	(0.0008)	(0.0011)	(0.0008)	(0.0011)	(0.0008)
R&D/GNP	0.1100	0.0541	0.0834	0.0529	0.0831
	(0.0432)	(0.0471)	(0.0418)	(0.0458)	(0.0413)
w		−0.0074		−0.0174	
		(0.0036)		(0.0116)	
$w(1 - \text{FTC})$			−0.0073		−0.0151
			(0.0038)		(0.0187)
w^2				0.0342	
				(0.0375)	
$w^2(1 - \text{FTC})$					0.0269
					(0.0630)
$\hat{\sigma}$	0.0018	0.0016	0.0016	0.0016	0.0016
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$\log L$	77.1371	79.3389	79.1162	79.7464	79.2077
N	27	27	27	27	27

Note: The columns report coefficients from Tobit regressions in which the dependent variable is the ratio of royalties paid by foreign-owned affiliates to the affiliates' total U.S. sales in 1987. The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable w represents the withholding tax rate imposed by the United States on royalty payments from the United States. The variable FTC equals unity if an investor's home country taxes worldwide income and grants foreign tax credits to its residents, and equals zero otherwise. Observations are country-level aggregates of the behavior of all foreign-owned affiliates. Standard errors are in parentheses.

Column (3) of table 8.8 presents the same regression in which the withholding tax rate is now transformed to be zero for all investors from foreign tax credit countries. The results are very similar to those reported in column (2). Columns (4) and (5) report results of regressions in which squares of the withholding tax rates are introduced; the coefficient estimates are insignificant, reflecting the multicollinearity of the two tax rate variables and the limited amount of variation in a sample of this size.

Table 8.9 presents estimated coefficients from regressions that investigate the correlation between the R&D intensity of foreign-owned affiliates in the United States and the tax variables that influence the cost of imported technology. One striking feature of all of the regressions presented in table 8.9 is the strong correlation between the R&D intensity of foreign-owned affiliates in the United States and the R&D intensity of the countries in which their parent firms are located. Column (2) presents the simplest specification that includes tax rate variables; the estimated coefficient on the interaction between the withholding tax rate and home country R&D intensity is positive and significant. The implied elasticity of R&D with respect to the cost of imported technology (evaluated at sample means) is approximately 0.3. This is a very sizable

Table 8.9 **Royalty Tax Rates and R&D Intensities of Foreign-Owned Affiliates in the United States, 1987**

Variable	(1)	(2)	(3)	(4)	(5)
Constant	−0.1844	−0.1716	−0.1345	−0.1625	−0.1387
	(0.0697)	(0.0565)	(0.0456)	(0.0547)	(0.0472)
R&D/GNP	14.6146	12.1191	10.5524	12.2114	10.6242
	(3.5479)	(2.9640)	(2.3883)	(2.8594)	(2.4134)
w(R&D/GNP)		30.8403		−5.6039	
		(11.9140)		(42.1940)	
$w(1 - \text{FTC})\cdot(\text{R\&D/GNP})$			45.4557		72.9530
			(10.0257)		(63.4897)
w^2(R&D/GNP)				128.6451	
				(142.4354)	
$w^2(1 - \text{FTC})\cdot(\text{R\&D/GNP})$					−93.2700
					(212.7782)
$\hat{\sigma}$	0.1335	0.1094	0.0891	0.1060	0.0892
	(0.0225)	(0.0190)	(0.0153)	(0.0185)	(0.0154)
log L	6.7117	9.2883	13.0824	9.6807	13.1794
N	27	27	27	27	27

Note: The columns report coefficients from Tobit regressions in which the dependent variable is the ratio of the U.S. R&D expenditures of foreign-owned affiliates to the affiliates' total U.S. manufacturing labor compensation in 1987. The variable R&D/GNP represents country R&D/GNP ratios reported by the National Science Foundation (1991). The variable w represents the withholding tax rate imposed by the United States on royalty payments from the United States. The variable FTC equals unity if an investor's home country taxes worldwide income and grants foreign tax credits to its residents, and equals zero otherwise. Observations are country-level aggregates of the behavior of all foreign-owned affiliates. Standard errors are in parentheses.

elasticity, particularly in view of the smaller own-price elasticity of royalties implied by the estimates reported in table 8.8. Furthermore, the responsiveness of royalties to withholding tax rates reflects changes in reporting behavior in addition to changes in amounts of technology transferred. The elasticity implies that, in the absence of an effect arising through the scale of operations, doubling the withholding tax rate raises R&D expenditures by 30 percent. This estimated response magnitude is very large and may reflect the imprecision of estimates drawn from so small a sample. Nevertheless, it is striking that the pattern of substitutability between R&D and imported technology appears for foreign investors in the United States as well as for American investors in other countries.[24]

Column (3) of table 8.9 presents estimates from the specification in which the withholding tax rate is interacted with a variable that equals zero if the investor's parent company is located in a foreign tax credit country, and equals

24. Unfortunately, BEA does not require foreign-owned firms in the United States to distinguish the R&D they perform for their own use from R&D that they perform for others, so it is not possible to estimate equations of the type reported in table 8.7 for foreign investors in the United States.

one otherwise. The results are qualitatively very similar to those presented in column (2), with the difference that the estimated R&D appears in this specification to be even more responsive to withholding tax rates. Columns (4) and (5) present regression results for specifications that include quadratic withholding tax rate terms, which again exhibit symptoms of multicollinearity.

