1984

Normative Issues Raised by International Trade in Technology Services

Gene M. Grossman

Carl Shapiro

Follow this and additional works at: https://ir.lib.uwo.ca/economicscsier_wp

Part of the Economics Commons

Citation of this paper:
NORMATIVE ISSUES RAISED BY INTERNATIONAL TRADE
IN TECHNOLOGY SERVICES

Gene M. Grossman
and
Carl Shapiro

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.
CURRENT ISSUES IN TRADE AND INVESTMENT
IN SERVICE INDUSTRIES:
U.S.-CANADIAN BILATERAL AND MULTILATERAL PERSPECTIVES

THE THIRD ANNUAL WORKSHOP ON U.S.-CANADIAN RELATIONS

Sponsored by the Institute of Public Policy Studies of The
University of Michigan and the Centre for the Study of
International Economic Relations of the University of
Western Ontario, with financial support from the Ford
Foundation, Donner Foundation, National Science Foundation,
Ontario Economic Council, Bank of Montreal, IBM Canada, and
The Fishman-Davidson Center of the University of
Pennsylvania.

October 19-20, 1984
Ann Arbor, Michigan

Gene M. Grossman and Carl Shapiro
Princeton University

Normative Issues Raised by International Trade
in Technology Services
NORMATIVE ISSUES RAISED BY INTERNATIONAL TRADE
IN TECHNOLOGY SERVICES*

by

Gene M. Grossman
and
Carl Shapiro
Princeton University
September 1984

* This paper was prepared for the Third Annual Workshop on U.S. -
Canadian Relations, to be held at the Institute of Public Policy
Studies, University of Michigan, on October 19-20, 1984. Partial
financial support for this work was provided by the National Science
Foundation under grant No. SES-8408622.
I. **INTRODUCTION**

International competition between the industrialized countries is shifting increasingly to the arenas of the "high technology" or "sunrise" industries. Many feel that successful performance there may be critical to the long-run vitality of these economies. As a result, attention has been focused recently in the United States and elsewhere on the pace and direction of technological innovation and on the evolution of international market shares in the progressive, knowledge-intensive sectors. Policy recommendations in this area are abundant, sometimes forming part of a broader scheme of "industrial policies". Among the suggestions that have been voiced most frequently in this regard are those that would directly affect the conduct of international trade in technology services.

In the academic literature, the normative issues raised by trade in technology have until now received relatively little attention from international economists. The voluminous writings on the gains from international trade and on the welfare effects of various trade policies have been concerned almost exclusively with the exchange of goods and, to a lesser extent, factor services. And, although it is tempting to assume that the principles that emerge from this literature extend immediately to other forms of international transactions, we will argue as a main theme of this paper that, at least where purchases and sales of technology are concerned, this is unlikely to be the case. In particular, we will point to some special features of technology as a commodity, and of the environments in which it is most often produced and
traded, that should give rise to concern, if not outright skepticism, over the ability of the free market to yield efficient outcomes. If we are successful in our arguments, it will become apparent below that many of the interesting questions concerning technology trade are as yet unanswered.

What are the special characteristics of technology that distinguish it from ordinary commodities for the purposes of the formulation of trade policy? The key attribute to note is that as a form of information, technology (at least when it is disembodied) has all of the properties of a public good. That is, once a new technology has emerged as the outgrowth of a research and development (R&D) project, its use in some particular application by one firm does not preclude its simultaneous use elsewhere by the same or a different firm.

This public good aspect of R&D output has a number of implications, all of which suggest that the study of technological advance, and competition in progressive industries, cannot be conducted properly using the conventional models of perfect competition that are typically applied to problems in international trade. First, the public good character of innovations implies that it will be difficult, if not impossible, for a private innovator to appropriate all of the (potential) social benefits of any new discovery. Consequently, private incentives to undertake R&D are likely to deviate from social ones. This problem immediately gives a "second best" flavor to the theory of technological competition.

Second, the fact that R&D expenses generally vary relatively little with the quantity of output or the number of applications implies that the development of technology, if viewed as an intermediate input, imparts a substantial economy of scale in the production of final goods.
This means that imperfect competition is likely to be the appropriate market structure in which to analyze issues related to R&D and technology trade. The existence of some market power, either at the research level or the production level, is a prerequisite for R&D to be remunerative.

Often, innovators are vertically integrated into production and enjoy their market power at that level, or else they restrict the use of their technologies to a small number of producers in order to create monopoly profits downstream. Either way, the ultimate product market structure is one of imperfect competition, and it is in this context that technology trade typically takes place. This raises important public policy concerns, which we discuss below.

Alternatively, it is possible for the downstream market to be competitive, if the upstream (research) market yields sufficient rents to cover R&D costs. But the high ratio of fixed to marginal costs in R&D implies that, should two firms gain access to similar technologies and seek to license these to third parties, the competition between them is likely to be particularly intense. This means, among other things, that trade benefits may accrue disproportionately to technology-importing countries in such instances, and that, perhaps counterintuitively, opportunities for technology trade could dampen incentives to undertake R&D.

Recognition of these properties of information and the markets in which it is produced and traded suggests two important issues that a complete analysis of technology trade should seek to address. One is the question of whether technology is likely to be overproduced or underproduced in the marketplace in various situations and institutional settings, what effect the presence or absence of trade in technology has
on this determination in each case, and how public policy can be used to better the outcome from a national welfare perspective. The other question concerns the relationship between technology trade (and trade policy) and market performance in imperfectly competitive environments. Two considerations are relevant here. First, the inevitable existence of market power, though necessary as a return to innovation, implies that for any given state of technological advance the products of R&D intensive sectors are likely to be underconsumed. The second point is one that has become a recurrent theme in recent studies of trade under conditions of imperfect competition. That is, the possible existence of supernormal profits in industries where technology is produced and traded may mean that, from a strictly nationalistic perspective, governments will want to pursue those policies that ensure that the largest possible share of these oligopoly profits accrue to domestic firms. Laissez faire is unlikely to achieve this objective, since: (i) policy can be used to alter the the nature of strategic interaction between firms in oligopolistic industries (see, e.g., Grossman and Richardson, 1984); and (ii) firms, in making their corporate decisions regarding which R&D projects to undertake, which already developed technologies to sell or license to foreign and domestic firms, and what technologies to buy from others, will not take into account the external effects of these decisions on the profits of other domestic firms.

In the next section, we will discuss the various forms that trade in technology services can take, and present the available data on such trade (and also point out why measurement of the phenomena may well be impossible). In section 3, we will review the existing literature on trade in technology services, or as many of the papers refer to
themselves, on "technology transfer". The distinction between these phrases may in fact be more than semantic, since the models of technology transfer generally apply (implicitly or explicitly) to situations where technology is passed on from government to government (sometimes in exchange for a royalty payment, somehow determined), and then is made available by the importing country to all of its perfectly competitive producers, generally free of charge. This may be an accurate description of some North-South transactions, especially in the agricultural sector, but it probably holds little relevance for consideration of the exchange of industrial technologies between developed countries. The technology transfer paradigm is inappropriate for this purpose inasmuch as it fails to consider both the conditions under which new technologies are produced and the incentives for the sale of those technologies. In reality, most R&D gives rise to property rights (i.e. copyrights or patents) that do not reside with the government.

In section 4, we briefly discuss some issues that arise in the context of intra-firm trade in technology services. Then, in section 5, we take up the case of inter-firm trade, first treating the state of technological advance and the distribution of patent rights as given, and then inquiring into the effects of technology trade on the social appropriateness of private incentives to conduct R&D. This section, especially, is exploratory in nature, more in the way of an agenda for research than a reporting of well-established results. Section 6 concludes.
II. TRADE IN TECHNOLOGY SERVICES: DEFINITION AND MEASUREMENT

A firm that is in possession of some unique technology faces a choice among several alternative ways of exploiting its proprietary information in international markets. The most obvious and most common practice is for the firm to produce and export the goods that embody the technology. Such transactions can be thought of as implicit or embodied trade in technology service, much as trade that is motivated by factor endowment differences is sometimes viewed as implicit trade in factor services (as when the factor content of a country's trade bundle is computed). However, it is probably best to reserve the phrase "trade in technology services" for situations where the firm opts to export the technology itself, rather than the goods that embody it. This exportation can be accomplished in one of two very different ways. First, the firm may choose to establish an overseas subsidiary for the purposes of applying its technology to the production of goods there. Such technology trade is intra-firm, and is in a sense inseparable from the direct foreign investment that is its conduit. Alternatively, the firm may choose to trade its technology at arms length, or inter-firm, by licensing its patents to one or more foreign parties. The choice among these options is influenced by a host of economic factors, including the presence or absence of import barriers in the foreign market, the size of transportation costs, the differential in factor prices across the relevant markets, the importance of economies of scale and scope in the production and management process, the extent to which specific knowledge about local cultural and market conditions is essential for selling the goods in question, and the precision with which the technology can be specified and communicated in a contract, if it is to be sold to an
unaffiliated organization. These issues have been discussed at length elsewhere (see, e.g., Caves (1971, 1982) and McCulloch (1983)), so we choose not to deal with them further here.

