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**Technological change and  
outsourcing : competing or  
complementary explanations  
for the rising demand for skills  
during the 1980s?**

**Quaderno N. 06-09**

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by

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Last revision: 18.12.2006

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\*This paper represents a shortened and revised version of a Chapter of my Ph.D. Dissertation at the University of Konstanz entitled "Trends in Wage Inequality: The Role of Trade, Technical Change and Labor Market Institutions".

# Technological Change and Outsourcing: Competing or Complementary Explanations for the Rising Demand for Skills during the 1980s?

## Abstract

This paper combines two of the popular approaches used in the trade versus technology debate: the factor content approach and the cost-share regression across manufacturing industries. The resulting method allows to decompose skill upgrading at the industry level into a component attributed to outsourcing and a residual. Surprisingly, computer investment explains the component attributed to outsourcing better than the residual suggesting that technological change may have contributed to higher disintegration of production already during the 1980s.

# 1 Introduction

The early literature analyzing the sharp inequality increases since the 1980s proposed skill-biased technical change and international trade as the two major demand-side explanations. Although already Bound and Johnson (1992) noted that these explanations are not necessarily mutually exclusive, much of the research on the causes of inequality, including Bound and Johnson (1992), considered trade and technical change as two competing hypotheses. This opposition, while undoubtedly leading to a number of insightful methods, has posed also some dangers. First, it implies a single winner, resulting today in a generally limited role attributed to international trade. Second, the focus on trade versus technology deviated for a long time the attention from the potential interaction and complementarity between these two phenomena.

This paper extends one of the popular approaches used to estimate the contribution of trade and technical change to the rising relative demand for skilled labor: the cost-share regression applied on a sample of manufacturing industries (Berman, Bound And Griliches, 1994, Feenstra and Hanson, 1996, Autor, Katz and Krueger, 1998, Machin and Van Reenen, 1998, Feenstra and Hanson 1999). I develop a new measure of outsourcing based on the factor content approach (see Davis and Weinstein, 2003, for a general overview). This measure turns out to be a very good predictor of skill-upgrading at the industry level, supporting the view that outsourcing played an important role in increasing the relative demand

for skilled labor.

Rather than interpreting these results as evidence against the role of technological change I argue that the two phenomena, outsourcing and technological change, are strongly complementary. A similar argument has been put forward recently in a somewhat different context. Magnani (2006) and Bartel, Lach and Sicherman (2006) find that during the 1990s indicators of technological change are positively correlated with outsourcing of labor services to external US-establishments. Their analysis suggests that technological change has facilitated outsourcing during the 1990s.

The use of the new measure of outsourcing proposed here allows to uncover evidence that technological change may have facilitated outsourcing already during the 1980s. Initial support for this hypothesis comes from the high correlation between our measure of outsourcing and computer investment. As a more direct test, I decompose the actual change in the non-production wage bill share into a component attributed to outsourcing and a residual attributed to all other factors, including technological change. Surprisingly, computer investment appears to explain the first component better than the residual. This finding is in line with those of Magnani (2006) and Bartel, Lach and Sicherman (2006). Note, however, that while they find that technological change has facilitated outsourcing of services within the US during the 1990s, the present analysis suggests that technological change has facilitated outsourcing of intermediate goods from outside the US during the 1980s. The channels through which computerization may have

enhanced the disintegration of production during the 1980s are worth further research. One hypothesis is that computer technology has enhanced the technical compatibility of parts produced in different locations. (Consider for example two lines producing parts that have to fit together. One possibility to ensure good fitting is to produce both parts under the same roof. In the absence of an alternative this would imply that the two production lines, probably a skill-intensive and an unskill-intensive one, are spatially non-separable. An alternative solution may be provided by computer technology ensuring high precision and flexibility with respect to the technical parameters of the produced parts.) Another hypothesis is that computer technology has enhanced the management and coordination of productive activities performed in different locations (consider for example the use of computers and specialized software by a multinational company to manage its transborder logistic operations).

The present paper provides also an interesting input to the literature on the factor content approach. A unique feature of the present analysis is that it allows to check the assumptions used to calculate the factor content of imports. By contrast, traditional applications of the factor content approach state these as maintained assumptions of the underlying general equilibrium framework. The results from the cost-share regression provide support for our method to calculate the factor content of intermediate imports. The results support also the recent argument of Reimer (2006) that intermediate goods account for the bulk of factor service trade and that it is important to impute their factor content using the

input coefficients in the country of origin.

Finally, by emphasizing the importance of outsourcing and its interdependence with technical change our results point to some unexploited research avenues for explaining the complex dynamics of wage inequality over the last decades. A number of recent studies have addressed the issue focussing on the skill-biased-technical-change explanation (Card and DiNardo, 2002, Beaudry and Green, 2005, Lemieux, 2006, Autor, Katz and Kearney, 2005, and 2006). Outsourcing may also help explaining some differences in the composition of domestic labor demand across periods because the skill content of the goods and services outsourced is likely to keep pace with the technological advances (for example, the outsourcing of accounting services to India would have been impossible with the technologies available a decade or two ago). The method proposed here can be applied in future research to investigate the changing skill content of outsourcing and its implications for inequality.

The structure of the paper is as follows. In the next section a review briefly the results from previous applications of the cost-share regression. Section 3 develops the new measure of outsourcing. Section 4 explains the data used to construct it and presents some descriptive statistics. Section 5 presents the results and Section 6 concludes.

## 2 An overview of the previous results

The basic idea of the cost-share regression is to exploit the variation across industries in the rate of skill upgrading on one hand, and the variation in indicators of technological change and trade on the other, in order to see which of these two factors is more important in explaining the rising relative demand for skilled labor.<sup>1</sup> The results from five previous applications of this method are summarized in Table 1. In all five studies the dependent variable is defined analogously: the annualized change in the non-production wage bill share. Although the other variables and the periods considered differ slightly across the five studies, Table 1 provides a coherent picture. We see that across studies and specifications the technological change proxies are statistically significant. An inspection of the corresponding mean values would reveal that they account also quantitatively for a large part of the change in the dependent variable. Outsourcing, by contrast, has a statistically significant effect only when technological change is not controlled for. Outsourcing is never significant if the computer investment variable is in-

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<sup>1</sup>The method was introduced by Berman, Bound and Griliches (1994) who motivated their specification by referring to the traditional translog approach. It should be noted, however, that the traditional translog approach hinges on the assumption of stable cost functions, thus, it rules out a priori many forms of technological change. Moreover, the behavior of globally operating firms which can quickly substitute domestic inputs for foreign inputs, is hardly accounted for by treating domestic shipments and capital as quasi-fixed factors and domestic skilled and unskilled labor as the only optimally chosen inputs. Because the traditional translog approach can hardly nest the two hypotheses of primary interest, outsourcing and technical change, the cost share regression has evolved in the course of applications more as a tool for an explorative analysis of the data rather than as a rigid application of the translog approach. In fact, Berman Bound and Griliches (1994) were the first to undertake a significant departure from the translog framework by dropping the term involving the relative wages and adding technological change proxies to the set of regressors.



cluded in the regression. Taken as a whole, the evidence summarized in Table 1 has contributed to the view that technological change is the dominant factor and that international trade has played a rather minor role in increasing the relative demand for skilled labor during the 1980s.

### **3 Methodological Notes**

The problem with any attempt to link trade flows to skill upgrading in a cross-industry regression is that trade flows can change for a variety of reasons that we would not expect to affect the composition of labor demand. For example, the total imports can increase as a result of a consumption demand shock, which we would expect to have a rather neutral effect on relative labor demand over the long run. This suggests that in order to uncover a relationship between international trade and skill upgrading at the industry level it is critical to concentrate on trade flow changes that are most likely linked to changes in domestic production. Feenstra and Hanson (1996) made a significant contribution in this respect by emphasizing the importance of international outsourcing as reflected by the increased trade in intermediate products. In what follows I argue that although their measure works well as an approximation (industries that outsource more tend to have higher values), it can be further refined if one takes carefully into account the definition of the dependent variable.

To see that there is scope for refinement suppose that the production process in each industry consists of many separable stages, each requiring fixed amounts of

production and non-production labor in different proportions or, alternatively, each paying fixed wage shares to non-production and production workers (any aggregate wage-bill or employment ratio can be represented as a sum of the wage-bills or employments in many small plants each employing a different Cobb-Douglas or Leontieff technology). Suppose further that these small plants (or divisions, or production stages, or production lines) do not change in size, they are simply shifted across borders such as they are. Note that this is exactly the perspective on outsourcing suggested by Feenstra and Hanson (1996): they characterize outsourcing as "the fragmentation of production into discrete activities which are then allocated across countries" (p.240). In the data outsourcing of this kind, i.e. the relocation of an intermediate production stage, would show up as follows: (i) reduction of the value of shipments and primary factor usage in the US corresponding to the size of the relocated activity, (ii) increase in the imports of intermediate goods equal to the value of shipments of the relocated activity.<sup>2</sup>

This implies that the wage bills/employment of production and non-production workers that obtain in an industry as a result of outsourcing can be expressed as the difference between two vectors: the vector of initial wage bills/employment minus the vector of the wage bills/employment contained in the outsourced ac-

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<sup>2</sup>For simplicity I present outsourcing as the closing of a domestic plant and the opening a foreign. The implications would be basically the same if plants under consideration, i.e. projects, are "relocated". The reduction in domestic value of shipments referred to above should be interpreted as a reduction relative to the firms and industries that do not outsource.

tivities. This idea is illustrated in Figures 1 and 2 which make it clear that outsourcing implies a change in the relative wage bill/employment (the same holds also for the change in the share of non-production wage bill/employment) which depends upon three factors: (i) the size of the outsourced activities relative to the size of domestic production (in the figures this is the length of the two vectors), (ii) the initial skill intensity of the domestic production, and (iii) the skill intensity of the outsourced activities (in the figures this are the slopes of the two vectors). The Feenstra-Hanson measure represents an approximation because it captures only the first of these factors, while completely ignoring the other two.

