How Contagious is the "Baumol's Cost Disease"? Intermediates Use in the United States.*

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June 2010

Abstract

This paper shows that the "Baumol's cost disease" has contaminated the intermediates use of United States economy body. The increasing use of the relatively expensive services-intermediates enforces the increasing costs of production from the increasing final demand for services. This paper establishes that the aggregate trend is driven also by the continuous substitution of goods-intermediates with services-intermediates at the industry-level. A regression analysis supports that the complementarity between goods and services-intermediates is an important factor behind the pure substitution effect. The latter is a factor conducive to mitigating the aggregate labour productivity losses from the intermediates reallocation over time.

JEL classification: L16, O14, O41, O47
Keywords: Baumol's cost disease, intermediates, goods, services, elasticity of substitution

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*The author would like to thank Francesco Caselli, Byeongju Jeong, Peter Katuščák, Rachel Ngai, Peter Ondko, Christopher Pissarides, Jonathan Temple, Katrin Tinn and Alwyn Young for their helpful comments and suggestions. Financial support from the Lilian Voudouri Foundation, ESRC and Global Development Network (RRC IX-73) in various stages of the project is gratefully acknowledged. CERGE-EI is a joint workplace of the Center for Economic Research and Graduate Education, Charles University, and the Economics Institute of the Academy of Sciences of the Czech Republic.
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1 Introduction

The literature has extensively studied the sources and consequences of the continuous expansion of the services-sector in aggregate value added of the advanced economies (e.g., see Ngai and Pissarides 2007, Echevarria 1997, Kongsamut, Rebelo, and Xie 2001). For the United States in the course of the past four decades the cumulative effect of this change is a 13pp. value added reallocation.[1] At the same time, despite some notable exceptions (e.g., Finance) the services-sector at the aggregate level exhibits relatively low productivity growth (e.g., see Bosworth and Triplett 2004, Jorgenson, Ho, and Stiroh 2005). These secular trends are the main symptoms of the "Baumol's cost disease" (originally developed in Baumol and Bowen 1965, Baumol 1985, Baumol, Blackman, and Wolff 1967). The prediction of this theory is that the dynamic impact of this composition change is the increasing cost of each unit of production and long-run stagnation.

This paper highlights a secular trend in the composition of the aggregate intermediate inputs used in production: there is continuous substitution of goods-intermediates with services-intermediates in aggregate production. As an illustration, Figure 1 shows that in 1970 28 cents out of every US dollar of (gross output) production was spent on the goods-intermediate inputs and 18 cents for services-intermediates. By 2005, only 20 cents were allocated for goods-intermediates, while the expenditure on services-intermediates had reached 23 cents. Overall, the rising importance of the United States services-sector for the production and use of intermediates is quantitatively similar to that for value added.[2]

Studying the secular trend in intermediates use and investigating its sources is important in view of the role of intermediates in the supply side. This is because, intermediates account for half of production input and output and constitute inter-sectoral

[1] Table 10 in Appendix A.3 demonstrates for selected years that this trend is prevalent in both the final and gross output production.

[2] See Table 11 in Appendix A.3. The presence of these trends is confirmed in the analysis of data for the 1997-2005 period by Strassner, Medeiros, and Smith (2005) of the Bureau of Economic Analysis.

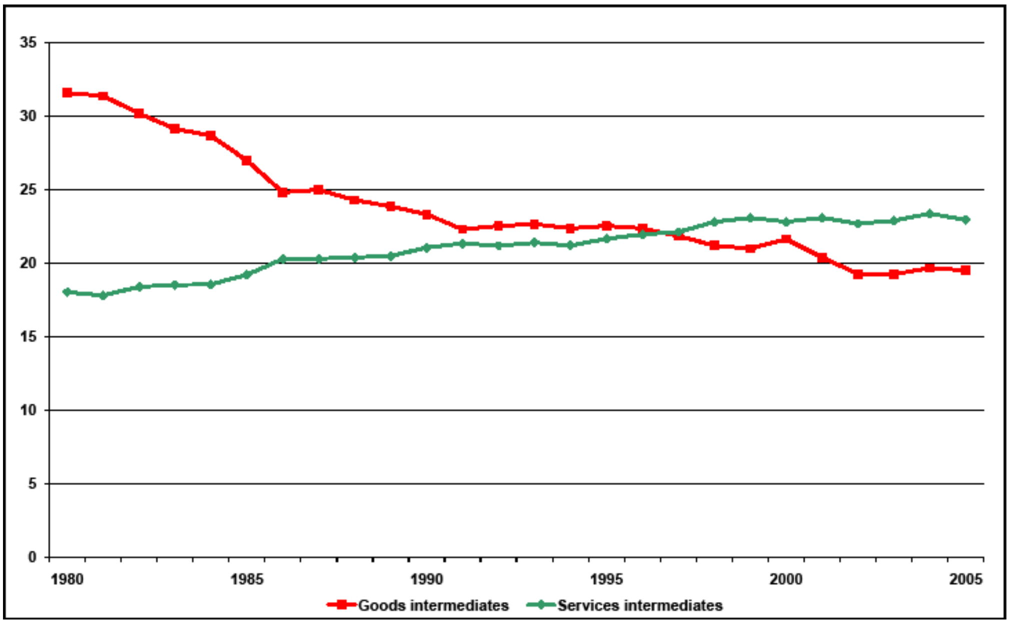

Figure 1: United States composition of gross output in terms of goods and services-intermediates.

production linkages and thereby propagation mechanisms of any technology shocks (e.g., see Jorgenson, Ho, and Stiroh 2005, Ngai and Samaniego 2009, Vourvachaki 2009). This paper fills in the gap in earlier studies and examines the role of this trend in contributing to the well-celebrated increasing cost of services.[3]

This paper shows that when controlling for the changing composition of the economy, the rising importance of the services-intermediates expenditures is driven by a substitution of goods-intermediates expenditures with the services ones for the average United States industry. Using detailed industry information from the United States Input-Output (I-O) tables this paper establishes a statistically significant 7pp. rise in the services-intermediates expenditure share during the 1970-2005 period. It shows further that there is a negative trend in the relative price of the goods-intermediates; namely, the relative gross output prices of goods fall at a -1.4% statistically significant rate.[4] These

[3] Earlier studies do not put explicit attetion to this fact partly due to the lack of detailed data on intermediates until recently. Besides, the conventional view is that technical coefficients are virtually constant over time. For example, see comments in Chapter 4 of Jorgenson, Ho, and Stiroh (2005).

[4] For description of the price data see in Sections 3, and Appendix A.2. See also Figures 8-10 in

symptoms clearly resemble the "cost disease".

It then becomes puzzling why the average industry in the United States spends more on the intermediate inputs that are relatively more expensive thereby contributing to increasing the costs (and thus price) of each unit of their production. This paper explores the hypothesis that the "intermediates cost disease" exists due to the complementarity between goods and services-intermediates in production. For example, consider food production that uses both goods-intermediates inputs, like agricultural products, as well as services ones, like advertising. There is only a limited scope for substitutability between these inputs. To a great degree advertising is *necessary* for the production of any unit of food products and getting more agricultural products, electronic components, utensils etc. cannot create and implement an advertising idea. As a result, if agricultural products become cheaper over time they lower food input costs and raise production level. This creates a positive effect on the demand of the relatively expensive advertising services.

In order to test whether the complementarity hypothesis is supported by the data, this paper builds an empirical framework for the allocative decisions of an industry regarding intermediates inputs. The regression results support throughout a statistically significant and below one elasticity of substitution between goods and services-intermediates. This is robust to the inclusion of additional controls that hold explanatory power for the observed patterns of intermediates use other than prices. Such controls capture factors that are latent at the data detail available (e.g., technology, policy, industrial structure).

Regarding the aggregate impact of the changing composition in intermediates expenditures of the average United States industry, this paper reaches two conclusions. First, it shifts total requirement coefficients over time to imply lower aggregate production costs, but also higher (lower) exposure of the services (goods)-sector to any external demand shocks in the economy. Second, the intermediates reallocation that is driven by the industry size composition is large enough to offset the benefits from the changing

Appendix A.3.

composition within intermediates and bring about losses in labour productivity growth at the aggregate level. Thus, intermediates reallocation increases production costs over time; the "cost disease" is particularly severe for services.

As a final note, this paper acknowledges that its conclusions are limited from the information available. The analysis at the goods and services sector-level is well motivated by their distinct technological features and products and the literature on the rising importance of services sector and offers a solid overview of the patterns in intermediates use. However, the lack of finer detail in the data arguably restricts the ability to shed more light to the factors relevant for the observed aggregate trends. Moreover, the results are subject to the common criticisms for studies that aim to account for the intermediates' use based on information from the Input-Output (I-O) tables. This is because the I-O tables only account for the intermediates' purchases of domestic firms from suppliers that come from the same or different industry and are located domestically or abroad. Therefore, the importance of factors like industrial structure (degree of vertical integration), within-firm intermediates production and imports in driving the intermediates' use patterns cannot be fully understood and quantified. This would be feasible with detailed micro-level information with sufficiently long time dimension. The present study is a first step to account at a "macro" level the drivers of the intermediates use in a consolidated framework.

This paper contributes to the literature originated by W. J. Baumol on the costs associated with the services-sector growth and its causes (for a review see Nordhaus 2008), by explicitly studying intermediates in this context. In a similar spirit, Oulton (2001) shows that allowing the low productivity sectors to produce intermediates can overturn the original dim prediction that the cost disease results in declining aggregate growth rate in the long-run. His main insight is that services-intermediates can be substitute for the primary inputs (e.g., labour) of the fastest growing economic sector. This insight is shared by views that the new technologies in the 1980s created scope for reducing goods' production costs by outsourcing (and/or offshoring) some labour intensive activities (ten Raa and Wolff 2001). The rising importance of services outsourcing (see Abraham and Taylor 1993, Girma and Görg 2004, Yuskavage, Strassner, and Medeiros 2006, Abramovsky and Griffith 2007) is in line with the rising use of services-intermediates highlighted in this paper, but cannot by itself account for the aggregate trend. Moreover, this paper's key insight is that the scope for reducing intermediate costs of production is limited by their complementarity in production. A further discussion of these issues is postponed until the in-depth presentation of the results.

