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REVEALED FACTOR ABUNDANCE AND THE FACTOR CONTENT OF TRADE IN HEADQUARTER SERVICES

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REVEALED FACTOR ABUNDANCE AND THE FACTOR CONTENT OF TRADE IN HEADQUARTER SERVICES

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Abstract

This paper analyzes how usual measures of revealed factor abundance (RFA), based on trade in merchandise, are affected by the existence of trade in services of intangible assets; trade that is mainly associated with multinational firms. It presents empirical estimates of both usual measures of RFA and new measures that take account of trade in headquarter services for the United States; a country that has a substantial surplus in the recorded components of such trade. It is found that the usual measures underestimate the abundance of highly skilled labor and technological knowledge, and overestimate the abundance of physical capital.

JEL Classification: F11; F23.

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I. Introduction

One reason for the widespread discontent with traditional trade theory as an explanation of the determinants of trade is the poor performance of the factor proportions theory in empirical tests. The Heckscher-Ohlin-Vanek (HOV) model's predictions have been rejected in several studies (e.g., Maskus 1985; Bowen, Leamer & Sveikauskas 1987; Brecher & Choudhri 1988; Staiger 1988). The HOV model is, however, based on several restrictive assumptions, e.g., identical technologies across countries and factor price equalization. Thus, one way to try to explain why the empirical data does not correspond to the theoretical predictions that immediately suggests itself is to relax some of these assumptions (see, e.g., Bowen *et. al.* 1987; Trefler 1993). This paper focuses on another possible source of the failure of the HOV theorem, namely the omission of important cross-border flows of services in the measures of revealed factor abundance that are used to test the HOV theorem.

Usually, measures of revealed factor abundance (RFA) are based on net trade in merchandise only. This means that any trade that takes place in services is omitted from these measures. Provided that the factor content of net trade in a subset of all commodities that are subject to international trade is strongly correlated to the factor content of total net trade, it may, however, not matter much for the conclusions about relative factor abundance if observations on net trade in services are omitted. On the other hand, if there is a large systematic discrepancy in factor content of net trade between the commodities which are included in the calculations and those which are not, there might be a systematic bias in the usual measures of RFA.

In the case of services like R&D, advertising and management, i.e., services that are used as inputs possibly at several plants for production of final goods, it is likely that the factor content differs in a systematic way from the factor content of, say, raw materials and industrial products. International trade in such inputs occurs when they are used to serve plants that are located abroad. Since we normally associate such trade with the multinational enterprises

(MNEs), we will call these inputs "headquarter services".[1] Given that the production of headquarter services requires inputs of primary factors of production, the pattern of trade in these services is likely to reflect international differences in relative endowments just as it does in any other commodity. Since it is likely that headquarter services are more intensive in technological knowledge and highly trained labor than other commodities, their omission in measures of RFA may lead to a systematic under- or overestimation of net trade in these factors for countries that tend to be, on average, net exporters or net importers of headquarter services.[2]

This paper analyzes how the factor content of trade in goods may differ from the factor content of a broader concept of trade that includes trade in headquarter services. To do so, the HOV model is modified by the assumption that there is international trade in headquarter services. This modified HOV model is then used to calculate some empirical estimates of the factor content of a broader concept of international trade. In the empirical part of the paper, the problem arises of how to measure trade in headquarter services. There are two major obstacles to obtaining an adequate measure of trade in headquarter services. First, not all cross-border flows that constitute receipts and payments for what may be considered as headquarter services are registered in a way in which they can be separated from other types of cross-border flows.[3] Second, detailed industry-distributed data on the components of the

[1]The term headquarter services was originally used by Helpman (1984, 1985) to signify inputs that can become firm-specific assets and that can serve many plants. In principle, there may well be trade in headquarter services between unaffiliated companies, but it is mainly because this trade is likely to be associated with high transaction costs that we expect the market for headquarter services to be internalized within the firm.

[2]This is one implication of the analyses in Helpman (1984, 1985) and Helpman & Krugman (1985), Chapters 12 and 13, where the production of headquarter services is assumed to require inputs of primary factors of production and headquarter services can be traded internationally through MNEs. When there are two countries and two factors of production, say, skilled and unskilled labor, the country which is relatively abundant in skilled labor will be a net exporter of headquarter services assuming that the production of headquarter services is that activity which is the most skilled-labor intensive. If this component of total trade is left out of the analysis of the factor content of net trade, the country which is relatively abundant in skilled labor will appear as less abundant and the other country as more abundant in skilled labor.

[3]Cross-border flows of what may be considered as headquarter services are probably for the most part registered in the current account; as royalties and license fees, as trade in other private services, and as factor income. However, many countries do not collect information about reinvested earnings, which means that this component of total factor income is not reported in the current account. Furthermore, it is difficult to determine to what extent factor incomes constitute returns to firm-specific assets like technological knowledge and know-how, in which case they should be defined as receipts for headquarter services, and to what extent they constitute returns to capital, in which case they should not be defined as receipts for headquarter services.

current account that do report trade in what may be considered as headquarter services is not usually available in national official statistics sources. An exception is the United States, where industry-distributed data on royalties and license fees that flow between affiliated companies, and on payments and receipts for other direct investment services are available. Therefore, we shall use data for the United States to compute measures of RFA that takes at least part of the total trade in headquarter services into account. By comparing these new measures with those that are obtained from the usual calculations based on the HOV theory, we can assess the likely direction of a more complete correction of measures of RFA.

The rest of this paper is organized as follows: The modified HOV model is developed in section II. From this model we derive an expression for RFA and show how it differs from the analogous measure based on the usual HOV model. In section III and IV, we calculate measures of RFA for the United States based on a partial correction for international trade in headquarter services, and compare these with the analogous measures based on the usual HOV model. Section III gives an account of the variables and the data used, while section IV presents the results. We find that although our partial correction for international trade in headquarter services has a minor impact on the ranking of factors according to their revealed abundance, the direction in which the measures of RFA change has a distinct profile and the magnitude of change is quite large in some cases. The correction for trade in headquarter services results in an increase in the measures of RFA for labor categories that include highly trained labor and for variables measuring technological knowledge, while it results in a decrease for labor categories that include unskilled labor and physical capital. This is what we would expect given that the United States, on average, is a net exporter of headquarter services. In section V, some concluding remarks are given.

Another problem is that royalties and license fees probably offer more scope for transfer pricing than do goods flows. The accuracy of these components of the balance of payments is thus difficult to assess.

II. A Heckscher-Ohlin-Vanek Model with Trade in Headquarter Services

Suppose that there are N goods that are all traded freely and M factors that are all available in inelastic supplies. To produce and sell a good, two different activities have to be carried out. First, headquarter services have to be produced. These services are then combined with factor inputs in order to produce the final output. All industries are vertically integrated, so that both the production of headquarter services and of final output take place within the same industry. Further, suppose that headquarter services can be directly exported abroad or imported from abroad. Total industry output then consists not only of goods that embody headquarter services, but also of headquarter services that are directly exported abroad.