Based on these insights I propose an alternative measure of outsourcing which is constructed as the change in the non-production wage-bill share, implied by the factor content of intermediate imports. To construct this measure I first estimate the share of production that is relocated abroad during a period by putting the increase in the imports of intermediate goods in relation to the initial value of shipments (to simplify notation I shall omit the industry index throughout):

$$O_{sh} = \frac{m^1 - m^0 g}{Y^0} \quad (1)$$

In this expression  $m$  denotes the real imports of intermediate goods, the superscripts 0 and 1 denote start-of-period and end-of-period values respectively,  $Y$  is the real value of shipments and  $g$  is a benchmark growth rate defined as the

ratio of end-of-period to start-of-period real non-energy inputs. This formulation decomposes the change in the imports of intermediate goods over the period into two components. The first component is the change that would obtain if intermediate imports were to change exactly proportionately to total non-energy materials. The second component is the additional change, starting from the level that would obtain with the first component alone. I take only the second component to reflect outsourcing and implicitly attribute the first component to other factors.<sup>3</sup> Note that when  $g$  is defined as explained above, Eq. 1 can be rewritten as  $O_{sh} = \Delta S_O \times (\text{ex ante real non-energy inputs}) / (\text{ex post real shipments})$ . Thus, our estimate of the outsourced share is roughly proportional to  $\Delta S_O$  used in previous work, see Table 1. As a next step, I calculate the implied change in the non-production and production wage bills:

$$\widehat{\Delta W_n} = -O_{sh} \times W_T^0 \times fshare \quad (2)$$

$$\widehat{\Delta W_p} = -O_{sh} \times W_T^0 \times (1 - fshare) \quad (3)$$

In these expressions  $\widehat{\Delta W_n}$  and  $\widehat{\Delta W_p}$  denote the implied change in the non-production and production wage bills respectively,  $W_T^0$  is the total industry wage bill at the start of the period and  $fshare$  is the wage bill share of non-production

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<sup>3</sup>I obtain almost identical results when using total material costs or shipments to calculate the benchmark growth rate  $g$ . I experimented also with setting  $g = 1$  for all industries. This formulation ignores all other factors that cause industries to expand or shrink in size and attributes the whole observed change in intermediate imports to outsourcing. The results were generally close, reflecting the fact that on average over the period considered the proportional change in intermediate imports was significantly larger than the proportional change in total non-energy inputs.

labor in overseas production. With this formulation the implied change in the total industry wage bill (the latter is obtained by summing up the above two expressions) is constructed proportional to the implied domestic value of shipments change obtained in Eq.1.<sup>4</sup> As to the composition of the replaced wage-bill I impute the shares of production and non-production labor observed in the typical outsourcing destinations (see the data Section). Finally, I construct the implied change in the non-production wage bill share as follows:

$$\Delta S_{fci} = c \left( \frac{W_n^0 + \widehat{\Delta W}_n}{W_n^0 + \widehat{\Delta W}_n + W_p^0 + \widehat{\Delta W}_p} - \frac{W_n^0}{W_n^0 + W_p^0} \right) \quad (4)$$

where  $W_n^0$  and  $W_p^0$  are the industry start-of-period non-production and production wage bills respectively and  $c$  is a constant equal to  $100 \times 1 / (\text{the length of the period in years})$ . The subscript "fci" indicates that the variable represents the change in the non-production wage-bill share implied by the *Factor Content* of (intermediate) *Imports*. This completes the derivation of our new measure of outsourcing. Note that  $\Delta S_{fci}$  is constructed analogously to the dependent variable. If the wage bill changes implied by the factor content of intermediate imports  $\widehat{\Delta W}_n$  and  $\widehat{\Delta W}_p$  are substituted with the actual changes we would obtain the dependent variable. If the factor content calculation is accurate, we would expect the coefficient on  $\Delta S_{fci}$  in the cost-share regression to be equal to one. Note also that according to the theoretical framework used to derive  $\Delta S_{fci}$  outsourcing has

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<sup>4</sup>The minus sign reflects the fact that increases in the intermediate imports (positive  $O_{sh}$ ) are taken to imply substitution of domestic production, i.e. reductions in the domestic wage bill and value of shipments.

direct implications for the change in the domestic value of shipments, thus, it is obviously inappropriate to control for the change in shipments in a regression including  $\Delta S_{fci}$ . Accordingly, I consider the following benchmark specification:

$$\Delta S_i = \beta_0 + \beta_1 CI/I_i + \beta_2 \Delta S_{fci} + \beta_3 \Delta S_{xi} + \beta_4 \Delta \text{Log}(K_i/Y_i) + \epsilon_i \quad (5)$$

This corresponds to the specification estimated by Autor Katz and Krueger (1998), see column 3 in Table 1, except that the Feenstra-Hanson measure of outsourcing  $\Delta S_O$  has been replaced by  $\Delta S_{fci}$  and the change in the log of real shipments,  $\Delta \text{Log}(Y)$ , is omitted. To facilitate comparison with their results, all variables except  $\Delta S_{fci}$  are defined analogously.

The change in the export share  $\Delta S_x$  may be considered a crude measure of a type of outsourcing not accounted for in  $\Delta S_{fci}$ : the relocation abroad of the final processing or assembly. When this final stage of the production process is moved abroad we would expect this to show up as (i) substantial increase in the exports of intermediate products, (ii) a reduction in domestic value of shipments, (iii) increase in the imports of final goods (to the extent that the final good is consumed in the US, otherwise we would observe a fall in the exports of final goods which would offset partially the increase in the exports of intermediate goods). The high imports under the offshore assembly program 9802 (formerly items 806 and 807, schedule 8 of the Tariff Schedule of the United States) suggest that outsourcing of this type may be quite important (Feenstra, Hanson and Swenson,

1998). In the absence of appropriate data on the exports of intermediate goods, I use the aggregate export share introduced by Autor Katz and Krueger (1998) to account for this phenomenon.

Finally, I would like to address one potential problem related to the fact that  $\Delta S_{fci}$  is a function of the level of the wage bill-share while the dependent variable represents the change in the latter. I believe that this is not a reason for concern because the way the wage bill share enters the formula is rather neutral. For example, if intermediate imports change in real terms proportionately to total non-energy materials,  $\Delta S_{fci}$  is zero, regardless of the values of all other variables in the formula.  $\Delta S_{fci}$  is zero also if the imputed foreign factor content  $fwshare$  coincides with the initial domestic wage-bill share, regardless of the values of the other variables. The sign of  $\Delta S_{fci}$  is directly related to each of the following two factors: 1) the sign of  $O_{sh}$  which coincides with the sign of  $\Delta S_O$  used in previous work, and 2) the relative skill intensities of domestic and foreign production. Furthermore, for given skill intensities,  $\Delta S_{fci}$  depends monotonically (although not linearly) upon the change in intermediate imports.<sup>5</sup>

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<sup>5</sup>If the performance of  $\Delta S_{fci}$  in the regression was driven by the fact that it includes the level of the wage-bill share we would expect the variable to retain its explanatory power even with the wrong values of  $O_{sh}$  and  $fwshare$ . As a practical check on this hypothesis I experimented with randomly reallocating  $O_{sh}$  and  $fwshare$  (after they have been correctly computed for each industry) across industries and then matching them with the correct wage-bill data to construct  $\Delta S_{fci}$ . After repeating this experiment many times I was not able to detect any pattern in the results. In the regressions including  $\Delta S_{fci}$  constructed in this way its coefficient estimate varied unpredictably in sign and magnitude and was almost always insignificant.

## 4 Data

### 4.1 Data sources

Most of the data used in the present analysis are well known from previous work and will not be discussed here. I am grateful to David Autor for providing me with the computer investment variable and with the Feenstra-Hanson broad measure of outsourcing. The data on production and non-production wages, shipments, capital stock, none-energy inputs and material costs, and the corresponding deflators are from the current version of the NBER Manufacturing Productivity database (Bartelsman and Gray, 1996).<sup>6</sup> The exports needed for  $\Delta S_x$  are from Feenstra (1997). I discuss in some more detail the data used to construct  $\Delta S_{fci}$ . A key element in constructing  $\Delta S_{fci}$  are the data on intermediate imports, see Eq.1. I perform a parallel analysis using two alternative measures. On one hand, I use the Feenstra-Hanson (1996) estimates of imported intermediate usage by industry. I obtain the Feenstra-Hanson estimates by multiplying their broad measure of outsourcing with total non-energy materials from the NBER Manufacturing Productivity database. As an alternative, I use the imports of parts and components compiled recently by Schott (2004).<sup>7</sup> Scott (2004) obtained these series by aggregating to the the 4-digit 1987 SIC level the imports of products

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<sup>6</sup>Recently the former SIC 3671, SIC 3672 and SIC 3673 have been merged into a single industry with code 3671, thereby reducing the total number of industries in the NBER Manufacturing Database from 450 to 448. I aggregated the other variables accordingly.