Finally, this paper broadly relates to studies that deviate from the conventional wisdom of unit elasticity of substitution across factors of production in order to explain important disaggregate dynamics in their use patterns (e.g., see Krusell, Ohanian, Rios-Rull, and Violante 2000, Antràs 2004, Jin and Jorgenson 2007).[5] It also relates to studies that consider non-unit elasticities of substitution between final goods and confirms earlier findings of complementarity between goods and services in aggregate consumption (e.g., see Stockman and Tesar 1995, Ngai and Pissarides 2004).

This paper is organized as follows: Section 2 presents the data sources and their properties and defines the main variables used. The empirical analysis and presentation of results is in Section 3. Section 4 analyzes the aggregate impact of structural change in intermediates use. Section 5 concludes.

[5] Jin and Jorgenson (2007) find "material-saving" technical bias and also a positive correlation between "input-using" technical bias and high input prices in their sample of United States industries. However, unlike the present paper they cannot link their results to structural change trends, because they do not pin down their results explicitly in terms of goods and services-intermediates.

2 Data Sources and Definitions

2.1 The EU KLEMS dataset

The data used for this analysis come from the latest detailed public version of the EU KLEMS database (version March 2008). This database includes data for 25 European countries (EU-25), the Australia, Japan, Korea and the United States. The database includes measures of gross output, value added, employment and capital formation. The input measures include both primary inputs in production, capital (K) and labour (L), as well as secondary inputs in production, energy (E), materials (M) and service intermediates (S). The growth accounts are consistent with the standard practices developed in the literature (e.g., see Fraumeni, Gollop, and Jorgenson 1987). This analytical framework is based on well-defined production functions at the industry and aggregate level and has the benefit of a sound economic growth theory background.

The data for the United States economy are based on the annual industry accounts provided by the Bureau of Economic Analysis (BEA). The BEA accounts used the Standard Industry Classification (SIC) until 1998 when they moved to the North American Industry Classification (NAICS). The version available from EU KLEMS with greatest possible detail for the purposes of the study of this paper, US SIC version, is based on SIC KLEMS data for 1970-2000 and are extrapolated forward using NAICS. The sources for nominal and volume measures regarding the inter-industry accounts come from the National Accounts. For the 1960-2000 period, the data are taken from Dale Jorgenson. The details for the method followed for the construction of these data and their comparison with direct BEA and BLS statistics is provided in Chapter 4 of Jorgenson, Ho, and Stiroh (2005). The breakdown of their 44-industry level into the industry detail of EU KLEMS database is made on the basis of weights, that are calculated with the use of Benchmark Input-Output (I-O) tables from BEA. For the 2000-2005 period, there is forward projection of the data on intermediate inputs from the Bureau of Labour Statistics (BLS) Office of Employment Projections, using the BEA GDP by industry accounts. Original Industry classification for the dataset follows NACE ("Nomenclature statistique des Activités économiques dans la Communauté Européenne", i.e. Statistical classification of economic activities in the European Community). Details on the mapping to NACE for the United States economy is found in the country notes details of the dataset. Finally, this paper examines directly also the "Benchmark and Annual Input-Output Accounts" available from the BEA, in order to cross-verify the validity of some results or robustness of trends in EU KLEMS.

It is worth noting some particular properties of the data that make them particularly conducive to the needs of the present paper. First, intermediates inputs are valued at purchasers' prices, which account for the actual marginal costs assumed from their users. Importantly, the trade margins are treated separately and are allocated as services provided from the respective industry implying that the role of the respective industries in the production of intermediates is correctly accounted.[6] Second, the intra-industry intermediates purchases are excluded in the reported aggregated series of intermediates used, which is important for the proper account of the "sector" gross output (e.g., see Gullickson 1995, Jorgenson, Ho, and Stiroh 2005). Third, the intermediate purchases for every industry include the intermediates imported that are not separately identified.[7] Fourth, the principle for reporting intermediates purchases in I-O Tables is that they result from trade of plants within the same or across firms/industries. As a result, these data do not provide any information on the intermediates' use produced within the firm itself. They also do not distinguish between purchases of intermediates within

[6] This could matter for cross-country comparisons since the European data do not treat the trade margins distinctly. Nevertheless, using directly the BEA I-O Tables shows that in the United States the trends in intermediates use would have been the same, should the intermediates were valued at producer prices, i.e., excluding any taxes/subsidies or trade margins.

[7] For the United States, the intermediates purchases of commodities that do not have a domestic analog are classified as "non-comparable imports" and are reported at a separate line in the I-O Tables. For details about their treatment see Chapter 4 of Jorgenson, Ho, and Stiroh (2005).

plants/firms that belong to the same group (vertically integrated) and the ones across firms that are not related through the firm's structure.

2.2 Industry classification

The industry "Public administration and defence; compulsory social security" is excluded throughout, in order to focus more on market activities.[8,9] The remaining 2-digit level NACE industries are aggregated at the level of goods-sector (*hereafter denoted by subscript "G"*) and services-sector (*hereafter denoted by subscript "S"*). The goods-sector includes all the non-services industries, i.e., Agriculture, Hunting, Forestry and Fishing, Mining and Quarrying, Manufacturing, Utilities and Construction (NACE A-F). The analysis is repeated at the two-/three-digit level; total of 64 industries. The 40 goods-industries and 24 services-industries aggregate to the sector-level analysis goods and services data respectively. The total market economy is the aggregate of the goods and services-sector. Table 12 in Appendix A.3 presents the set of industries that were used at the sector and industry-level analysis, together with their NACE codes.

2.3 Variables definitions and aggregation method

For every industry the following value variables are available:[10]

Gross Output at current basic prices (millions of USD). Basic prices are the prices received by the producer for each unit of its production. They include subsidies to production.

Intermediate inputs at current purchasers' prices (millions of USD). Purchasers' prices are the prices paid by an industry for a unit of intermediates. They reflect the marginal cost

[8] Direct check from the BEA I-O Tables suggests that this would ot change any of the qualitative features in this study.

[9] The indusries "Private Households with Employed Persons" (NACE P) and "Extra-territoria Organizations and Bodies" (NACE Q) are also excluded due to lack of any information for intermediates use.

[10] Details on the definitions in original United States National Accounts.

paid by the using industry, and thus they include any taxes on commodities paid by the user (non-deductible VAT included), while they exclude any subsidies on commodities[11].

Energy, Materials and Services Intermediate inputs at current purchasers' prices (millions of USD). Energy intermediates are all the energy mining (NACE 10-12), oil-refining (NACE 23) and electricity and gas (NACE 40) products. services-intermediates are all services (NACE 50-99) products. The rest of the products are classified as materials. *Goods-intermediates* is the aggregate of the energy and materials products.

Value Added (gross) at current basic prices (millions of USD).

The aggregation over industries at the sector or total market economy-level is straightforward and follows directly from the income identity. In every period t, the value of gross output of an industry i, $p_Y Y_{it}$, is the sum of its value added, $p_V V_{it}$ and intermediate input, $p_I I_{it}$.[12] The value of intermediates used is the sum of the goods-intermediates (*hereafter denoted by superscript "g"*), $p_{I^g} I_{it}^g$, and services-intermediates (*hereafter denoted by superscript "s"*), $p_I^s I_{it}^s$.

Gross Output Volume Index (1995=100). Each industry i produces a set of K distinct products. The growth of industry gross output, Y_i, is the Törnqvist index of the growth rates of each product k, Y_i^k. Hence, at every point in time the annual real gross output growth rate is given by the following formula: $\Delta \ln Y_{it} = \sum_{k=1}^{K} \bar{v}_{kit} \Delta \ln Y_{it}^k$, where $\bar{v}_{kit}$ is the $(t-1, t)$ period average share of product k in the value of the industry i output. The aggregation at the sector (or total economy-level) is done in a similar manner, where weights are the industry output shares in the sector (total economy) output.

[11] These prices should include the margins of trade and transportation as well. However, when trade and transportation products are listed seperately, then all margins should be allocated to them. This is the case for the US SIC-based data. The data in EUKLEMS for the rest of the countries do not report the margins on trade and transportation costs separately. That leads to biases on the potential contribution of each type of intermediate on output growth. For the United States, the BEA I-O Use Tables data show that there is an upward bias in the level of the share of use of goods intermediates. The trend over time is not affected.

[12] Note that the notation here is that for example $p_V V_{it}$ stands for the value overall of the maesured output makes at this point no explicit distinction for the variation of their prices.

Intermediate Inputs Volume Index (1995=100). Each industry i uses a set of X distinct commodities. The growth of the aggregate intermediate input quantity of the industry, I_i, is calculated is the Törnqvist aggregate over the growth rates of all type-x intermediates, I_i^x. Hence, at every point in time the annual intermediate input volume growth rate is given by: $\Delta \ln I_{it} = \sum_{x=1}^{X} \bar{v}_{it}^x \Delta \ln I_{it}^x$, where $\bar{v}_{it}^x$ is the $(t-1,t)$ period average use share of type-x intermediate, $x \in \{g, s\}$. For the aggregation at the sector (or total economy-level) the industry-level intermediate inputs volume growth is weighted with the industry output shares in the sector (total economy) output.

Energy, Materials and Services Intermediate inputs Volume Index (1995=100). Each of these indexes is defined in the same way as the total intermediate input volume index for the particular type of intermediates (energy, materials, services). While the services-intermediates volume index is directly available at the industry-level, the goods-intermediates one is constructed as the Törnqvist aggregate index of the energy and materials intermediates volume indexes. Hence, for every industry, it is the weighted sum of the volume indexes of material and energy intermediates, with weights the use share of each type in total goods-intermediates.