If the alternative of intra-firm trade via direct foreign investment is selected, the technology is transferred to the overseas affiliate when the firm communicates information on product design and production processes to its engineers abroad, when it trains foreign managers and technicians, or when it transfers its home personnel with their knowledge of the specific technology to the subsidiary. The very nature of this sort of technology trade, insofar as it cannot be associated with any one particular transaction, creates fundamental conceptual problems for any effort to assess its magnitude. For a process innovation, one might attempt to measure the cost savings at prevailing factor prices that are realized by the firm in using the transferred technology rather than the next best locally available alternative. However, this measure is sensitive to the amount of output that is being produced, and there would seem to be no way to hold constant the quality or mix of inputs in comparing the subsidiary to other local plants. The task is even more formidable for a product innovation, where no standard of comparison is locally available. An alternative might be to take a cost-based approach, allocating in some way the firm's research and development expenditures among its several production facilities. However, any such allocation method would be quite arbitrary, given the fixed cost, public good nature of information, and given the risky nature of research and development activities.

The figures that have been assembled thus far on intra-firm technology trade take an altogether different, and less satisfactory
tack. Data are reported as part of the balance of payments accounts on international transactions in royalties and fees, the former being payments for the use of copyrights and trademarks, the latter charges for the use of industrial patents. These figures are taken as an indicator of the volume of technology trade, although it is widely recognized that they are determined more by efforts of the multinational firm to minimize its global corporate tax liability than by any economically-based attempt to measure the significance (or even the R&D costs) of the technology transfers that have occurred. Perhaps the best that can be said for these data is that they give some indication of trends in and the sectoral distribution of intra-firm technology trade, at least if effective tax rates do not vary too widely over time or across industries.

Table 1 shows the U.S. balance of trade for royalties and fees associated with direct foreign investment for various years and trade partners, while Table 2 gives the breakdown of U.S. receipts of royalties and fees by industry. The total value of royalty and fee transactions associated with direct foreign investment is quite small in relation either to the total value of trade in R&D-intensive goods or the total national expenditure on R&D activities. The figures do show a steady trend increase in U.S. receipts, with annual growth averaging over 12 percent during 1967-1981. More than eighty percent of U.S. royalty and fee receipts associated with direct foreign investment originate from subsidiaries in developed countries, with about half of the total being paid by affiliates located in Europe. Similarly, the developed countries, and especially the European countries, account for the bulk of U.S. intra-firm technology imports.
Table 1
U.S. receipts and payments of royalties and fees associated with foreign direct-investment: 1967-81, Selected Years
($millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total net receipts(^1)</td>
<td>$1,123</td>
<td>$1,561</td>
<td>$2,309</td>
<td>$3,262</td>
<td>$4,645</td>
<td>$5,531</td>
</tr>
<tr>
<td>Developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>809</td>
<td>1,142</td>
<td>1,783</td>
<td>2,570</td>
<td>3,885</td>
<td>4,489</td>
</tr>
<tr>
<td>European Community(^2)</td>
<td>153</td>
<td>217</td>
<td>302</td>
<td>448</td>
<td>719</td>
<td>795</td>
</tr>
<tr>
<td>Other Europe</td>
<td>237</td>
<td>354</td>
<td>625</td>
<td>833</td>
<td>1,370</td>
<td>1,444</td>
</tr>
<tr>
<td>Canada</td>
<td>78</td>
<td>104</td>
<td>157</td>
<td>258</td>
<td>355</td>
<td>579</td>
</tr>
<tr>
<td>Japan</td>
<td>242</td>
<td>311</td>
<td>394</td>
<td>613</td>
<td>849</td>
<td>945</td>
</tr>
<tr>
<td>ANZSA(^3)</td>
<td>37</td>
<td>66</td>
<td>153</td>
<td>239</td>
<td>368</td>
<td>389</td>
</tr>
<tr>
<td>Developing countries</td>
<td>62</td>
<td>95</td>
<td>152</td>
<td>179</td>
<td>224</td>
<td>347</td>
</tr>
<tr>
<td>Developing countries</td>
<td>315</td>
<td>418</td>
<td>525</td>
<td>693</td>
<td>969</td>
<td>1,301</td>
</tr>
<tr>
<td>Total net payments(^4)</td>
<td>62</td>
<td>111</td>
<td>209</td>
<td>293</td>
<td>523</td>
<td>429</td>
</tr>
<tr>
<td>Developed countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>62</td>
<td>108</td>
<td>208</td>
<td>267</td>
<td>497</td>
<td>729</td>
</tr>
<tr>
<td>European Community(^2)</td>
<td>11</td>
<td>19</td>
<td>20</td>
<td>8</td>
<td>102</td>
<td>247</td>
</tr>
<tr>
<td>Other Europe</td>
<td>-3</td>
<td>2</td>
<td>23</td>
<td>25</td>
<td>164</td>
<td>83</td>
</tr>
<tr>
<td>Canada</td>
<td>11</td>
<td>21</td>
<td>91</td>
<td>132</td>
<td>141</td>
<td>215</td>
</tr>
<tr>
<td>Japan</td>
<td>43</td>
<td>62</td>
<td>73</td>
<td>137</td>
<td>163</td>
<td>269</td>
</tr>
<tr>
<td>ANZSA(^3)</td>
<td>--</td>
<td>4</td>
<td>1</td>
<td>-34</td>
<td>-75</td>
<td>-84</td>
</tr>
<tr>
<td>Developing countries</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>27</td>
<td>25</td>
<td>-302</td>
</tr>
</tbody>
</table>

1 Represents net receipts of payments by U.S. firms from their foreign affiliates for the use of intangible property such as patents, techniques, processes, formulas, designs, trademarks, copyrights, franchises, manufacturing rights, management fees, etc.

2 Original six members only.

3 ANZSA = Australia, New Zealand, and the Republic of South Africa

4 Payments measure net transaction between U.S. affiliates and their foreign parents. See footnote 1.

NOTE: Detail may not add to totals because of rounding. Negative payments represent foreign liabilities to U.S.-based subsidiaries. Beginning with 1977 (negative) receipts from international organizations are included in the total but are not shown separately.

Table 2
Direct Investment-Related U.S. Receipts of Royalties and Fees\(^1\)
by Industrial Area: 1981 ($ millions)

<table>
<thead>
<tr>
<th>Country</th>
<th>All industries</th>
<th>Total mfg.</th>
<th>Food products</th>
<th>Chemicals</th>
<th>Primary &amp; ferrous metals</th>
<th>Machinery</th>
<th>Electrical machinery</th>
<th>Transportation equipment</th>
<th>Other Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total net receipts</td>
<td>$5,867</td>
<td>$4,007</td>
<td>$247</td>
<td>$1,001</td>
<td>$159</td>
<td>$1,140</td>
<td>$429</td>
<td>$337</td>
<td>$694</td>
</tr>
<tr>
<td>Developed countries</td>
<td>4,805</td>
<td>3,510</td>
<td>188</td>
<td>881</td>
<td>117</td>
<td>1,106</td>
<td>304</td>
<td>308</td>
<td>606</td>
</tr>
<tr>
<td>Canada</td>
<td>980</td>
<td>747</td>
<td>35</td>
<td>104</td>
<td>25</td>
<td>176</td>
<td>44</td>
<td>219</td>
<td>143</td>
</tr>
<tr>
<td>Europe</td>
<td>3,035</td>
<td>2,264</td>
<td>112</td>
<td>657</td>
<td>84</td>
<td>736</td>
<td>216</td>
<td>73</td>
<td>387</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>832</td>
<td>669</td>
<td>34</td>
<td>197</td>
<td>28</td>
<td>217</td>
<td>31</td>
<td>36</td>
<td>125</td>
</tr>
<tr>
<td>West Germany</td>
<td>369</td>
<td>311</td>
<td>17</td>
<td>68</td>
<td>22</td>
<td>107</td>
<td>31</td>
<td>18</td>
<td>49</td>
</tr>
<tr>
<td>France</td>
<td>324</td>
<td>327</td>
<td>10</td>
<td>105</td>
<td>25</td>
<td>105</td>
<td>28</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>Japan</td>
<td>413</td>
<td>310</td>
<td>27</td>
<td>47</td>
<td>4</td>
<td>175</td>
<td>26</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>Developing countries</td>
<td>1,331</td>
<td>497</td>
<td>59</td>
<td>120</td>
<td>42</td>
<td>35</td>
<td>123</td>
<td>28</td>
<td>88</td>
</tr>
</tbody>
</table>

\(^1\) Includes film and tape rentals, which represent 6 percent of total net receipts.