<sup>7</sup>These data and a detailed description are available at <http://www.som.yale.edu/faculty/pks4/sub-international.htm>



containing the word "part" (or its variants "parts", "prts", "pts" and "component") in their verbal description. For the years up to 1988 aggregation proceeded from the 7-digit TSUSA, for the years since 1989 aggregation proceeded from the 10-digit Harmonized System. The switch from the TSUSA to the HS in 1989 introduces an important break in the Schott series. For consistency, with either measure of intermediate imports I shall report results for the period 1979-1987.<sup>8</sup> In order to match the Schott data (1987 SIC version) with computer investment and the other variables (SIC 1972 version) I delete industries that changed classification from the 1972 to the 1987 SIC version. Thus, the analysis based on the two types of data is based also on two different samples. I use the implicit deflator for non-energy materials from the NBER MPD (Bartelsman and Gray, 1996, p. 21) to convert both, the Feenstra-Hanson and the Schott measures into real values.

The Feenstra-Hanson and the Schott measures of intermediate imports have each its strengths and limitations for the purposes of the present analysis. The Feenstra-Hanson data include both parts and components, and contract work (see Feenstra and Hanson 1996, p. 242), thus they account for outsourcing more fully. They are also available for a larger sample of industries and allow direct comparison with previous work. The Schott data, on the other hand, have the

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<sup>8</sup>Since the Schott data cannot be used for a period including 1989 and the Feenstra-Hanson data are available only for 1972, 1979, 1987 and 1990, the period 1979-1987, considered also by Berman, Bound and Griliches (1994), is a natural choice. Unreported results for the period 1979-1990 using the Feenstra-Hanson data are quite similar to the reported results for the 1979-1987 period.

advantage to be the sum of directly observed imports of disaggregated product categories, not an imputed value.<sup>9</sup> Moreover, the Schott data include only products assigned strictly to the same 4-digit industry, thus, they are more likely to reflect relocation of production from the same industry.

A second key element in constructing  $\Delta S_{fci}$  are the data used to impute the factor content of the intermediate imports, see Eq. 2. I obtain these data from the United Nations General Industrial Statistics Dataset.<sup>10</sup> I use the data on three typical outsourcing destinations, Korea, Portugal and Turkey, to construct the variable  $fwshare$ .<sup>11</sup> In order to match the data from the UNGISD, which are available according to the International Standard Industrial Classification Revision 2 (ISIC2), I constructed a concordance that assigns each 4-digit industry of SIC 1972 to one of the 28 industries in ISIC2.<sup>12</sup> The same value of " $fwshare$ " has been imputed to all 4-digit SIC industries assigned to a given ISIC2 code, see

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<sup>9</sup>See Feenstra Hanson (1996), p.241, Table 1, for the technique used to calculate their measure.

<sup>10</sup>This dataset provides comparable information on wages and employment of production and non-production workers for a wide range of countries. It has been used also by MVR and BBM. However, in their analysis they do not exploit the information available on foreign countries' skill intensities.

<sup>11</sup>These countries have been selected according to two basic criteria: low-wage countries with complete and reliable data. Imputing the average skill-intensity of these countries to all of the US imports of intermediate goods can be justified as follows. In general, we expect the outsourced activities to be less skill intensive than the US production, thus it would be a bad idea to impute the factor content of intermediate imports using the production data from high-wage countries with average skill-intensities higher than that in the US. In fact, the imports originating from such countries may have lower skill intensity than the average of the US production because they are likely to embody parts previously processed in third countries.

<sup>12</sup>Two industries, SIC 3398 "Metal heat treating" and SIC 3399 "Primary metal products, not elsewhere classified" could not be allocated to a single ISIC2 code and were deleted. The concordance is available in a separate file

Table 2.

## 4.2 Sample description and summary statistics

When using the Feenstra-Hanson data the sample includes all manufacturing industries in the current SIC 1972 Version of the NBER MPD except four, thus it consists of 444 industries.<sup>13</sup> When using the Schott data the sample consists of 284 industries.<sup>14</sup>

In the period considered both measures of intermediate imports increased on average much more than the other inputs, which is consistent with our treatment of intermediate imports as reflecting relocation of production abroad. In the sample of 444 industries obtained with the Feenstra-Hanson data the total manufacturing imports of intermediate goods increased in real terms by 54.6 per-

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<sup>13</sup>SIC 3398 and 3399 were lost in merging the data with the UNGISD. SIC 3339 "Primary smelting and refining of nonferrous metals, not elsewhere classified" is dropped due to its badly measured export share, see Figure 3.  $\Delta Sx$  for this industry is -28.98, compare to Table 3. The omission of SIC 3339 from the sample has important implications for the coefficient estimate on  $\Delta Sx$  but has almost no effect on all other results. SIC 3573 "Electronic Computing Equipment" had to be eliminated due to its extreme value of  $\Delta S_{fci} = 2.37$  (compare to Table 3). If included, this industry dominates the whole sample and influences the results significantly. Obviously, our approach to estimate outsourcing is inappropriate for this industry which featured an extraordinary growth in output. As Berman Bond and Griliches note (see the NBER working paper, Berman, Bound and Griliches, 1993, p.23, footnote 24): "*The computer investment industry shows a growth in output unmatched by any growth in inputs. One plausible explanation for this phenomenon is that input and output deflators have not been correctly matched.*" This industry has extreme values also on the other variables:  $\Delta \text{Log}(Y) = 27.04$ ,  $\Delta \text{Log}(K/Y) = -15.61$ ,  $O_{sh} = 0.33$ ,  $\Delta S_{fci} = 2.37$ ,  $CI/I = 0.21$ , compare to Table 3.

<sup>14</sup>Excluded are the industries with missing values in the original data and the industries without one-to-one correspondence in their SIC 1972 and SIC 1987 codes. In addition, SIC 3565 "Industrial patterns" has been excluded when using the Schott data due to its extraordinary high imports of parts. In fact, this is the only industry for which the imports of parts exceed total non-energy inputs (they exceed also shipments). This is also the only case in which  $O_{sh}$  exceeds one and in which the change in the wage-bill predicted by Eqs.1-2 exceeds the initial wage-bill value in absolute terms.

cent.<sup>15</sup> In the sample of 284 industries obtained with the Schott data the total imports of parts increased in real terms by 98.7 percent.<sup>16</sup> Still, in both samples there are some industries in which intermediate imports increased less than total non-energy inputs. For these industries the estimated outsourced share, see Eq. 1, takes negative values.<sup>17</sup> I decided to report the results without according any special treatment to these industries.<sup>18</sup>

The use of the Feenstra-Hanson data here allows a direct comparison with their approach to measure outsourcing. Not surprisingly, the correlation between our estimate of the outsourced share of production  $O_{sh}$  and the measure they use in the regression analysis  $\Delta S_O$  is 0.88, which is very high. By contrast, the correlation between  $\Delta S_{fci}$  and  $\Delta S_O$  is only 0.28.<sup>19</sup> This illustrates how important is the additional information incorporated in  $\Delta S_{fci}$ . I believe that the account of

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<sup>15</sup>In the same sample the corresponding changes in non-energy inputs, material costs, shipments and employment were 2.7, 2.2, 7.1 and -10.6 percent respectively.

<sup>16</sup>In the same sample the corresponding changes in non-energy inputs, material costs, shipments and employment were 3.0, 2.2, 4.7 and -13.9 percent respectively.

<sup>17</sup>In the sample obtained with the Schott data there are 14 such industries. For only two of them is  $O_{sh}$  less than -0.01, see also Table 4. In the sample obtained with the Feenstra-Hanson data there are 59 such industries. Only for 15 of them is  $O_{sh}$  less than -0.01, see also Table 3

<sup>18</sup>The fact that intermediate imports in an industry lag behind the growth in total non-energy inputs by a certain amount represents a useful information that we would like to use somehow. The formulation of Eqs.1-4 enables us to do this as it translates lower values of  $O_{sh}$  directly into lower values of  $\Delta S_{fci}$ , provided the estimated foreign skill intensity is lower than the domestic skill intensity. Moreover, the problem of negative outsourcing is not specific to our approach: as shown in the previous Section  $O_{sh}$  is roughly proportional (and always takes the same sign) as  $\Delta S_O$  used in previous work. I experimented also with redefining  $O_{sh}$  as follows:  $O_{sh} = \max[0, O_{sh}]$ . This formulation predicts zero change in the dependent variable for all industries with estimated reverse outsourcing. In all cases were the results very robust to this transformation, perhaps reflecting the fact that there are only few industries with falling intermediate imports. The results are robust also to deleting single industries with the lowest values of  $O_{sh}$ .