Value Added Volume Index (1995=100). Given the gross output identity, $p_Y Y_{it} = p_V V_{it} + p_I I_{it}$, then the Törnqvist index for the output volume growth of an industry i is: $\Delta \ln Y_{it} = \bar{v}_{it}^V \Delta \ln V_{it} + \left(1 - \bar{v}_{it}^V\right) \Delta \ln I_{it}$, where $\bar{v}_{it}^V$ is the average share of value added in gross output. Therefore, the implicit value added growth index is:
$\Delta \ln V_{it} = \frac{1}{\bar{v}_{it}^V} \left[\Delta \ln Y_{it} - \left(1 - \bar{v}_{it}^V\right) \Delta \ln I_{it}\right]$.

Aggregation at the sector/economy-level is the Törnqvist index of the volume growth of all different industries within the sector/economy, where weights are the average value added shares of each industry. The gross output and intermediates price indexes are constructed by the difference between the value and the volume growth of the corresponding series for both the industry and the aggregate level.

3 Empirical Analysis

3.1 The stylized facts of intermediates use structural change

Main features of the 1970-2005 period in the United States are the increasing share of the services-sector in the production of both final and intermediates products, and increasing expenditure share on services-intermediates out of every unit of production (namely, a 0.9% statistically significant trend).[13] The latter is confounded by the mild shift away from the use of intermediates in gross output production that also took place during the same period.[14] To control for its impact, Figure 2 shows the nominal and the real expenditure share of goods-intermediates in total intermediates expenditures for the 1980-2005 period.[15] It confirms the presence of a continuous substitution of goods-intermediates with services-intermediates in total intermediates expenditures. It also highlights that the trend in nominal terms was not matched by the one in real terms (trends are statistically different at -2.9% and -1.4% respectively).

The afore evidence is supportive of the presence of structural change in the United States intermediates use, yet inconclusive. This is because the aggregate trend can be driven from the expansion of services, if the latter use intensively the services-intermediates. This is a composition effect due to the "size effect". The remaining analysis is devoted to quantifying the size effect and establishing the presence of the pure "substitution effect" in the United States intermediates use data.[16]

[13] Recall the related discussion in the Introduction together with Figure 1 and Tables 10 and 11 of Appendix A.3.

[14] The share of intermediates in gross output was 47% in 1970 and 43% in 2005; see Figure A.3 in Appendix A.3). This trend suggests that the overall volume of market transactions of goods and services across industries reduces over time (a -0.76% statistically significant trend).

[15] Figure 2 illustrates the "nominal use share" of goods-intermediates in terms of the services-intermediates, $\frac{p_{I^g} I_j^g}{p_{I^s} I_j^s}$, and the "real use share" of goods-intermediates (equals the nominal share when 1995=1), $\frac{I_j^g}{I_j^s}$. For the entire 1970–2005 period and for both goods and services sectors, see Figures A.3-A.3 in Appendix A.3 that present the real and nominal shares series, along with information on the relative prices of goods-intermediates in terms of gross-output prices (price index 1995=1), $\frac{p_{Y_G}}{p_{Y_S}}$, .

[16] For a detailed exposition of the size effect and its relevance in aggregate trends see Appendix A.1.

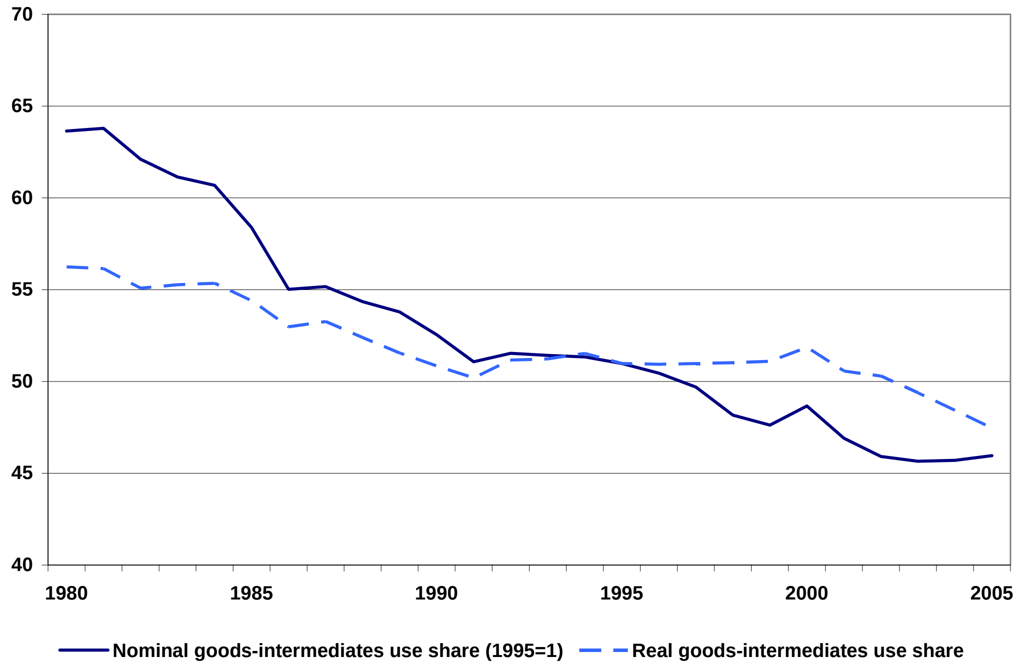

Figure 2: United States goods-intermediates nominal and real use share.

3.1.1 Disaggregate-level analysis

Table 1 presents the composition of the gross output of the goods and services-sector in terms of value added, intermediate inputs, and goods and services-intermediates.[17] The downward trend in the goods-intermediates share is confirmed when controlling for the changing sector size. Moreover, Table 1 shows that the goods-sector uses more intermediates for the production of its gross output compared to the services one, while each sector uses more intensively the intermediates produced by itself (e.g., the goods-sector production uses more goods-intermediates).

In order to systematically decompose the aggregate measures into the pure substitution and other effects, define $\frac{p_{I^x} I_j^x}{p_V V_j}$; the share of type-$x$ intermediates, $x \in \{g, s\}$, used by sector $j \in \{G, S\}$, $p_{I^x} I_j^x$, out of the using sector's value added, $p_V V_j$.[18] De-

[17] Recall that the gross output identity holds at any level of a productive unit, so that for a sector $j \in \{G, S\}$ in every period t: $p_Y Y_{jt} = p_V V_{jt} + p_I I_{jt}$, where $p_I I_{jt} = p_{I^g} I_{jt}^g + p_{I^s} I_{jt}^s$.

[18] Recall that for example I_G^g stands for the goods-intermediates (I^g) *used* by goods-sector G. For

Table 1: United States goods and services-sector gross output composition

Gross output of	Goods-sector			Services-sector		
year/sector	VA	Intermediates		VA	Intermediates	
		goods	services		goods	services
1980	38.8	47.7	13.5	63.1	11.5	23.7
1985	39.9	44.3	15.8	65.3	9.8	22.6
1990	41.1	41.6	17.3	65.2	8.6	24.1
1995	41.0	41.7	17.3	64.9	8.4	24.9
2000	41.7	41.1	17.3	63.5	8.5	26.6
2005	42.8	38.8	18.3	66.5	7.7	25.8

fine also the total value of intermediates used by sector j as $p_I I_j$ (i.e., by construction, $p_I I^j = p_{I^g} I_j^g + p_{I^s} I_j^s$). The share of type-$x$ intermediates used in the sector's value added can be expressed as follows:

$$\frac{p_{I^x} I_j^x}{p_V V_j} = \frac{p_{I^x} I_j^x}{p_I I_j} \frac{p_I I_j}{p_V V_j},$$

so that the its exponential growth rate, g, can be decomposed as follows:

$$g\left(\frac{p_{I^x} I_j^x}{p_V V_j}\right) = g\left(\frac{p_{I^x} I_j^x}{p_I I_j}\right) + g\left(\frac{p_I I_j}{p_V V_j}\right).$$

This shows that the growth of the share of type-x intermediates used in the sector's final output can be driven by a pure substitution effect, i.e. the change in the expenditure share of the type-x intermediates, $\frac{p_{I^x} I_j^x}{p_I I_j}$, and/or overall changes in the production structure of the sector in terms of combining the set of primary inputs with that of secondary ones, $\frac{p_I I_j}{p_V V_j}$.

Table 2 presents such decompositions of the 1981-2005 average annual growth of the value added share of goods and services-intermediates for both goods and services sectors.[19,20] The results support that goods-intermediates (services-intermediates) expen-

details on the decomposition see Appendix A.1.

[19]There is no bias due to the data-break point in 1983. The 1985-2005 period analysis gives similar qualitative and quantitative results.

[20]In a similar manner, define the share of the value of type-x intermediates that are used by sector j out of the value added of type-x intermediates' producing sector $j' \neq j$, $p_V V_{j'}$, as $\frac{p_{I^x} I_j^x}{p_V V_{j'}} =$

diture share has been strongly decreasing (increasing) in both sectors. The downward trend in the goods-intermediates use share is statistically significant: equals -1.16% (s.e. 0.08) for the services-sector and -0.44% (s.e. 0.03) for the goods-sector.[21] In support of the structural change fact there is a statistically significant fall of the goods-intermediates share by 7 pp. for both sectors. It is also noteworthy that while the share of intermediates in value added has decreased in either sector, this effect is almost always dominated by the pure substitution trend.