Denote the supply of factor i with V_i. Factor-market clearing implies that

$$V_i = \sum_{j=1}^{N}\left(a_{ij}^H Q_j^H + a_{ij}^P Q_j\right), \tag{1}$$

where Q_j^H is output of headquarter services in industry j, Q_j is output of good j, $a_{ij}^H \equiv V_{ij}^H / Q_j^H$ is the quantity of factor i used in the production of a unit of headquarter services in industry j, and $a_{ij}^P \equiv V_{ij}^P / Q_j$ is the quantity of factor i used directly in the production stage of a unit of good j.

If we were to look at the whole integrated world economy, $a_{ij}^H Q_j^H + a_{ij}^P Q_j$ could be expressed as $(a_{ij}^H a_{Hj} + a_{ij}^P) Q_j$, where $a_{Hj} \equiv C_j^H / X_j$ is the volume of headquarter services used in the production of a unit of good j (C_j^H is the amount of headquarter services used as input by industry j, which for the integrated world economy is equal to the total production of headquarter services, Q_j^H). That is, for the world economy as a whole, all headquarter services are embodied in goods. However, for a specific country, the volume of headquarter services used in the domestic industry does not have to equal the amount of headquarter services that is being produced. (1) can then be expressed as

$$V_i = \sum_{j=1}^{N} \left\{ (a_{ij}^H a_{Hj} + a_{ij}^P) Q_j + a_{ij}^H T_j^H \right\}, \tag{2}$$

where $T_j^H \equiv Q_j^H - C_j^H$ is net exports of headquarter services. In matrix form, the conditions for factor-market clearing can be written as

$$\mathbf{V} = \mathbf{AQ} + \mathbf{A_H T_H}, \tag{3}$$

where **V** is the M×1 vector of factor supplies, **A** is the M×N matrix of total factor input requirements in domestic production of goods (i.e., a matrix with elements $a_{ij} = a_{ij}^H a_{Hj} + a_{ij}^P$), **Q** is the N×1 vector of outputs of goods, $\mathbf{A_H}$ is the M×N matrix of factor input requirements in the production of headquarter services (i.e., a matrix with elements a_{ij}^H), and $\mathbf{T_H}$ is the N×1 vector of net trade in headquarter services.

Given these assumptions, the vector of a country's net trade in factor services ($\mathbf{V_T}$) is

$$\mathbf{V_T} \equiv \mathbf{AT_G} + \mathbf{A_H T_H} = \mathbf{AQ} - \mathbf{AC} + \mathbf{A_H T_H}, \tag{4}$$

where $\mathbf{T_G}$ is the N×1 vector of net trade in goods, and **C** is the N×1 vector of consumption of goods.

Let us now assume that the technology matrix **A** is identical across countries, that preferences are homothetic and identical, and that the number of goods and factors are equal so that the inverse of the matrix **A** can be found.[4] As in the usual HOV model, the vector of net trade in factor services will then equal the country's excess factor supplies:[5]

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[4]The assumption that the technology matrix **A** is identical across countries implies that technology is universal and that factor prices are equalized.

[5]This was shown for the usual Heckscher-Ohlin model by Vanek (1968). See Ekholm (1995, Appendix 4.1) for a proof of this proposition based on this modified model.

$$V_T = V - sV_W, \tag{5}$$

where V_W is the M×1 vector of world factor supplies and s is the country's consumption share. Allowing for the possibility that there are trade imbalances, the consumption share, s, can be shown to equal $(GNP - B)/GNP_W$, where $B = B_G + B_H$ is the sum of the trade balance for goods and headquarter services (see Appendix 1).

If we take (4) as the basis for a calculation of RFA, we should thus make the following correction for trade imbalances;

$$V_T^A \equiv AT_G + A_H T_H - V_W(B/GNP_W) = V - (GNP/GNP_W)V_W. \tag{6}$$

Since $V_W = AQ_W$, where Q_W is the vector of world outputs, the vector of adjusted net trade in factor services, V_T^A, can also be written as

$$V_T^A = A(T_G - BS) + A_H T_H, \tag{7}$$

where S is the N×1 vector with elements $s_j = Q_{Wj}/GNP_W$, i.e., the share of world output of a final good in world GNP.

Suppose that we now calculate net trade in factor services based on observations of trade in merchandise only. We thus observe the vector T_G, make the correction for any overall imbalance in merchandise trade, and use observations on total factor requirements related to output in goods to construct the technology matrix A. The calculated vector of adjusted net trade in factor services ($\overline{V}_T^A$) is then based on the following equation;

$$\overline{V}_T^A \equiv A^C(T_G - B_G S), \tag{8}$$

where A^C is the matrix of factor requirements that we use to calculate the factor content of adjusted net trade in merchandise. If $A^C = A$, the difference between V_T^A and $\overline{V}_T^A$ is equal to $A_H T_H - B_H AS$, i.e., the true adjusted net trade in factor services and the observed adjusted net trade in factor services differ with the trade imbalance adjusted value of the factor content of headquarter services. The observed value of the adjusted net exports of factor services would in this case underestimate the true value for factors that with balanced trade in headquarter services would be net exports through this trade. Analogously, it would overestimate the true value for factors that with balanced trade in headquarter services would be net imports through this trade.

Notice that $\mathbf{V}_T^A$ and $\overline{\mathbf{V}}_T^A$ may differ even if factor intensities in the production of headquarter services are identical across industries. A surplus (deficit) in the trade balance of headquarter services will lead to a correspondingly higher (lower) level of consumption of final goods. Hence, the trade imbalance correction implies that it is the bundle of factors incorporated in this increase (decrease) in the consumption of final goods rather than in the consumption of headquarter services that should be subtracted from (added to) the bundle of factors that are incorporated in the net trade in headquarter services. If factor intensities are identical in all industries, a factor may still be net exported or net imported. This presupposes, however, that the factor is used more or less intensively in the production of headquarter services than in the production of final goods, and that trade in headquarter services is not in balance (see Appendix 1). Suppose that there is no net trade in factor services through trade in merchandise when such trade is balanced. Then, a country that has a net surplus in the trade in headquarter services will be a net exporter (importer) of any factor that is used more (less) intensively in the production of headquarter services than in the production of final output. A country that has a net deficit in the trade in headquarter services will be a net importer (exporter) of any factor that is used more (less) intensively in the production of headquarter services than in the production of final output.