<sup>19</sup>These two correlations are based on the sample of 444 industries considered here. They are weighted by the industry shares in the total manufacturing wage bill.

the relative skill intensity of domestic and foreign production represents a critical advantage of  $\Delta S_{fci}$ . Another very interesting difference is with respect to the correlation between outsourcing and the technology proxy  $CI/I$ . The correlation between  $CI/I$  and  $\Delta S_{fci}$  based on the Feenstra-Hanson data is 0.53, by contrast, the correlation between  $CI/I$  and  $\Delta S_O$  is only 0.16.<sup>20</sup>

Another interesting comparison is between the two samples obtained with the Feenstra-Hanson and the Schott data. Summary statistics on these two samples are presented in Tables 3 and 4. The means of most variables are similar across the two samples, only the difference in the mean of  $\Delta \text{Log}(Y)$  which exceeds 10 percent of the standard deviation is more pronounced. One possible explanation for this finding is that the Schott sample may select industries that are more prone to outsourcing.<sup>21</sup> This explanation fits well the hypothesis that outsourcing may be associated with lower output growth and supports the argument that the change in the log of output and capital intensity should better not be included as "controls" in the regression.

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<sup>20</sup>Both correlations are based on the sample of 444 industries obtained with the Feenstra-Hanson data and are weighted by the industry shares in the total manufacturing wage bill.

<sup>21</sup>Remember that two types of industries are missing in the Schott sub-sample. First, this are the industries that changed codes from 1972 SIC to 1987 SIC. These are perhaps randomly selected. Second, this are the industries with missing values in the original Schott data, i.e. the industries for which no TSUSA product definition containing the word "part" existed. Here there is perhaps some systematic component, because we expect the industries that rely more heavily on "parts" to be also more prone to outsourcing.

## 5 Results

### 5.1 Estimates from traditional cost-share regressions

Regressions based on variants of Eq. 5 with alternative sets of regressors are reported in Table 5. Consider first the results based on the Schott data (columns 5-8). The coefficient on  $\Delta S_{fci}$  is in all cases close to the theoretically expected value of one. This can be interpreted as strong evidence in support of our method to calculate the factor content of intermediate imports. Moreover, the coefficient on  $\Delta S_{fci}$  is statistically significant throughout, including columns (7) and (8) in which computer investment is controlled for. The coefficient on the export share is also statistically significant throughout. Overall, these results suggest that both technological change and international trade played an important role in increasing the relative demand for skilled labor during the 1980s. In this context, it should be warned against measuring the contribution of trade and technical change by multiplying the mean values of the corresponding proxies with the coefficient estimates and putting the result in relation to the mean of the dependent variable. On one hand, this would reveal a negative contribution of the export share variable, which has a negative mean in the sample. Obviously, it would be wrong to conclude from this that the change in exports during the period worked to reduce the relative demand for skilled labor. On the other hand, it may not be possible at all to decompose the change in the dependent variable into components attributable separately to outsourcing and technological change

because, as I shall argue below, the two phenomena may be complementary.

Let us now consider the results based on the Feenstra-Hanson data.  $\Delta S_{fci}$  is highly significant in the first two specifications, but loses significance when computer investment is controlled for. At first glance these results resemble those from previous work and one might be tempted to interpret them the same way. Our new measure, however, provides additional information, which suggests an alternative interpretation. First, it allows to reveal that computer investment and outsourcing are highly correlated, second, our new measure comes with a theoretically expected value for the coefficient estimate, which suggests that the latter is significantly overestimated in columns (1) and (2).

All these findings can be well explained by what I would call the "complementarity hypothesis". This hypothesis claims that technological change has enhanced both the disintegration of the production process and the coordination of productive activities in different locations, thus contributing directly to outsourcing. According to this hypothesis part of the computer investment has been made directly in relation to outsourcing. As an example, consider the use by a multinational company of electronic computing equipment and specialized software to manage its transborder logistic operations. The complementarity hypothesis implies that it might be difficult to separate the contribution of technical change and outsourcing to skill upgrading because part of the skill upgrading may actually be caused by "outsourcing induced by technical change", i.e. by both factors acting together.

The results obtained with the Feenstra-Hanson data illustrate this very clearly. In columns (1) and (2)  $\Delta S_{fci}$  appears to capture part of the effect of the omitted computer investment variable with which it is highly correlated. When computer investment is controlled for, the coefficient on  $\Delta S_{fci}$  becomes closer to its theoretically expected value, but is insignificant. This is not surprising given that  $CI/I$  accounts for a large part of the variation in  $\Delta S_{fci}$ . This may be also the reason why previous work failed to uncover a significant effect of outsourcing in regressions in which computer investment is controlled for.

The results obtained with the Schott data are also consistent with the complementarity hypothesis. The fact that both  $\Delta S_{fci}$  and  $CI/I$  are less significant when included together (compare also to Table 6) can be taken as a hint that both measures may be partially accounting for one and the same phenomenon. The omitted variable problem does not appear so pronounced in columns (5) and (6) because  $\Delta S_{fci}$  obtained with the Schott data is not so correlated with  $CI/I$ , this correlation is 0.20. In what follows, I provide more direct evidence on the complementarity between technological change and outsourcing using both types of data.

## **5.2 More direct evidence on the complementarity between technological change and outsourcing**

Note that under the alternative of the complementarity hypothesis, i.e. under the view that technological change and outsourcing are two unrelated phenomena,



each affecting the dependent variable independently, the contribution of each, trade and technical change, to skill upgrading can be separated. We can use the fact that  $\Delta S_{fci}$  has the format of the dependent variable to design a test of this alternative view, which I would call the "separability hypothesis". In fact, with  $\Delta S_{fci}$  we have already separated the change in the non-production wage bill share into two components:  $\Delta S_{fci}$ , a component attributed to outsourcing, and a residual,  $\Delta S - \Delta S_{fci}$ , attributed to all other factors, including technological change. Under the separability hypothesis computer investment should explain the second component better than the first.

Regressions of these two components on computer investment and a constant are reported in Table 6. It appears that computer investment explains the component attributed to outsourcing better than the residual: note the higher t-statistics on the computer investment variable and the higher R-squared in columns (2) and (5) as compared to columns (3) and (6) respectively. Note that this is the case also with the Schott data, for which  $\Delta S_{fci}$  is not so highly correlated with computer investment. The results in Table 6 seem to provide strong evidence against the separability hypothesis.

## 6 Conclusion

Technological change and outsourcing have been traditionally considered as two alternative, competing explanations for the increasing relative demand for skilled labor during the 1980s. Based on a new measure of outsourcing the present

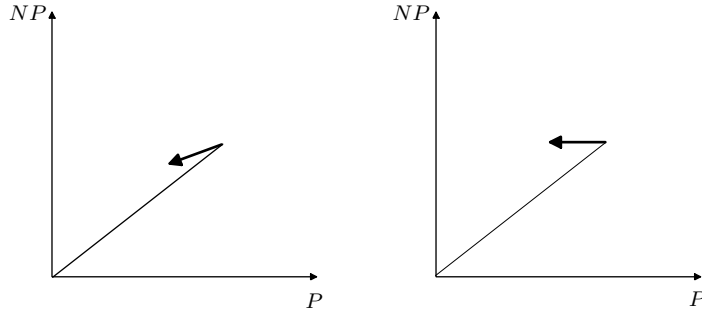
analysis has shown that there may be a significant overlap in the role of these two phenomena. The size of this overlap and the precise mechanisms through which technical change may have contributed to outsourcing are worth further research.

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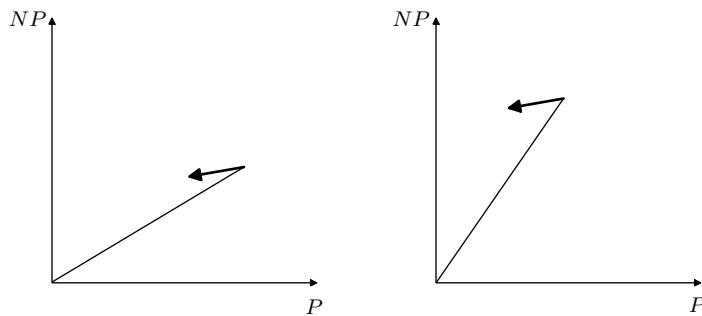
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Figure 1: Different effects of outsourcing depending on the skill intensity of the relocated production activities



*Notes:* In this figure the solid lines going through the origin represent the initial use of non-production and production workers, the small thick arrows represents employment displaced by imports of intermediate goods. The length of this arrow is the same in both the left and the right panel of the Figure indicating that a plant of similar size has been relocated abroad in both cases. Obviously the changes in the non-production ratio (and also in the non-production employment share) in both cases is different.

Figure 2: Different effects of outsourcing depending on the initial aggregate skill intensity of the industry



*Notes:* The left and right panel in this figure depict two industries of approximately equal size (as captured by the equal length of the line through the origin) which experienced increases in the imports of intermediate goods of approximately equal size and equal factor content (the small thick arrows are parallel and of equal length). Obviously in both cases the implied change in the ratio non-production - production employment is different and we expect the same to be true for the wage-bill ratio and for the corresponding shares.