Table 2: United States trends in the goods and services-sector shares of intermediates in value added and their decomposition

Sector using intermediates:	Goods		Services	
Goods-intermediates share in value added	$\frac{p_{I^g} I^g_G}{p_V V_G}$	-1.21	$\frac{p_{I^g} I^g_S}{p_V V_S}$	-1.72
contribution by:				
expenditure share of goods-intermediates	$\frac{p_{I^g} I^g_G}{p_I I_G}$	-0.55	$\frac{p_{I^g} I^g_S}{p_I I_S}$	-1.41
all intermediates share in value added	$\frac{p_I I_G}{p_V V_G}$	-0.66	$\frac{p_I I_S}{p_V V_S}$	-0.30
Services-intermediates share in value added	$\frac{p_{I^s} I^s_G}{p_V V_G}$	0.83	$\frac{p_{I^s} I^s_S}{p_V V_S}$	0.24
contribution by:				
expenditure share of services-intermediates	$\frac{p_{I^s} I^s_G}{p_I I_G}$	1.49	$\frac{p_{I^s} I^s_S}{p_I I^S}$	0.54
all intermediates share in value added	$\frac{p_I I_G}{p_V V_G}$	-0.66	$\frac{p_I I_S}{p_V V_S}$	-0.30

Notes: units in 1981-2005 average annual exponential growth (%)

As a further robustness check, Figures 3 and 4 employ the information at the 64-industry detail to illustrate respectively how the goods and services sector-level growth of the goods-intermediates use share is decomposed into the "within-industry" and "between-industry" effects.[22] Clearly, the within-industry effect accounts almost completely for the

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$\frac{p_{I^x} I^x_j}{p_I I_j} \frac{p_I I_j}{p_V V_j} \frac{p_V V_j}{p_V V} \frac{p_V V}{p_V V_{j'}}$. This implies $g\left(\frac{p_{I^x} I^x_j}{p_V V_{j'}}\right) = g\left(\frac{p_{I^x} I^x_j}{p_I I_j}\right) + g\left(\frac{p_I I_j}{p_V V_j}\right) + \left[g\left(\frac{p_V V_j}{p_V V}\right) - g\left(\frac{p_V V}{p_V V_{j'}}\right)\right]$ that high-tlights how the relative size of the services-sector (2.55% annual rate) affects production patterns.

[21] The regression fit is $\bar{R}^2$=0.83 for the goods-sector and $\bar{R}^2$=0.85 for the services one. When controlling for a set of time-dummies, one can identify the time period that drives this negative trend. This shows that the only period that the share was actually increasing was in the period of the oil-shocks and United States early 1980s' recession (1974-1984). During this period there was a big increase in the goods-intermediates prices (especially energy) and major changes in financial services.

[22] The average industry in the goods-sector has annual trend of -0.32% –the median ones "Agriculture" (NACE 1) and "Textiles" (NACE 17) have -0.21%. The average industry in services has a trend of -0.85% –the median "Hotels and Restaurants" (NACE H) and "Other recreational activities" (NACE 923t7) has -0.73%.

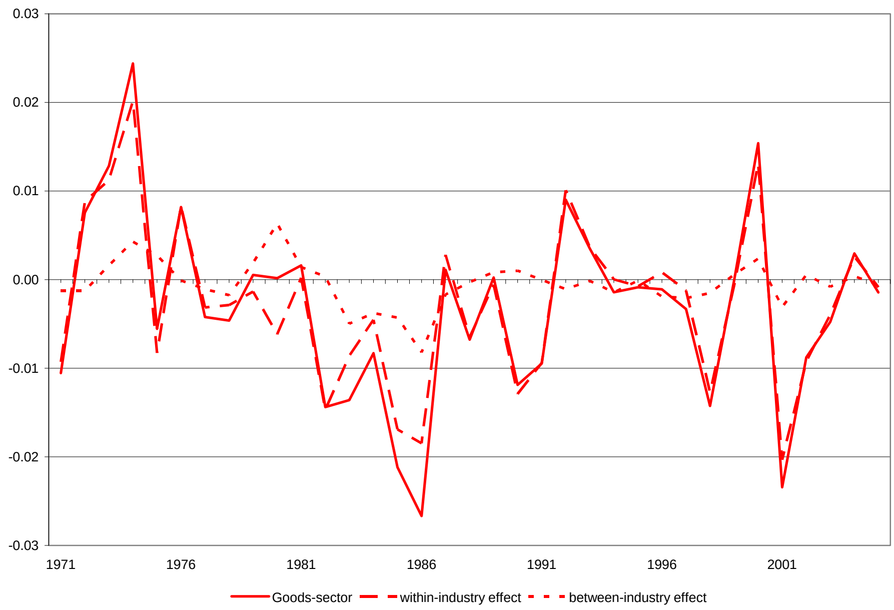

Figure 3: United States decomposition of the growth of the goods-sector's goods-intermediates use share.

sector-level growth data. The explanatory power of the between-industry effect is marginally bigger in the goods-sector and on average accounts alone for 30% of the sector-level variation.

Table 3 demonstrates that there is a 7pp. statistically significant decrease in the goods-intermediates use share during the 1970-2005 period. Regressions of the (log) goods-intermediates use share, γ_{it}, on a linear time trend among other controls indicate a stronger trend for the services-sector, albeit more noisy (columns (1)-(3)).[23] Also, the results suggest that unobserved fixed industry-specific heterogeneity accounts for most of the observed trend in goods-intermediates use share (columns (4)-(5)).

[23] In the data, the cross-sectional standard deviation of growth is 0.83 for services compared to 0.53 for goods. As an illustration, the annual trend ranges from 0.27% for the industry "Other Inland Transport" (NACE 60) to -3.08% for "Insurance and pension funding, except compulsory social security" (NACE 51). For the goods-sector the range is between 0.43% for "Radio and television receivers" (NACE 323) to -2.33% for "Chemicals excluding pharmaceuticals" (NACE 24x). The annual trend ranges from 0.27% for the industry "Other Inland Transport" (NACE 60) to -3.08% for "Insurance and pension funding, except compulsory social security" (NACE 51). For the goods-sector the range is between 0.43% for "Radio and television receivers" (NACE 323) to -2.33% for "Chemicals excluding pharmaceuticals" (NACE 24x).

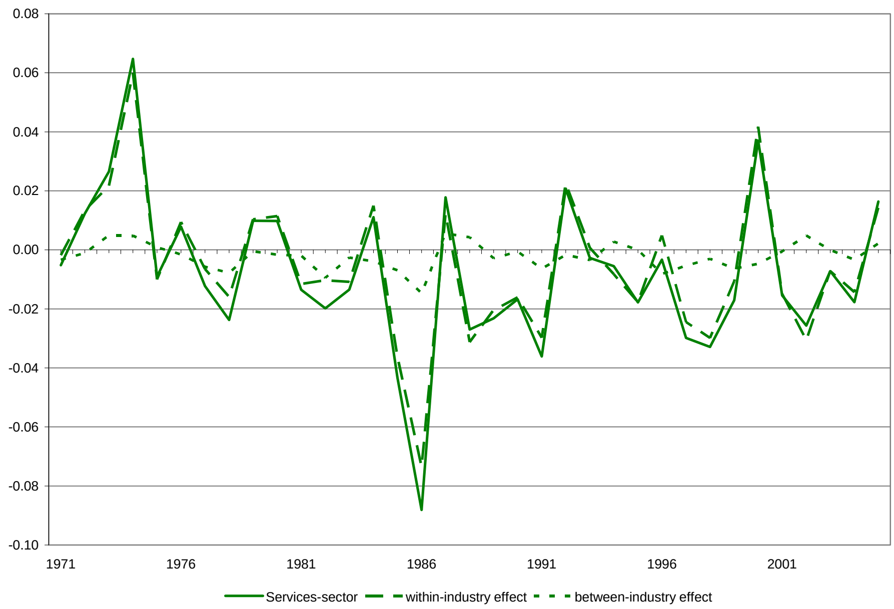

Figure 4: United States decomposition of the growth of the services-sector's goods-intermediates use share.

3.2 Econometric analysis

This section proceeds with a systematic account of the sources of the substitution effect present in the industries' intermediates expenditures. Specifically, it investigates the validity of the hypothesis services-intermediates have a sufficiently price inelastic demand. If this is the case, then in the face of their increasing prices their expenditure shares would rise as well. This hypothesis is tested in the context of a regression specification that is derived from the conditions characterizing the optimal allocative decisions of the average industry.

The corresponding theoretical framework makes assumptions that are consistent with the standard growth accounting assumptions and the principles underlying the construction of industry accounts (e.g., the use of superlative indexes). The model also imposes restrictions to the data that are necessary for the identification of the parameter of interest in view of the "impossibility theorem" of Diamond, McFadden, and Rodriguez (1978) that the elasticity of substitution between two factors of production of a gen-

Table 3: United States industry-level trends in the goods-intermediates use share

Dependent variable: $\ln \gamma_{it}$					
Controls:	(1)	(2)	(3)	(4)	(5)
constant	4.001 (0.027)***	3.453 (0.039)***	0.410 (0.038)***	yes	yes
trend	−0.007 (0.001)***	−0.012 (0.002)***	−0.012 (0.000)***		
D_j		0.889 (0.039)***			
$D_j * trend$		0.008 (0.002)***	0.008 (0.000)***		
$industry\ fixed-effects$			yes**	yes**	yes**
$D_j * time-effects$				yes**	
$industry\ trends$					yes**
obs	2304	2304	2304	2304	2304
$\bar{R}^2$	0.01	0.64	0.98	0.98	0.99
F-test	28.62	895.86	2145.64	1667.43	3484.12
Implied average annual trend (%) in industry group					
Goods-sector	−0.68 (0.13)***	−0.38 (0.06)***	−0.38 (0.02)***	-	-
Services-sector	−0.68 (0.13)***	−1.18 (0.20)***	−1.18 (0.04)***	-	-

Notes: s.e. in parentheses, (***) denotes significance at 1%, (**) at 5%, (*) at 10%,

(yes) denotes control for fixed-effects; (yes**) denotes the F-test rejects the H_0 of no joint-significance at 5%

D_j is a dummy for goods sector

eral neoclassical production function cannot be identified in the presence of technological change. Such restrictions regard the production function itself and the properties of the technological process.