An additional complication concerning the computation of measures of RFA is that the observed technology matrix $\mathbf{A}^C$ may differ from the true matrix $\mathbf{A}$. When we collect data on factor inputs we are likely to get data that cover both the factors involved in the production stage of the good, and any factors that are involved in the domestic production of headquarter services. Factor requirement coefficients will then measure the total amount of factors that go into the production of headquarter services and goods per unit of final output. The typical element of the observed technology matrix $\mathbf{A^C}$ will be $a_{ij}^C = a_{ij}^H b_{Hj} + a_{ij}^P$, where $b_{Hj} = \left(Q_j^H / Q_j\right)$ is output of headquarter services as a fraction of output of goods in industry j. If some headquarter services are sold abroad instead of being embodied in the domestic production of goods, this coefficient will overestimate the amount of factors required to produce a unit of good j. This is because it includes the amount of factors per unit of domestically produced output of good j that really is used in the production of foreign goods, via exports of headquarter services. If headquarter services are imported in order to produce good j, the observed factor input coefficient will underestimate the amount of factors required to produce a unit of the finished good. In this case b_{Hj}=0, and the observed factor input coefficient is really a measure of the per unit amount of factors used directly in the production stage.

By adding and subtracting $a_{ij}^H a_{Hj}$ to a_{ij}^C, it can be shown that

$$a_{ij}^C = a_{ij} + \frac{a_{ij}^H T_j^{H}}{Q_j}. \tag{9}$$

Hence, we can express the adjusted value of net trade in factor services based on trade in merchandise as

$$\overline{\mathbf{V}}_{\mathrm{T}}^{\mathrm{A}} = \mathbf{A}(\mathbf{T}_{\mathrm{G}} - B_G\mathbf{S}) + \mathbf{A}_{\mathrm{H}}(\overline{\mathbf{T}}_{\mathrm{G}} - B_G\overline{\mathbf{S}}), \tag{10}$$

where $\overline{\mathbf{T}}_{\mathrm{G}}$ is a N×1 vector with elements $t_j = T_j(T_j^H / Q_j)$, and $\overline{\mathbf{S}}$ is a N×1 vector with elements $s_j = (Q_{Wj} / GNP_W) / (Q_j / T_j^H)$.

By combining (7) and (10), we find that

$$\mathbf{V}_{\mathrm{T}}^{\mathrm{A}} - \overline{\mathbf{V}}_{\mathrm{T}}^{\mathrm{A}} = \mathbf{A}_{\mathrm{H}}\mathbf{T}_{\mathrm{H}} - B_H\mathbf{A}\mathbf{S} - \mathbf{A}_{\mathrm{H}}(\overline{\mathbf{T}}_{\mathrm{G}} - B_G\overline{\mathbf{S}}). \tag{11}$$

Equation (11) reveals that, when the technology matrix is measured incorrectly, the difference between the true and calculated value of adjusted net trade in factor services is not simply the adjusted factor content of net trade in headquarter services. There will be an overestimation of factors used in industries which are net exporters of headquarter services, and an underestimation of factors used in industries which are net importers of headquarter services. This means that there is a partial correction for the factor content of trade in headquarter services in industries that are net exporters of goods. When the industry is a net exporter of both goods and headquarter services, the overestimation of factors that are embodied in the exported goods partly corrects for the missing exports of factors that are embodied in headquarter services. When the industry is a net exporter of goods but a net importer of headquarter services, the underestimation of factors that are embodied in the exported goods partly corrects for the missing imports of factors that are embodied in headquarter services.

For industries that are net importers of goods, however, the error in the calculation of adjusted net trade in factor services is aggravated by the incorrectly measured technology matrix. When the industry is a net importer of both goods and headquarter services, the under-estimation of factors that are embodied in the imported goods is added to the missing imports of factors that are embodied in headquarter services. When the industry is a net importer of goods but a net exporter of headquarter services, the overestimation of factors that are embodied in the imported goods is added to the missing exports of factors that are embodied in headquarter services.

Based on equation (11), we can express the difference between the true and calculated value of adjusted net trade in factor i as

$$V_{Ti}^{A}-\overline{V}_{Ti}^{A}=\sum_{j=1}^{N}a_{ij}^{H}T_{j}^{H}\left(1-T_{j}/Q_{j}\right)-B_{H}\sum_{j=1}^{N}a_{ij}s_{j}+B_{G}\sum_{j=1}^{N}a_{ij}^{H}s_{j}\left(T_{j}^{H}/Q_{j}\right). \tag{12}$$

In (12), each term of the form $a_{ij}^{H}T_{j}^{H}$ is multiplied with a factor $(1-T_j/Q_j) = C_j/Q_j$. This factor is less than one if good j is net exported (i.e., if $Q_j > C_j$), and greater than one if good j is net imported (i.e., if $Q_j < C_j$). This is a reflection of the fact that the incorrect measurement of the technology matrix leads to a partial correction for the missing trade in headquarter services in industries that are net exporters of goods, and an aggravation of the error in industries that are net importers of goods.

There is also an error in the trade imbalance correction as a consequence of the incorrect measurement of the technology matrix. Because the observed matrix $\mathbf{A}^C$ will overestimate the factor requirements in industries with net exports of headquarter services, and underestimate them in industries with net imports of headquarter services, the trade balance of merchandise multiplied by a vector that includes net trade in factor services has to be added in order to get the true trade balance correction. This is done by adding $B_G \sum_{j=1}^{N} a_{ij}^H s_j (T_j^H / Q_j)$ in (12).

Whether $\overline{V}_{Ti}^A$ tends to over- or underestimate V_{Ti}^A thus depends on several factors. To begin with, it depends on whether factor i tends to be net imported or net exported through trade in headquarter services if such trade is in balance. Furthermore, it depends on whether or not factor i is used more intensively in the production of final goods than in the production of headquarter services. If trade in headquarter services is not in balance, this will determine whether the amount of factor i that is net exported (net imported) through trade in headquarter services is larger or smaller than the amount that is net imported (net exported) through trade in goods, when the headquarter service balance is used to increase (decrease) consumption of final goods. If the country is a net exporter of headquarter services, a factor that is used more (less) intensively in the production of headquarter services than in the production of final goods tends to be underestimated (overestimated) by $\overline{V}_{Ti}^A$. If the country is a net importer of headquarter services, it will be the other way around. Of course, the significance of this effect depends crucially on the size of the surplus or deficit in the balance of trade in headquarter services.

If the technology matrix $\mathbf{A}$ is measured incorrectly, the over- or underestimation of V_{Ti}^A by $\overline{V}_{Ti}^A$ also depends on whether the industries that are net importers of goods tend to be net exporters or net importers of headquarter services. If factor i is used intensively in headquarter services in industries which are either net exporters or net importers of both headquarter services and goods, $\overline{V}_{Ti}^{A}$ will tend to overestimate V_{Ti}^{A}. Should it be the other way around, i.e., factor i is used intensively in headquarter services in industries which are either net exporters of headquarter services and net importers of goods, or net importers of headquarter services and net exporters of goods, $\overline{V}_{Ti}^{A}$ will tend to underestimate V_{Ti}^{A}.