Royalty and fees data provide a better measure of the value of inter-firm trade in technology, although there is reason to believe that these figures may well underestimate the extent of such trade. This is so because the sale of technology is often accompanied by other considerations in addition to the direct licensing fee, such as provisions that call for tie-in sales, consulting contracts, agreements to purchase spare parts or intermediate inputs from the licensing firm, and the exchange of patent rights to other technologies (so-called cross-licensing agreements). Furthermore, as we shall argue in section 5 below, the market price of technology exports may well understate the economic significance of the information being provided, particularly in cases where several domestic firms offer competing technologies for export.

As is clear from Table 3, the amount that U.S. firms receive for licensing to unaffiliated foreign residents is quite small, both in absolute magnitude and in comparison to the amount collected in fees and royalties associated with direct foreign investment. Only in the case of Japan have purchases of technology by unaffiliated parties historically accounted for more U.S. receipts than have intra-firm payments. And even here, a reversal of this pattern has been emerging in recent years, as Japan has liberalized its restrictions on inward direct foreign investment.

There are two possible interpretations of this evidence, neither of which can be rejected on the basis of available information. On the one hand, some have argued that the small amounts of receipts from arms-length technology exports is indicative of the difficulties associated with specifying the details of a technology in contract form,
### Table 3

U.S. receipts and payments of royalties and fees associated with unaffiliated foreign residents: 1967-81, Selected Years ($millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total net receipts</strong></td>
<td>$393</td>
<td>$573</td>
<td>$712</td>
<td>$822</td>
<td>$1,102</td>
<td>$1,386</td>
</tr>
<tr>
<td><strong>Developed countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>343</td>
<td>509</td>
<td>638</td>
<td>703</td>
<td>923</td>
<td>1,126</td>
</tr>
<tr>
<td>European Community</td>
<td>107</td>
<td>157</td>
<td>169</td>
<td>210</td>
<td>267</td>
<td>351</td>
</tr>
<tr>
<td>Other Europe</td>
<td>29</td>
<td>38</td>
<td>59</td>
<td>87</td>
<td>120</td>
<td>133</td>
</tr>
<tr>
<td>Canada</td>
<td>33</td>
<td>33</td>
<td>32</td>
<td>45</td>
<td>43</td>
<td>64</td>
</tr>
<tr>
<td>Japan</td>
<td>95</td>
<td>202</td>
<td>273</td>
<td>246</td>
<td>343</td>
<td>379</td>
</tr>
<tr>
<td><strong>ANZSA</strong></td>
<td>24</td>
<td>23</td>
<td>31</td>
<td>43</td>
<td>48</td>
<td>71</td>
</tr>
<tr>
<td><strong>Developing countries</strong></td>
<td>50</td>
<td>65</td>
<td>74</td>
<td>120</td>
<td>179</td>
<td>260</td>
</tr>
<tr>
<td><strong>Total net payments</strong></td>
<td>$104</td>
<td>$114</td>
<td>$176</td>
<td>$189</td>
<td>$241</td>
<td>$264</td>
</tr>
<tr>
<td><strong>Developed countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>101</td>
<td>108</td>
<td>168</td>
<td>184</td>
<td>234</td>
<td>248</td>
</tr>
<tr>
<td>European Community</td>
<td>46</td>
<td>52</td>
<td>72</td>
<td>67</td>
<td>80</td>
<td>81</td>
</tr>
<tr>
<td>Other Europe</td>
<td>16</td>
<td>13</td>
<td>23</td>
<td>17</td>
<td>29</td>
<td>20</td>
</tr>
<tr>
<td>Canada</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Japan</td>
<td>4</td>
<td>4</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>39</td>
</tr>
<tr>
<td><strong>ANZSA</strong></td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Developing countries</strong></td>
<td>3</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>

1 Represents net receipts of payments by U.S. firms from their foreign affiliates for the use of intangible property such as patents, techniques, processes, formulas, designs, trademarks, copyrights, franchises, manufacturing rights, management fees, etc.

2 Original six members only (Belgium, France, West Germany, Italy, Luxemburg and the Netherlands).

3 ANZSA - Australia, New Zealand, and the Republic of South Africa

4 Payments measure net transaction between U.S. affiliates and their foreign parents. See footnote 1.

NOTE: Detail may not add to totals because of rounding.

Table 4

World Trade in Technology ($millions)

<table>
<thead>
<tr>
<th></th>
<th>Receipts</th>
<th>Payments</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA (1979)</td>
<td>5804</td>
<td>706</td>
<td>+ 5098</td>
</tr>
<tr>
<td>UK (1978)</td>
<td>744</td>
<td>625</td>
<td>+ 119</td>
</tr>
<tr>
<td>Netherlands (1978)</td>
<td>277</td>
<td>446</td>
<td>- 169</td>
</tr>
<tr>
<td>France (1978)</td>
<td>346</td>
<td>679</td>
<td>- 333</td>
</tr>
<tr>
<td>Italy (1978)</td>
<td>103</td>
<td>498</td>
<td>- 396</td>
</tr>
<tr>
<td>West Germany (1979)</td>
<td>492</td>
<td>1065</td>
<td>- 573</td>
</tr>
<tr>
<td>Japan (1979)</td>
<td>321</td>
<td>1274</td>
<td>- 953</td>
</tr>
</tbody>
</table>

and the preference of firms for maintaining exclusive control over their know-how and its dissemination by exploiting it themselves through exporting and direct investment. But other observers have pointed to the reputed fact that between 1950 and 1978 Japanese companies have entered into more than 32,000 licensing and other technology-importing agreements with U.S. concerns while paying only a total of $9 billion for these as *prima facie* evidence that U.S. exports of technology services, though substantial in content and economic significance, have yielded less than their social value in return. 3 A determination of which of these interpretations is in fact correct would be an important input into future policy deliberations.

Finally, Table 4 documents the revealed comparative advantage of the United States in the production of technology. U.S. receipts from royalties and fees far exceed those of all the other major developed country exporters of technology combined. The only other industrialized country with a positive balance in its technology trade is the United Kingdom, while Japan and West Germany are seen to be the largest net importers of foreign technologies.

III. REVIEW OF THE LITERATURE

The standard two-good, general equilibrium model of international trade offers a familiar framework for an initial exploration into the normative implications of technology exchange. McCulloch and Yellin (1982) have taken this as their starting point, with the assumption that initially the home country has sole possession of a technology to produce one of the two goods (computers). They consider the effect on domestic welfare of a "transfer" of this technology to the foreign country. Such
a transfer is effected free of charge, and serves to make the technology accessible to an unlimited number of actual and potential foreign producers. Thus, technology transfer in their conceptualization preserves a perfectly competitive market structure in each country. Implicitly, they must assume that the property rights to the technology initially reside with the domestic government, and that these are passed from government to government before being widely disseminated by the recipient country. Their conclusion is easily derived, but instructive nonetheless. In an initial distortion-free situation, the home country must be harmed by the transfer if it continues to be an exporter of computers in the post-transfer equilibrium. The reason is that, in this case, the sole effect on the domestic economy of the transfer is to deteriorate the terms of trade at which computers are exported. This result points to a general principle that is bound to be present in any model of technology trade. That is, the introduction of trade in technology from an initial situation of trade in goods is not symmetric to the case of the introduction of goods trade from an initial situation of complete autarky. While the latter must confer social welfare gains, the former need not do so, since the terms of trade on prior goods trade can be adversely affected. (In fact, this is the presumption, since the technology-exporting country is likely to also be an exporter of the R&D intensive good, and wider dissemination of the information is bound to lower the world price of this good.)

McCulloch and Yellin (1982) and Rodriguez (1975) also study the optimal policy from the point of view of the technology-transferring country. The former authors show that the home country will always benefit from charging some positive (ad valorem) royalty for its
technology, and that the optimal royalty may in fact be prohibitive (i.e., preclude technology transfer altogether). The latter proves, in a similar model, that if the technology exporting country winds up as an importer of the technology-intensive good, the optimal per-unit royalty should be accompanied by an import subsidy, so that the foreign producers are led to charge the monopoly price in their own market, but domestic consumers can obtain the product at foreign marginal factor cost. He notes that when the optimum policy package is implemented the proceeds of the import subsidy are not earned by foreign suppliers, but rather accrue to the domestic government indirectly, in the form of higher royalty payments.

