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Outsourcing of Services and Productivity Growth in Goods Industries

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Abstract

Outsourcing refers to the process of replacing in-house services, such as legal, advertising, accounting, and related business services with services purchased from outside the firm. If these services have lower productivity growth rates than the production of goods, then outsourcing will increase measured productivity growth within the goods industries. To analyze this we reduce service inputs to their constituent elements of labor, capital, and goods inputs, circumventing their problem of measurement. Total factor productivity growth amounts 1.3 - 0.2 = 1.1 percent a year over the period 1947-82 where the second term accounts for the service drag. Two thirds of the drag can be ascribed to an increase of service inputs (outsourcing) and one third to the negative productivity growth within the service sectors. The service drag was concentrated in 1977-82. Goods sectors which have rapid rates of standard total factor productivity growth have, on average, been successful in outsourcing sluggish services, but this source of sectoral productivity growth dried up in the last subperiod.

Introduction

In this paper, we consider the role of service inputs in the pattern of productivity growth of manufacturing over the postwar period in the U.S. The major motivation for this study comes from the "contracting-out" or "out-sourcing" issue that has received considerable attention in recent years. This refers to the process of replacing in-house services, such as legal, advertising, accounting, and related business services with services purchased from outside the firm (see, for example, Postner, 1990 for a discussion of this issue from an accounting point of view).[1]

Anne Carter in her 1970 book noted early on the rapid increase in total service requirements per unit of manufacturing output between 1947 and 1967. Studies of the U.K. economy indicate that this phenomenon has continued in more recent years. Using U.K. input-output data, Barker (1990) reported that about 20 percent of the growth in service (gross) output between 1979 and 1984 was attributable to changes in manufacturing intermediate demand, and Barker and Forssell (1992) calculated that 22 percent of the growth of business services over the same period was associated with change in input-output coefficients in manufacturing. Though these percentages are modest, the results do suggest that outsourcing has continued through the 1980s.

Our study focuses on a different (but related) issue, which is the effect of changes in intermediate demand for services on productivity growth within manufacturing. The motivation for this study comes from a recent empirical issue that has received considerable attention, namely the recovery of manufacturing productivity growth during the 1980s, after a protracted period of slowdown during the 1970s, while other sectors, particularly services, did not recover. Statistics calculated from the National Income and Product Accounts and shown in Table 1 illustrate this point. Average annual labor productivity growth increased from 1.0 percent over the 1973-79 period to 4.6 percent over the 1979-88 period in durable goods manufacturing, from 2.1 to 2.8 percent in non-durable goods manufacturing, and from 0.7 to 2.7 percent in goods production as a whole. In contrast, it rose from -0.1 percent to only 0.4 percent in service production.

Our speculation is that part of the alleged recovery of manufacturing productivity growth may be a consequence of the outsourcing of services from manufacturing (and from goods industries in general). The argument is that if these services have lower productivity growth rates than the production of goods within manufacturing, then the outsourcing of previously internally provided services will increase measured productivity growth within manufacturing. Note that this source of productive growth is not of a technological nature, but industrial organizational. It is of direct interest to determine how much of the change in measured productivity growth in manufacturing (and goods production) is due to the outsourcing process.

Our analytical technique is based on a consolidation framework first developed by Leontief (1967). Using this approach, service inputs into manufacturing are essentially reduced to their constituent elements of labor, capital, and goods inputs. The consolidation framework will allow us to decompose the change in total factor productivity (TFP) growth within manufacturing into effects emanating from the outsourcing of services and from the rate of material productivity growth in manufacturing.

Another advantage of this approach is that it avoids many of the problems of measurement associated with the output of service industries. In traditional measures of TFP growth within manufacturing, service inputs are treated in analogous fashion to inputs of goods industries, labor, and capital. Difficulties in measuring service outputs may seriously distort measures of TFP within manufacturing. On the other hand, input measures are quite adequate in service sectors, as in other industries within the economy. Labor, capital, and material inputs are easily identifiable and measurable in services, and are, in principle, no different than in other industries.

The basic data sources for this study are U.S. 85-order input-output tables for 1947, 1958, 1963, 1967, 1972, 1977, and 1982. The use-make framework will be exploited in the analysis for the last four tables. It should be noted at the outset that our time-series ends in 1982 because of the availability of input-output tables. This is unfortunate for two reasons. First, most of the interesting questions concerning outsourcing -- particularly, the recovery of productivity growth in manufacturing and its absence in services -- refer to the 1980s. Second, 1982 was a recession year, which will distort some of the productivity measurements over the 1977-82 period.

The next section of the paper presents the basic framework for the measurement of productivity in the service sectors. In Section 2 we generalize the analysis to accommodate secondary production in the so called use-make framework and the phenomenon of outsourcing is analyzed in Section 3. A description of the data sources and methods is given in Section 4, the results are discussed in Section 5, and concluding remarks and interpretations are made in the last section.

1. Service productivity measurement basics

Carter (1970) found an increase in the total requirements of service output over the 1947-67 period in the U.S., but could not decompose it into a real interindustry effect of greater specialization and a specious effect from the reclassification of such service activities from sectors where they are secondary output to sectors where they constitute primary output. By introducing the use-make activity framework, ten Raa and Wolff (1988) showed that many establishments which produced services in addition to their primary output during the 1960s sloughed off this production during the 1970s. In this paper we want to assess the implication of this process by decomposing total factor productivity growth of the goods sectors into an own component and a service component.

A main problem is that service output is not tangible. In other words, how do we measure the output of services required for nonservice production and how do we impute factor inputs to this output? The idea proposed in this paper is to circumvent the problem by relating the inputs of services to the outputs of the sectors that use those services. We will do so by elimination of the intermediate services, where the elimination is to be understood in a mathematical sense. The basic point is clearest when we assume away secondary products and confine ourselves to a single type of services. These restrictions will be lifted later on. The inclusion of multi-services is straightforward and will conclude this section. The generalization to production with secondary outputs requires a full analysis of the use-make framework and is relegated to the next section.

Thus, for the time being the data are as follows. U is an n×n-dimensional matrix of input flows, with the last row representing service inputs and the last column representing the inputs of the service sector. Hence

$$U = \begin{bmatrix} U_{11} & U_{12} \\ U_{21} & U_{22} \end{bmatrix}$$

with U_{11} a (n-1)×(n-1)-dimensional matrix, U_{21} a 1×(n-1)-dimensional row vector, U_{12} a (n-1)×1-dimensional column vector, and U_{22} a scalar. $L = (L^1 \;\; L^2)$ is an n-dimensional labor employment factor with L^1 (n-1)-dimensional and L^2 scalar. $K = (K^1 \;\; K^2)$ is similar, but for capital.

$$x = \begin{bmatrix} V_{11} \\ \vdots \\ V_{nn} \end{bmatrix}$$

is an output vector. The wage rate and rental rate are denoted by w and r, respectively. This completes the description of the data.