Finally, if the technology matrix is measured incorrectly, it also matters whether factor i is used intensively in headquarter services that tend to be exported or imported on average, since this will determine whether the correction for any trade imbalance for merchandise will tend to over- or underestimate the true correction. If factor i is used intensively in headquarter services that tend to be exported, the correction for any trade imbalance in merchandise in $\overline{V}_{Ti}^{A}$ tends to overestimate the true correction in V_{Ti}^{A}. The factor content of the change in consumption that is implied by the trade imbalance correction is overestimated by the factors that are really used to produce exports of headquarter services. In this case, $\overline{V}_{Ti}^{A}$ underestimates V_{Ti}^{A} if there is a surplus and overestimates V_{Ti}^{A} if there is a deficit in the trade balance for merchandise. If factor i is used intensively in headquarter services that instead tend to be imported, it will be the other way around.

If total industry output is large relative to net trade in goods and headquarter services, the effects on the difference between V_{Ti}^{A} and $\overline{V}_{Ti}^{A}$ due to the incorrect measurement of the technology matrix **A** tend to be small. In this case, the first two effects discussed will dominate. Suppose that headquarter services are produced with quite similar technology in all industries, and that total industry output is large enough relative to net trade in goods and services such that we can disregard any effects due to the incorrect measurement of **A**. Then, the two crucial factors determining whether $\overline{V}_{Ti}^{A}$ will give an unbiased measure of V_{Ti}^{A} are the difference in factor intensities between the production of headquarter services and the production of final goods, and the overall imbalance in trade in headquarter services. We would expect that factor intensities could differ substantially between the production of headquarter services and the production of final goods. For instance, we expect the production of headquarter services to be more intensive in skilled and less intensive in unskilled labor than production of final goods. Whether this causes $\overline{V}_{Ti}^{A}$ to be a biased measure of V_{Ti}^{A} then ultimately depends on whether or not trade in headquarter services is in balance. If B_H has a large positive value, the calculated measure of adjusted factor content of trade will underestimate (overestimate) the true measure for factors that are used more (less) intensively in the production of headquarter services than in the production of final goods. If B_H has a large negative value, the calculated measure will overestimate (underestimate) the true measure for factors that are used more (less) intensively in the production of headquarter services than in the production of final goods.

In the subsequent analysis we will estimate empirically a vector of adjusted factor content of trade in both merchandise and at least part of what may be considered as headquarter services for the United States. The United States, which is perhaps the most important home country of MNEs, has a substantial surplus in the recorded components of trade in headquarter services.[6] Based on the discussion above, we thus expect there to be a tendency for the usual measures of RFA to underestimate the U.S. adjusted net exports of factors that are used more intensively in the production of headquarter services than in the production of final goods. By comparing the usual measure of factor content, $\overline{V}_{Ti}^{A}$, with our broader measure, V_{Ti}^{A}, we can determine whether the former in fact over- or underestimates the latter for the United States.

As has been shown by Leamer (1980), the correct basis for a judgment of RFA in a factor proportions model is the factor intensity in net exports relative to the factor intensity in production or consumption. In a model with only two factors, capital (K) and labor (L), a country is revealed by trade to be relatively capital abundant if either of the conditions $K_T/K>L_T/L$ or $K_T/K_C>L_T/L_C$ hold, where K_T and L_T are capital and labor services embodied in net exports,[7] K and L are the total endowments of capital and labor, and K_C and L_C are the amounts of capital and labor that are embodied in total consumption of goods and services (see also Leamer 1984, pp. 51-53). According to this theory, the ranking of factor abundance can be inferred from the ranking of the ratios between the amount of each factor contained in net exports and either the total endowment of the factor or the amount of the

[6]Recently, the United States has become also an important host country of MNEs. According to the available data on services trade and factor income flows, however, this has not yet changed the United States' position as a net exporter of headquarter services.

[7]K_T and L_T take negative values if the country is an importer of capital and labor services.

factor contained in consumption. In the subsequent analysis, we will choose the latter as a basis for judgments of RFA. In other words, we will calculate measures of V_{Ti}^{A}/V_{Ci} and $\overline{V}_{Ti}^{A}/V_{Ci}$, where V_{Ci} is the amount of factor i that is contained in total consumption.

III. Data and Measurement of Variables

To compute $\mathbf{V}_{\mathrm{T}}^{\mathrm{A}}$ and $\overline{\mathbf{V}}_{\mathrm{T}}^{\mathrm{A}}$, we use data on trade in merchandise and headquarter services from 1989.[8] Trade in headquarter services is measured by the payments and receipts for royalties, licenses, and other services that are traded between affiliated companies, plus the exports and imports of business services that take place between unaffiliated companies. The net value of royalties, license fees and service charges that U.S. parent companies receive from their affiliates is defined as exports of headquarter services, while the net value of royalties, license fees and service charges that U.S. affiliates pay to their foreign parents is defined as imports of headquarter services.[9]

Our measure of trade in headquarter services does not include any royalties and license fees that constitute transactions between unaffiliated parties. Such transactions were reported to make up approximately 20 per cent of total exports and approximately 30 per cent of total imports of total U.S. royalties and license fees in 1989 (Sondheimer & Bargas 1993, Table 2, p. 122). Furthermore, it is likely that international flows of direct investment income at least partly reflect returns to firm-specific knowledge or other firm-specific assets. If this is the case, part of the international flows of direct investment income should, from an analytical point of view, be interpreted as international trade in headquarter services. However, since we have no way of knowing to what extent flows of direct investment income reflect payments and

[8]The data on imports of headquarter services was partly constructed by distributing totals for 1989 on the dis-aggregated distribution according to data from a benchmark study of foreign direct investment in the United States in 1987 (see Appendix 2).
[9]Direct investment royalties and license fees are fees paid for the use or sale of intangible property or rights - such as patents, industrial processes, trademarks, copyrights, franchises, designs, know-how, formulas, techniques, manufacturing rights, and other intangible assets or proprietary rights. Service charges consist of fees for services such as management, professional, or technical services (see U.S. Department of Commerce 1992, pp. M-23 - M-24).

receipts for headquarter services rather than returns to capital investments, we will not include direct investment income in our measure of headquarter services.

The vectors of net trade in merchandise and headquarter services are combined with two different sets of factor requirements data; one set that has been constructed particularly for this study and which is mainly based on industry statistics for 1987, and another set that has been used in several other factor content studies and which refers to the year 1967. The factor requirements for 1967 were obtained from Sveikauskas (1984), and have been used previously in studies by Bowen *et. al.* (1987), Sveikauskas (1983), and Bowen & Sveikauskas (1992).

The factor input requirements are as usual calculated as direct plus indirect factor requirements to take account of the factor services embodied in intermediate goods.[10] To calculate the direct plus indirect factor requirements in 1987, the U.S. 85-industry level input-output table for 1982 was employed.