In particular, it is assumed that every industry i's gross output production function, $Y_i = F\left(V_i(K_i, L_i), I_i(I_i^g, I_i^s)\right)$, is separable in its value added, $V_i(.)$, and intermediates, $I_i(.)$,component and homogeneous of degree one with respect to both primary (capital K_i or labour L_i) and intermediate inputs (goods I_i^g or services I_i^s). It follows also that each of the two components of the gross output production function, value added $V_i(.)$ and intermediates, $I_i(.)$, is a homogeneous of degree one function of its inputs. These assumptions on the production technology allow for the industry production control problem to take place in two stages: In the first one, the industry decides the aggregate level of intermediate expenditures. In the second one the industry chooses its demand for each type of intermediates. Both input and output markets are assumed to be perfectly competitive. Given this, the prices of intermediates equal the marginal costs in their production and no single industry affects their price.[24,25]

Under these assumptions, at every point in time each industry i belonging to sector $j \in \{G, S\}$ chooses its demand for goods and services-intermediates, given their respective prices p_{I^g} and p_{I^s}, and level of total intermediates expenditures $\tilde{I}_i$:[26]

$$\max_{\{I_i^g,\, I_i^s\}} \left\{ \left[\theta \left(I_i^g\right)^{\rho} + (1-\theta)\left(I_i^s\right)^{\rho}\right]^{\frac{1}{\rho}} ;\ \tilde{I}_i = p_{I^g} I_i^g + p_{I^s} I_i^s \right\}, \tag{1}$$

where θ is a distribution parameter and ρ, $\rho < 1$, is the parameter determining the elasticity of substitution of the two types of intermediates, $\sigma = \frac{1}{1-\rho}$; $\sigma > 0$. The CES production is a widely used and flexible specification of the production that reduces the elasticity to the estimation of a single parameter. Despite restrictive, as discussed earlier this assumption is one of the steps necessary step to overcome the "impossibility theorem".[27]

The solution of the allocation problem (1) gives the following condition that describes the relative demand for the two types of intermediates of every industry:

$$\frac{I_i^s}{I_i^g} = \left(\frac{1-\theta}{\theta} \frac{p_{I^g}}{p_{I^s}} \right)^{\sigma}$$

Therefore, the goods-intermediates' use share for industry i, $\gamma_i \equiv \frac{p_{I^g} I_i^g}{p_{I^g} I_i^g + p_{I^s} I_i^s}$, grows

[24] The identification would be still valid if prices are a constant mark-up over marginal costs. It would also be valid if prices growth are a noisy signal over the marginal costs as long as their errors are random.

[25] This assumption is consistent with the way that National Accounts construct the series of intermediates' prices. Detailed discussion of the properties of the data is in Section 2.

[26] Recall that at this decision stage $\tilde{I}_i$ is taken as given. The "price" of an industry's own intermediates "basket" used in production can be normalised to one.

[27] The actual estimation outlined below accomodates industry/sector-level heterogeneity in the production function, e.g., allows θ_i and ρ_j. This is consistent with the presence of structural differences across industries in their production technology–see Section 3.1– and "normalizes" the CES estimation (e.g., see de La Grandville 1989).

optimally at a rate, $g(\gamma_i)$:

$$\frac{g(\gamma_i)}{1-\gamma_i} = (1-\sigma) g\left(\frac{p_{I^g}}{p_{I^s}}\right), \tag{2}$$

where $g\left(\frac{p_{I^g}}{p_{I^s}}\right)$ is the growth of the relative prices of goods-intermediates. Falling prices for the goods-intermediates, $g\left(\frac{p_{I^g}}{p_{I^s}}\right) < 0$, imply that the use share of goods-intermediates decreases over time, $g(\gamma_i) < 0$, only if the two types of intermediates are complements, i.e., when $\sigma < 1$.[28]

The regression equation implied by (2) is estimated using industry-level time-series data transformed in terms of growth rates, given that price data are directly available in the form of superlative indexes.[29] This transformation also controls for unobserved heterogeneity in levels of the goods-intermediates use shares and would correct for the presence of non-stationary variables.

The identification of the parameter of interest is feasible when the relative prices of intermediates (final output) reflect the relative productivity (TFP) of their producing industries, changes in productivity are exogenous and random around a constant, and productivity shocks across industries are uncorrelated. In the available data, the source of industry-level variation in the intermediates price growth data comes from the fact that different industries use different detailed goods and services-intermediates. For example, both the agriculture and the motor vehicle industries use car components, such as tires or wiper blades, but the motor vehicle industry uses them more intensively among its intermediates. But while the agriculture industry would be among the industries using

[28] As is stadard in the growth accouting context, the implicit assumption is that any technological progress is Hicks neutral. If technology was specific to an intermediates type, i.e., if production was $\left[\theta\left(A_i^g I_i^g\right)^\rho + (1-\theta)\left(A_i^s I_i^s\right)^\rho\right]^{\frac{1}{\rho}}$ with A_i^x being the industry-specific productivity of using intermediate type-x, then the allocation decision rule would be $\frac{I_i^s}{I_i^g} = \left(\frac{1-\theta}{\theta}\frac{p_{I^g}}{p_{I^s}}\right)^\sigma \left(\frac{A_i^s}{A_i^g}\right)^{\sigma-1}$. Then, $g(\gamma_i) < 0$ is consistent with both the case that $\sigma < 1$ and increasing $\frac{p_{I^g}}{p_{I^s}}$ (and/or decreasing $\frac{A_i^s}{A_i^g}$) ceteris paribus, and the case that $\sigma > 1$ and increasing $\frac{A_i^s}{A_i^g}$. The independent role of prices would still be identified to the extent that the technology of use is industry-specific and input markets are perfect. The use of additional controls would proxy for such latent technological factors.

[29] While (2) is an exact equation in a continuous time framework it becomes an approximation in a discreet time framework through log-linearization.

pharmaceuticals, this wouldn't be the case for the motor vehicle industry. In sum, these two industries would be exposed to a different set of prices.[30] Thus, the elasticity is identified when a technology shock transmits to a price shock to the using industries and elasticities of substitution within each type of intermediates are proportional to the use shares and constant.

These assumptions are arguably restrictive for the level of data detail available, even though independent studies support that the relative prices are strongly correlated with the (inverse of) relative productivities of their producing industries and that perfect markets hypothesis is not rejected at the aggregate level (e.g., see Jorgenson, Ho, and Stiroh 2005, Nordhaus 2008). Nevertheless, acknowledging the implied inference limitations, the prime goal of the investigation below is to test the complementarity hypothesis that $H_0 : \sigma = 1$ against the alternative $H_1 : \sigma < 1$. The exact estimates in each specification below are rather used to form the boundaries of the underlying coefficient and the direction of the potential bias in estimated coefficients is discussed in detail. Nevertheless, the data information for the relative prices growth data is rich enough to allow for flexible specifications that control for generalized functions of industry/time/sector variation. Such controls capture other factors that affect the industry input choices but are absent in the stylized model, e.g., non-neutral technological change, policy, capacity constraints, level of input expenditures, supply shocks, expectations etc. (see also Diamond, McFadden, and Rodriguez 1978, Deaton and Muellbauer 1980, Nordhaus 2008).

In particular, the regression specification is:[31]

$$\frac{\tilde{\Delta}\ln(\gamma)}{1-\gamma}\ _{it} = b_1 \tilde{\Delta}\ln\left(\frac{p_{I^g}}{p_{I^s}}\right)\ _{it} + b_2 \tilde{\Delta}\ln\left(\frac{p_{I^g}}{p_{I^s}}\right)\ _{it} * D_j + x'_{ijt} b_3 + \varepsilon_{it};\ i = 1..N,\ j \in \{G, S\},\ t = 1..T, \tag{3}$$

[30] Further details on the price data and their properties are found in Appendix A.2.

[31] In order that the point estimates of coefficients to directly give elasticities, dependent and explanatory variables in (3) are transformed in the following way: $\frac{\tilde{\Delta}\ln(\gamma)}{1-\gamma}\ _{it} \equiv \frac{\Delta\ln(\gamma)}{1-\gamma}\ _{it} - \Delta\ln\left(\frac{p_{I^g}}{p_{I^s}}\right)\ _{it}$ and $\tilde{\Delta}\ln\left(\frac{p_{I^g}}{p_{I^s}}\right)\ _{it} = -\Delta\ln\left(\frac{p_{I^g}}{p_{I^s}}\right)\ _{it}$.

where D_j is a dummy for the goods-sector industries, the coefficient b_1 estimates σ_S and b_2 estimates $\sigma_G - \sigma_S$. The vector x_{ijt} includes the following controls and their interactions: a constant to control for common factors across time and industries, a linear trend to control for any nonstationarity in the growth data, sector/industry-specific fixed-effects to control for sector/industry specific technological progress and other structural differences across production units, and time fixed-effects to control for macro shocks common across (a set of) industries. Specification (3) allows for a different elasticity of substitution across the two sectors, given that industries in the goods-sectors use on average very different detailed intermediates inputs within each type of intermediates compared to the services ones.

3.2.1 Results

Tables 4 and 5 present the estimated coefficients and respective robust standard errors, as well as the implied elasticities of substitution and their 95 percent confidence intervals. Regressions in Table 4 use the limited information aggregate-level price growth data that have only time or sector/time variation. The full information regressions in Table 5 use the price growth data with industry/time variation. The progressive presentation of the results provides the opportunity to scrutinize the sources of variation in the price growth data and robustness of estimates.

The regressions of Table 4 support uniformly a statistically significant and below one elasticity of substitution between goods and services-intermediates, despite the weak regression fit. An important explanatory role is held by time-varying macro shocks, even though controlling for them expectably makes the estimate of the elasticity of substitution very imprecise (column (6)).

In view of the fact that this specification uses very limited information, the coefficients in front of the relative prices are likely biased. On the one hand, if prices reflect demand shocks then the lower demand on goods-intermediates would feed back to lower prices for them and thereby a larger estimate in front of the relative price growth data. This corresponds to a downward bias for σ and even to negative estimate in the case of a severe endogeneity problem. On the other hand, if prices are noisy signals of the technological shocks of the industries producing them, then the coefficient would be biased downwards corresponding to an upward bias in σ. [32]

Turning to Table 5, column (1) confirms the earlier results of a statistically significant and below one elasticity of substitution. The estimate is somewhat higher than those reported in Table 4, consistent with a higher scope for noise in more aggregated price data. Standard errors increase as well, due to higher degree of noise in the industry-level data. Estimates of columns (2)-(7) indicate a statistically different elasticity across the goods and services sector. In view of the underlying properties of the data, as reviewed in Section 3.1: services industries exhibit stronger substitution trends and the whole production structure shifts towards services sector. This can suggest that there is more scope for endogeneity problem with regard to estimates for the services industries alone.[33] Adding industry fixed-effects in column (3) reduces the earlier estimates of the elasticity of substitution for both sectors; more so for services. The full-information prices preserve their explanatory power when the specifications control for time/industry fixed-effects (column (6)) and the macro shocks are allowed to vary across sector (column (7)).