To define total factor productivity growth, it is convenient to introduce notation for the derived constructs of net outputs and production prices, y and p, respectively. They are defined as to balance the material flows and the financial figures. The material balance of commodity i, $x_i = \sum_j u_{ij} + y_i$, defines net output y_i, and the financial statements, $p_i x_i = \sum_j p_j u_{ji} + wL_i + rK_i$, determine the p_i's, simultaneously. In short,

$$y = x - Ue$$

and

$$p(\hat{x} - U) = wL + rK$$

or

$$p = (wL + rK)(\hat{x} - U)^{-1},$$

where e is the vector with all entries equal to unit y and $\hat{x}$ is the diagonal matrix derived from vector x. Economy wide net output over factor input equals $\frac{py}{wLe + rKe}$. Its relative real rate of change is called <u>total factor productivity (TFP) growth</u>,

$$\rho = d\left(\frac{py}{wLe + rKe}\right)/\frac{py}{wLe + rKe}$$

where the prices are constant. By the quotient rule,

$$\rho = \frac{d(py)}{py} - \frac{d(wLe + rKe)}{wLe + rKe} = \frac{pdy}{py} - \frac{wdLe + rdKe}{wLe + rKe}$$

By definitions of p and y, $py = (wL + rK)(\hat{x} - U)^{-1}(x - Ue) = wLe + rKe$. Hence

$$(1) \qquad \rho = \frac{pdy - wdLe - rdKe}{py}$$

It is illuminating to push this back to sectoral levels by defining technical coefficients. Thus, let $a_{ij} = u_{ij}/x_j$, $\ell_i = L_i/x_i$ and $k_i = K_i/x_i$ and organize them in a matrix, A, and two row vectors, ℓ and k. Then the material balance, $x_i = \sum_j u_{ij} + y_i$, becomes x = Ax + y and $Le = \ell x$ and Ke = kx. Substituting, the numerator of ρ becomes

$$pdy - wdLe - rdKe = pd[(I - A)x] - wd(\ell x) - rd(kx) =$$

$$= [p(I - A) - w\ell - rk]dx - (pdA + wd\ell + rdk)x$$

Postmultiplying the expression defining p, $p(\hat{x} - U) = wL + rK$, by $\hat{x}^{-1}$ makes the first term on the right hand side vanish. Substituting,

$$(2) \qquad \rho = -(pdA + wd\ell + rdk)x/(py)$$

where the components of $pdA + wd\ell + rdk$ refer to technical change in the respective sectors. So far, the input-output analysis of TFP growth is standard. We are interested in TFP growth associated not with all net output, y, but only with the net output of goods, y^1. In this way all service output is induced by the demand for goods and can be allocated to the various goods sectors. This device is necessary if we want to free the analysis from the problem of measurement of services. As before, y^1 comprises all components of y but the last one. The same convention holds for p and other row vectors. For example, labor coefficients are partitioned according to $\ell = (\ell^1 \;\; \ell^2)$. Gross output of services will be taken into account, but only to the extent that they are induced by the output of goods. So we define <u>goods TFP growth</u> by

$$(3) \qquad \rho^* = \frac{p^1dy^1 - wdL^* - rdK^*}{p^1y^1}$$

where L^* is the part of Le associated with y^1 instead of y, and similar for K^*. More precisely,

$$(4) \qquad L^* = \ell(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} \text{ and } K^* = k(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix}$$

On the right hand sides of these expressions we have full dimensional row vectors and matrices of technical coefficients, including service rows and columns, applying to net output with zero service component. Alternatively, one may apply n-1 dimensional row vectors and matrices to the reduced net output vector, y^1, provided the coefficients are extended to account for the material and factor input charging to induced services. For a related purpose, Leontief (1967) defined the lower dimensional matrix and row vectors,

$$A^* = A_{11} + A_{12}(I - A_{22})^{-1}A_{21}$$

and

$$\ell^* = \ell^1 + \ell^2(I - A_{22})^{-1}A_{21}, \quad k^* = k^1 + k^2(I - A_{22})^{-1}A_{21}.$$

With these constructs,

$$L^* = \ell^*(I - A^*)^{-1}y^1 \text{ and } K^* = k^*(I - A^*)^{-1}y^1.$$

Since the starred expressions are defined in terms of the technical coefficients, A, ℓ and k, the equalities have to be proved. The crux of the matter is a useful

<u>Fact 1</u>. $(I - A)^{-1}\begin{bmatrix} I \\ 0 \end{bmatrix} = \begin{bmatrix} I \\ (I - A_{22})^{-1}A_{21} \end{bmatrix}(I - A^*)^{-1}$,

where, in $\begin{bmatrix} I \\ 0 \end{bmatrix}$, the entries are the unit matrix and zero row vector of the smaller dimension (n-1). For a proof, see the appendix.

The equalities follow immediately from the fact. By definition and fact 1,

$$L^* = \ell(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = \ell(I - A)^{-1}\begin{bmatrix} I \\ 0 \end{bmatrix}y^1 =$$

$$= (\ell^1 \quad \ell^2)\begin{bmatrix} I \\ (I - A_{22})^{-1}A_{21} \end{bmatrix}(I - A^*)^{-1}y^1 =$$

$$= [\ell^1 + \ell^2(I - A_{22})^{-1}A_{21}](I - A^*)^{-1}y^1 = \ell^*(I - A^*)^{-1}y^1$$

by definition of ℓ^*. Repeating the standard input-output reduction of total (1) to (2), but now to the lower dimensional economy with the starred technical coefficients, we obtain

$$(5) \qquad \rho^* = -(p^1 dA^* + wd\ell^* + rdk^*)x^*/(p^1y^1)$$

where

$$(6) \qquad x^* = (I \quad 0)(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = (I - A^*)^{-1}y^1$$

which can be established by using the above fact. Using the definitions of A^*, ℓ^* and k^*, the right hand side of the expression for ρ^* can be decomposed into two terms, namely

$$\rho_1 = -(p^1 dA_{11} + wd\ell^1 + rdk^1)x^*/(p^1y^1)$$

and

$$\rho_2 = -\{p^1 d[A_{12}(I - A_{22})^{-1}A_{21}] + wd[\ell_2(I - A_{22})^{-1}A_{21}] + $$
$$+ rd[k_2(I - A_{22})^{-1}A_{21}]\}x^*/(p^1y^1).$$

In short,

$$(7) \qquad \rho^* = \rho_1 + \rho_2$$

where the first term represents goods TFP growth realized directly in the goods sectors and the second term the same, but realized indirectly through the service sector. ρ_1 represents goods cost reductions and is observed directly, while ρ_2 represents reductions in the material requirements charged through to the services and is hidden in the structure that connect the goods sectors with the services and the services themselves.

Note that both ρ^*, and its constituent parts, ρ_1 and ρ_2, are inner products of cost vectors and an output vector. In other words, they are output weighted changes of sectoral coefficients and can be decomposed accordingly. Thus we can assess the direct and indirect components of the goods TFP growth on a sector by sector basis. Specifically, define

$$(8)\qquad \pi_1 = -(p^1 dA_{11} + wd\ell^1 + rdk^1)\hat{p}^{1^{-1}}$$

and

$$(9)\qquad \pi_2 = -\{p^1 d[A_{12}(I - A_{22})^{-1}A_{21}] + wd[\ell_2(I - A_{22})^{-1}A_{21} + rd[k_2(I - A_{22})^{-1}A_{21}]\}\hat{p}^{1^{-1}}$$

as row vectors of <u>sectoral productivity growth rates</u>. π_1 lists the goods components of TFP in the various goods sectors. π_2 lists the service components of the same. Each term of π_2 consists of an input price and a change of a composite of technical coefficients. For example, the second term features $\ell_2(I - A_{22})^{-1}A_{21}$. A_{21} are the direct service requirements of the goods sectors. Premultiplication with the Leontief services inverse yields the total service requirements and further multiplication with labor coefficients yields the service labor embodied in nonservice outputs. Similarly, the first and the third term yield the materials and capital embodied in the output of goods through services. Substituting,

$$(10)\qquad \rho^* = (\pi_1 + \pi_2)\hat{p}^1 x^*/(p^1 y^1)$$

This formula charges services TFP growth back to the goods sectors through row vector π_2. It is important to note that this redistribution is independent of the unit of measurement of services, as we will explain now. Take the first composite of technical coefficients in π_2, $A_{12}(I - A_{22})^{-1}A_{21}$. Thus far, services constitute one sector, and the technical coefficients, including the Leontief inverse, easily be pushed back to the data:

$$A_{12}(I - A_{22})^{-1}A_{21} = \frac{U_{12}}{x_n}\left[1 - \frac{U_{22}}{x_n}\right]^{-1} U_{21}\hat{x}^{1^{-1}}$$

where x^1 represents the first n-1 components of x. Typical element, (i,j), of the last equation is

$$\frac{u_{in}}{x_n}\left[1 - \frac{u_{nn}}{x_n}\right]^{-1} u_{nj}/x_j = \frac{u_{in}}{x_j}\left[1 - \frac{u_{nn}}{x_n}\right]^{-1} \frac{u_{nj}}{x_n}.$$

The point is that service flows, u_{nj}, u_{nn} and x_n, enter this expression only through ratios, $\frac{u_{nj}}{x_n}$ and $\frac{u_{nn}}{x_n}$, which are dimensionless entities. Thus, the unit of measurement for services is irrelevant to the evaluation of $A_{12}(I - A_{22})^{-1}A_{21}$. The same holds true for the second and third terms in π_2.