Similarly using the two-good paradigm, Brecher (1982) considers the gains from technology trade and optimal policy from the perspective of the technology-importing country. His initial situation is one where both countries can produce both goods, but the "foreign" country has exclusive rights to a superior technology for producing one of them. He assumes, somewhat arbitrarily, that the home country must pay a royalty exactly equal to the full amount of the extra output made possible at the ultimate factor input combination by the use of the superior technology. He finds that a technology importing country which must pay such a royalty, but is free to set its commercial policy optimally, may or may not benefit relative to a situation of complete prohibition of technology imports, depending on whether the technology is used by this country to produce its importable or exportable good. The intuition here is exactly the same as in McCulloch and Yellin, since the assumed royalty scheme eliminates any direct benefit from the technology imports, and all that
is left is the (possibly deleterious) effect on the commodity terms of trade.

All of these analyses would suffer from two serious drawbacks, if an attempt were made to apply their conclusions to cases of inter-developed country trade in technology. First, and most important, because they each embody the implicit assumption that the property rights to the technology being traded (or, more accurately, "transferred") reside initially with one government (and ultimately with both governments), they are ill-equipped to deal with the issue of whether or not individual firms would choose to buy or sell rights to some technology, and if so, what the equilibrium volume and price of technology trade would be. The relevant scenario for trade in technology services between industrialized countries is not one where a technology that is available to a large number of competitive domestic producers in one country is made available, possibly subject to the payment of some royalty fee, to an equally large number of producers in another country. Instead, the situation is almost always one in which a single firm in one country holds a patent to some process or product (or several firms hold patents that are close substitutes for one another), and contemplates licensing the use of that patent to one or more other firms, either domestic or foreign. When one considers optimal policy in these circumstances, the royalty rate itself is not necessarily a policy tool that the government can manipulate directly; it might well need to resort to indirect methods such as various taxes or subsidies, or patent laws, with their attendant effects on the equilibrium amount of technology that is traded.
The second drawback is that the studies discussed thus far take as their starting point a situation in which the technologies to be traded have already been developed, so that no further resources are being devoted either to R&D or to adapting the technology for use in a different environment. A major policy concern in the developed-country context should be the effect of technology trade and trade policy on the pace and direction of R&D in the exporting and importing countries. This is so, because the special characteristics of technology as information make it more than likely that the laissez-faire pace and direction of innovation would be socially suboptimal. And even where government intervention in the innovation process through subsidies, favorable tax treatment and so on does occur, as is the case in all of the industrialized countries, one would want to know how the presence of technology trade and the implementation of policies that affect it alter the optimal levels of these R&D-related policies. How, for example, should the presence of foreign subsidies for R&D expenditures affect optimal domestic R&D subsidies or taxes?

Several authors have attempted to endogenize the R&D process in models of technology transfer. Connolly (1973) considers a static model in which resources can be diverted from the production of goods into an R&D activity in one country. Each country specializes in the production of a different good, and the R&D activity yields information that improves the technologies for producing both goods. Connolly compares the production of technology that maximizes global welfare with that which maximizes welfare in the innovating country alone. In performing this comparison he assumes (again, without apparent justification) that the innovating country appropriates via royalty fees the full value of
the extra output produced in the non-innovating country with the improved technology, and he finds that the nationally optimal level of R&D exceeds the globally efficient one. The reason is that a marginal diversion of resources from goods production into R&D activities in the innovating country (starting at the globally efficient level of R&D) must improve its commodity terms of trade. However, this finding is of limited use in addressing the issues raised in the preceding paragraph, since Connolly does not explicitly model the R&D market and the incentives facing private innovators, and thus he cannot compare either the global or the national optimum with a market-determined, equilibrium outcome.

This criticism does not apply as directly to Pugel (1982), who models the R&D process as a third, competitive sector in the home economy. He assumes that the R&D output improves the technology of production of each of two goods in a Ricardian framework (i.e., that it is a public good), and that the production of information is subject to decreasing returns to scale. However, his analysis relies on the ad hoc assumption that the per-unit royalty fees are set by the domestic government, which also legislates mandatory dissemination. Pugel compares the amount of R&D activity and the levels of domestic and foreign welfare under four rather arbitrary royalty fee structures: (i) the rate that achieves global efficiency, (ii) a rate charged to domestic firms that achieves domestic productive efficiency but neglects any induced terms of trade effects, with foreign firms paying zero royalties, (iii) this same rate for domestic firms, with foreign firms facing a prohibitive fee, and (iv) the rate for foreign firms that maximizes domestic welfare, given that domestic firms are charged as in (i).
A recent paper that does attempt to model both the incentives facing private producers of technologies and the equilibrium rate at which these technologies are traded is Feenstra and Judd (1982). These authors consider a trade model with many differentiated products and a monopolistically competitive (product) market structure. Each new product (of which their are a potentially infinite variety) must be developed by the diversion of a fixed bundle of labor to an R&D activity. Technologies are country-specific, however, so that additional resources are needed to adapt an existing technology for use in a second location. As a consequence, there will be no incentive for any firm to produce the same good in both countries, provided that trade barriers are not too large. One country (the home) is assumed to have a comparative advantage in R&D, in that fewer laborers are needed to develop any and all products. In the equilibrium, all R&D takes place in the home country, which may or may not also manufacture goods. Feenstra and Judd offer two possible interpretations for their equilibrium. One is that the R&D industry is a competitive sector, which develops products and then sells the patent rights for a fixed fee to one of many potential entrants into manufacturing. The second is that R&D is conducted by integrated firms, some of which become multinational corporations by establishing their production facilities in the foreign country. Under this latter interpretation, the technology trade that results is of the intra-firm variety.

Since this model is isomorphic to that analyzed by Krugman (1979), who instead regarded the product development expense as a general fixed cost of production, we know that the equilibrium entails gains from trade for each country relative to a situation of complete autarky.
and Judd did not investigate, however, whether the home country gains from allowing trade in technology, relative to a situation in which it engages in commodity trade alone. Instead, they examine the welfare implications for the home country of small policy departures from laissez faire. They find that a small, uniform import tariff and a small tax on technology exports (applied to the royalty fee) are both welfare improving, although they recognize that the latter policy may not be feasible if the technology trade is actually intra-firm, whence the royalty payments would exist in a bookkeeping sense only.

The Feenstra and Judd analysis is important, in that it is the first to carefully consider the industry structure in both the R&D and product markets, and to determine the level and price of technology trade as an equilibrium outcome. It is carried out under some special assumptions, however, such as those of perfect competition at the research stage, free entry into the product market, perfect symmetry between each of an infinite number of potential products, complete certainty in the R&D process and the absence of process innovation or indeed any form of competition in the individual product markets. There remains to be considered the normative implications of trade in technology services for a host of realistic, alternative assumptions about the market environment. In Section V we will sketch out how such an analysis of international licensing might proceed. But first we will discuss briefly the case of intra-firm technology trade.

IV. INTRA-FIRM TRADE IN TECHNOLOGY SERVICES

The policy issues posed by the occurrence of intra-firm trade in technology services are inextricably linked with those that relate to
direct foreign investment in general. Indeed, it is difficult to conceive of a policy that would effect one but not the other.

The normative implications of direct foreign investment (DFI), with its attendant intra-firm transfer of technology, may differ according to the circumstances that give rise to the firm's decision to establish overseas production facilities. Several of the possible motives for DFI imply an enhancement of economic efficiency relative to all alternative modes of transaction, and thus create at least the potential for mutual benefits to home and host countries. Four examples illustrate this point. First, DFI may occur due to factor price differences across countries, if these imply that various activities in the production process can be performed at lowest cost in different locations. Then, if economies of scope are also present, DFI entails a savings of production costs relative both to the situation with integrated production by a single firm in one country alone, and to that with vertical specialization by different firms in each country and arms-length trade. Second, when a firm's monopoly position in some good is protected by an internationally recognized patent, so that local production by domestic competitors is precluded, DFI by a foreign firm will provide a resource savings relative to a situation with international trade in this good if transport costs are high. Third, where international trade in equities is restricted, DFI represents a vehicle for portfolio diversification, and thus an improvement in the international allocation of risk-bearing. Finally, overseas investment as a means of vertical integration can help to overcome the inefficiencies associated with bilateral-monopoly bargaining situations. In each of these cases, welfare gains for both the home and host countries can only be assured theoretically under
rather restrictive assumptions about market structure, firm behavior, and the effect of the DFI on the commodity terms of trade. Nonetheless, when the efficiency gains from DFI are substantial, there is a presumption that such gains will be shared.