Evidence on the behavior of foreign owned affiliates in the United States suggests conclusions that are very similar to those that emerge from the behavior of the foreign affiliates of American corporations. Foreign investors in the United States pay fewer royalties, and use more R&D-intensive operations, when facing higher tax rates on royalties paid to their home countries. The restricted size of the sample of investing foreign countries makes statistical inference difficult, but the estimated coefficients indicate a responsiveness that is somewhat greater than that for the foreign affiliates of American corporations.

8.7 Conclusion

This paper uses information on the behavior of the foreign affiliates of U.S. firms and foreign-owned affiliates in the United States to estimate the relationship between technology imports and local R&D. The idea is to use the tax treatment of royalty payments to identify the degree of substitutability between these sources of technology. Evidence from the actions of American and foreign firms indicates that R&D expenditures respond to local tax rates, and that technology imports and local R&D are substitutes. The substitutability of these two sources of technology carries numerous implications for the impact of tax policy on R&D activity, particularly when contrasted with the complementarity that is sometimes thought to characterize their relationship.

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Comment

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This paper examines the effect of the tax treatment of royalties paid by foreign affiliates for the use of their parents' technology both on the magnitude of such royalties paid and on the expenditures by the affiliates on research and development (R&D). The paper finds that royalty payments do respond negatively to tax rates, and that affiliate R&D is *increased* by higher taxes on royalties, which implies that affiliate R&D and imported technology from the corporate parent are substitutes rather than complements in generating net revenues for the affiliate. The first result is probably satisfying to tax economists, but is of limited significance because we cannot tell how much of the effect corresponds to changes in the use of technology and how much represents changes in the valuation of technology for royalty tax purposes. The second result, however, is a provocative one that is contrary to most people's prior beliefs. If it is true that affiliate R&D is a substitute for parent technology, this would have important implications for understanding multinational corporations and for the design of domestic policy. My comment will address why this result is significant, and then go on to consider how convincing the paper is about the complementarity question.

Significance of the Result

There are a number of reasons why we care about whether parent and affiliate R&D are complements or substitutes. First, there is the important industrial

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organization question of how companies decide whether to start operations overseas, and what the role of R&D is in that process. A standard view of why companies engage in overseas investment is that they have intangible assets, such as technology, that are at least partially nonrival across countries, but that it is difficult to capture the returns to these assets through arm's-length transactions such as technology licenses. Hence, establishing overseas operations captures quasi rents to these assets that would otherwise be lost. A puzzle within this view is why companies would then engage in research *at* the affiliate location. A potential answer to this puzzle is that such research is complementary to the home research, either because it is more easily focused on specific conditions of the host-country market (or input markets) or because local R&D allows the parent to benefit from spillovers from the R&D performed in the host country. If parent and affiliate research are *not* complements, then the puzzle of why affiliates do research reappears.[1]

The second reason why complementarity matters is that governments may wish to encourage R&D within their borders because of a belief that R&D generates positive externalities. As Hines discusses, the tax treatment of royalty payments might be an instrument to encourage local R&D, but the instrument can only be used if we know whether raising the cost of "buying" technology from the parent company increases or decreases the incentive to do R&D locally, that is, whether affiliate and parent technology are complements or substitutes.

This policy conundrum is, however, actually more complicated than simply asking whether raising the cost of importing technology stimulates or inhibits local R&D. If the location of R&D matters at all, it has to be the case that R&D spillovers are geographically localized, that is, that technology developed at home creates greater external benefits for domestic firms than does technology developed abroad.[2] This implies that domestic firms are not fully benefiting from technology developed in other countries. It is plausible that the importation of that technology for use by an affiliate might bring with it the spillovers that otherwise would not be readily available to domestic firms. Thus, there is a crucial policy question that is logically prior to the question of whether taxing technology imports encourages or discourages local R&D. That is: Which creates more local externalities, the import of technology from abroad or the production of technology at home? This would seem to turn on the question of whether the spillovers are generated by the process of the creation of technology or by its use. Both the theoretical and empirical literature on spillovers appears to be silent on this question, largely because creation and use are typically thought of as occurring in the same place.

1. I return to this issue below.

2. As the paper mentions, the primary analytical justification for policies to encourage R&D is the belief that R&D generates positive externalities to other firms. If such externalities are *not* geographically localized, then they cannot be a source of differences in growth rates across countries and policymakers should not care whether R&D is done at home or abroad. See Jaffe, Henderson, and Trajtenberg (1993) for evidence on the extent of geographic localization of research spillovers.