The extension of the irrelevance result for the unit of measurement of services to the multi-services case is straightforward. The expression for π_2 is maintained, but the constituent elements are now matrices instead of (row) vectors. Take, again, the first term,

$$A_{12}(I - A_{22})^{-1}A_{21}.$$

and consider a change of units of services. If the last service unit is halved, then x_n is doubled, its material input coefficients are halved, and the last service coefficients are doubled. Slightly more generally, if the last service unit is divided by s_n, x_n is multiplied by s_n, its material inputs are divided by s_n, and the last service coefficients are multiplied by s_n. If all service units are divided by quantities organized in a vector s, A_{12} is replaced by $A_{12}\hat{s}^{-1}$, A_{21} by $\hat{s}A_{21}$ and A_{22} by $\hat{s}A_{22}\hat{s}^{-1}$. Thus the first term becomes

$$A_{12}\hat{s}^{-1}(I - \hat{s}A_{22}\hat{s}^{-1})^{-1}\hat{s}A_{21} = A_{12}\hat{s}^{-1}[\hat{s}(I - A_{22})\hat{s}^{-1}]^{-1}\hat{s}A_{21}$$

$$= A_{12}\hat{s}^{-1}\hat{s}(I - A_{22})^{-1}\hat{s}^{-1}\hat{s}A_{21} = A_{12}(I - A_{22})^{-1}A_{21}$$

which is unaffected by the units of measurement. The logic of this result extends to the entire vector of charged through total factor productivity growth terms, π_2. The intuition of all this is simple. Productivity growth is charged to the services by relating its inputs to the outputs of the consuming sectors, in short by elimination of the services outputs. The result ought to be independent of the units of measurement of the eliminated entities.

2. Use-make analysis of service productivity measurement

The next assumption to be lifted is the absence of secondary products. So now we turn to the formal productivity analysis of outsourced services in the use-make framework. The data remain the same as regards inputs,

$$U = \begin{bmatrix} U_{11} & U_{12} \\ U_{21} & U_{22} \end{bmatrix}$$

with U_{11} a $(n-k)\times(n-k)$ dimensional matrix, U_{21} a $k\times(n-k)$ dimensional matrix, U_{12} a $(n-k)\times k$ dimensional matrix, and U_{22} a $(k\times k)$ dimensional matrix representing the own inputs of the various services, $L = (L_1 \;\; L_2)$ and $K = (K_1 \;\; K_2)$ partitioned accordingly, but the outputs now constitute a matrix,

$$V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix}.$$

In the use-make framework, columns of U list inputs of sectors, but rows of V list outputs of sectors. Consequently, the net output matrix is $V^T - U$. It is fairly straightforward to reproduce the productivity growth analysis in this general setting. Summing over sectors, the commodity net output vector now is

$$y = (V^T - U)e.$$

Pricing the net output columns and equating with factor costs, where L and K are factor employment row vectors by sector,

$$p(V^T - U) = (wL + rK)$$

These financial balances determine prices:

$$p = (wL + rK)(V^T - U)^{-1}.$$

With these modification of y and p in mind, TFP growth continues to be defined by expression (1) and to be pushed back to the sectoral levels according to expression (2), provided that the technical coefficients are defined by the commodity technology model,

$$A = UV^{-T}, \; \ell = LV^{-T}, \; k = KV^{-T}$$

and

$$x = V^T e.$$

As before, goods TFP growth is defined by expression (3) with y^1 representing the net output of goods and L* and K* defined by expression (4). Once more, we want to relate L* and K* directly to y^1 by the Leontief inverse of an augmented matrix of technical coefficients and by augmented labor and capital coefficients, respectively. The analysis is more complicated:

$$(11) \qquad L^* = \ell(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = LV^{-T}(I - UV^{-T})^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} =$$

$$= LV^{-T}[(V^T - U)V^{-T}]^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = L(V^T - U)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix}.$$

A useful fact is

<u>Fact 2</u>. $$(V^T - U)^{-1}\begin{bmatrix} I \\ 0 \end{bmatrix} = \begin{bmatrix} I \\ (V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T) \end{bmatrix}.$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1},$$

where the dimension of I is the number of goods sectors (the same as the dimension of U_{11}) and 0 has dimension # service sectors × # goods sectors (the same as the dimension of U_{21}). For a proof, see the appendix.

The expression for L* can thus be developed further:

$$L^* = L(V^T - U)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = L(V^T - U)^{-1}\begin{bmatrix} I \\ 0 \end{bmatrix} y^1 =$$

$$= (L^1 \ \ L^2)\begin{bmatrix} I \\ (V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T) \end{bmatrix}.$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1} y^1 =$$

$$= [L^1 + L^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)].$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1} y^1.$$

This expression shows the labor flows charged to the services, $L^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)$, and the net outputs, charged to the services, $-(U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(V_{21} - V_{12}^T)$. The implications for the technical coefficients are obtained by inserting $V_{11}^{-T}V_{11}^T$ between the factors on the right hand side of the last expression and bracketing. This yields

$$L^* = [L^1V_{11}^{-T} + L^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}].$$

$$[I - U_{11}V_{11}^{-T} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}]^{-1}\ y^1$$

$$= \ell^*(I - A^*)^{-1}\ y^1$$

with

$$\ell^* = L^1V_{11}^{-T} + L^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T} \tag{12}$$

and

$$A^* = U_{11}V_{11}^{-T} + (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}. \tag{13}$$

The first terms represent the technical coefficients of the goods sectors, ignoring the service sectors. The second terms account the labor and material requirements of total service requirements of the goods sectors. The charging through of capital requirements goes analogous.

The coefficients based expression for goods TFP growth is given by equations (5) and (6) with the coefficients given by expressions (13) and (12) (for labor, similar for capital), and

$$p^1 = (wL + rK)(V^T - U)^{-1}\begin{bmatrix} I \\ 0 \end{bmatrix} = (w\ell^* + rk^*)(I - A^*)^{-1}.$$

The last equality is established by the same derivation as of equation (11).

So, for each sector changes in technical coefficients consist of not only changes in own coefficients, $U_{11}V_{11}^{-T}$ for materials, $L^1V_{11}^{-T}$ for labor, and $K^1V_{11}^{-T}$ for capital, but also changes in charged through parts. (The latter are essentially net service input coefficients in the goods sectors, inflated by the Leontief inverse of the service sectors, and premultiplied by the material coefficients of the service sectors.) We formally obtain goods TFP growth expression (10) with

$$(8') \qquad \pi_1 = -[p^1 d(U_{11}V_{11}^{-T}) + wd(L^1V_{11}^{-T}) + rd(K^1V_{11}^{-T})]\hat{p}^{1^{-1}}$$

and

$$(9') \qquad \pi_2 = -\{p^1 d[(U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}]$$
$$+ wd[L^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}]$$
$$+ rd[K^2(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}]\}\hat{p}^{1^{-1}}$$

If secondary production is absent, the formulas of the previous section are recovered by substitution of $V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix} = \begin{bmatrix} \hat{x}^1 & 0 \\ 0 & \hat{x}^2 \end{bmatrix}$. For example,

$$A^* = U_{11}\hat{x}^1 + U_{12}(\hat{x}^2 - U_{22})^{-1}U_{21}\hat{x}^{1^{-1}} = A_{11} + U_{12}\hat{x}^{2^{-1}}(I - U_{22}\hat{x}^{2^{-1}})^{-1}A_{21}$$
$$= A_{11} + A_{12}(I - A_{22})^{-1}A_{21}.$$

With secondary production present, we have to go back to the flows, (U,V). The reason is that the leading terms, e.g. $U_{11}V_{11}^{-T}$ in case of A^*, are no longer equal to the corresponding part of the full matrix (or vector) of technical coefficients, e.g. $A_{11} = (I\ 0)UV^{-T}\begin{bmatrix} I \\ 0 \end{bmatrix}$.