Figure 3: The badly measured export share of SIC 3339

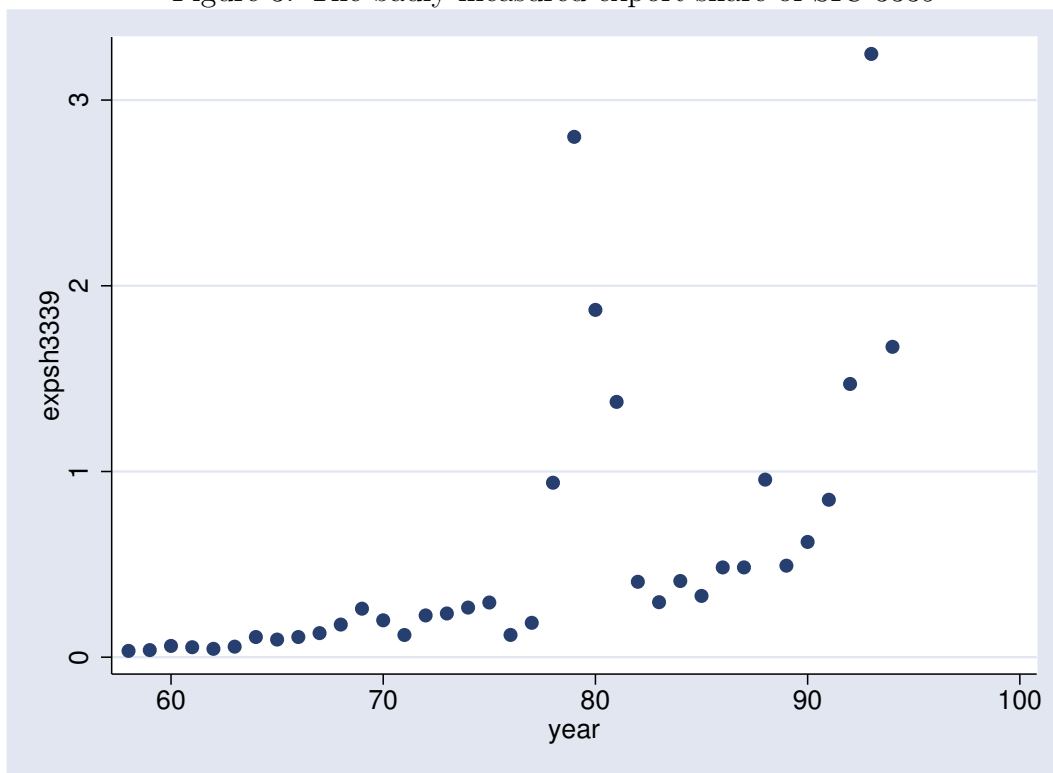


Table 1: Trade, Technical Change and Skill Upgrading in the US Manufacturing Sector during the 1980s: An Overview of Previous Results

study	Berman Bound Griliches (1994)	Feenstra Hanson (1996)	Autor Katz Krueger (1998)	Machin VanReenen (1998)	Feenstra Hanson (1999)
period	1979-1987	1979-1990	1979-1989	1973-1989	1979-1990
sample	143 three-digit industries	450 four-digit industries	450 four-digit industries	15x4 15 two-digit industries observed in 4 subperiods	447 four-digit industries
estimation method	WLS	WLS	WLS	GLS/Random Effects	WLS
<b>Technology proxies</b>					
$CI/I^a$	0.028*** (0.006)		2.192** (0.865)		0.019*** (0.007)
$RD/Sales$				0.016* (0.008)	
<b>Outsourcing</b>					
$\Delta S_O$		0.384*** (8.136) <sup>b</sup>	0.116 (0.143)		
$\Delta S_O^{narrow}$					0.193 (0.166)
$\Delta S_O^{difference}$					0.038 (0.054)
<b>Other trade proxies</b>					
$\Delta S_x$			0.066** (0.033)		
$I/Y$				-0.004 (0.003)	
<b>Other variables included</b>	$\Delta \log(P/Y)$	$\Delta \log(K/Y)$	$\Delta \log(K/Y)$	$\Delta \log(K)$	$\Delta \log(K/Y)$
	$\Delta \log(E/Y)$	$\Delta \log(Y)$	$\Delta \log(Y)$	$\Delta \log(Y)$	$\Delta \log(Y)$
	$\Delta \log(Y)$			time dummies	high – tech share
	constant	constant	constant	constant	constant
<b>R<sup>2</sup></b>	0.420	0.595	0.215	na	0.20

Notes: This Table reproduces the results from Berman, Bound and Griliches, 1994, p.387, Table VII, Column 1, Feenstra and Hanson, 1996, p.243, Table 2, Column 4a, Autor Katz and Krueger, 1998, p.1201, Table VIII, Column 8, Machin and Van Reenen, 1998, p. 1234, Table V, row 18, Feenstra and Hanson, 1999, p.927, Table III, Column 4. The dependent variable in all cases is the annualized change in the non-production workers' share in the wage bill. All studies weight the regressions by the industry's share in the total manufacturing wage bill. All studies report in parentheses standard errors, except Feenstra and Hanson (1996) who reported t-statistics. None of the studies used a special symbol to denote significance level. This symbol has been added by the author to facilitate a quick reading. Three, two and one star(s) indicate statistical significance at the 1, 5 and 10-percent level respectively.

a) In Berman Bound and Griliches (1994)  $CI/I$  is the computer investment share in 1987, in Autor, Katz and Krueger (1998) and Feenstra and Hanson (1999) it is the average of the computer investment shares in 1982 and 1987. Berman Bound and Griliches (1994) and Feenstra and Hanson (1999) measure  $CI/I$  in percentage terms, Autor, Katz and Krueger (1998) as a ratio, thus the coefficient estimate of Autor, Katz and Krueger (1998) has to be multiplied by 100 in order to be comparable with those in the other studies.

b) This number is a t-statistic, not a standard error, see Feenstra and Hanson (1996).

$\Delta S_O$  is  $100 \times$  the annualized change in the Feenstra-Hanson broad measure of outsourcing. The latter is defined as the ratio of imported intermediate inputs to total non-energy inputs used by the industry.

See the original studies for more detail.

Table 2: Estimates of the skill intensity of imported products and domestic production

ISIC	TURKEY	KOREA	PORTUGAL	FWSHARE	US
311	0.287	0.357	0.252	0.318	0.346
313	0.475	0.49	0.275	0.459	0.526
314	0.117	0.179	0.344	0.145	0.303
321	0.196	0.187	0.156	0.185	0.241
322	0.215	0.192	0.153	0.19	0.274
323	0.113	0.26	0.208	0.246	0.331
324	0.171	0.219	0.146	0.196	0.231
331	0.216	0.235	0.163	0.211	0.244
332	0.234	0.204	0.18	0.202	0.292
341	0.259	0.295	0.224	0.275	0.299
342	0.305	0.469	0.428	0.444	0.517
351	0.332	0.323	0.338	0.327	0.442
352	0.448	0.53	0.512	0.51	0.552
353	0.369	0.366	0.291	0.358	0.378
354	0.364	0.42	.	0.407	0.415
355	0.232	0.157	0.203	0.166	0.302
356	0.325	0.278	0.238	0.278	0.347
361	0.223	0.174	0.164	0.184	0.27
362	0.274	0.224	0.182	0.231	0.227
369	0.27	0.271	0.185	0.257	0.317
371	0.18	0.229	0.242	0.213	0.263
372	0.315	0.273	0.191	0.284	0.3
381	0.231	0.278	0.211	0.262	0.345
382	0.258	0.308	0.286	0.296	0.455
383	0.332	0.3	0.293	0.302	0.497
384	0.286	0.313	0.199	0.296	0.383
385	0.28	0.284	0.177	0.279	0.568
390	0.208	0.22	0.278	0.22	0.406

*Notes:* The non-production workers' shares in the wage bill have been obtained for each country and industry as averages over all years between 1979 and 1987. The values of *fwshare* for each industry are obtained as average over the three countries, Korea, Portugal and Turkey, weighted by the average size of the corresponding industry in each country. The figure for ISIC 354 for Portugal is missing because wages and employment of both production and non-production workers were zero during the period. The values for the US are given only for comparison. Source: United Nations General Industrial Statistics Dataset.