Since we have no direct observations regarding factor input requirements for headquarter services, we have to estimate these coefficients. In this study, we will assume that direct and indirect factor input requirements for headquarter services in all industries are reflected by those found for one particular input-output (I-O) sector, namely I-O industry 73. This industry consists of business and professional services such as computer and data processing, testing and research services, advertising, legal, engineering, and accounting services.[11]

The number of factors that are included in the calculations differ between the two data sets. In both sets we include a measure of physical capital and seven labor categories with different occupational status. The labor categories differ somewhat between the two data sets. The 1987 data has been obtained from the surveys of occupational employment conducted by the Bureau of Labor Statistics, and the classification of labor in major occupational groups

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[10]The theoretical justification for this method is explained in Hamilton & Svensson (1983).
[11]I-O industry 73 includes the following sub-industries: computer and data processing services, management and consulting services, testing and research services, detective and protective services, equipment rental and leasing, photofinishing labs, photocopy, and commercial photography, miscellaneous repair shops, services to dwellings and other buildings, other business services, advertising, legal services, engineering, architectural, and surveying services, accounting, auditing and bookkeeping, and related services, n. e. c.

corresponds to those made by the Bureau.[12] The 1967 data is based on a combination of data from the Bureau of Labor Statistics and the U.S. Census of Population, and the classification of major occupational groups has been made by Sveikauskas (1984). Physical capital is measured as the current-cost net stock of fixed private capital for 1987, and as the sum of equipment, plant, and inventories, where equipment and plant input is measured by constant dollar capital stocks, for 1967.[13] For 1967, we include two additional input variables that are intended to capture aspects of the technology intensity and which have been constructed and used by Sveikauskas (1983, 1984): the amount of R&D embodied in capital investment, and innovation intensity (see Appendix 2 for a description of these variables).[14]

Trade data, input-output data for 1982, and factor requirement data have been re-classified so that they conform to the industry classification used by the Bureau of Economic Analysis for data on FDI and the operations of MNEs.[15] In general, this means that data has been aggregated to a higher level. The industry classification used for FDI data at most includes 65 industries. In practice, it includes fewer because of the frequent suppression of data at the most disaggregated level due to requirements of confidentiality. The calculations made here are based on an industry classification that contains 49 industries.[16] The computation of the adjusted factor content of trade in merchandise, $\overline{V}_T^A$, is therefore based on more aggregated data than in most factor content studies. The results for the factor content of trade in merchandise, however, can be easily compared with results obtained in other studies.

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[12]These categories are the following: 1. Professional, paraprofessional, and technical workers; 2. Managers and administrative workers; 3. Clerical and administrative workers; 4. Sales and related workers; 5. Service workers; 6. Production, construction, operating, maintenance, and material handling workers; 7. Agriculture, forestry, and fishing, and related workers.

[13]See Sveikauskas (1984, p. 137-138) for an account of how capital was measured for the 1967 data set.

[14]In Sveikauskas' study of science and technology in U.S. trade (Sveikauskas 1983), some other factor inputs that would have been interesting to look at in this context were used, such as personnel from different skill categories engaged in R&D. However, the input requirements for these factors were calculated on the assumption that no R&D is undertaken outside the manufacturing sector; an assumption that in this context would have the peculiar implication that there was no R&D undertaken at all as a headquarter service.

[15]The industry classification used for direct investment data is adapted from, but is less detailed than, the one used in the Standard Industrial Classification (SIC) system, which forms the basis of all industry statistics. The exact relationship between these two systems for industry classification can be found in the appendix of U.S. Department of Commerce (1992).

[16]The key to reclassification of I-O data and industry statistics to FDI data can be found in Ekholm (1995, Appendix 4.3).

With these data on total factor inputs and net trade in merchandise and headquarter services, we can calculate the factor content of net trade. However, to calculate the measures of RFA defined in (7) and (10), we have to decide on how to make the trade imbalance correction suggested by these equations. To begin with, equation (7) involves the unknown technology matrix **A**. Since we cannot observe this matrix, we rewrite (7) as

$$\mathbf{V}_{\mathrm{T}}^{\mathrm{A}} = \mathbf{A}^{\mathrm{C}}(\mathbf{T}_{\mathrm{G}} - B\mathbf{S}) + \mathbf{A}_{\mathrm{H}}\mathbf{U}, \tag{13}$$

where **U** is the N×1 vector with elements $u_j = T_j^H (C_j + s_j B)/Q_j$. Equation (13) involves only the technology matrices $\mathbf{A}^{\mathrm{C}}$ and $\mathbf{A}_{\mathrm{H}}$, which, in principle, are observable.

To compute **S** in (10) and **S** and **U** in (13), we need information about world outputs that is not readily available. By invoking the assumption of identical homothetic preferences we can however measure s_j as the expenditure share of good j in one country (cf. Bowen & Sveikauskas 1992). Homotheticity implies that a country's share of expenditure on good j is equal to the world's share of expenditure on this good, and since world expenditure is equal to world production of any good, the country's expenditure share of good j must also equal the world's output share of this good. We thus use U.S. data on expenditure shares to estimate world output shares. More specifically, we measure consumption as final demand minus net exports, and we find the expenditure shares by dividing consumption for each of the 49 goods by total consumption. This way, the vector **S** is normalized so that $\sum_{j=1}^{N} s_j = 1$ (see Appendix 1).

IV. The Factor Content of U.S. Trade in Merchandise and Headquarter Services

The results from the computations of the factor content of net trade in headquarter services and in merchandise are presented in Tables 1 and 2. In Table 1, we find the measures of RFA that have been based on factor requirement data for 1987, and in Table 2, the measures that are based on factor requirement data for 1967. All figures on factor content of net trade are expressed as percentages of the factors that are contained in consumption.

The first two columns of Tables 1 and 2 show the value and ranking of the factor content of adjusted net trade as it is usually calculated. i.e., based on trade in merchandise only. As in some other studies of the factor content of U.S. trade, the United States is revealed to be most abundant in agricultural workers (cf. Bowen *et. al.* 1987). It is however worth noting that Sveikauskas (1983) found professional scientists-engineers and technical managers to rank higher than farm managers and workers in his study of U.S. trade in 1967. Since the rankings in Table 2 are based on the same industry data, although at a more aggregated level, this would suggest that the United States may have strengthened its comparative advantages in agricultural production. Moreover, according to the results in Tables 1 and 2, the United States is revealed by trade in merchandise to be least abundant in production workers and operatives. This may be contrasted with the results reported by Bowen *et. al.* (1987). They found that service and sales workers were revealed to be less abundant than production workers. Compared to their results, which are also based on U.S. trade in 1967, the revealed abundance of sales and service workers based on merchandise trade in 1989 thus ranks higher. This seems to support the view that the U.S. has gained comparative advantages in service industries, while losing comparative advantages in manufacturing industries. Tables 1 and 2 also show that the U.S. is revealed by trade in merchandise to be more abundant in total labor than in physical capital in 1989. Hence, the Leontief paradox also prevails in this data material (cf. Baldwin 1971, 1979; Maskus 1985; Niroomand 1991).