Most arguments in support of restrictions on direct foreign investment are based on a "second-best" type of reasoning. For example, where trade barriers are in force, and DFI represents a means of "tariff jumping," such investment can be harmful to the host country. This is because the DFI causes an increase in production of the protected good in this country, exacerbating an existing distortion caused by the import impediment. In this case the obvious policy solution is to remove the trade barrier, but if doing so is not politically feasible, then a restriction on inward DFI may be a second-best alternative.

From the perspective of the source country, outward DFI is sometimes criticized on the grounds that it has deleterious effects on employment at home. Those who put forth this view assume the existence of some distortion in the home country labor market, and note that the transfer of production activities abroad by multinational firms can exacerbate the problem. A valid argument for restricting outward DFI can be constructed on this basis, but it rests on the (unlikely) premise that all of the superior policy instruments for dealing with labor market distortions are unavailable to the government.

Only a few new issues are raised for the evaluation of direct foreign investment when the associated intra-firm transfer of technology is considered explicitly. One such issue is that the establishment of an overseas production facility by some domestic firm may increase the extent of "spillovers" of new technologies to foreign firms. This can
occur if proximity facilitates imitation, or if leakage results from the mobility of skilled employees between the innovative firm and its foreign rivals. Of course, the domestic firm that chooses to undertake DFI will have taken into account the implications of such spillovers for its own profits. But external effects will be present if the foreign firms that obtain the new technology as a consequence of the DFI use this information in competition with other domestic companies. In this event, the overall effect of the DFI plus technology transfer on the welfare of the home country can be ambiguous.

From the point of view of the technology-importing country (i.e. the host country for the DFI), a question that is sometimes is raised concerns the "appropriateness" of the technology being transferred to local market conditions. In particular, multinationals originating in industrialized countries have been criticized for transferring capital-intensive technologies to their subsidiaries in labor-abundant less developed countries. But no valid argument for restricting direct foreign investment exists if all that can be established is that the employment generated by these multinationals is less than what "might have been" had different and more "appropriate" technologies been imported. To justify intervention, the policy analyst must construct the relevant counterfactual to the direct foreign investment, and show that intra-firm technology transfer somehow impedes the development of alternative technologies, and that there are no compensating benefits to the host country from the DFI.

In a developed country context, inward DFI may be an issue if it affects the incentives faced by local firms for conducting R&D. As we discuss in detail in the next section, normative analysis of policy
options is made difficult by the fact that, theoretically, the private incentives for engaging in R&D may be either socially excessive or socially deficient, and that the effects of various policies on the equilibrium level of R&D investment often are unclear. But it seems possibly that, in some situation, a restriction on DFI would induce domestic firms to develop competing products and processes where it otherwise would not be profitable for them to do so. This can be welfare improving if the market structure is imperfectly competitive, and if the international distribution of oligopolistic profits is at stake. (See for example, Dixit and Kyle (1983), who argue analogously that import protection that promotes domestic entry into an industry can be welfare improving if the domestic market is oligopolistic.)

In conclusion we note that although intra-firm trade in technology may, in some circumstances have deleterious welfare consequences, this does not seem to be a likely outcome. In part, this is because when technology is transferred via direct foreign investment the property rights to the technology remain with the original owners alone. Thus, there is no real sense in which the price of the technology being traded can be socially too high from the point of view of the importing country, or too low from that of the exporting country. This, as we shall see, is in sharp contrast to the case of inter-firm trade in technology, to which we turn now.

V. INTERNATIONAL LICENSING OF TECHNOLOGY

As in the literature on technology transfer, an analysis of international licensing might gainfully proceed in two stages. First we
can study the welfare implications of technology trade for a given and exogenous state of technical advancement and distribution of patent rights. Then, we can endogenize the R&D process, and consider the effects of licensing on the incentives to innovate.

The simplest starting point is a partial equilibrium (or industry analysis) framework, in which a single domestic firm has made a discovery that generates for itself a monopoly position for some new product. This firm contemplates licensing the technology to a foreign firm, either because factor costs are lower abroad and the firm does not wish to undertake direct foreign investment, or because the foreign firm has some specific knowledge that would allow it to better market the product abroad (and, perhaps, in the home country as well). Without needing to know anything more about the markets or the licensing arrangement (for example, whether the domestic and foreign markets are segmented or integrated, whether the innovator will also produce the good in question in competition with its foreign licensee, whether the license will restrict the foreigners domain of competition to the foreign market, etc.), it is possible to conclude that trade in technology, if it occurs, is welfare improving for both countries. The reason is that both the domestic and the foreign firm must themselves benefit from the ability to engage in technology trade, since any licensing contracts are entered voluntarily. At the same time, consumers worldwide can only benefit (or, at worst, be unaffected) by more widespread diffusion of the new technology, since diffusion potentially leads to more competition and lower prices, or if the foreign firm becomes the sole producer, lower production costs and again lower prices. Thus, producer plus consumer surplus cannot fall in either country under a licensing regime.
This result, while at odds with one of the main conclusions of the technology transfer literature, is easily understood when an analogy is drawn with a standard result from the theory of trade policy. There, we know that a competitive industry will export more than the nationally optimal amount, and that an export tax raises the exporting country's welfare. Similarly, competitive imports are socially excessive, and an import tariff is welfare improving for the importing country. However, no trade policy is needed when exporting or importing is conducted by a monopolist, who will optimally exploit the country's monopoly power in trade. By analogy, when there is only one domestic agent on the supply side or the demand side of the market for technology, and no other domestic firms are active in the industry, there can be no pecuniary externalities associated with (excessive) technology sales or purchases.

This reasoning immediately suggests the next scenario to consider. Suppose there is a single domestic firm in possession of a new technology (in this case, a process innovation), but that now several domestic and foreign firms are also active in the industry. In this situation, licensing abroad by the innovator imposes negative externalities on the other domestic firms. These firms must now compete (in the foreign, and perhaps the home market) with foreign rivals who have access to the superior technology. Their profits will be lower in the cum-licensing equilibrium than if no licensing were to take place. Indeed it is possible for the total loss in profits of the non-licensing domestic firms to exceed the gain to the innovator from the license arrangement. Against this must be set the potential benefit to home consumers, if licensing leads to lower domestic prices.
As an extreme policy option, one might consider the effects of a complete ban on foreign licensing. It is possible for this policy to be welfare improving even if the no-licensing equilibrium is inferior to the free-trade-in-technology equilibrium. The reason is that the innovator, having determined the profit-maximizing number of firms to which it would like to license its technology, may be close to indifferent as to whether it licenses to domestic or to foreign firms. A ban on foreign licensing may lead it to substitute domestic licensees, with only a small adverse effect on its profits. Similarly, domestic consumers may be little affected, if the substitution yields roughly the same number of competitors in the home market, and roughly the same proportion of these using the superior technology. However, the non-innovating domestic firms may reap significantly higher profits under a ban on foreign licensing, in which event they would become the licensees in place of the foreign firms.

An analysis of the situation when two or more domestic firms are in possession of new technologies that are close or perfect substitutes for one another is even more instructive. Consider a simple example in which two domestic firms each have developed a superior technology that allows them to produce widgets at unit cost $c$. A single foreign firm also is active in the integrated world widget market, but initially uses an inferior technology with a constant marginal cost of $C>c$. Imagine now the following depiction of the (two-stage) industry competition. Each domestic firm quotes a fixed licensing fee to the foreign firm, at which price it will allow the foreign firm to have access to its superior technology. This quote may, of course, be prohibitive. The foreign firm then purchases a license at the lower of the two fees, if doing so raises
its profits relative to no purchase at all. Finally, the three firms engage in Cournot competition in the product market. At the licensing stage, each firm is assumed to form accurate expectations about the subsequent Cournot levels of profit with and without licensing (i.e., in the jargon of game theory, we solve for a subgame-perfect Nash equilibrium).

The surprising outcome in this example is that there always exists (for any demand function and unit cost pair) an equilibrium in which both innovators offer to license their technology to the non-innovator at a fee that is arbitrarily close to the licensors' direct licensing costs. In this equilibrium, each domestic firm expects that its rival will license to the foreigner if it does not do so. Since the ultimate Cournot outcome (at the product level) is the same no matter which of the two is the licensor, each realizes that any positive receipt for the technology is better than none at all.