Table 3: Summary statistics on the sample obtained when using the Feenstra-Hanson data, 1979-1987

Variable	Mean	Stand. Deviat.	lowest three		highest three	
			value	SIC	value	SIC
$\Delta S$	0.428	0.515	-1.39	2083	2.32	3743
			-1.15	2429	3.09	3332
			-1.11	2098	3.68	3661
$CI/I$	0.054	0.049	0	2021	0.19	2342
			0	2045	0.19	3483
			0	2076	0.23	2791
$O_{sh}$	0.016	0.019	-0.26	2283	0.09	3732
			-0.16	2231	0.10	3942
			-0.10	3356	0.13	3691
$\Delta S_{fci}$	0.015	0.040	-0.16	3691	0.18	3574
			-0.10	3832	0.19	2279
			-0.10	3356	0.25	3942
$\Delta S_x$	-0.063	0.441	-2.88	3769	3.18	3533
			-2.37	3483	4.10	3292
			-2.10	3795	4.57	3636
$\Delta \text{Log}(K/Y)$	1.235	3.673	-13.71	2279	20.27	3533
			-12.91	3483	21.70	3332
			-10.68	2292	60.79	2794
$\Delta \text{Log}(Y)$	1.129	4.681	-64.74	2794	12.05	3674
			-19.18	3332	12.88	2017
			-18.23	3743	13.07	3483

*Notes:* The mean and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1979 and 1987. The variables are defined as follows:

$\Delta S = 100 \times$  the annual change in the nonproduction wage-bill share

$CI/I$ =Average of the computer investment share in 1982 and 1987.

$\Delta S_{fci}$  is computed based on the Feenstra-Hanson data as explained in the text, see Eqs. 1-4, and Section 4.

$\Delta S_x = 100 \times$  annual change in the exports-to-shipments ratio.

$\Delta \text{Log}(K/Y) = 100 \times$  the annual change in the log of the real capital stock to real shipments ratio.

$\Delta \text{Log}(Y) = 100 \times$  the annual change in the log of the real value of shipments.

Sample: 444 industries, see Section 4 for a sample definition and more details on the data used.

Table 4: Summary statistics on the sample obtained when using the Schott data, 1979-1987

Variable	Mean	Stand. Deviat.	lowest three		highest three	
			value	SIC	value	SIC
$\Delta S$	0.392	0.438	-1.39	2083	2.01	2023
			-1.15	2429	2.11	3547
			-1.09	2842	2.32	3743
$CI/I$	0.053	0.050	0	2021	0.18	3586
			0	2076	0.18	3761
			0	2083	0.19	2342
$O_{sh}$	0.01	0.031	-0.22	3911	0.13	3692
			-0.17	3915	0.13	3648
			-0.01	3511	0.29	2599
$\Delta S_{fci}$	0.016	0.072	-0.50	3911	0.30	3674
			-0.26	3915	0.37	3579
			-0.11	3692	0.65	2599
$\Delta S_x$	-0.025	0.452	-2.10	3795	2.35	3652
			-1.88	2399	3.18	3533
			-1.72	3341	4.10	3292
$\Delta \text{Log}(K/Y)$	1.362	3.719	-8.30	3446	13.26	3292
			-7.84	2386	18.43	3743
			-7.35	2231	20.27	3533
$\Delta \text{Log}(Y)$	0.649	4.684	-18.23	3743	10.63	2741
			-15.73	3292	11.33	3841
			-14.82	2429	12.05	3674

*Notes:* The mean and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1979 and 1987. Sample: 284 industries, see Section 4 for a precise description. The variables are as in Table 3, except  $S_{fci}$  which is computed based on the Schott data, see Eqs. 1-4, and Section 4.

Table 5: Outsourcing, Technical Change and Skill Upgrading in the US Manufacturing Sector, 1979-1987

	Results based on Feenstra-Hanson data				Results based on Schott data			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$CI/I$			3.372*** (1.189)	2.976*** (1.149)			1.941* (1.046)	1.828* (1.017)
$\Delta S_{fci}$	2.642*** (0.960)	2.970*** (0.997)	0.815 (0.848)	1.043 (0.842)	1.040*** (0.353)	1.037*** (0.358)	0.759* (0.428)	0.760* (0.410)
$\Delta S_x$		0.177** (0.077)	0.204*** (0.074)	0.120* (0.064)		0.212** (0.084)	0.229*** (0.079)	0.125** (0.054)
$\Delta \text{Log}(K/Y)$				0.036*** (0.007)				0.036*** (0.009)
<i>Constant</i>	0.388*** (0.033)	0.394*** (0.033)	0.247*** (0.047)	0.215*** (0.044)	0.375*** (0.039)	0.380*** (0.039)	0.282*** (0.053)	0.237*** (0.054)
$R^2$	0.041	0.063	0.135	0.195	0.029	0.077	0.124	0.206
$n$	444	444	444	444	284	284	284	284

*Notes:* Dependent Variable is  $\Delta S = 100 \times (\text{Annual Change in the Nonproduction Wage-Bill Share})$ . All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate. The variables are defined in Tables 3 and 4.

Table 6: Uncovering the Complementarity between technological Change and Outsourcing, 1979-1987

	Results with the Feenstra-Hanson data			Results with the Schott data		
	(1)	(2)	(3)	(4)	(5)	(6)
dependent variable	$\Delta S$	$\Delta S_{fci}$	$\Delta S - \Delta S_{fci}$	$\Delta S$	$\Delta S_{fci}$	$\Delta S - \Delta S_{fci}$
$CI/I$	3.429*** (1.149)	0.434*** (0.116)	2.995*** (1.151)	2.011* (1.048)	0.292* (0.149)	1.719* (1.017)
<i>Constant</i>	0.244*** (0.048)	-0.008 (0.005)	0.252*** (0.047)	0.258*** (0.056)	0.0004 (0.006)	0.285*** (0.054)
$R^2$	0.104	0.284	0.082	0.053	0.042	0.040
$n$	444	444	444	284	284	284

*Notes:* All variables are as defined in Tables 3 and 4. All regressions are weighted by the average industry share of the total manufacturing wage bill. Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate.

Table 7: Concordance between the US standard Industrial classification 1972 and the International Standard Industrial Classification Revision 2

ISIC Rev.2 code and description	US SIC 72 code	US SIC 72 description
311: Food products	2011	Meat packing plants
	2013	Sausages and other prepared meat products
	2016	Poultry dressing plants
	2017	Poultry and egg processing
	2021	Creamery butter
	2022	Cheese, natural and processed
	2023	Condensed and evaporated milk
	2024	Ice cream and frozen desserts
	2026	Fluid milk
	2032	Canned specialties
	2033	Canned fruits, vegetables, pre serves, jams, and jellies
	2034	Dried and dehydrated fruits, vegetables and soup mixes
	2035	Pickled fruits and vegetables, vegetable sauces and seasonings, and salad dressings
	2037	Frozen fruits, fruit juices and vegetables
	2038	Frozen specialties
	2041	Flour and other grain mill products
	2043	Cereal breakfast foods
	2044	Rice milling
	2045	Blended and prepared flour
	2046	Wet corn milling
	2047	Dog, cat and other pet food
	2048	Prepared feeds and feed ingredients for animals and fowls, not elsewhere classified
	2051	Bread and other bakery products, except cookies and crackers
	2052	Cookies and crackers
	2061	Cane sugar, except refining only
	2062	Cane sugar refining
	2063	Beet sugar
	2065	Candy and other confectionery products
	2066	Chocolate and cocoa products
	2067	Chewing gum

(1)	(2)	(3)
	2074	Cottonseed oil mills
	2075	Soybean oil mills
	2076	Vegetable oil mills, except corn, cottonseed, and soybean
	2077	Animal and marine fats and oils
	2079	Shortening, table oils, margarine and other edible fats and oils, not elsewhere classified
	2091	Canned and cured fish and sea-foods
	2092	Fresh or frozen packaged fish and seafoods
	2095	Roasted coffee
	2097	Manufactured ice
	2098	Macaroni, spaghetti, vermicelli, and noodles
	2099	Food preparations, not elsewhere classified
313: Beverages	2082	Malt beverages
	2083	Malt
	2084	Wines, brandy, and brandy spirits
	2085	Distilled, rectified, and blended liquors
	2086	Bottled and canned soft drinks and carbonated waters
	2087	Flavoring extracts and flavoring sirups, not elsewhere classified
314: Tobacco	2111	Cigarettes
	2121	Cigars
	2131	Tobacco (chewing and smoking) and snuff
	2141	Tobacco stemming and redrying
321: Textiles	2211	Broad woven fabric mills, cotton
	2221	Broad woven fabric mills, manmade fiber and silk
	2231	Broad woven fabric mills, wool (including dyeing and finishing)
	2241	Narrow fabrics and other small-wares mills: cotton, wool, silk, and man-made fiber
	2251	Women's full length and knee length hosiery
	2252	Hosiery, except women's full length and knee length hosiery
	2253	Knit outerwear mills
	2254	Knit underwear mill's
	2257	Circular knit fabric mills
	2258	Warp knit fabric mill's
	2259	Knitting mills, not elsewhere classified
	2261	Finishers of broad woven fabrics of cotton
	2262	Finishers of broad woven fabrics of man-made fiber