The third column of Tables 1 and 2 shows the factor content of adjusted net trade based on equation (13), i.e., when trade in headquarter services has been taken into account. It is evident from the fourth column, which shows the ranking of factors according to their RFA based on this new measure, that the correction for trade in headquarter services leads to only minor changes in the ranking of RFA. The ranking based on factor requirements in 1987 is basically unaffected by the additional component of net trade in headquarter services. The only change is that clerical and managerial workers trade places so that clerical workers are revealed to be more abundant than managerial workers when the factor content of net trade in headquarter services is included in the calculations.

When calculations are based on the earlier data set, the effect on the ranking of RFA is somewhat greater. As already noted, the factor categories in this data set differ from those in the 1987 data set. For instance, scientists and technicians are classified in one skill category, leaving other professionals and managers in another category. There are also the two additional input categories; the amount of R&D embodied in capital investment and innovation intensity. The ranking of the factor inputs that are placed highest, i.e., farm labor and the category other professionals and managers, and of those placed lowest, i.e., craftsmen and operatives, remains unaffected when net trade in headquarter services is taken into account in the calculations. Among the other factors, however, there are some changes. The revealed abundance of scientists-engineers/technical managers, R&D embodied in capital investment, and innovations move up one step in the ranking, while sales/clerical personnel, laborers/service workers, and capital move down one step.

The last two columns of Tables 1 and 2 show the difference between V_{Ti}^{A} and $\overline{V}_{Ti}^{A}$ as a percentage share of V_{Ci}, and the sign of this difference, respectively. According to the signs of the differences in Table 1, the correction of the measure of RFA leads to an upward revision for categories of labor with professional/technical occupations, managerial and administrative occupations, clerical/administrative support occupations, and service occupations. It leads to a downward revision of physical capital, sales personnel, production workers, and labor occupied in agriculture, forestry, and fishing. According to the signs of the differences in Table 2, the correction of the measure of RFA leads to an upward revision for professional scientists-engineers/technical managers, other professionals and managers, sales and clerical personnel, R&D embodied in capital investment, and innovations. It leads to a downward revision of physical capital, craftsmen, operatives, laborers and service workers, and farm managers and workers. In Table 1, the largest positive difference between V_T^A/V_C and $\overline{V}_T^A/V_C$ is found in labor with professional/technical occupations, while the largest negative difference is found in agriculture, forestry, fishing, and related occupations. In Table 2, the largest positive difference between V_T^A/V_C and $\overline{V}_T^A/V_C$ is found for professional scientists-engineers/technical managers and R&D embodied in capital investments, while the largest negative difference is found for farm managers and workers. Hence, it seems that the omission of trade in headquarter services in measures of RFA leads to an underestimation of the United States' abundance of highly trained labor and possibly of technological knowledge. It also seems as if it leads to an overestimation of the abundance of physical capital and labor categories that include unskilled labor and, in particular, agricultural workers.

It is worth noting that the correction for trade in headquarter services leads to a downward revision of the United States' revealed abundance of physical capital. That is, when trade in headquarter services is taken into account, the United States appears as even less abundant in physical capital than from the usual measures of RFA. This can be compared to the change in revealed abundance of total labor, which is positive when calculations are based on the 1987 data set and negative, but with a smaller absolute value than for physical capital, when calculations are based on the 1967 data set. Thus, the recalculation of RFA performed here does not seem to be able to reverse, or even mitigate, the result that the United States appear to be relatively well endowed with labor, and relatively poorly endowed with physical capital.

V. Concluding Remarks

In this study we have explored the consequences for measures of RFA of omitting cross-border flows of headquarter services such as the creation of new technology through R&D, management, and professional and technical services. We have shown that this omission is likely to lead to biased measures of RFA for countries that are, on average, large net exporters or large net importers of these kinds of services. We have also presented some empirical evidence on both the usual measures for calculating RFA and measures that have been corrected for international trade in headquarter services for the United States, which is an important net exporter of headquarter services. This evidence supports the idea that usual measures of RFA for the United States tend to underestimate the abundance of highly skilled labor and technological knowledge, and overestimate the abundance of labor categories with a low level of skills.

The fact that our measure of trade in headquarter services only accounts for part of actual trade makes it difficult to assess the overall empirical relevance of this trade. In particular, the potential importance of foreign direct investment income in the total payments and receipts for headquarter services makes the calculations somewhat uncertain. In 1989, the year to which the trade data in this study relates, the net surplus of foreign direct investment income was more than twice as large as the total surplus of the components of headquarter services used in our calculations.[17] Hence, this might be an important source of error in the calculated measures. However, if the subset of trade in headquarter services that we have analyzed here is representative for all this trade, we can still draw conclusions about the likely direction of change that a more complete correction of measures of RFA would entail. The results concerning the direction of change seem to be robust as to the choice of factor requirement data used, since a similar pattern of change emerged from calculations based on factor input requirements in 1987 and 1967.

[17]The estimated total surplus of royalties, license fees, and other service charges between affiliate companies plus trade in business services was 17,368 millions of dollars, while the estimated surplus of foreign direct investment income was 39,613 millions of dollars (see the August issue of *Survey of Current Business* 1990).

Table 1. Adjusted net trade in factors based on trade in merchandise and headquarter services 1989 as percentage shares of endowments contained in total consumption. Factor requirements are based on data for 1987.

	$\overline{V}_T^A/V_C$	**Rank**	V_T^A/V_C	**Rank**	$\left(V_T^A-\overline{V}_T^A\right)/V_C$	**Sign**
Capital	-0.63	7	-0.65	7	-0.02	-
Labor	0.83	-	0.93	-	0.10	+
Professional/technical	1.20	4	1.65	4	0.45	+
Managerial	1.17	5	1.33	6	0.16	+
Clerical/administrative support	1.11	6	1.42	5	0.31	+
Sales	2.44	3	2.30	3	-0.14	-
Service	2.59	2	2.71	2	0.12	+
Production	-1.99	8	-2.05	8	-0.06	-
Agriculture, forestry, fishing	6.23	1	5.98	1	-0.25	-

Note: Definitions of factor variables and data sources are stated in Appendix 2.

Table 2. Adjusted net trade in factors based on trade in merchandise and headquarter services 1989 as percentage shares of endowments contained in total consumption. Factor requirements are based on data for 1967.

	$\overline{V}_T^A/V_C$	**Rank**	V_T^A/V_C	**Rank**	$\left(V_T^A-\overline{V}_T^A\right)/V_C$	**Sign**
Capital	0.14	7	-0.48	8	-0.62	-
Labor	0.51	-	0.34	-	-0.17	-
Professional scientists-engineers/ technical managers	1.63	4	2.88	3	1.25	+
Other professionals and managers	2.12	2	2.94	2	0.82	+
Sales and clerical	1.71	3	1.94	4	0.23	+
Craftsmen	-0.25	9	-0.56	9	-0.31	-
Operatives	-7.49	10	-8.14	10	-0.65	-
Laborers and service workers	0.71	5	0.35	6	-0.36	-
Farm managers and workers	17.52	1	16.40	1	-1.12	-
R&D embodied in capital investment	0.71	6	1.73	5	1.03	+
Innovations	0.02	8	0.23	7	0.21	+

Note: Definitions of factor variables and data sources are stated in Appendix 2.