This result, though somewhat sensitive to our assumption about the particular way in which the licensing market operates, is suggestive of a more general conclusion about the possible implications of free technology export. That is, when two firms have access to technologies that are close substitutes, the competition between them to license to third parties is likely to be quite intense. This is due to the public good nature of technology as information: since the marginal cost of dissemination to an additional firm is nearly zero, a bidding war can drive equilibrium fees to quite low levels. Perhaps the existence of such intense competition offers a partial explanation for alleged "bargain rates" at which Japanese firms have been able to obtain technologies from U.S. corporations in the post-war years.
If the innovation is sufficiently large (but only then), another bidding equilibrium will also exist (for this example) in which no licensing occurs. Such an equilibrium can result if each domestic firm would lose more in profits net of royalty receipts by having the technology disseminated to the third firm than the foreign firm would gain by having access to the superior technology. When such an equilibrium exists, it yields higher profits for both domestic firms than does the other equilibrium with licensing at a zero (net of licensing costs) fee. For this reason, one could argue that it is the more plausible of the two candidate equilibria for the case of large innovations.

What would be the national welfare implications of a ban on foreign licensing in this example? It is possible to show that, if world demand for widgets is linear, any ban that is binding must raise domestic welfare. In cases where licensing would take place absent government policy, the positive effect of the prohibition in augmenting domestic firms' profits always dominates its negative effect on the surplus enjoyed by domestic consumers. This is true under linear demand even if all of the surplus generated by widget consumption accrues to consumers in the home market. Whether this result generalizes to nonlinear demand and to different numbers of domestic and foreign firms remain as open questions.

A complete ban on foreign licensing is not the only policy option open to the domestic government, of course. The home country might be able to impose a tax on royalty transactions, although such a policy might be difficult to enforce in some circumstances, since as we have noted, compensation for technology trade can often be accomplished for
considerations other than direct fee payments. An alternative might be for the domestic government to establish a technology export board. Such an agency would be responsible for reviewing licensing contracts, and approving their provisions. This would amount to an "administrative price floor." (A uniform price floor would make little sense, since technological services are fundamentally a heterogeneous product.)

If it were known to the potential licensors that technology offers at very low royalty rates would not be approved, then the intensity of the licensing competition would be mitigated. Any negotiations between licensors and licensees would take place in an altered context, with new threat points for the two parties. And though the establishment of such a procedure might appear to be a beggar-thy-neighbor policy in this context, it might be argued that it is a necessary one to ensure an equitable international distribution of the gains from technology trade. Furthermore, if the resulting increase in royalty fees were to have the effect of providing a greater incentive for investment in R&D, even the technology importing country could benefit in the long run.

While the situations just described obviously are ones where the technology-importing country would benefit greatly from free technology trade, pecuniary externalities and excessive competition could also arise as policy issues for the importing country if the market were characterized by a somewhat different structure of competition. Consider, for example, the case of an industry with two domestic firms and a single foreign firm, and with the latter holding exclusive patent rights to a low-cost production process. If the foreign firm were to offer to license its superior technology to one of the domestic oligopolists, that firm would be willing to enter into an agreement
provided that the increment to its profits exceeded the proposed royalty fee. However, if the fee were set to extract most of the potential surplus, the loss in profits suffered by the non-involved domestic firm could easily exceed the net gain enjoyed by the licensee. Domestic consumers would benefit, of course, but the overall effect on domestic social welfare could be detrimental.

The outcome would be even worse for the technology-importing country if the two domestic firms were to enter into a bidding war for the use of the patent. Each would be willing to bid up to the price that left it just indifferent between purchasing the technology and not; but in doing so, each would recognize that if its bid were not accepted, its rival would instead acquire the rights to the superior process. Thus, each would be led to bid more than the increment to profits relative to a situation where neither firm operated using the low cost technology. In other words, the interdependence of demands for technology among oligopolists can create a situation where a single licensor can play one firm off against the others, and leave all with lower profits than would result if licensing from foreigners were not an option for any of them.

Once again, a policy alternative less extreme than a ban on technology imports would be the establishment of a government review board empowered to reject licensing agreements that seem likely to confer substantial negative pecuniary externalities on domestic third parties. It is interesting to note in this regard that under the Foreign Investments Act of 1950, Japanese firms are required to submit proposed licensing agreements with foreign firms for MITI approval. MITI has been able to intervene in licensing contracts to influence both the scope of technology imports and the terms of purchase. 7
We turn now to the long-run welfare effects of technology trade and trade policy via their influence on the intensity and scope of R&D activities. The complicating factor for normative analysis here is that, even before international licensing is considered, the relationship between the social and private incentives to undertake R&D investment is theoretically ambiguous. We have already argued that private incentives to innovate may be inadequate due to the appropriability problem. Since information has many of the attributes of a public good, the holder of a patent may find it difficult to exploit the full social benefit of an invention in all its potential uses. This is true because competitors may continue to operate using inferior techniques, or may imitate the innovator without paying anything for the information acquired through reverse engineering or employee defection. Some uses for the innovation may be in industries outside the patent-holder's field of expertise. And consumers of the goods produced using new technologies may realize increases in their consumer surplus, if the innovator is unable to perfectly price discriminate in the product market. For all these reasons, the private return to the innovator might fall short of the social return. 8

The presence of competition at the R&D stage, where it exists, introduces a market bias that works in the opposite direction. The problem is again one of negative pecuniary externalities. Each firm, when it chooses the level of resources to devote to R&D, does not take into account the fact that some of the potential private gains from any discovery it makes will be realized only at the expense of its oligopolistic competitors. The development of a new product will allow the firm to steal customers from its rivals. A reduction in costs
through process innovation facilitates an expansion of market share. In each case, the private return includes the full increment to oligopolistic profits, but the social return on the supply side is only the net gain in (domestic) producer surplus. It has been argued, for example, that the introduction of new, differentiated products may be socially excessive for this reason.

The preceding analysis indicates that the normative impact of foreign licensing on domestic welfare is theoretically complex. This is so for two reasons. First, the direction of divergence between social and private returns to R&D is ambiguous, for a given licensing regime. Second, the effect of licensing on R&D incentives is mixed.

It is generally believed that having the opportunity to license technologies to foreign firms increases the private return to innovation. Indeed, supporters of free trade in technology services, presuming that increased R&D expenditures are always in the national interest, cite this alleged benefit as a primary justification for their non-interventionist policy stance (see, e.g., Hufbauer (1980)). However, if competition at the licensing stage is especially intense, this need not be the case. As we have seen, profits for each domestic firm having access to a new technology might be higher if all were prevented from transferring that technology to foreign rivals than if dissemination were to result at competitive licensing rates. Firms might be more inclined to invest in new products and processes if they were secure in the knowledge that domestic rivals making competing discoveries would not be able to transfer these to competitors abroad, even if this meant foregoing the opportunity to do so themselves.
The question of whether free technology trade encourages or discourages investment in R&D is even more complex than we have thus far suggested. For, what is relevant to this issue is not only the effect of overseas licensing opportunities on the potential returns to innovating, but also their effect on the profits associated with not innovating. A firm may be led to invest more in R&D under a regime of free technology trade than otherwise, not because it expects to realize significant gains from potential royalty transactions, but because it fears that if it does not keep pace it will find itself at a competitive disadvantage with respect to technology-importing foreign firms (as well as the progressive domestic firms). On the other hand, domestic firms may be discouraged from engaging in their own R&D by a policy and market environment that allows them to purchase particularly important technologies from foreign research laboratories if and as they emerge. It would be comforting to know that in such instances only projects for which social costs exceed benefits would be foregone, but unfortunately there is little on which to base such an optimistic judgment.

The purpose of this section has not been to suggest that restrictions on licensing transactions with foreign enterprises are justified in most, or even many, situations. Rather, we have tried to point out that conventional wisdom drawn from the literature on commodity trade is not immediately applicable, when what is being exchanged is information rather than goods. Likewise, the existing literature on technology transfer is not applicable to many of the questions of trade in technology. Careful consideration must be given to the market structure and institutional setting under which such trade takes place. Furthermore, the analysis must begin with an investigation of the
incentives facing private firms, since these are most often the
participants in the markets for technology creation and exchange. Only
by understanding what the equilibrium outcome is likely to be under
various policy regimes can we hope to evaluate the normative consequences
of international trade in technology services and to formulate a sensible
public policy response.

VI. CONCLUDING REMARKS

The tone of this paper has been speculative and inquisitive,
suggesting a framework for analysis, rather than providing definitive
answers. Since it would be presumptuous to offer "conclusions" at this
stage, we will end instead in the spirit of what has preceded by posing
some subsidiary policy questions that relate to trade in technology
services.

(i) In instances where the appropriability problem is severe, a
common government response has been the subsidization of R&D. How is the
optimal subsidy level altered by the presence of technology transfer to
and from foreign firms, or by presence of foreign R&D subsidies?

(ii) When (if ever) are restriction on the export of technologies
via licensing agreements desireable?

(iii) What is the optimal response to restrictions placed by
foreign governments limiting the ability of their firms to engage in
international licensing arrangements or in technology transfer via direct
foreign investment?