The independence of the charged through terms in A^*, ℓ^*, and k^*, of the units of measurements of the services holds though. Take the charged through term of A^*,

$$(U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)V_{11}^{-T}.$$

Changing the service units of measurement as before, amounts to replacement of U_{21} by $\hat{s}U_{21}$, U_{22} by $\hat{s}U_{22}$, V_{12} by $V_{12}\hat{s}$ and V_{22} by $V_{22}\hat{s}$, rendering the term

$$(U_{12} - V_{21}^T)[(V_{22}\hat{s})^T - \hat{s}U_{22}]^{-1}[\hat{s}U_{21} - (V_{12}\hat{s})^T]V_{11}^{-T}$$

$$= (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}\hat{s}^{-1}\hat{s}(U_{21} - V_{12}^T)V_{11}^{-T},$$

that is, unaffected.

3. Productivity analysis of outsourcing

In this section we address the question to which extent the TFP performance of the goods sectors can be explained by the phenomenon of oursourcing of services. Recalling equations (3), (5) and (10), the goods TFP growth figure is defined and rewritten:

$$\rho^* = \frac{p^1 dy^1 - wdL^* - rdK^*}{p^1 y^1} = -(pdA + wd\ell + rdk)\mathring{x}/(p^1 y^1) =$$

$$= -(p^1 dA^* + wd\ell^* + rdk^*)x^*/(p^1 y^1) = (\pi_1 + \pi_2)\hat{p}^1 x^*/(p^1 y^1) = \rho_1 + \rho_2$$

with $\mathring{x} = (I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix}$ and x^* given by (6).

These two expressions of TFP growth (without or with the stars, based on $\mathring{x}$ and x^*, respectively) are the standard and consolidated ones, respectively. The standard expression has separate components for the service sectors and the consolidated one has augmented technical coefficients for the goods sectors only. The standard TFP growth components, which will be spelled out below, have the defect of being dependent on the choice of unit of measurement of the services in the presence of secondary products. The consolidated terms capture not only direct service cost reductions in the goods sectors, but also redistribute back indirect services TFP growth. More precisely, if we partition A, ℓ, k into goods and services blocks, then, noting that $\mathring{x}^1 = (I \;\; 0)\mathring{x} = (I \;\; 0)(I - A)^{-1}\begin{bmatrix} y^1 \\ 0 \end{bmatrix} = x^*$,

$$\rho^* = -[(p^1 \;\; p^2)d\begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} + wd(\ell^1 \;\; \ell^2) + rd(k^1 \;\; k^2)]\mathring{x}/(p^1 y^1)$$

$$= -(p^1 dA_{11} + p^2 dA_{21} + wd\ell^1 + rdk^1)x^*/(p^1 y^1)$$

$$- (p^1 dA_{12} + p^2 dA_{22} + wd\ell^2 + rdk^2)x^2/(p^1 y^1)$$

Define

$$(14) \quad \pi^1 = -(p^1 dA_{11} + wd\ell^1 + rdk^1)\hat{p}^{1^{-1}},$$

$$(15) \quad \pi^2 = -p^2 dA_{21}\hat{p}^{1^{-1}},$$

$$(16) \quad \pi^3 = -(p^1 dA_{12} + p^2 dA_{22} + wd\ell^2 + rdk^2)\hat{p}^{2^{-1}}.$$

Then the <u>standard</u> decomposition is

$$(17) \quad \rho^* = \rho^1 + \rho^2 + \rho^3 = (\pi^1 + \pi^2)\hat{p}^1 x^*/(p^1 y^1) + \pi^3 \hat{p}^2 \overset{\circ}{x}{}^2/(p^1 y^1)$$

where ρ^1, ρ^2 and ρ^3 are defined term by term. The first term represents the material input reductions, the second term the service input reductions, and the third term the total factor productivity growth realized within the service sectors. The first two terms, ρ^1 and ρ^2, are compilations of the TFP growth rates of the goods sectors, π^1 and π^2, but the third term, ρ^3, is a compilation of the same across the service sectors, π^3. TFP growth within the service sectors is imputed to the goods sectors by our methodology. More precisely, the terms of equation (7) represent the direct and indirect material cost savings and are compilations of our <u>consolidated</u> TFP growth rates across goods sectors in view of equation (10). Traditional π^1 and our π_1 are close, in fact equal where secondary production is absent. For the same reason, ρ^1 is approximately equal to ρ_1, and, as a result, the sum of ρ^2 and ρ^3 is approximately equal to ρ_2. Our services component of sectoral TFP growth, π^2, is different from the standard one, π_2, as the former picks up the TFP growth that takes place within the service sectors. If some sectoral component of standard TFP growth, $\pi^1 + \pi^2$, is great, but the corresponding component of our consolidated measure, $\pi_1 + \pi_2$, is little, it means that a negative portion of TFP growth within the service sectors has been imputed to the goods sector under consideration. The sector features high standard TFP growth, but there is low growth in the services that it employs. We call such a sector a "smart outsourcer". Goods sector i is a smart outsourcer if $(\pi_1 + \pi_2)_i < (\pi^1 + \pi^2)_i$. (See Figure 1.)

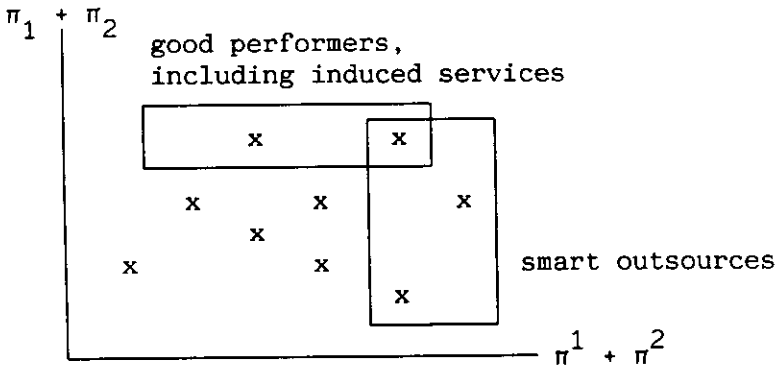

Figure 1

If the services are "sick" in that they feature negative TFP growth, $\rho_3 < 0$, then $\rho^1 + \rho^2 > \rho_1 + \rho_2$ and, since all terms are compilations of sectoral TFP growth rates, standard measures will typically exceed our consolidated ones which account for the service drag. Only if the traditional measure exceeds ours far above average, we may speak of a smart outsourcer. To be specific, premultiply ρ^* of equation (17) by $p^1y^1/(p^1x^*)$ to render it a weighted average of the sectoral TFP growth rates. Substituting equation (10) we obtain

$$(\pi_1 + \pi_2)\ \vartheta = (\pi^1 + \pi^2)\vartheta + \rho^3 p^1 y^1/(p^1 x^*)$$

where $\vartheta = \hat{p}^1 x^*/(p^1 x^*)$ is a vector of weigths. The difference between consolidated sectoral TFP growth, $\pi_1 + \pi_2$, and standard sectoral TFP growth, $\pi^1 + \pi^2$, is the <u>residual</u> that imputes service TFP growth to the goods industries. The weighted average of the residual amounts $\rho^3 p^1 y^1/(p^1 x^*)$ where ρ^3 is service TFP growth. A goods industry with a low residual component is imputed much service TFP drag. In other words, such an industry stands out relatively well before the imputation is undertaken, in terms of standard TFP growth. A low residual component signals a "smart outsourcer." For negative values of service TFP growth, ρ^3, we classify sector i as <u>smart outsourcer</u> if the i-th component of the residual is less than ten times the average, $10\rho^3 p^1 y^1/(p^1 x^*)$.