(1)	(2)	(3)
		and silk
	2269	Finishers of textiles, net else-where classified
	2271	Woven carpets and rugs
	2272	Tufted carpets and rugs
	2279	Carpets and rugs, not elsewhere classified
	2281	Yarn spinning mills: cotton, man-made fibers and silk
	2282	Yarn texturizing, throwing, twisting, and winding mills: cotton, man-made fibers, and silk
	2283	Yarn mills, wool, including carpet and rug yarn
	2284	Thread mills
	2291	Felt goods, except woven felts and hats
	2292	Lace goods
	2293	Paddings and upholstery filling
	2294	Processed waste and recovered fibers and flock
	2295	Coated fabrics, not rubberized
	2297	Nonwoven fabrics
	2298	Cordage and twine
	2299	Textile goods, not elsewhere classified
322: Wearing apparel, except footwear	2311	Men's, youths', and boys' suits, coats, and overcoats
	2321	Men's, youths', and boys' shirts (except work shirts) and nightwear
	2322	Men's, youths', and boys' underwear
	2323	Men's, youths', and boys' neckwear
	2327	Men's, youths', and boys' separate trousers
	2328	Men's, youths', and boy's' work clothing
	2329	Men's, youths', and boys' clothing, not elsewhere classified
	2331	Women's, misses', and juniors' blouses, waists' and shirts
	2335	Women's, misses', and juniors' dresses
	2337	Women's, misses', and juniors' suits, skirts, and coats
	2339	Women's, misses', and juniors' outerwear, not elsewhere classified
	2341	Women's, misses,, children's, and infants' underwear and nightwear
	2342	Brassieres, girdles, and allied garments
	2351	Millinery
	2352	Hats and caps, except millinery
	2361	Girls', children's, and infants' dresses, blouses, waists, and shirts
	2363	Girls', children's, and infants' coats and suits

(1)	(2)	(3)
	2369	Girls', children's, and infants' outerwear, not elsewhere classified
	2371	Fur goods
	2381	Dress and work gloves, except knit and all-leather
	2384	Robes and dressing gowns
	2385	Raincoats and other water-proof outer garments
	2386	Leather and sheep lined clothing
	2387	Apparel belts
	2389	Apparel and accessories, not elsewhere classified
	2391	Curtains and draperies
	2392	Housefurnishings, except curtains and draperies
	2393	Textile bags
	2394	Canvas and related products
	2395	Pleating, decorative and novelty stitching, and tuck-ing for the trade
	2396	Automotive trimmings, apparel findings, and related byproducts
	2397	Schiffli machine embroideries
	2399	Fabricated textile products, not elsewhere classified
	3151	Leather gloves and mittens
323: Leather pro- ducts	3111	Leather tanning and finishing
	3161	Luggage
	3171	Women's handbags and purses
	3172	Personal leather goods, except women's handbags
	3199	Leather goods, not elsewhere classified
324: Footware, ex- cept rubber or plastic	3131	Boot and shoe cut stock and findings
	3142	House slippers
	3143	Men's footwear, except athletic
	3144	Women's footwear, except athletic
	3149	Footwear, except rubber, not elsewhere classified
331: Wood products, except furniture	2411	Logging camps and logging con-tractors
	2421	Sawmills and planing mills, general
	2426	Hardwood dimension and flooring mills
	2429	Special product sawmills, not elsewhere classified
	2431	Millwork
	2434	Wood kitchen cabinets
	2435	Hardwood veneer and plywood
	2436	Softwood veneer and plywood
	2439	Structural wood members, not elsewhere classified
	2441	Nailed and lock corner wood boxes and shook
	2448	Wood pallets and skids



(1)	(2)	(3)
	2449	Wood containers, not elsewhere classified
	2451	Mobile homes
	2452	Prefabricated wood buildings and components
	2491	Wood preserving
	2492	Particleboard
	2499	Wood products, not elsewhere classified
332: Furniture, except metal	2511	Wood household furniture, except upholstered
	2512	Wood household furniture, up-holstered
	2515	Mattresses and bedsprings
	2517	Wood television, radio, phonograph, and sewing machine
	2519	Household furniture, not elsewhere classified
	2521	Wood office furniture
	2531	Public building and related furniture
	2541	Wood partitions, shelving, lock-era, and office and store fixtures
	2591	Drapery hardware and window blinds and shades
	2599	Furniture and fixtures, not else-where classified
341: Paper and products	2611	Pulp mills
	2621	Paper mills, except building paper mills
	2631	Paperboard mills
	2641	Paper coating and glazing
	2642	Envelopes
	2643	Bags, except textile bags
	2645	Die-cut paper and paperboard and cardboard
	2646	Pressed and molded pulp goods
	2647	Sanitary paper products
	2648	Stationery, tablets and related products
	2649	Converted paper and paperboard. products, not elsewhere classified
	2651	Folding paperboard boxes
	2652	Set-up paperboard boxes
	2653	Corrugated and solid fiber boxes
	2654	Sanitary food containers
	2655	Fiber cans, tubes, drums, and similar products
	2661	Building paper and building board mills
342: Printing and publishing	2711	Newspapers: publishing, publishing and printing
	2721	Periodicals: publishing, publishing and printing
	2731	Books: publishing, publishing and printing
	2732	Book printing
	2741	Miscellaneous publishing

(1)	(2)	(3)
	2751	Commercial printing, letterpress and screen
	2752	Commercial printing, lithographic
	2753	Engraving and plate printing
	2754	Commercial printing, gravure
	2761	Manifold business forms
	2771	Greeting card publishing
	2782	Blankbooks, looseleaf binders and devices
	2789	Bookbinding and related work
	2791	Typesetting
	2793	Photoengraving
	2794	Electrotyping and stereotyping
	2795	Lithographic platemaking and related services
351: Industrial chemicals	2812	Alkalies and chorine
	2813	Industrial gases
	2816	Inorganic pigments
	2819	Industrial inorganic chemicals, not elsewhere classified
	2821	Plastics materials, synthetic resins, and nonvulcanizable elastomers
	2822	Synthetic rubber (vulcanizable elastomers)
	2823	Cellulosic man-made fibers
	2824	Synthetic organic fibers, except cellulosic
	2861	Gum and wood chemicals
	2865	Cyclic (coal tar) crudes, and cyclic intermediates, dyes, and organic pigments (lakes and toners)
	2869	Industrial organic chemicals, not elsewhere classified
	2873	Nitrogenous fertilizers
	2874	Phosphatic fertilizers
	2875	Fertilizers, mixing only
	2879	Pesticides and agricultural chemicals, not elsewhere classified
352: Other chemicals	2831	Biological products
	2833	Medicinal chemicals and botanical products
	2834	Pharmaceutical preparations
	2841	Soap and other detergents, except specialty cleaners
	2842	Specialty cleaning, polishing, and sanitation preparations
	2843	Surface active agents, finishing agents, sulfonated oils and assistants
	2844	Perfumes, cosmetics, and other toilet preparations

(1)	(2)	(3)
	2851	Paints, varnishes, lacquers; enamels, and allied products
	2891	Adhesives and sealants
	2892	Explosives
	2893	Printing ink
	2895	Carbon black
	2899	Chemicals and chemical preparations, not elsewhere classified
353: Petroleum refin	2911	Petroleum refining
354: Miscellaneous petroleum and coal products	2951	Paving mixtures and blocks
	2952	Asphalt felts and coatings
	2992	Lubricating oils and greases
	2999	Products of petroleum and coal, not elsewhere classified
355: Rubber products	3011	Tires and inner tubes
	3021	Rubber and plastics footwear
	3031	Reclaimed rubber
	3041	Rubber and plastics hose and belting
	3069	Fabricated rubber products, not elsewhere classified
356: Plastic products	3079	Miscellaneous plastics products
361: Pottery, china, earthenware	3261	Vitreous china plumbing fixtures and china and earthenware fittings and bathroom accessories
	3262	Vitreous china table and kitchen articles
	3263	Fine earthenware (whiteware) table and kitchen articles
	3264	Porcelain electrical supplies
	3269	Pottery products, not elsewhere classified
362: Glass and products	3211	Fiat glass
	3221	Glass containers
	3229	Pressed and blown glass and glassware, not elsewhere classified
	3231	Glass products, made of purchased glass
369: Other non-metal mineral products	3241	Cement, hydraulic
	3251	Brick and structural clay tile
	3253	Ceramic wall and floor tile
	3255	Clay refractories
	3259	Structural clay products, not elsewhere classified
	3271	Concrete block and brick
	3272	Concrete products, except block and brick
	3273	Ready-mixed concrete
	3274	Lime

(1)	(2)	(3)
	3275	Gypsum products
	3281	Cut stone and stone products
	3291	Abrasive products
	3292	Asbestos products
	3293	Gaskets, packing, and sealing devices
	3295	Minerals and earths, ground or otherwise treated
	3296	Mineral wool
	3297	Nonclay refractories
	3299	Nonmetallic mineral products, not elsewhere classified
unknown whether	3398	Metal heat treating
371 or 372	3399	Primary metal products, not elsewhere classified
371: Iron and steel	3312	Blast furnaces (including coke ovens), steel works, and rolling mills
	3313	Electrometallurgical products
	3315	Steel wire drawing and steel nails and spikes
	3316	Cold rolled steel sheet, strip, and bars
	3317	Steel pipe and tubes
	3321	Gray iron foundries
	3322	Malleable iron foundries
	3324	Steel investment foundries
	3325	Steel foundries, not elsewhere classified
372: Non-ferrous metals	3331	Primary smelting and refining of copper
	3332	Primary smelting and refining of lead
	3333	Primary smelting and refining of zinc
	3334	Primary production of aluminum
	3339	Primary smelting and refining of nonferrous metals, not elsewhere classified
	3341	Secondary smelting and refining of nonferrous metals
	3351	Rolling, drawing, and extruding of copper
	3353	Aluminum sheet, plate, and foil
	3354	Aluminum extruded products
	3355	Aluminum rolling and drawing, not elsewhere classified
	3356	Rolling, drawing, and extruding 'of nonferrous metals, except copper and aluminum
	3357	Drawing and insulating of non-ferrous wire
	3361	Aluminum foundries (castings)
	3362	Brass, bronze, copper, copper base alloy foundries (castings)