(iv) Another possible channel for technology transfer that has not
been discussed here is the formation of research and development joint
ventures. Should foreign firms be permitted or encouraged to take part
in domestic R&D ventures? Should the answer depend on whether or not the venture has received government funding or has been granted special exemption from antitrust statutes? How should a country react to the exclusion of its domestic firms from foreign joint ventures?

We believe that all of these questions (and more!) are subject to analysis using models of imperfect competition in innovating industries. It is essential that economists move beyond the perfectly competitive models of technology transfer that have been inherited from standard trade theory. The incentives for private firms to engage in innovation activity, and the form of competition for technology services are the essential elements upon which such analysis must be based.
FOOTNOTES

1. U.S. exports of R&D-intensive goods, defined as products associated with industries with an average of 25 or more scientists and engineers engaged in R&D per 1000 employees and total R&D funding amounting to 3.5 percent of net sales, totaled $98.3 billion in 1980 (see National Science Board (1983), p.214). The same source reports (p.195) that total U.S. expenditure on R&D in 1980 was $62.9 billion.


3. See Norris (1984). Lohr (1984) cites slightly different statistics (more than 30,000 contracts between 1950 and 1980 for an estimated $10 billion) in making much the same point. We have been unable to verify either of these figures.

4. It could be argued that these analyses do have relevance to some cases of technology transfer between a developed and a less developed country, especially in the agricultural sector. Such transfers often fall under the rubric of technical assistance, and one could ask what the effect of such assistance is on national welfare in the assisting country, as well as what the optimal charge for that assistance would be.

5. Krugman (1983) explores some further implications of this latter interpretation of the Feenstra and Judd model.

6. Strictly speaking, this conclusion relies on the further assumption, adopted by both Krugman and Feenstra and Judd, that the aggregate utility function has a constant-elasticity-of-substitution form.
7. Caves and Uekasa (1976, p.152) argue that the MITI review process has on several occasions reduced substantially the price that Japanese firms have paid for imported technology.

8. These and other reasons why the market provides socially inadequate incentives to undertake R&D are discussed in Arrow (1962) and Shapiro (1984).
REFERENCES


<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8104C</td>
<td>Laidler, David. On the Case for Gradualism</td>
</tr>
<tr>
<td>8105C</td>
<td>Wirick, Ronald G. Rational Expectations and Rational Stabilization Policy in an Open Economy</td>
</tr>
<tr>
<td>8107C</td>
<td>Burgess, David F., Energy Prices, Capital Formation, and Potential GNP</td>
</tr>
<tr>
<td>8108CDSJ</td>
<td>Jimenez, E. and Douglas H. Keare. Imitating Consumption and Income in the Low Income Urban Setting: Estimates from Panel Data in El Salvador</td>
</tr>
<tr>
<td>8109CDSJ</td>
<td>Whalley, John Labour Migration and the North-South Debate</td>
</tr>
<tr>
<td>8110C</td>
<td>Manning, Richard and John McMillan Government Expenditure and Comparative Advantage</td>
</tr>
<tr>
<td>8111C</td>
<td>Freid, Joel and Peter Howitt Why Inflation Reduces Real Interest Rates</td>
</tr>
</tbody>
</table>

**1982**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8201C</td>
<td>Manning, Richard and James R. Markusen Dynamic Non-Substitution and Long Run Production Possibilities</td>
</tr>
<tr>
<td>8202C</td>
<td>Peenstra, Robert and Ken Judd Tariffs, Technology Transfer, and Welfare</td>
</tr>
<tr>
<td>8203C</td>
<td>Ronald W. Jones, and Douglas D. Purvis: International Differences in Response to Common External Shocks: The Role of Purchasing Power Parity</td>
</tr>
<tr>
<td>8204C</td>
<td>James A Brander and Barbara J. Spencer: Industrial Strategy with Committed Firms</td>
</tr>
<tr>
<td>8205C</td>
<td>Whalley, John, The North-South Debate and the Terms of Trade: An Applied General Equilibrium Approach</td>
</tr>
<tr>
<td>8206C</td>
<td>Roger Betancourt, Christopher Clague, Arvind Panagariya CAPITAL UTILIZATION IN GENERAL EQUILIBRIUM</td>
</tr>
<tr>
<td>8207C</td>
<td>Mansur, Ahsan H. On the Estimation of Import and Export Demand Elasticities and Elasticity Pessimism</td>
</tr>
<tr>
<td>8208C</td>
<td>Whalley, J. and Randy Wigle PRICE AND QUANTITY RIGIDITIES IN ADJUSTMENT TO TRADE POLICY CHANGES: ALTERNATIVE FORMULATIONS AND INITIAL CALCULATIONS</td>
</tr>
<tr>
<td>8209CDSU</td>
<td>Jimenez, E. SQUATTING AND COMMUNITY ORGANIZATION IN DEVELOPING COUNTRIES: A CONCEPTUAL FRAMEWORK</td>
</tr>
</tbody>
</table>
1982

8210C Grossman, G.M. INTERNATIONAL COMPETITION AND THE UNIONIZED SECTOR

8211C Laidler,D. FRIEDMAN AND SCHWARTZ ON MONETARY TRENDS - A REVIEW ARTICLE

8212C Imam, M.H. and Whalley, J. INCIDENCE ANALYSIS OF A SECTOR SPECIFIC MINIMUM WAGE IN A TWO SECTOR HARRIS-TODARO MODEL.

8213C Markusen, J.R. and Melvin, J.R. THE GAINS FROM TRADE THEOREM WITH INCREASING RETURNS TO SCALE.

8214C INDUSTRIAL ORGANIZATION AND THE GENERAL EQUILIBRIUM COSTS OF PROTECTION IN SMALL OPEN ECONOMIES.

8215C Laidler, D. DID MACROECONOMICS NEED THE RATIONAL EXPECTATIONS REVOLUTION?

8216C Whalley, J. and Wigle, R. ARE DEVELOPED COUNTRY MULTILATERAL TARIFF REDUCTIONS NECESSARILY BENEFICIAL FOR THE U.S.?

8217C Bade, R. and Parkin, M. IS STERLING M3 THE RIGHT AGGREGATE?

8218C Kosch, B. FIXED PRICE EQUILIBRIA IN OPEN ECONOMIES.

1983

8301C Kimbell, L.J. and Harrison, G.W. ON THE SOLUTION OF GENERAL EQUILIBRIUM MODELS.

8302C Melvin, J.R. A GENERAL EQUILIBRIUM ANALYSIS OF CANADIAN OIL POLICY.

8303C Markusen, J.R. and Svensson, L.E.O. TRADE IN GOODS AND FACTORS WITH INTERNATIONAL DIFFERENCES IN TECHNOLOGY.

8304C Mohammad, S. Whalley, J. RENT SEEKING IN INDIA: ITS COSTS AND POLICY SIGNIFICANCE.

8305C DSU Jimenez, E. TENURE SECURITY AND URBAN SQUATTING.

8306C Parkin, M. WHAT CAN MACROECONOMIC THEORY TELL US ABOUT THE WAY DEFICITS SHOULD BE MEASURED.

8307C Parkin, M. THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR.

8308C Wooton, I. LABOUR MIGRATION IN A MODEL OF NORTH-SOUTH TRADE.

8309C Deardorff, A.V. THE DIRECTIONS OF DEVELOPING COUNTRIES TRADE: EXAMPLES FROM PURE THEORY.

8310C Manning, R. ADVANTAGEOUS REALLOCATIONS AND MULTIPLE EQUILIBRIA: RESULTS FOR THE THREE-AGENT TRANSFER PROBLEM.
Mohammad, S. and Whalley, J. CONTROLS AND THE INTERSECTORAL TERMS OF TRADE IN INDIA.


Jones, R.W., Neary, J.P. and Ruane, F.P. TWO-WAY CAPITAL FLOWS: CROSS-HAULING IN A MODEL OF FOREIGN INVESTMENT.

Follain, J.R. Jr. and Jimenez, E. THE DEMAND FOR HOUSING CHARACTERISTICS IN DEVELOPING COUNTRIES.

Shoven, J.B. and Whalley, J. APPLIED GENERAL EQUILIBRIUM MODELS OF TAXATION AND INTERNATIONAL TRADE.

Boothe, Paul and Longworth David. SOME IRREGULAR REGULARITIES IN THE CANADIAN/U.S. EXCHANGE MARKET.

Hamilton, Bob and Whalley, John. BORDER TAX ADJUSTMENTS AND U.S. TRADE.

Neary, J. Peter, and Schweinberger, Albert G. FACTOR CONTENT FUNCTIONS AND THE THEORY OF INTERNATIONAL TRADE.

Veall, Michael R. THE EXPENDITURE TAX AND PROGRESSIVITY.