In sum, the results support the complementarity hypothesis and the estimated elasticity of substitution broadly ranges between 0.3 and 0.5. Intuitively, the average industry (e.g., motor vehicles) cannot substitute away services (e.g., advertising) with energy or

[32] Interestingly, using data at the aggregate economy level and exploring only the time variation the estimated elasticity is $\sigma \leq 0.2$, whereas with a single cross-section of industries the estimated elasticity is $\sigma \geq 0.6$. These findings are common in studies that aim for an elasticity of substitution among production factors and provide further comfort to the estimates coming from the full information panel data.

[33] In IVE regressions not reported here that relative prices growth data and their sector interaction were instrumented by their first and second lags supported the estimates of the elasticity of substitution but not the statistically different elasticity for the services-sector.

non-durable goods (e.g., tires, tools) in the same degree it substitutes away labour with automated machines. The results further indicate that latent factors are important in determining the use patterns of intermediates across industries; particularly macro/sector-specific shocks over time. The following discussion concerns factors other than prices relevant in driving the observed intermediates use patterns and the scope of their explanatory power.

Table 4: United States goods and services industry-level regressions when prices have time and sector variation

Dependent variable: $\frac{\tilde{\Delta}\ln(\gamma)}{1-\gamma}\ _{it}$

Controls:	(1)	(2)	(3)	(4)	(5)	(6)
$constant$	-0.011 (0.001)***	-0.002 (0.003)***				
$\tilde{\Delta}\ln\left(\frac{p_{Ig}}{p_{Is}}\right)_t$	0.410 (0.038)***					
D_j		-0.011 (0.003)				
$\tilde{\Delta}\ln\left(\frac{p_{Ig}}{p_{Is}}\right)_{jt}$		0.375 (0.040)***	0.375 (0.040)***	0.364 (0.042)***	0.364 (0.042)***	0.477 (0.268)*
$industry\ fixed\text{-}effects$			yes**	yes**	yes**	yes***
$trend$				-0.000 (0.000)		
$trend * D_j$				0.000 (0.000)		
$trend * industry\ fixed\text{-}effects$					yes***	
$time\ fixed\text{-}effects$						yes***
obs	2240	2240	2240	2240	2240	2240
$\bar{R}^2$	0.05	0.04	0.07	0.07	0.09	0.22
$F - test$	114.29	44.43	3.08	3.20	3.50	9.66
95% conf. int. for σ	[0.33, 0.48]	[0.30, 0.45]	[0.30, 0.45]	[0.28, 0.45]	[0.28, 0.45]	[-0.05, 1.00]

Notes: robust s.e. in parentheses, (***) denotes significance at 1%, (**) at 5%, (*) at 10%

(yes) denotes control for fixed-effects; (yes**) denotes the F-test rejects the H_0 of no joint-significance at 5%

Table 5: United States goods and services industry-level regressions when prices have time-industry variation

Dependent variable: $\frac{\tilde{\Delta}\ln(\gamma)}{1-\gamma}_{it}$							
Controls:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$constant$	-0.012 (0.006)***	-0.007 (0.002)***					
$\tilde{\Delta}\ln\left(\frac{p_{Ig}}{p_{Is}}\right)_{it}$	0.425 (0.046)***	0.267 (0.094)***	0.187 (0.100)*	0.171 (0.102)*	0.123 (0.104)	0.192 (0.107)*	0.012 (0.138)
D_j		-0.003 (0.003)					
$\tilde{\Delta}\ln\left(\frac{p_{Ig}}{p_{Is}}\right)_{it} * D_j$		0.233 (0.104)**	0.247 (0.065)**	0.261 (0.111)**	0.294 (0.113)**	0.232 (0.098)**	0.463 (0.149)***
$industry\ fixed\text{-}effects$			yes***	yes***	yes**	yes***	yes**
$trend$				0.000 (0.000)**			
$trend * D_j$				-0.000 (0.000)			
$trend * industry\ fixed\text{-}effects$					yes***		
$time\ fixed\text{-}effects$						yes***	yes**
$time\ fixed\text{-}effects * D_j$							yes**
obs	2240	2240	2240	2240	2240	2240	2240
$\bar{R}^2$	0.10	0.15	0.16	0.17	0.24	0.33	0.35
$F-test$	85.45	44.58	5.07	5.26	3.75	12.46	11.27
point estimate for $\hat{\sigma}_G$	-	0.500 (0.045)***	0.434 (0.042)***	0.432 (0.043)***	0.417 (0.045)***	0.424 (0.053)***	0.476 (0.056)***
95% conf. int. for σ_S	[0.36, 0.51]	[0.08, 0.45]	[-0.00, 0.38]	[-0.03, 0.37]	[-0.08, 0.33]	[-0.02, 0.41]	[-0.26, 0.28]
95% conf. int. for σ_G	-	[0.41, 0.59]	[0.35, 0.52]	[0.35, 0.52]	[0.33, 0.55]	[0.32, 0.53]	[0.36, 0.59]

Notes: s.e. in parentheses, (***) denotes significance at 1%, (**) at 5%, (*) at 10%,

(yes) denotes control for fixed-effects; (yes**) denotes the F-test rejects the H_0 of no joint-significance at 5%

Discussion of the results The analysis so far highlights the shift in the demand of intermediates towards services-intermediates. This evidence indirectly gives support to the hypothesis that the technological advances of the 1980s induced a pattern of increased specialization for the average industry's production and outsourcing/offshoring of its least productive (skill-intensive) activities, i.e., services. Consistent with this hypothesis the aggregate United States trend of low skilled compensation has been strongly declining relative to the services-intermediates expenditures. However, services outsourcing/offshoring mostly concerns computer, engineering and accounting services ("Business services") that are skill-intensive industries.[34] This suggests that the relevant hypothesis is not what explains the increased demand for services-intermediates. The literature has further highlighted the role of transaction and agency costs in the decision of an industry to outsource services activities.[35] Such factors would arguably be controlled for by the prices and general functions of time in the regression model.

As an indication of the importance of outsourcing in the United States, business services during the 1970-2000 had a trade surplus and their value added share increased from 6% to 13%, which accounts for a 11% to 19% increase in its share in value added of the services-sector. Moreover, Strassner, Medeiros, and Smith (2005) report that the outsourcing-related services increased as a share of total services from 30.8% in 1997 to 33.9% in 2005, while the share of outsourcing-related services that were imported increased from 2.1% to 2.7% during the same period. For the same period, the durable goods-producing industries had the largest increases in its share of outsourcing (from 31% to 37%), while the business services have the highest share in outsourcing among all private economies (50%). Nevertheless, the role of imported services (offshoring) is very limited. To summarize, while outsourcing accounts for up to 1/3 of

[34]The role of communications, finance and insurance and other services is usually not accounted, because such services inputs are commonly considered as the ones that cannot be produced within the firm.

[35]Recent examples in this area of theoretical research includes Antràs and Helpman (2004) and Grossman and Helpman (2002).

total services-intermediates use it cannot by itself fully account for the upward trend in services-intermediates use that the present paper brings forth.

Another issue related to the limitations of the I-O based information is that the evidence cannot account for the degree of vertical integration of industries. The existence of vertical integration would affect any inference regarding the use of services-intermediates (whether or nor directly related to outsourcing) for two reasons. On the one hand, as one cannot measure all intermediates produced within the firm, then the actual use of intermediates is mismeasured, since they would be accounted as value added. On the other hand, as one cannot measure which part of the observed transactions are due to vertical integration across industries, then to the extent that firms are integrated across different industries matters for the observed transaction patterns.[36]

The importance of vertical integration can be accounted only with the use of plant-level data that provide detailed information on ownership and are ideally linked to the basis of information of I-O Tables. In a study of the Commodity Flow Survey of the United States Economic Census, Hortaçsu and Syverson (2009) provide evidence that vertical integration is stable at the aggregate level over the 1977-1997 period. Moreover, the vertically integrated firms are on average larger. Interestingly, only little output of upstream establishments in vertically integrated structures is shipped in the same firm. In view of this evidence, for the United States, the restructuring of the industries does not come out as a driving force of the shift of the economy towards using more services-intermediates. A more in-depth investigation of the importance of these factors in accounting for the variation in goods-intermediates share is left for the future.

As a final note, there are two further competing explanations of the cost disease put forth originally by Baumol himself. The first explanation concerns the role of government. One way that government could play a role is by increasing and sizable demand of

[36] It is worth noting that by not excluding the intra-industry intermediates transactions, the EU KLEMS does not bias further the inference.

services intermediates in the United States. The original EU KLEMS data show constant over time use shares of both goods (1.5% of total) and services-intermediates (0.9%) for the "Public Administration and defence; Compulsory Social Security" (NACE L). Also, government could have a role by affecting the prices of services, either by subsidies or by producing directly some services-intermediates. Nevertheless, employing the original I-O Tables from BEA showed that including the taxes/subsidies and other trade margins make no difference in the underlying trends. The second explanation concerns that services are high income elastic goods. In the context of production this hypothesis has no substantive role unless it is interpreted in terms of "increased complexity" of the produced goods as technology advances. As mentioned earlier, the technology factors would be imputed in the industry/time varying controls other than prices.

4 The Impact of Structural Change in Intermediates Use

This section presents the impact of structural change in intermediates' use on the aggregate economy over the 1970-2005 period. It accounts for the cost impact of the structural change and how it affects the measured labour productivity via the intermediates reallocation. It further sheds light on the role of the pure substitution effect and its impact in the input-output system, as summarized by total requirement coefficients and income multipliers.