An interesting observation derives from the combination of the results that affiliate and parent R&D are substitutes, while parent R&D appears to be "free," that is, sufficiently nonrival across countries that the incremental cost of using parent technology in another affiliate is zero (table 8.6 and related discussion). If both results are correct, then, in the absence of tax distortions, it seems unlikely that affiliates would do R&D (since affiliate R&D is merely a substitute for something that is free). In the presence of taxes, this result no longer holds. It is possible that affiliates would choose to perform what is essentially duplicative R&D, merely to avoid paying withholding taxes on the transfer of the parent's already created knowledge. This result might appear to be highly wasteful from a social point of view, but that is unclear given that the affiliate's R&D will generate spillovers.

Convincingness of the Result on Complementarity

Within the confines of the paper itself, the finding that affiliate and parent R&D appear to be substitutes is quite robust. The paper takes three distinct cuts at the issue: it shows that foreign affiliates of U.S. corporations do more R&D in countries with high withholding rates (table 8.6), that affiliates of foreign corporations do more R&D in the United States if their parents are in countries whose tax treaties with the United States result in higher withholding rates on royalties emanating from the United States (table 8.9), and that foreign affiliates (of U.S. corporations) that operate in high-withholding-rate countries have a higher *fraction* of their R&D that is for their own purposes rather than for contract research (table 8.7).

I do have reservations about two aspects of these results. First, as the paper points out, the effect of the withholding rate on the U.S. R&D of foreign firms is implausibly large, suggesting that affiliate R&D responds *more* to the royalty tax rate than do the royalties themselves, despite the fact that the royalty effect is the sum of a real effect and an effect from the incentive to undervalue technology to reduce the tax. This suggests that some kind of spurious correlation may be at work.

My second reservation derives from the fact that in table 8.6 and table 8.9 (though *not* in table 8.7) the royalty tax effect is estimated from the interaction of the withholding tax rate variable with the R&D intensity of the host country (in the case of foreign affiliates of U.S. firms) or the parent country (in the case of U.S. affiliates of foreign firms). This interaction is motivated by the need to allow for the effects of unobserved differences in the R&D incentives in different countries. Such differences are likely to be important, and the interaction effect is plausible. It is also the case, however, that the R&D/GNP variables are extremely significant on their own in both tables 8.6 and 8.9. It is very likely that the effects of R&D intensity, even ignoring any tax effects, are nonlinear and vary depending on economic and institutional features of the countries involved. This makes it hard to know for sure whether the coefficient on the interaction term is really picking up the effect attributed to it by the model,

or whether it is simply picking up additional aspects of the R&D intensity effect.

Overall, whether these results are convincing depends on one's prior belief regarding the complementarity of affiliate R&D and imported technology from the parent. I have a strong prior that they are complements. First, analyses of the relationship between different kinds of R&D in other settings have generally found complementarity. Jaffe (1986) shows that spillovers from the R&D of a technologically related firm can increase another firm's patents, profits, and market value, but the effectiveness of such spillovers is itself a function of how much R&D the spillover-receiving firm performs. That is, firms' own R&D and spillovers from other firms are complements in the generation of economically useful new knowledge. Cohen and Levinthal (1989) find that firms must undertake their own R&D in order to learn about research results produced elsewhere, again suggesting complementarity. Though it is possible that the affiliate and parent R&D combine in a way that is wholly different from how knowledge inside and outside the firm combine, it is unclear why this should be so.

A second reason to expect complementarity is that affiliate R&D ought to facilitate the absorption of locally generated R&D spillovers from other firms. If it is true that R&D spillovers are geographically localized, then one reason to enter a foreign country (particularly an R&D-intensive one such as the United States) would be to absorb its R&D spillovers. If Cohen and Levinthal are right and you have to do your own R&D to absorb spillovers, it seems likely that you have to have a local R&D presence to benefit from local spillovers. To the extent that such spillovers are complements with own R&D, then own local R&D ought to be complementary with parent R&D.

Finally, Hines's paper itself contains results that seem to suggest complementarity. Among firms in the United States that are foreign owned, the strongest predictor of R&D intensity is the R&D intensity of their parent countries. The paper explains this as reflecting differences in the *nature* of the firms established here by parents from different origins, and this is plausible. But it also can be interpreted as saying that firms whose parents have a strong technology base do more R&D here, which would suggest complementarity.

One possibility is that these complementarity effects are masked in the country aggregates. It could be that, for any given firm, affiliate and parent R&D are substitutes for some values of affiliate R&D and complements for others. For example, it seems plausible that some small scale of affiliate research is necessary to combine what the parent knows with locally available knowledge about both supply-side factors (e.g., the characteristics of locally available inputs) and demand-side factors (local tastes and availability of complementary products). Beyond this small scale, perhaps incremental affiliate R&D is merely a substitute for parent technology. If this is true, we could find that the country aggregates act like substitutes despite features of complementarity at the micro level.

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