It is of interest to determine the correlation between the residual and the standard TFP growth measures. If the correlation is negative, then high standard TFP growers are smart outsourcers. The strong performance of goods sectors could thus be ascribed to some extent to the sloughing off of sluggish services. The phenomenon of outsourcing of services would thus be identified as a source of standard TFP growth. On the other hand, if the correlation were positive, TFP growth in the relatively well performing goods industries would be accompanied by TFP growth in the supporting services and hence be robust with respect to consolidation. In short, negativity of the correlation between the residual and standard TFP growth measures identifies outsourcing of services as a standard productivity booster.

Variations of the service residual across sectors may spot TFP spurs in segments of the economy due to outsourcing, but are a wash in the aggregate. 'Smart outsourcers' are defined in relative terms and accompanied by 'dumb outsources', sectors of which the outsourced services enjoy relatively high productivity gains. The service residual adds to TFP growth within the services, ρ^3. In a dynamic rather than cross-sectional setting it is possible, however, to assess the overall effect of technical change in the services. Fluctuations in the use of services as well as in the technology of services may stabilize or destabilize TFP. TFP has been decomposed into a goods term and a services term. If the latter is relatively volatile, service changes amplify TFP fluctuations and vice versa. To examine this question, we must determine the coefficients of variation of the material TFP growth and the consolidated TFP growth rates, ρ_1 and ρ^*, respectively.

4. Data Sources and Methods

Our basic data source consists of U.S. input-output dollar flow tables, which were originally obtained from the Bureau of Economic Analysis on the 87-sector level for years 1947, 1958, 1963 and 1967 in single-table format, and on the 85-sector level for years 1967, 1972, 1977, and 1982 in the dual use-make table format. The single-table format relies on the so-called BEA transfer method. In this method, the transaction matrix is constructed on an industry by industry basis. A secondary product produced by industry i which is primary to industry j is recorded as a purchase made by industry j from industry i. The actual sales of the secondary product produced in i are then "transferred" to the sales row of industry j.[2]

The 1967, 1972, 1977, and 1982 data are available in separate make and use tables.[3] The 1972, 1977, and 1982 tables use the same accounting conventions. However, there are four important changes between the 1967 tables and those of the later years. First, two dummy sectors, business travel and entertainment and office supplies, are present in the 1967 table but were eliminated in the 1972, 1977, and 1982 tables. We follow the later convention and distribute the output of the two dummy sectors to the appropriate using industries. Second, in the 1972, 1977, and 1982 tables, the restaurant sector was separated from the trade sector, while in the 1967 table the two are aggregated into a single sector. It was not possible to separate the restaurant sector from the trade sector in the 1967 data. As a result, we have aggregated the two sectors in the 1972, 1977, and 1982 data for consistency with the earlier year.[4]

Third, in the 1967 table, a portion of the wholesale and retail trade activity and real estate (rental) activity engaged in by the various sectors were recorded as a secondary product of these sectors, whereas in the later years these transactions were recorded as primary to the trade and real estate sectors, respectively. For consistency with the later years, we transferred these secondary outputs to their primary sector.[5] Fourth, in the 1967 table, comparable imports are recorded as if purchased by the industry producing the comparable domestic commodity and then added to that industry's output for distribution to the actual purchasing industries. In the later tables, comparable imports are recorded as directly purchased by the using industry from the comparable domestic industry. We follow the later convention in our work.

Labor coefficients for 1947, 1958, and 1963 were obtained from Peter Petri of the Brandeis Economic Research Center; those for 1967 and 1972 were calculated from U.S. Bureau of Labor Statistics (1979); and those for 1977 were directly available in Yuskavage (1985). Sectoral employment for 1982 was estimated by first calculating the growth rates of employment by input-output industry on the basis of the Bureau of Labor Statistics' Historical Output and Employment Data Series (obtained on computer diskette) and then applying these growth rates to the 1977 input-output sectoral employment totals to update to 1982.[6]

Capital stock by input-output industry for 1967-77 was calculated directly from the net stocks of plant and equipment by input-output industry provided on computer tape by the U.S. Bureau of Industry Economics (the BIE Capital Stocks Data Base as of January 31, 1983). These series ran through 1981 for manufacturing industries and through 1980 for the other sectors. They were updated to 1982 on the basis of the growth rate of constant dollar net stock of fixed capital between 1980 (or 1981) and 1982 calculated from the National Income and Product Accounts (NIPA).[7]

Sectoral price indices for years 1947, 1958, 1963, and 1967 were provided by Brandeis Economic Research Center and those for 1972 and 1977 from the Bureau of Economic Analysis worksheets. Deflators for 1982 were calculated from the Bureau of Labor Statistics' Historical Output Data Series (obtained on computer diskette) on the basis of the current and constant dollar series.[8]

Five sectors -- research and development (74), business travel (81), and office supplies (82), scrap and used goods (83), and inventory valuation adjustment (87) -- appeared in some years but not in others (the earlier years for the first three sectors and the later years for the last two sectors). In order to make the accounting framework consistent over the seven years of analysis, we eliminated these sectors from both gross and final output. This was accomplished by distributing the inputs used by these sectors proportional to either the endogenous sectors which purchased the output of these five sectors or to final output.[9]

One additional refinement, suggested by Leontief (1941), was made. Instead of treating noncompetitive imports as exogenous, an endogenous column of exports was incorporated in the input-output matrix to balance the row of noncompetitive imports. In this way, imports can also be thought of as being "produced" domestically by the exports required to sell in exchange for them. The final output vector was adjusted for this. (See Wolff, 1985, and ten Raa and Wolff, 1991, for more details.)

All matrices were deflated to 1972 dollars using the sectoral price deflators. Productivity growth rates for 1947-58, 1958-63, and 1963-67 are calculated using the single-table basic framework (and making use of the 1967 single table data). Productivity growth rates for 1967-72, 1972-77, and 1977-82 are calculated using the use-make framework (and relying on the 1967 dual table data). Productivity growth rates for the whole 1947-82 period are then calculated as the logarithmic sum of the productivity growth rates of the individual sub-periods.

We divided the 85 industries into two groups, goods and services. The goods industries include: agriculture (1-4)[10], mining (5-10), construction (11-12), manufacturing (13-64), transportation (65), communications (66-67), and utilities (68).[11] Services include: trade (69), finance, insurance, and real estate (70-71), government services (78, 79, and 82), and all other services (72-77 and 84).

5. Results

We begin with aggregate results on total factor productivity (TFP) growth, as shown in Table 2. Average annual TFP growth for the whole economy, ρ (top line), was 1.0 percent over the 1947-58 period, increased to 1.6 percent in the 1958-63 period, fell somewhat to 1.3 percent in 1963-67, thence to

0.6 in 1967-72, 0.4 in 1972-77, and once again to -0.2 in 1977-82.[12] Over the whole 35-year period, from 1947 to 1982, TFP growth averaged 0.8 percent per year.

Standard TFP growth ρ (line 1) among all goods industries, computed as a weighted sum of the terms in TFP formula (2) representing goods industries i, was generally higher than TFP growth for the whole economy. Over the 1947-82 period, TFP growth for goods industries averaged 1.1 percent per year, compared to 0.8 percent per year for the overall ρ. This is not unexpected since (measured) productivity growth in services has been lower than in goods industries. However, what is particularly interesting is that during the 1977-82 period, TFP growth in the goods sector was lower than overall TFP growth.

TFP growth for the consolidated goods industries, ρ^* (line 2), was also generally higher than overall TFP growth ρ. Over the 1947-82 period, ρ^* averaged 1.1 percent per year, compared to 0.8 percent per year for ρ. This relation is to be expected since the slow growing TFP of the service sectors is only partially captured in ρ^*. Interestingly, ρ^* for the consolidated goods industries over the 1947-82 period is almost identical to TFP growth ρ for the goods sector -- 1.08 compared to 1.05 percent per year. On the surface, this result seems to imply that consolidation has no effect on measured TFP growth within the goods-producing sector. Yet, the measures differ among the six sub-periods, with ρ^* higher than ρ in the first four of these and lower in 1972-77 and 1977-82.