Unit costs

Figure 5 presents the United States gross output unit cost, i.e. price, for the 1970-2005 period and contribution of each of its components: value added, goods-intermediates and services-intermediates.[37] Apart from the oil-shock period of the 1970s and in sharp

[37] The gross output price index of each productive unit is a weighted average of the prices of its value added and intermediate inputs, where the corresponding weights are the input shares in the current-dollar

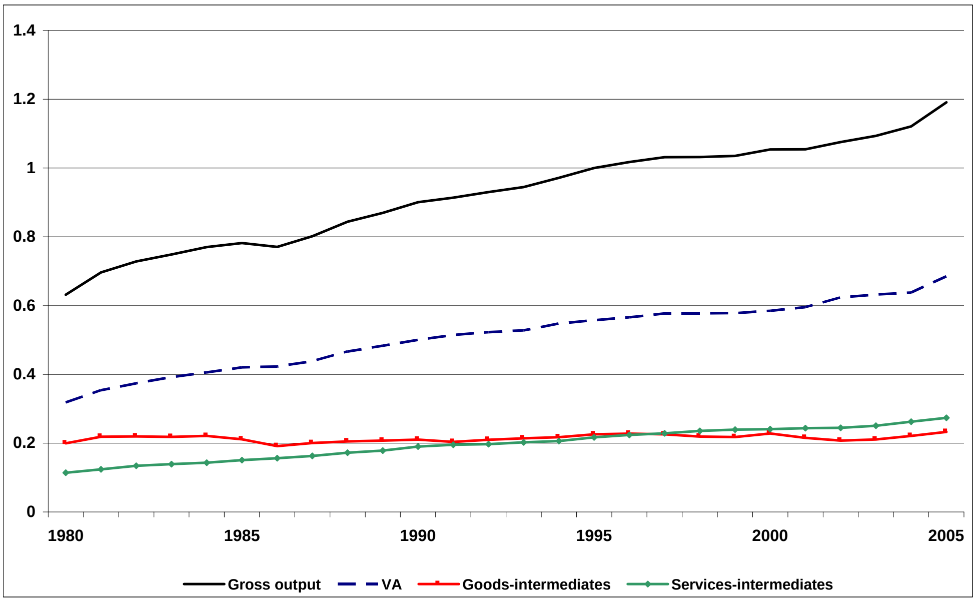

Figure 5: United States economy current-dollar cost per unit of real gross output.

contrast to the services-intermediates the goods-intermediates contributed the least to aggregate costs. Table 6 confirms that the prevalence of the same patterns at the sector-level and highlights the self-enforcing role of services-intermediates in increasing the costs of services output.

Table 6: United States gross output price growth decomposition

Sector average growth 1981-2005	Goods	Services
Gross output price index growth contribution by:	1.83	3.20
value added	0.91	2.20
goods-intermediates	0.43	0.14
services-intermediates	0.49	0.86

In order to account for the extent to which the changing composition in inputs affected the unit cost growth at the aggregate level, the following exercise is conducted for each gross output unit cost component. The counterfactual contributions to unit cost growth is calculated, by fixing the value added, goods and services-intermediates shares in gross

cost of gross output production.

output to their initial levels (average for the 1970-1971 period). Therefore, the counterfactual unit cost growth and its components net out composition effects. Comparing this to the actual contribution shows the average impact of the structural change on gross output price growth. The results of this exercise in Table 7 highlight that the structural change relating to intermediates' use increases the unit cost of production. Specifically, higher annual cost by 0.06pp. over the entire 35-year period amounts to 2.1pp. of unit cost growth.

Table 7: Impact of internediates composition on United States gross output unit cost growth

1971-2005 average annual growth	Actual	Counterfactual	Difference
Gross output unit cost growth	4.05	3.99	-0.06
contribution by:			
value added	2.26	2.27	0.02
goods-intermediates	0.89	0.84	-0.04
services-intermediates	0.91	0.87	-0.04

Labour productivity

As a way to get a better intuition about the real impact of the "cost disease" and the role of the size and pure substitution effects, note that the average aggregate labour productivity growth $\nu = \frac{V}{H}$ is decomposed as follows:[38]

$$
\begin{aligned}
\Delta \ln \nu_t &= \Delta \ln V_t - \Delta \ln H_t \\
&= \sum_i \bar{w}_{it} \Delta \ln Y_{it} - \sum_i \bar{w}_{it} \frac{1-\bar{v}_{it}^V}{\bar{v}_{it}^V} \left(\Delta \ln I_{it} - \Delta \ln Y_{it} \right) - \Delta \ln H_t \\
&= \underbrace{\sum_i \bar{w}_{it} \Delta \ln y_{it}}_{\text{"Direct productivity effect"}} + \underbrace{\left(\sum_i \bar{w}_{it} \Delta \ln H_{it} - \Delta \ln H_t \right)}_{\text{"Hours reallocation effect"}} \\
&\quad - \underbrace{\left[\sum_i \bar{w}_{it} \frac{1-\bar{v}_{it}^V}{\bar{v}_{it}^V} \left(\Delta \ln I_{it} - \Delta \ln Y_{it} \right) \right]}_{\text{"Intermediates reallocation effect"}},
\end{aligned}
$$

[38] Labour productivity is real value added per hours worked. For details of this decomposition see (Jorgenson, Ho, and Stiroh 2005).

where $\Delta \ln y_{it}$ is the labour productivity of industry i (gross output per hour worked), $\Delta \ln H_{it}$ is the growth in hours of industry i, and $\bar{w}_{it}\frac{1-\bar{v}_{it}^{V}}{\bar{v}_{it}^{V}}$ is the share of the value of intermediates in total value added.

Thus, aggregate labour productivity growth is decomposed into three components. The first term is the within-industry labour productivity growth, where each industry is weighted by its value added share over time. The second term captures the impact of the variation of hours growth across industries. The "hours reallocation effect" has a positive contribution to aggregate labour productivity growth when hours grow more in industries that are growing over time. In a similar spirit, the last term captures the variation in intermediates input intensity across industries. The "intermediates reallocation effect" has a negative impact on aggregate labour productivity when $\Delta \ln I_{it} > \Delta \ln Y_{it}$. This is because when an industry uses more intermediates to produce the same units of gross output, this corresponds to a decrease in the industry's productivity and thus such reallocations need to be subtracted from aggregate calculations.

Figure 6 shows that unlike the hours reallocation, the intermediates one has a sizeable and highly volatile (ranges from 1.81pc to -1.04pc) impact on annual labour productivity growth of the United States. In view of the potential of intermediates reallocation to affect aggregate productivity, the following exercise further decomposes it into its sources of structural change and evaluates their labour productivity growth impact.

In particular, given the actual growth rates in the volume of gross output and goods and services-intermediates for every industry, there are three composition effects that are related to the intermediates use can have a role in affecting the intermediates reallocation. First, the industry-size composition effect, related to the industry value added share, $\bar{w}_{it}$. Second, the VA-intermediate input composition effect, related to the value added-to-gross output share between intermediate inputs and value added in the gross output production of every industry, $\frac{1-\bar{v}_{it}^{V}}{\bar{v}_{it}^{V}}$. Finally, the intermediates use composition effect

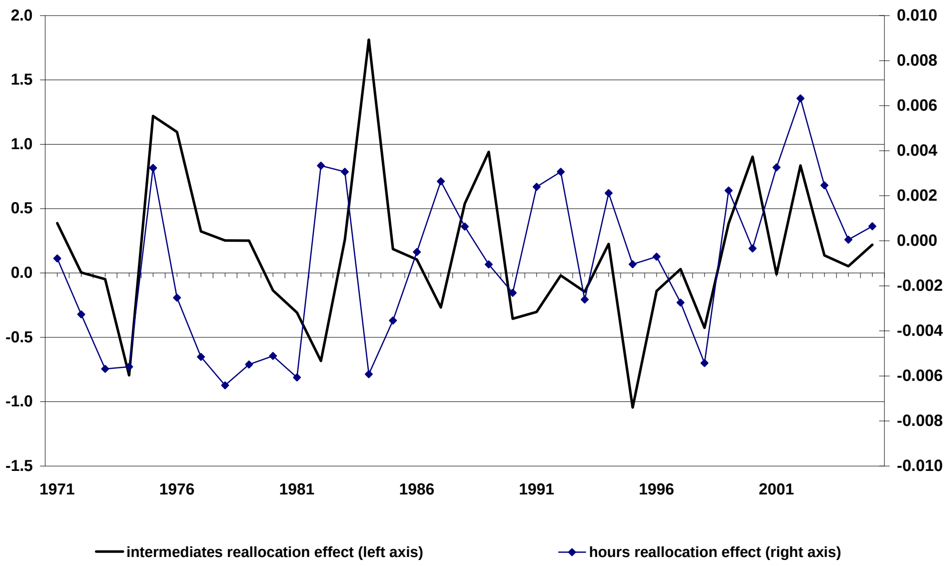

Figure 6: United States inputs reallocations across industries.

that comes from the variation in the use of different types of intermediates, and related to their intermediate expenditures shares, $\bar{v}_{it}^{g}$ and $\bar{v}_{it}^{s}$.[39] The aggregate composition effect relates to the interplay of all these individual components.