(1)	(2)	(3)
	3369	Nonferrous foundries (castings), not elsewhere classified
381: Fabricated metal products	2514	Metal household furniture
	2522	Metal office furniture
	2542	Metal partitions, shelving, lock-era, and office and store fixtures
	3411	Metal cans
	3412	Metal shipping barrels, drums, kegs, and pails
	3421	Cutlery
	3423	Hand and edge tools, except machine tools and hand saws
	3425	Hand saws and saw blades
	3429	Hardware, not elsewhere classified
	3431	Enameled iron and metal sanitary ware
	3432	Plumbing fixture fittings and trim (brass goods)
	3433	Heating equipment, except electric and warm air furnaces
	3441	Fabricated structural metal
	3442	Metal doors, sash, frames, molding, and trim
	3443	Fabricated plate work (boiler shops)
	3444	Sheet metal work
	3446	Architectural and ornamental metal work
	3448	Prefabricated metal buildings and components
	3449	Miscellaneous metal work
	3451	Screw machine products
	3452	Bolts, nuts, screws, rivets, and washers
	3462	Iron and steel forgings
	3463	Nonferrous forging.
	3465	Automotive stampings
	3466	Crowns and closures
	3469	Metal stampings, not elsewhere classified
	3471	Electroplating, plating, polishing, anodizing and coloring
	3479	Coating, engraving, and allied services, not elsewhere classified
	3482	Small arms ammunition
	3483	Ammunition, except for small arms, not elsewhere classified
	3484	Small arms
	3489	Ordinance and accessories, not elsewhere classified
	3493	Steel springs, except wire

(1)	(2)	(3)
	3494	Valves and pipe fittings, except plumbers' brass goods
	3495	Wire springs
	3496	Miscellaneous fabricated wire products
	3497	Metal foil and leaf
	3498	Fabricated pipe and fabricated pipe fittings
	3499	Fabricated metal products, not elsewhere classified
382: Machinery, except electrical	3511	Steam, gas, and hydraulic turbines, and turbine generator set units
	3519	Internal combustion engines, not elsewhere classified
	3523	Farm machinery and equipment
	3524	Garden tractors and lawn and garden equipment
	3531	Construction machinery and equipment
	3532	Mining machinery and equipment, except oil field machinery and equipment
	3533	Oil field machinery and equipment
	3534	Elevators and moving stairways
	3535	Conveyors and conveying equipment
	3536	Hoists, industrial cranes, and monorail systems
	3537	Industrial trucks, tractors, trailers, and stackers
	3541	Machine tools, metal cutting types
	3542	Machine tools, metal forming types
	3544	Special dies and tools, die sets, jigs and fixtures, and Industrial molds
	3545	Machine tool accessories and measuring devices
	3546	Power driven hand tools
	3547	Roiling mill machinery and equipment
	3549	Metalworking machinery, not elsewhere classified
	3551	Food products machinery
	3552	Textile machinery
	3553	Woodworking machinery
	3554	Paper industries machinery
	3555	Printing trades machinery and equipment
	3559	Special industry machinery, not elsewhere classified
	3561	Pumps and pumping equipment
	3562	Ball and roller bearings
	3563	Air and gas compressors
	3564	Blowers and exhaust and ventilation fans
	3565	Industrial patterns
	3566	Speed changers, Industrial high speed drives, and gears
	3567	Industrial process furnaces and ovens

(1)	(2)	(3)
	3568	Mechanical power transmission equipment, not elsewhere classified
	3569	General industrial machinery and equipment, not elsewhere classified
	3572	Typewriters
	3573	Electronic computing equipment
	3574	Calculating and accounting machines, except electronic computing equipment
	3576	Scales and balances, except laboratory
	3579	Office machines, not elsewhere classified
	3581	Automatic merchandising machines
	3582	Commercial laundry, dry cleaning, and pressing machines
	3585	Air conditioning and warm air heating equipment and commercial and Industrial refrigeration equipment
	3586	Measuring and dispensing pumps
	3589	Service industry machines, not elsewhere classified
	3592	Carburetors, pistons, piston rings and valves
	3599	Machinery, except electrical, not elsewhere classified
383: Machinery, electric	3552	Phonograph records and pre-recorded magnetic tape
	3612	Power, distribution, and specialty transformers
	3613	Switchgear and Switchboard apparatus
	3621	Motors and generators
	3622	industrial controls
	3623	Welding apparatus, electric
	3624	Carbon and graphite products
	3629	Electrical industrial apparatus, not elsewhere classified
	3631	Household cooking equipment
	3632	Household refrigerators and home and farm freezers
	3633	Household laundry equipment
	3634	Electric housewares and fans
	3635	Household vacuum cleaners
	3636	Sewing machines
	3639	Household appliances, not elsewhere classified
	3641	Electric lamps
	3643	Current-carrying wiring devices
	3644	Noncurrent-carrying wiring devices
	3645	Residential electric lighting fixtures
	3646	Commercial, industrial, and institutional electric lighting fixtures

(1)	(2)	(3)
	3647	Vehicular lighting equipment
	3648	lighting equipment, not else-where classified
	3651	Radio and television receiving sets, except communication types
	3661	Telephone and telegraph apparatus
	3662	Radio and television transmitting, signaling, and detection equipment and apparatus
	3671	Radio and television receiving type electron tubes, except cathode ray
	3672	Cathode ray television picture tubes
	3673	Transmitting, industrial, and special purpose electron tubes
	3674	Semiconductors and related devices
	3675	Electronic capacitors
	3676	Resistors, for electronic applications
	3677	Electronic coils, transformers and ether inductors
	3678	Connectors, for electronic applications
	3679	Electronic components, not elsewhere classified
	3691	Storage batteries
	3692	Primary batteries, dry and wet
	3693	Radiographic X-ray, fluoroscopic X-ray, therapeutic X-ray, and other X-ray
	3694	Electrical equipment for internal combustion engines
	3699	Electrical machinery, equipment and supplies, not elsewhere classified
384: Transport equipment	3711	Motor vehicles and passenger car bodies
	3713	Truck and bus bodies
	3714	Motor vehicle parts and accessories
	3715	Truck trailers
	3721	Aircraft
	3724	Aircraft engines and engine parts
	3728	Aircraft parts and auxiliary equipment, not elsewhere classified
	3731	Ship building and repairing
	3732	Boat building and repairing
	3743	Railroad equipment
	3751	Motorcycles, bicycles, and parts
	3761	Guided missiles and space vehicles
	3764	Guided missile and space vehicle propulsion units and propulsion unit parts



(1)	(2)	(3)
	3769	Guided missile and space vehicle parts and auxiliary equipment, not elsewhere classified
	3792	Travel trailers and campers
	3795	Tanks and tank components
	3799	Transportation equipment, not elsewhere classified
385: Professional and scientific equipment	3811	Engineering, laboratory, scientific, and research instruments, and associated equipment
	3822	Automatic controls for regulating residential and commercial environments and appliances
	3823	Industrial instruments for measurement, display, and control of process variables; and related products
	3824	Totalizing fluid meters and counting devices
	3825	Instruments for measuring and testing of electricity and electrical signals
	3829	Measuring and controlling devices, not elsewhere classified
	3832	Optical instruments and lenses
	3841	Surgical and medical instruments and apparatus
	3842	Orthopedic, prosthetic, and surgical appliances and supplies
	3843	Dental equipment and supplies
	3851	Ophthalmic goods
	3861	Photographic equipment and supplies
	3873	Watches, clocks, clockwork operated devices, and parts
390: Other manufactured products	3911	Jewelry, precious metal
	3914	Silverware, plated ware, and stainless steel ware
	3915	Jewelers' findings and materials, and lapidary work
	3931	Musical instruments
	3942	Dolls
	3944	Games, toys, and children's vehicles; except dolls and bicycles
	3949	Sporting and athletic goods, not elsewhere classified
	3951	Pens, mechanical pencils, and parts
	3952	Lead pencils, crayons, and artists' materials
	3953	Marking devices
	3955	Carbon paper and inked ribbons
	3961	Costume jewelry and costume novelties, except precious metal
	3962	Feathers, plumes, and artificial trees and flowers

(1)	(2)	(3)
	3963	Buttons
	3964	Needles, pins, hooks and eyes, and similar notions
	3991	Brooms and brushes
	3993	Signs and advertising displays
	3995	Burial caskets
	3996	Linoleum, asphalted-felt-base, and other hard surface floor coverings; not elsewhere classified
	3999	Manufacturing industries, not elsewhere classified

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