Moreover, during the first three periods, 1947-58, 1958-63, and 1963-67, ρ^* for the goods sector was greater than ρ for the total economy, while during the last three periods, the opposite was the case. Indeed, the difference between ρ for the whole economy and ρ^* for the goods sector widened between 1967-72 and 1972-77 and again between 1972-77 and 1977-82. In the 1977-82 period, ρ^* was considerably lower than ρ, -1.2 in comparison to -0.2 percentage points. These results already suggest that outsourcing of services was accelerating over time, particularly since 1967.

A breakdown is shown of ρ^* into ρ_1, TFP growth in goods industries attributable to a reduction in direct materials, labor, and capital inputs; and into ρ_2, TFP growth in goods industries attributable to a reduction in **indirect** materials, labor, and capital inputs as embodied in the service inputs into goods industries. Over the full 1947-82 period, ρ_1 (line 3) averaged 1.3 percent per year, while ρ_2 (line 4) averaged -0.2 percent per year. Consequently, ρ_1 was 0.2 percentage points higher than ρ^* over these years. In other words, while (direct) materials, labor, and capital inputs per unit of output in goods-producing industries fell over time, their indirect materials, labor, and capital inputs (as embodied in their service inputs) per unit of output actually increased over time, thus creating a drag on productivity growth within the goods industries. Goods industries were much more successful in reducing their direct material, labor, and capital inputs than in decreasing their indirect inputs from the service sectors.

Interestingly, this relation showed considerable variability over time. During the 1947-58, 1958-63, 1963-67, and 1967-72 periods, the productivity drag from indirect inputs from services was rather insignificant. However, the productivity drag increased during the 1972-77 period to -0.4 percentage points and again to -1.1 percentage points over the 1977-82 period. Over the 1977-82 period, in particular, there was a very significant drag on productivity growth from increasing indirect inputs from services in the consolidated goods industries. In fact, the large negative value of ρ^* was almost entirely due to increasing indirect inputs embodied in direct service inputs, a phenomenon suggesting considerable outsourcing of service functions.

In Section 3, we indicated that ρ^1 was approximately equal to ρ_1, except for the presence of secondary products, and that, as a result, ρ^2 and ρ^3 summed approximately to ρ_2. This is confimed by Table 2. A further breakdown of ρ_2 into ρ^2, productivity growth in the consolidated goods industries emanating from a reduction in direct service inputs, and ρ^3, productivity growth in the consolidated goods industries emanating from productivity growth in the service industries which supply the goods industries, is again revealing. Over the 1972-77 period, of the -0.35 percentage points attributable to ρ_2, -0.07 percentage points is ascribable to ρ^2 (line 6) and -0.28 percentage points to ρ^3 (line 7). Thus, over this period, the main culprit in explaining the drag on TFP growth in the consolidated goods sector was the slow (actually negative) TFP growth of the service industries supplying the goods industries. Over the 1977-82 period, of the -1.06 percentage points attributable to ρ_2, -0.58 percentage points is ascribable to ρ^2 and -0.48 percentage points to ρ^3. Over these years, the major effect was the increasing direct service inputs into the goods industries.

As discussed in Section 3 above, a more direct indication of the productivity gains from the outsourcing of services is given by the correlation between standard sectoral TFP growth $(\pi^1+\pi^2)$ and residual $(\pi_1+\pi_2-\pi^1-\pi^2)$ that imputes intra-service TFP growth to the goods industries. This is approximately the same as the correlation between standard TFP π and the difference between π^* and π. A negative correlation means that goods sectors which have rapid rates of standard TFP growth have, on average, been successful in outsourcing service sectors with productivity growth low relative to goods sector productivity growth. The correlation coefficients, shown in line 9, indicate that this is, in fact, what has happened. For the full 1947-82 period, the correlation coefficient is -0.36. Moreover, the correlation is negative for every sub-period except 1967-72. We have thus identified outsourcing as a factor of TFP growth in the goods industries. Interestingly, the phenomenon is strongest (most negative) for the 1947-58 period -- a correlation of -0.73 -- and second strongest for the 1972-77 period, at -0.45. For the 1977-82 period, the correlation has petered out, reaching a level of -0.03.

Results are somewhat more dramatic for the manufacturing sector of the goods industries (Panel B of Table 2). Standard TFP growth (line 1') among all manufacturing industries, computed as a weighted sum of the terms in TFP formula (2) representing manufacturing industries i, averaged 1.2 percent per year between 1947 and 1982, compared to 0.8 percent per year for the total economy and 1.1 percent per year for the goods sector. However, during the 1967-72, 1972-77, and particularly the 1977-82 period, standard TFP growth in manufacturing was lower than overall TFP growth.

TFP growth for consolidated manufacturing, ρ^* (line 2'), was also higher than overall TFP growth ρ over the full 1947-82 period. This relation held for the 1947-58, 1958-63, 1963-67, and 1972-77 periods but not for the other two periods. The difference between ρ for the whole economy and ρ^* for the manufacturing sector was particularly high in the 1977-82 period -- -0.2 in comparison to -1.3 percentage points. This difference was greater than that between the overall economy and the goods sector, suggesting that outsourcing of services was greater in manufacturing than other goods industries during the 1977-82 period.

The differences between ρ^* and ρ_1 are generally greater for the consolidated manufacturing sector than the total goods industries. Over the entire 1947-82 period, ρ^* averaged 1.1 percent per year and ρ_1 1.5 percent per year, suggesting a pronounced productivity drag from service inputs. The productivity drag was also negative in each of the sub-periods, except for 1958-63. The effects were particularly pronounced in the 1977-82 period, when the value of ρ_2 was -1.2 percentage points. Despite a value of ρ_1 of -0.1 percentage points in this period, TFP growth in the consolidated manufacturing industry, ρ^*, was -1.3 percentage points. From lines 6' and 7', it is clear that the main source of the productivity drag was the rising use of direct service inputs by the manufacturing sector (ρ^2), which accounted for -0.9

percentage points, while the slow productivity growth within the service industries (ρ^3) accounted for -0.3 percentage points.

The correlation coefficient between $(\pi^1+\pi^2)$ and $(\pi_1+\pi_2-\pi^1-\pi^2)$, shown in line 10', is negative for the whole period, at -0.37, slightly stronger than the coefficient for the entire goods sector. For manufacturing, the correlation is negative for every sub-period except 1977-82, for which it is 0.03. It is again strongest (most negative) for the 1947-58 period, at -0.74, and second strongest for the 1972-77 period, at -0.33. Thus, with the exception of the 1977-82 period, manufacturing industries have been successful at externalizing the slow productivity growth service activities. Outsourcing was a contributor to manufacturing TFP growth.

A study by Siegel and Griliches (1991) also looked at the relation between manufacturing productivity growth in 1973-79 and 1979-86 and the outsourcing of services, measured as the average ratio of purchased services within manufacturing to manufacturing output in 1977 and 1982. They found very weak correlations between the latter measure and manufacturing productivity growth in each of the two periods as well as the change in productivity growth between these two periods across 392 manufacturing industries. This seems to correspond to our results as well for the 1977-82 period. Our results are a bit stronger, as they capture the intra-services productivity drag.

In Table 3, we attempt to identify the goods industries which have been most successful in externalizing the low productivity growth service industries. As discussed in Section 3 above, this is based on a comparison of $(\pi_1+\pi_2)$ and $(\pi^1+\pi^2)$, or, approximately, π^* and π. If the difference for an industry exceeds $10\rho^3(p_1y_1)/(p_1x^*)$, we call the industry a "smart outsourcer" in the sense that it has managed to externalize service activities that have relatively slow productivity growth.

The results shown in Table 3 are for the full 1947-82 period. The term $10\rho^3(p_1y_1)/(p_1x^*)$ is equal to -0.10 percentage points, or about zero, so that we also show the difference between $(\pi_1+\pi_2)$ and $(\pi^1+\pi^2)$ in the last column. It is of interest that the differences are generally quite small. 'Smart' outsources are ordnance (with a difference of -0.76 percentage points), metal containers (-0.13), and office machines (-0.14). Over the full period, outsourcing has had relatively little effect on measured industry TFP growth in the goods sector. This is due to the modest value of ρ_3 (Table 3, line 7); the effect of outsourcing can be dated in the last period, 1977-82.