REFERENCES

Baldwin, R. E. (1971), "Determinants of the commodity structure of U.S. trade", *American Economic Review*, 61, 126-146.

Baldwin, R. E. (1979), "Determinants of trade and foreign investment: further evidence", *Review of Economics and Statistics*, 61, 40-48.

Bowen, H. P., E. E. Leamer and L. Sveikauskas (1987), "Multicountry, Multifactor Tests of the Factor Abundance Theory", *American Economic Review*, 77, 791-809.

Bowen, H. P. & L. Sveikauskas (1992), "Judging factor abundance", *Quarterly Journal of Economics*, 107, 599-620..

Brecher, R. A. & E. U. Choudhri (1988), "The factor content of consumption in Canada and the United States: A two-country test of the Heckscher-Ohlin-Vanek model", Chapter 1 in Feenstra, R. C. (ed.): *Empirical Methods for International Trade*, Cambridge, MA: MIT Press.

Ekholm, K. (1995), *Multinational Production and Trade in Technological Knowledge*, Lund Economic Studies No. 58, Lund University.

Hamilton, C. & L. E. O. Svensson (1983), "Should direct or total factor intensities be used in tests of the factor proportions hypothesis?", *Weltwirtschaftliches Archiv*, 119, 453-463.

Helpman, E. (1984), "A simple theory of international trade with multinational corporations", *Journal of Political Economy*, 92, 451-471.

Helpman, E. (1985), "Multinational corporations and trade structure", *Review of Economic Studies*, 52, 443-457.

Helpman, E. & P. Krugman (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*, Cambridge, MA: MIT Press.

Leamer, E. E. (1980), "The Leontief Paradox, reconsidered", *Journal of Political Economics*, 88, 495-503.

Leamer, E. E. (1984), *Sources of International Comparative Advantages: Theory and Evidence*, Cambridge, MA: MIT Press.

Leamer. E. E. (1994), "Testing trade theory", Chapter 4 in Greenaway, D. & L. A. Winters (eds.), *Surveys in International Trade*, Oxford: Basil Blackwell.

Maskus, K. E. (1985), "A test of the Heckscher-Ohlin-Vanek theorem: the Leontief commonplace", *Journal of International Economics*, 19, 201-12.

Niroomand (1991), "Factor inputs and U.S. manufacturing trade structure", *Weltwirtschaftliches Archiv*, 127, 744-763.

Sondheimer, J. A. & S. E. Bargas (1993), "U.S. International sales and purchases of private services", *Survey of Current Business*, 73, 120-156.

Staiger, R. W. (1988), A specification test of the Heckscher-Ohlin theory", *Journal of International Economics*, 25, 129-141.

Survey of Current Business (1994), Bureau of Economic Analysis, U.S. Department of Commerce, April.

Sveikauskas, L. (1983), "Science and technology in United States foreign trade", *Economic Journal*, 93, 542-54.

Sveikauskas, L. (1984), "Science and technology in many different industries: Data for the analysis of international trade", *Review of Public Data Use*, 12, 133-156.

Trefler, D. (1993), "International factor price differences: Leontief was right!", *Journal of Political Economics*, 101, 961-987.

U.S. Bureau of the Census (1991), *Statistical Abstract of the United States*, U.S. Department of Commerce, Washington DC.

U.S. Bureau of the Census (1993), *U.S. Commodity Exports and Imports as Related to Output: 1990 and 1989*, U.S. Government Printing Office, Washington, DC.

U.S. Department of Commerce (1992), *U.S. Direct Investment Abroad: 1989 Benchmark Survey, Final Results*, Bureau of Economic Analysis, Washington DC: U.S. Government Printing Office.

U.S. Department of Labor (1988), "Occupational employment in manufacturing industries", *Bulletin of the Bureau of Labor Statistics*, No. 2312, Washington.

U.S. Department of Labor (1989), "Occupational employment in mining, construction, finance, and services", *Bulletin of the Bureau of Labor Statistics*, No. 2330, Washington.

U.S. Department of Labor (1990), "Occupational employment in selected nonmanufacturing industries", *Bulletin of the Bureau of Labor Statistics*, No. 2348, Washington.

Vanek, J. (1968), "The factor proportions theory: The N-factor case", *Kyklos*, 24, 749-756.

Appendix 1

Total trade is the sum of trade in goods and trade in headquarter services. If we substitute $\mathbf{V}_T$ for $\mathbf{V} - s\mathbf{V}_W$ in (4) and solve for $\mathbf{T}_G$ we get

$$\mathbf{T}_G = \mathbf{A}^{-1}(\mathbf{V} - s\mathbf{V}_W - \mathbf{A}_H\mathbf{T}_H). \tag{A1}$$

To find the value of the trade balance in goods (B_G), we pre-multiply $\mathbf{T}_G$ with the row vector of goods prices, $\mathbf{p}'_G$, and to find the value of the trade balance in headquarter services (B_H), we pre-multiply $\mathbf{T}_H$ with the row vector of returns to headquarter services, $\mathbf{p}'_H$:

$$B_G = \mathbf{p}'_G\mathbf{A}^{-1}(\mathbf{V} - s\mathbf{V}_W - \mathbf{A}_H\mathbf{T}_H), \tag{A2}$$

$$B_H = \mathbf{p}'_H\mathbf{T}_H. \tag{A3}$$

To find the value of the total trade balance we add (A2) and (A3);

$$B \equiv B_G + B_H = \mathbf{p}'_G\mathbf{A}^{-1}(\mathbf{V} - s\mathbf{V}_W - \mathbf{A}_H\mathbf{T}_H) + \mathbf{p}'_H\mathbf{T}_H. \tag{A4}$$

If we solve (A4) for s we get

$$s = \left(\mathbf{p}'_G\mathbf{A}^{-1}(\mathbf{V} - \mathbf{A}_H\mathbf{T}_H) + \mathbf{p}'_H\mathbf{T}_H - B\right) \Big/ \mathbf{p}'_G\mathbf{A}^{-1}\mathbf{V}_W. \tag{A5}$$

Now, we define *GNP* as the value of the country's total output, which is the sum of output of goods that embody headquarter services and net trade in headquarter services;

$$GNP \equiv \mathbf{p}'_G\mathbf{Q} - \mathbf{p}'_H\mathbf{C}_H + \mathbf{p}'_H\mathbf{Q}_H = \mathbf{p}'_G\mathbf{Q} + \mathbf{p}'_H\mathbf{T}_H. \tag{A6}$$

If we solve (3) for $\mathbf{Q}$ and substitute into (A6) we get

$$GNP = \mathbf{p}'_G\mathbf{A}^{-1}(\mathbf{V} - \mathbf{A}_H\mathbf{T}_H) + \mathbf{p}'_H\mathbf{T}_H. \tag{A7}$$

With identical technology, total world output of goods can be expressed as $\mathbf{A}^{-1}\mathbf{V}_W$. The world's GNP, defined as the value of total output of goods, can then be expressed as

$$GNP_W \equiv \mathbf{p}'_G \mathbf{Q}_W = \mathbf{p}'_G \mathbf{A}^{-1} \mathbf{V}_W . \tag{A8}$$

Substitution of (A7) and (A8) into (A5) yields

$$s = (GNP - B)/GNP_W , \tag{A9}$$

which is the definition of s stated on page 6 (cf. Leamer, 1994, p.74).