Melvin, James R. DOMESTIC EXCHANGE, TRANSPORTATION COSTS AND INTERNATIONAL TRADE.

Hamilton, Bob and Whalley, John. GEOGRAPHICALLY DISCRIMINATORY TRADE ARRANGEMENTS.

Bale, Harvey Jr. INVESTMENT FRICTIONS AND OPPORTUNITIES IN BILATERAL U.S.-CANADIAN TRADE RELATIONS.

Wonnacott, R.J. CANADA-U.S. ECONOMIC RELATIONS--A CANADIAN VIEW.

Stern, Robert M. U.S.-CANADIAN TRADE AND INVESTMENT FRICTIONS: THE U.S. VIEW.

Harrison, Glenn, H. and Kimbell, Larry, J. HOW ROBUST IS NUMERICAL GENERAL EQUILIBRIUM ANALYSIS?

Wonnacott, R.J. THE TASK FORCE PROPOSAL ON AUTO CONTENT: WOULD THIS SIMPLY EXTEND THE AUTO PACT, OR PUT IT AT SERIOUS RISK?

Bradford, James C. CANADIAN DEFENCE TRADE WITH THE U.S. Conklin, David. SUBSIDY PACTS.

Rugman, Alan M. THE BEHAVIOUR OF U.S. SUBSIDIARIES IN CANADA: IMPLICATIONS FOR TRADE AND INVESTMENTS.
1983

8328C  Boyer, Kenneth D.  U.S.-CANADIAN TRANSPORTATION ISSUES.

8329C  Bird, Richard M.  and Brean, Donald J.S.  CANADA-U.S. TAX RELATIONS: ISSUES AND PERSPECTIVES.

8330C  Moroz, Andrew R.  CANADA-UNITED STATES AUTOMOTIVE TRADE AND TRADE POLICY ISSUES.


1984

8401C  Harrison, Glenn W.  and Manning, Richard.  BEST APPROXIMATE AGGREGATION OF INPUT-OUTPUT SYSTEMS.

8402C  Parkin, Michael.  CORE INFLATION: A REVIEW ESSAY.

8403C  Blomqvist, Åke, and McMahon, Gary.  SIMULATING COMMERCIAL POLICY IN A SMALL, OPEN DUAL ECONOMY WITH URBAN UNEMPLOYMENT: A GENERAL EQUILIBRIUM APPROACH.

8404C  Vonnacott, Ronald.  THE THEORY OF TRADE DISCRIMINATION: THE MIRROR IMAGE OF VINERIAN PREFERENCE THEORY?

8405C  Whalley, John.  IMPACTS OF A 50% TARIFF REDUCTION IN AN EIGHT-REGION GLOBAL TRADE MODEL.

8406C  Harrison, Glenn W.  A GENERAL EQUILIBRIUM ANALYSIS OF TARIFF REDUCTIONS.

8407C  Horstmann, Ignatius and Markusen, James R.  STRATEGIC INVESTMENTS AND THE DEVELOPMENT OF MULTINATIONALS.

8408C  Gregory, Allan W.  and McCurdy, Thomas H.  TESTING THE UNBIASEDNESS HYPOTHESIS IN THE FORWARD FOREIGN EXCHANGE MARKET: A SPECIFICATION ANALYSIS.

8409C  Jones, Ronald W.  and Kierzkowski, Henryk.  NEIGHBORHOOD PRODUCTION STRUCTURES WITH APPLICATIONS TO THE THEORY OF INTERNATIONAL TRADE.

8410C  Weller, Paul and Yano, Makoto.  THE ROLE OF FUTURES MARKETS IN INTERNATIONAL TRADE: A GENERAL EQUILIBRIUM APPROACH.

8411C  Brecher, Richard A.  and Bhagwati, Jagdish N.  VOLUNTARY EXPORT RESTRICTIONS VERSUS IMPORT RESTRICTIONS: A WELFARE-THEORETIC COMPARISON.
Ethier, Wilfred J. ILLEGAL IMMIGRATION.

Eaton, Jonathon and Gene M. Grossman. OPTIMAL TRADE AND INDUSTRIAL POLICY UNDER OLIGOPOLY.

Wooton, Ian. PREFERENTIAL TRADING AGREEMENTS - A 3xn MODEL.


Deardorff, Alan V. FIRless FIRwoes: HOW PREFERENCES CAN INTERFERE WITH THE THEOREMS OF INTERNATIONAL TRADE.

Greenwood, Jeremy. NONTRADED GOODS, THE TRADE BALANCE, AND THE BALANCE OF PAYMENTS.

Blomqvist, Ake and Sharif Mohammad. CONTROLS, CORRUPTION, AND COMPETITIVE RENT-SEEKING IN LDCs.

Grossman, Herschel I. POLICY, RATIONAL EXPECTATIONS, AND POSITIVE ECONOMIC ANALYSIS.

Garber, Peter M. and Robert G. King. DEEP STRUCTURAL EXCAVATION? A CRITIQUE OF EULER EQUATION METHODS.

Barro, Robert J. THE BEHAVIOR OF U.S. DEFICITS.

Persson, Torsten and Lars E.O. Svensson. INTERNATIONAL BORROWING AND TIME-CONSISTENT FISCAL POLICY.

Obstfeld Maurice. CAPITAL CONTROLS, THE DUAL EXCHANGE RATE, AND DEVALUATION.

Kuhn, Peter. UNION PRODUCTIVITY EFFECTS AND ECONOMIC EFFICIENCY.

Hamilton, Bob and John Whalley. TAX TREATMENT OF HOUSING IN A DYNAMIC SEQUENCED GENERAL EQUILIBRIUM MODEL.

Hamilton, Bob, Sharif Mohammad, and John Whalley. RENT SEEKING AND THE NORTH-SOUTH TERMS OF TRADE.

Adams, Charles and Jeremy Greenwood. DUAL EXCHANGE RATE SYSTEMS AND CAPITAL CONTROLS: AN INVESTIGATION.

Loh, Choon Cheong and Michael R. Veall. A NOTE ON SOCIAL SECURITY AND PRIVATE SAVINGS IN SINGAPORE.

Whalley, John. REGRESSION OR PROGRESSION: THE TAXING QUESTION OF INCIDENCE ANALYSIS.

Kuhn, Peter. WAGES, EFFORT, AND INCENTIVE-COMPATIBILITY IN LIFE-CYCLE EMPLOYMENT CONTRACTS.
Greenwood, Jeremy and Kent P. Kimbrough. AN INVESTIGATION IN THE THEORY OF FOREIGN EXCHANGE CONTROLS.

Greenwood, Jeremy and Kent P. Kimbrough. CAPITAL CONTROLS AND THE INTERNATIONAL TRANSMISSION OF FISCAL POLICY.

Nguyen, Trien Trien and John Whalley. EQUILIBRIUM UNDER PRICE CONTROLS WITH ENDOGENOUS TRANSACTIONS COSTS.

Adams, Charles and Russell S. Boyer. EFFICIENCY AND A SIMPLE MODEL OF EXCHANGE RATE DETERMINATION.

Kuhn, Peter. UNIONS, ENTREPRENEURSHIP, AND EFFICIENCY.

Hercowitz, Zvi and Efraim Sadka. ON OPTIMAL CURRENCY SUBSTITUTION POLICY AND PUBLIC FINANCE.

Lenjosek, Gordon and John Whalley. POLICY EVALUATION IN A SMALL OPEN PRICE TAKING ECONOMY: CANADIAN ENERGY POLICIES.

Aschauer, David and Jeremy Greenwood. MACROECONOMIC EFFECTS OF FISCAL POLICY.

Hercowitz, Zvi. ON THE DETERMINATION OF THE EXTERNAL DEBT: THE CASE OF ISRAEL.

Stern, Robert M. GLOBAL DIMENSIONS AND DETERMINANTS OF INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

Deardorff, Alan V. COMPARATIVE ADVANTAGE AND INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

Daly, Donald J. TECHNOLOGY TRANSFER AND CANADA'S COMPETITIVE PERFORMANCE.

Grey, Rodney de C. NEGOTIATING ABOUT TRADE AND INVESTMENT IN SERVICES.

Grossman, Gene M. and Carl Shapiro. NORMATIVE ISSUES RAISED BY INTERNATIONAL TRADE IN TECHNOLOGY SERVICES.

Chant, John F. THE CANADIAN TREATMENT OF FOREIGN BANKS: A CASE STUDY IN THE WORKINGS OF THE NATIONAL TREATMENT APPROACH.

Aronson, Jonathan D. and Peter F. Cowhey. COMPUTER, DATA PROCESSING, AND COMMUNICATION SERVICES.