One last point of interest concerns the stability in TFP growth over time. As noted in Section 3 above, fluctuations in the use as well as the technology of services may stabilize or destabilize TFP growth among goods producers over time. One way of assessing this factor is to compare the variation over time in ρ^* and ρ_1. The coefficient of variation (the ratio of the standard deviation to the unweighted mean), computed over the six time periods, for all goods industries is 1.3 for ρ^* and 0.8 for ρ_1, and for manufacturing industries only, 1.3 and 0.7 respectively. Thus the reduction over time in the use of direct intermediate inputs from goods industries, direct labor inputs, and direct capital inputs by goods industries has been much more stable than that of indirect goods, labor, and capital inputs embodied in direct service inputs in these industries. As a result, the outsourcing of service inputs has not tended to stabilize TFP growth within the goods industries.

6. Concluding Remarks

Services are hard to analyze. There is no clear cut measure of output, let alone productivity. We have circumvented this problem by relating the inputs into the services to the outputs of the consuming goods industries. In this way we cannot account for the services consumed by the households, but we are able to measure service total factor productivity (TFP) growth as it pertains to business. All of that service TFP growth has been incorporated in the goods industries TFP growth rates. Thus consolidated TFP growth amounts $\rho^* = \rho_1 + \rho_2 = 1.3 - 0.2 = 1.1$ percent a year over the period 1947-82 where the first term is realized directly in the goods sectors and the second term accounts for the service TFP growth component. The U.S. economy therefore suffered from a mild Baumol (1967) disease. Two thirds of the service drag can be ascribed to an increase of service inputs, that is outsourcing, and one third to the negative productive growth within the service sectors.

However, the results are modest because productivity fluctuations cancel out over time. Recently, the Baumol disease has been acute. Over the period 1972-77, $\rho^* = \rho_1 + \rho_2 = 0.7 - 0.4 = 0.3$ and, more dramatically, over the period 1977-82, $\rho^* = \rho_1 + \rho_2 = -0.1 - 1.1 = -1.2$. Moreover, the diagnosis of the service drag components is different. In the first of these two periods, the main problem is the within services productivity slowdown, while in the last period outsourcing caused most of the service drag in the goods industries. The results are even more dramatic for the manufacturing sector.

Since outsourcing implies a greater reliance on inputs, it has a negative macro effect on TFP. However, the micro effects may vary. Some goods sectors may slough off services with low productivity growth and hence look 'smart' in terms of standard TFP measures. This source of sectoral TFP growth is indeed revealed by a negative correlation between the service residuals imputed to the goods industries and their own standard TFP growth rates. This means that goods sectors which have rapid rates of standard TFP growth have, on average, been successful in outsourcing service sectors with relatively low productivity growth. However, this sorting out of goods industries took place primarily in the beginning, during the 1947-58 period. The phenomenon of looking 'smart' by outsourcing sluggish services persisted throughout the whole time span, but has petered out. This result holds equally for the manufacturing subsector. 'Smart' outsources were ordnance, metal containers and office machines.

Unfortunately, we cannot say much about the productivity recovery in manufacturing during the 1980s, since our data series ends in 1982, which is also a recession year. However, our guess is that while standard productivity growth in manufacturing was likely to be high over this period, this was partly a reflection of continued outsourcing of services, as well as a negative productivity development within the services. Both effects would result in a lower consolidated measure of TFP growth and signal a continued suffering of manufacturing from the services disease.

Footnotes

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1. Actually, in the modern literature this idea can be traced back to Stigler (1951), who defined "externalization" or "unbundling" as referring to the portion of intermediate demand for services which is supplied by service firms, rather than in the production unit itself.
2. See, for example, U.S. Industry Economics Division (1974), for a discussion of methodology and for a listing for the sectors. This method creates artificial transactions. A formula for the transfer based input-output coefficients is given by Kop Jansen and ten Raa (1990) who also show that the method distorts the material and financial balance equations of input-output analysis. As a result, the method can distort the measurement of productivity growth in both industries i and j. Moreover, it can also affect the measurement of linkages between sectors.
3. A description of the 1972 tables can be found in Ritz (1979) and Ritz, Roberts, and Young (1979), of the 1977 tables in U.S. Interindustry Economics Division (1984), and of the 1982 tables in U.S. Bureau of Economic Analysis (1991). The 1967 data were not publisehd as separate make and use tables, but the raw data for them are available on computer tape, which Paula Young of BEA graciously supplied to us.
4. We refer to the aggregated sector as the trade sector.
5. To balance the flow tables, we adjusted the value added of the trade sector so that its total inputs equalled its new output total and adjusted both the value added of the real estate sector and the real estate input row so that the value of total output and inputs of the real estate sector matched.
6. Data on hours worked by sector, though the preferable measure of labor input to employment, are not available by sector and year and therefore could not be incorporated.
7. The source is Musgrave (1986), pp. 58-59. Since there are fewer industries in the NIPA breakdown than in the input-output data, we applied the same percentage growth rate across all input-output industries falling within a given NIPA classification. It should be noted

that this is the pre-1991 revision series. We used this series instead of the latest revised series in order to have greater consistency with the earlier input-output capital stock data. Data on government-owned capital stock for all years were obtained from Musgrave (1986), Table 7, p. 71.

8. In addition, the deflator for transferred imports was calculated from the NIPA import deflator, that for the Rest of the World industry was calculated as the average of the NIPA imports and export deflator, and the deflator for the inventory valuation adjustment was computed from the NIPA change in business inventory deflator. The source is Council of Economic Advisers (1992), Tables B-1, B-2, and B-3.

9. The allocation of the scrap sector was handled differently in the make-use framework of the 1967, 1972, 1977, and 1982. See ten Raa and Wolff (1991) for details.

10. Sector numbers refer to the standard BEA 85-sector classification scheme. See, for example, U.S. Interindustry Economics Division (1984) for details.

11. Although transportation, communications, and utilities are traditionally classified as services, their output is more easily measureable than that of other services and their productivity performance over time more closely mirrors that of the other goods industries rather than the other services. See Baumol, Blackman, and Wolff (1989), Chapter 6, for further discussion.

12. As noted above, 1982 was a deep recession year in the U.S., which accounts, in part, for the negative rate of TFP growth between 1977 and 1982.

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Table 1. Average Annual Rates of Labor Productivity Growth By Major Sector in the U.S., 1973-88[a]

	(percent) 1973-79	1979-88
Agriculture, forestry, fisheries	-0.29	1.40
Mining	-5.64	1.94
Construction	-1.99	-0.57
Manuf., Durable goods	1.02	4.55
Manuf., Nondurable goods	2.09	2.77
Transportation	-0.49	1.04
Communication	4.44	4.73
Electric, gas, sanitary services	2.31	2.21
Wholesale trade	-1.63	3.03
Retail trade	-1.06	0.75
Finance, insurance, real estate	0.11	-0.55
Services	0.08	-0.37
Government, govt. enterprises	0.13	0.19
Total Goods[b]	0.69	2.66
Total Services[c]	-0.11	0.37
Total Economy (GDP)	0.15	1.05

a. Source: Bureau of Economic Analysis, National Income and Product Accounts, computer database. Labor productivity is defined as the ratio of contribution to GDP (1972 dollars) to Full-Time Equivalent Employees (FTEE).

b. The goods sector includes: agriculture, forestry, and fisheries; mining; construction; manufacturing; and transportation, communications, and utilities.

c. The service sector includes: wholesale and retail trade; finance, insurance, and real estate; (general) services; and government and government enterprises.