According to equation (7), net trade in the services of factor i is

$$V_{Ti}^A = \sum_{j=1}^{N} a_{ij}\left(T_j - (B/GNP_W)Q_{Wj}\right) + \sum_{j=1}^{N} a_{ij}^H T_j^H . \tag{A10}$$

But a_{ij} and a_{ij}^H are measured as the amount of factors required per dollar's worth of output;

$$\tilde{a}_{ij} = V_{ij} / P_j Q_j ,$$
$$\tilde{a}_{ij}^H = V_{ij} \Big/ P_j^H Q_j^H .$$

Hence, we can write (A10) as

$$V_{Ti}^A = \sum_{j=1}^{N} \tilde{a}_{ij} P_j \left(T_j - (B/GNP_W)Q_{Wj}\right) + \sum_{j=1}^{N} \tilde{a}_{ij}^H P_j^H T_j^H . \tag{A11}$$

On the basis of (A11), the world's output share of good j can be redefined as $\tilde{s}_j = P_j Q_{Wj} / GNP_W$, in which case the sum of output shares for all goods is equal to one, i.e., $\sum_{j=1}^{N} \tilde{s}_j = 1$. As was stated on p. 16, s_j has been redefined as $\tilde{s}_j$ in the calculations.

Suppose that all goods are produced with the same factor intensities and that headquarter services in all industries are produced with the same factor intensities. That is, suppose that $a_{ij} \equiv a_i$ and $a_{ij}^H \equiv a_i^H$. According to (A11), net trade in the services of factor i can then be written as

$$V_{Ti}^A = \tilde{a}_i \sum_{j=1}^{N} (P_j T_j - B\tilde{s}_j) + \tilde{a}_i^H \sum_{j=1}^{N} P_j^H T_j^H . \tag{A12}$$

If we simplify expression (A12) by using the following relationships: $\sum_{j=1}^{N}\tilde{s}_j = 1$; $\sum_{j=1}^{N} P_j T_j = B_G$; $\sum_{j=1}^{N} P_j^H T_j^H = B_H$; and $B = B_G + B_H$; we can rewrite this expression as

$$V_{Ti}^{A} = B_H(\tilde{a}_i^H - \tilde{a}_i). \tag{A13}$$

Expression (A13) reveals that, when factor intensities are identical across industries, net trade in factor services is equal to the difference between the factor intensity in the production of headquarter services and the total factor intensity in the production of final output, multiplied by the trade balance in headquarter services. This implies that a factor may be net exported or net imported even if factor intensities are identical in all industries. It suffices that the factor at hand is used more or less intensively in the production of headquarter services than in the production of final goods, and that trade in headquarter services is not in balance. This was stated on p. 7.

Appendix 2

Data Sources

Headquarter Services

Data on the net value of royalties, license fees and service charges that U.S MNEs receive from their affiliates have been collected from U.S. Department of Commerce (1992), *U.S. Direct Investment Abroad: 1989 Benchmark Survey, Final Results*, Bureau of Economic Analysis, Tables II.X 2. and II.X 5. Data on the net value of royalties, license fees and service charges that U.S. affiliates pay to their foreign parents is partly unpublished data that has been supplied by the Bureau of Economic Analysis. Because data on royalties, license fees and other direct investment services by U.S. affiliates for 1989 are only available at a very aggregated level (14 industries), this data has been constructed by allocating the totals for the aggregated industries according to the distribution that was given by the 1987 benchmark survey of U.S. affiliates (*Foreign Direct Investment in the United States: 1987 Benchmark Survey, Final Results*, Bureau of Economic Analysis). Net receipts of U.S. parent companies were defined as exports and net payments by U.S. affiliates of foreign firms as imports of headquarter services. Data on exports and imports of business services between unaffiliated firms was collected from Sondheimer & Bargas (1993, Table 2, p. 122). All export and import figures were deflated by the fixed-weighted price index for exports and imports of services.

Trade in merchandise

Data on exports and imports of goods relates to 1989 and has been collected from U.S. Bureau of the Census (1993). The classification of this data was based on the 1987 Standard Industrial Classification (SIC). The reclassification to the industry classification used for FDI data was made according to a conversion key presented in Ekholm (1985, Table A4.1, Appendix 4.3). The export and import figures were deflated to 1987 dollar values by import and export price indexes in U.S. Bureau of the Census (1991), *Statistical Abstract of the United States 1991*, Table 781. These figures were then deflated by the fixed-weighted price indexes for exports and imports to obtain 1967 dollar values.

Factor requirement data

A. The 1987 data set
The technology matrix for the 1987 data set was constructed from the 85- industry level version of the U.S. input-output table for 1982. Capital inputs have been measured as the current-cost net stock of fixed private capital. The data was obtained from the Bureau of Economic Analysis' ***Detailed Wealth by Industry Series***. The distribution of the total number of employees in the seven occupational groups was carried out according to the data presented in the Bulletin of the Bureau of Labor Statistics (U.S. Department of Labor, 1988, 1989, 1990). Data on total employment levels was obtained from various U.S. Department of Commerce industry censuses. Production was measured as the value of shipments or receipts, and data on

this variable was also obtained from various U.S. Department of Commerce industry censuses. Consumption was defined as final demand minus net exports, and data was collected from the 95-industry level version of the input-output table for 1987 (*Survey of Current Business*, April 1994).

B. The 1967 data set

The data set that refers to the year 1967 was obtained from Sveikauskas (1984), and the data sources are stated in that article. R&D embodied in capital investment is measured by taking the research share of total employment as the research intensity in output, and then calculating average research intensity in capital purchased by an industry from a matrix that shows the particular capital goods that are purchased by each industry (Sveikauskas 1984, p. 138). Innovation intensity was measured by the number of major innovations 1953-1969 per dollar of gross output 1963 in each three-digit SIC industry; where the decision to judge an innovation as major was left to an international panel of industrial engineers (see Sveikauskas 1984, p. 136, and the sources referred to therein).

To calculate total factor requirements for industries used in FDI data that contain more than one I-O industry or more than one of Sveikauskas' industry categories, a weighted average was taken, where the weights were set equal to each industry category's share in total gross output. Industry categories in which there were no exports and imports were excluded from these calculations. Oil & gas field services were treated as if they were part of crude petroleum & natural gas.