Table 2. Aggregate Rates of TFP Growth by Component and Sub-Period, 1947-82

(Average annual growth in percentage points)

	1947-1958	1958-1963	1963-1967	1967-1972	1972-1977	1977-1982	1947-1982
All Sectors							
ρ	1.03	1.56	1.27	0.58	0.37	-0.21	0.80
A. Goods Sectors							
1. ρ [a]	1.42	2.71	1.80	0.37	0.49	-0.76	1.05
2. ρ^*	1.58	2.89	2.10	0.40	0.29	-1.18	1.08
3. ρ_1	1.65	2.62	2.14	0.32	0.64	-0.12	1.26
4. ρ_2	-0.08	0.27	-0.03	0.08	-0.35	-1.06	-0.18
5. ρ^1	1.65	2.62	2.14	0.32	0.64	-0.12	1.26
6. ρ^2	-0.14	0.23	-0.21	0.05	-0.07	-0.58	-0.12
7. ρ^3	0.07	0.04	0.18	0.02	-0.28	-0.48	-0.06
8. $\rho^1+\rho^2$	1.51	2.84	1.92	0.37	0.57	-0.70	
9. Correlation[b] $[(\pi^1+\pi^2),(\pi_1+\pi_2-\pi^1-\pi^2)]$	-0.730	-0.237	-0.112	0.141	-0.446	-0.031	-0.359
B. Manufacturing Sector							
1'. ρ [c]	1.74	2.82	2.06	0.50	0.32	-0.84	1.18
2'. ρ^*	1.61	2.92	2.14	0.46	0.54	-1.26	1.13
3'. ρ_1	2.00	2.65	2.34	0.80	0.64	-0.11	1.46
4'. ρ_2	-0.38	0.27	-0.20	-0.34	-0.09	-1.15	-0.33
5'. ρ^1	2.00	2.65	2.34	0.82	0.63	-0.08	1.47
6'. ρ^2	-0.25	0.35	-0.19	-0.38	-0.27	-0.87	-0.26
7'. ρ^3	-0.14	-0.09	-0.01	0.02	0.18	-0.32	-0.07
8'. $\rho^1+\rho^2$	1.75	3.00	2.15	0.44	0.36	-0.95	
9'. Correlation[d] $[(\pi^1+\pi^2),(\pi_1+\pi_2-\pi^1-\pi^2)]$	-0.743	-0.219	-0.322	-0.103	-0.334	0.033	-0.373

Notes to Table 2

a. ρ is computed as a weighted sum of the terms in TFP formula (2) representing goods industries i.
b. Correlation across 56 goods-producing industries. This is a pure number.
c. ρ is computed as a weighted sum of π_i for manufacturing industries i.
d. Correlation across 52 manufacturing industries. This is a pure number.

Table 3. Standard, Consolidated and Residual TFP Growth by Goods-Producing Industry, 1947-82.

(Average annual growth in percentage points)

	$\pi^1+\pi^2$	$\pi_1+\pi_2$	$(\pi_1+\pi_2) - (\pi^1+\pi^2)$
1 Agriculture	1.24	1.25	0.01
2 Mining	-1.39	-1.44	-0.05
3 Construction	-0.17	-0.15	0.02
4 Ordnance & Accessories	0.54	-0.22	-0.76
5 Food & Kindred Products	0.71	0.71	-0.00
6 Tobacco Manufactures	0.58	0.67	0.08
7 Fabrics, Yarn & Thread	0.96	0.94	-0.03
8 Miscel. Textile Goods	1.47	1.50	0.03
9 Apparel	1.11	1.13	0.02
10 Fabricated Textiles	1.53	1.71	0.17
11 Lumber & Wood Products	0.00	-0.03	-0.03
12 Wooden Containers	-0.67	-0.61	0.05
13 Household Furniture	0.57	0.53	-0.04
14 Other Furniture	0.41	0.38	-0.03
15 Paper & Allied Products	0.23	0.22	-0.01
16 Paperboard Containers	0.47	0.62	0.15
17 Printing & Publishing	0.34	0.26	-0.08
18 Chemical Products	0.11	0.07	-0.03
19 Plastics & Synthetics	2.06	2.29	0.23
20 Drugs & Cleaners	2.88	2.90	0.02
21 Paints & Allied Products	0.57	0.62	0.04
22 Refined Petroleum	0.51	0.49	-0.02
23 Rubber & Allied Products	0.58	0.58	-0.00
24 Leather Products	0.20	0.20	-0.00
25 Footwear	0.28	0.23	-0.05
26 Glass Products	-0.69	-0.70	-0.00
27 Stone & Clay Products	-0.28	-0.32	-0.04
28 Primary Iron & Steel	-0.47	-0.50	-0.03
29 Primary Nonferrous Metal	-0.03	-0.04	-0.00
30 Metal Containers	0.36	0.23	-0.13
31 Structural Metal Product	0.33	0.33	0.00
32 Screws, Bolts & Nuts	-0.46	-0.43	0.03
33 Other Fabricated Metal	-0.01	-0.03	-0.02
34 Engines & Turbines	-0.16	-0.15	0.02
35 Farm Machinery	0.34	0.31	-0.03
36 Construction, Etc. Mach.	-0.34	-0.36	-0.03
37 Materials Handling Equip.	0.49	0.47	-0.02
38 Metalworking Machinery	-0.92	-0.93	-0.01
39 Special Industrial Equip.	-1.06	-1.06	-0.00
40 General Industrial Equip.	-0.26	-0.29	-0.03
41 Machine Shop Products	-0.29	-0.34	-0.04
42 Office Machines	2.43	2.29	-0.14
43 Service Industry Machine	1.93	2.01	0.08
44 Electrical Ind. Equip.	0.23	0.21	-0.02
45 Household Appliances	2.63	2.60	-0.03
46 Electric Lighting Equip.	-0.46	-0.42	0.03
47 Radio & TV Equip.	2.30	2.35	0.05
48 Electronic Components	2.54	2.61	0.06
49 Miscel. Electrical Equip.	-0.66	-0.66	0.00

50 Motor Vehicles	0.23	0.26	0.02
51 Aircraft & Parts	0.46	0.39	-0.07
52 Other Transport Equip.	0.40	0.41	0.01
53 Professional Instruments	-0.01	0.07	0.08
54 Optical Equip.	2.11	2.10	-0.01
55 Miscel. Manufacturing	0.51	0.51	-0.00
56 Utilities	0.61	0.63	0.02
$10\rho^3(p_1y_1)/(p_1x^*)$			-0.10

Appendix

Proof of fact 1. It suffices to show that

$$(I - A)\begin{bmatrix} I \\ (I - A_{22})^{-1}A_{21} \end{bmatrix}(I - A^*)^{-1} = \begin{bmatrix} I \\ 0 \end{bmatrix}$$

Now the left hand side is

$$\begin{bmatrix} I - A_{11} & -A_{12} \\ -A_{21} & I - A_{22} \end{bmatrix}\begin{bmatrix} I \\ (I - A_{22})^{-1}A_{21} \end{bmatrix}(I - A^*)^{-1}$$

$$= \begin{bmatrix} I - A_{11} - A_{12}(I - A_{22})^{-1}A_{21} \\ - A_{21} + (I - A_{22})(I - A_{22})^{-1}A_{21} \end{bmatrix}(I - A^*)^{-1}$$

$$= \begin{bmatrix} I - A^* \\ 0 \end{bmatrix}(I - A^*)^{-1}$$

which is the right hand side indeed. Q.E.D.

Proof of fact 2. It suffices to show that

$$(V^T - U)\begin{bmatrix} I \\ (V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T) \end{bmatrix}\cdot$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1} = \begin{bmatrix} I \\ 0 \end{bmatrix}.$$

Now the left hand side is

$$\begin{bmatrix} V_{11}^T - U_{11} & V_{21}^T - U_{12} \\ V_{12}^T - U_{21} & V_{22}^T - U_{22} \end{bmatrix}\begin{bmatrix} I \\ (V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T) \end{bmatrix}\cdot$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1}$$

$$= \begin{bmatrix} V_{11}^T - U_{11} + (V_{21}^T - U_{12})(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T) \\ 0 \end{bmatrix}.$$

$$[V_{11}^T - U_{11} - (U_{12} - V_{21}^T)(V_{22}^T - U_{22})^{-1}(U_{21} - V_{12}^T)]^{-1},$$

which is the right hand side indeed. Q.E.D.