For each of the two-digit 14 NACE industries of Table 12, one-by-one the corresponding composition shares were fixed at their initial level (1970-1971 average) to calculate ceteris paribus the intermediates reallocation effect. This gives the counterfactual (*superscript "c"*) contribution of the corresponding composition share, i.e., in the absence of composition change. Aggregating over all three these gives the total counterfactual intermediates reallocation effect. The benefit in labour productivity growth is defined as $\Delta \ln v_t > \Delta \ln v_t^c$, which amounts to the difference between counterfactual and actual

[39] Recall that in the context of this study the intermediates growth index for an industry i is: $\Delta \ln I_{it} = \bar{v}_{it}^{g} \Delta \ln I_{it}^{g} + \bar{v}_{it}^{s} \Delta \ln I_{it}^{s}$, where $\bar{v}_{it}^{g}$ is the two-period average use share of goods-intermediates, $\bar{v}_{it}^{g} + \bar{v}_{it}^{s} = 1$.

intermediates reallocation effect:[40]

$$\begin{aligned}
& \Delta \ln v_t - \Delta \ln v_t^c = \\
= \quad & -\sum_i \bar{w}_{it} \tfrac{1-\bar{v}_{it}^V}{\bar{v}_{it}^V} \left(\bar{v}_{it}^g \Delta \ln I_{it}^g + \bar{v}_{it}^s \Delta \ln I_{it}^s - \Delta \ln Y_{it} \right) \\
& + \sum_i \bar{w}_{it}^c \left(\tfrac{1-\bar{v}_{it}^V}{\bar{v}_{it}^V} \right)^c \left[\left(\bar{v}_{it}^g\right)^c \Delta \ln I_{it}^g + \left(\bar{v}_{it}^s\right)^c \Delta \ln I_{it}^s - \Delta \ln Y_{it} \right].
\end{aligned}$$

Table 8 summarizes the results. Their main highlight is that the structural change that relates to the intermediates use patterns contributes positively to the labour productivity of either sector and thereby aggregate economy. This benefit compounds to a 2.9pc. benefit in (log) aggregate labour productivity level over the 35-year period. The opposite is true for the structural change relating to the changing size across industries, which compounds to 1.32pc. loss. The aggregate impact from the total intermediates reallocation is negative, due to the relative sector size.

Table 8: Impact of internediates composition on United States gross output unit cost growth

1972-2005 average annual benefit in labour productivity growth from aggregate	Aggregate economy	Sector-level Goods	Sector-level Services
size composition effect	-0.08	-0.04	-0.06
value added-intermediates composition effect	-0.01	-0.04	0.01
intermediates-mix composition effect	0.05	0.09	0.02
total	-0.05	0.00	-0.03

Finally, even though the focus is on the long-run average trends, Figure 7 illustrates the time variation related to the benefits in annual average productivity from the structural change in intermediates use. It highlights that the driving force of losses is the industry-size effect over the entire period, and the benefits from intermediates-mix reallocation is stronger in periods of intense change, such as the late-1990s.

[40] Alternatively, this answers to the following question: "By how much is aggregate labour productivity growth higher in the presence of structural change related to the composition effect "..", compared to the case that the latter would not have taken place?"

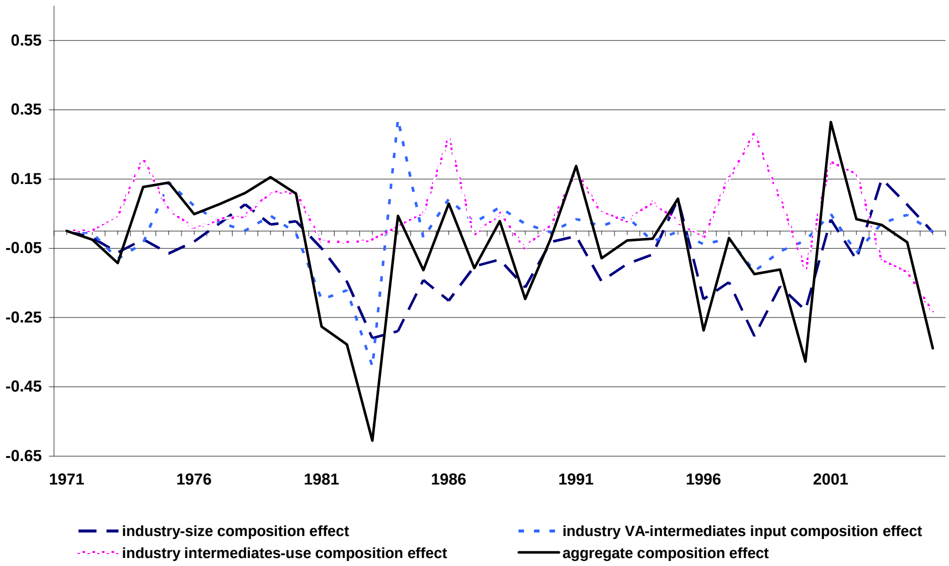

Figure 7: Benefit from the intermediates reallocation for the United States.

Total requirement coefficients

The changing composition in intermediates use affects the magnitude of any direct and indirect effects of any demand-side shocks in the economy. The by-product of the shift of economic activity towards services products is that it makes the services-sector more vulnerable to any external shock over time. This is important in view of the earlier discussion regarding the relatively low productivity of services products.

To investigate the importance of the structural change in the input-output system, the input-output system of the United States is collapsed in a two-by-two matrix of the goods and services sectors so as to calculate the direct and total requirement coefficients for the initial (average 1970-1971) and final (average 2004-2005) periods. Also, the impact of the structural change is projected in future using a simulation of (2) (see Section 3.2), given the estimated elasticity of substitution between goods and services-intermediates. Specifically, the 2060 shares in intermediates use are predicted using the average 1971-2005 growth of intermediates relative prices and estimated of the elasticity $\hat{\sigma} = 0.4$.

Table 9 presents how total requirement coefficients matrices change over time. According to the calculations, an increase by 1 USD of demand for services in the early 1970s requires the production of 1.35 USD of services, so as to cover the need for services throughout the value chain. By early 2000s there is clear shift of the burden of any demand shock on the services sector and the trend is projected to continue in the future. This confirms that the services-sector is becoming not only more costly but also increasingly exposed to any external shocks in itself. Despite this, the overall cost of meeting such shocks are lower, since the total output multipliers decrease over time for both sectors. The latter is consistent with the afore results regarding role of intermediates reallocation and its components.

Table 9: Total requirement coefficients matrix

Total requirement coefficients		
	1970-1971	
producing/using sector	Goods	Services
Goods	1.85	0.24
Services	0.35	1.35
	2004-2005	
Goods	1.69	0.18
Services	0.42	1.40
	prediction for 2060	
Goods	1.56	0.12
Services	0.50	1.44

Note: In each matrix column entries sum up to total activity output multipliers.

5 Conclusions

This paper diagnoses that the intermediates use in the United States bears all symptoms of the "Baumol's cost disease". It establishes that various composition effects contribute towards the increasing expenditure on services-intermediates relative to the goods-intermediates for each unit of production; namely, industries size, allocation between primary and secondary goods, and allocation between goods and service-intermediates. The latter is a pure substitution effect: the average industry decreases its goods-intermediates expenditures share by 7pp.

Given the relatively high prices of the services-intermediates, the increasing use of services-intermediates is confirmed to be conducive towards increasing even further the unit costs of production. However, the different composition effects play a different role in this cost inflation. The pure substitution effect by itself mitigates the overall costs of intermediates reallocations, suggesting that the industry-level intermediates allocations are on average cost-saving. Nevertheless, this benefit comes with another side of the "cost disease". The shift of the entire production system towards services increases the reliance on services and makes the services-sector, and the entire economy, most vulnerable to external demand shocks.

Furthermore, in order to explain the changing structure of intermediates expenditures, this paper puts forth the hypothesis that there is low degree of substitution between goods and services-intermediates. The econometric investigation's results thoroughly support the complementarity hypothesis, even though they do not exclude the role of other factors that are latent in the data of this study. The in-depth analysis of such factors is left for future research. The scope of policy in mitigating the costs of the "cost disease" is also left for further research, yet this paper suggests that ultimately policy hits the constraint of production technology itself and reallocations are not necessarily implying losses.

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A Appendix

A.1 Decomposition of the goods-intermediates use share

The trend in the goods-intermediates expenditure share of at the aggregate economy level can be driven by two distinct forces. The *substitution effect* relates to the trends in the expenditure shares of the individual sectors (goods and services). The *size effect* relates to the trends in the shares of the individual sectors in the total expenditure on intermediates.

In particular, consider again the framework where economy is assumed to consist of two sectors, goods and services, that produce the respective commodities and each sector uses both types of intermediates. Denote $\tilde{I}_j$ the total expenditure of sector j and $p_{I^x} I_j^x$ the expenditure of sector j on intermediates of type $x \in \{g, s\}$, $j \in \{G, S\}$. It holds that $\tilde{I}_G = p_{I^g} I_G^g + p_{I^s} I_G^s$ and $\tilde{I}_S = p_{I^g} I_S^g + p_{I^s} I_S^s$.[41] Hence, the aggregate economy's goods-intermediates expenditure share, γ_g, is

$$\begin{aligned} \gamma^g &= \frac{p_{I^g} I_G^g + p_{I^g} I_S^g}{\tilde{I}} \\ &= \frac{p_{I^g} I_G^g}{\tilde{I}_G} \frac{\tilde{I}_G}{\tilde{I}} + \frac{p_{I^g} I_S^g}{\tilde{I}_S} \frac{\tilde{I}_S}{\tilde{I}} \\ &= \gamma_G^g s_G + \gamma_G^s s_S, \end{aligned}$$

where γ_j^g is the goods-intermediates expenditure share of sector j, and s_j is the share of

[41] Recall that $\tilde{I}$ is the total expenditures of intermediates in the economy, $\tilde{I} = p_{I^g} I^g + p_{I^s} I^s$, where $p_{I^g} I^g$ is the total intermediates use of the goods-sector and $p_{I^s} I^s$ the total intermediates use of the services-sector.

sector j in the total expenditures on intermediates, $s_G + s_S = 1$. Therefore:

$$g_{\gamma_G} = \underbrace{\sum_{j\in\{G,S\}} \frac{\gamma_j^g s_j}{\gamma^g} g_{\gamma_j^g}}_{\text{“substitution effect”}} + \underbrace{\sum_{j\in\{G,S\}} \frac{\gamma_j^g s_j}{\gamma^g} g_{s^j}}_{\text{“size effect”}}.$$

The weights in either of these two effects equal $\frac{\gamma_j^g s_j}{\gamma^g} = \frac{p_{I_G} I_j^g}{\tilde{I}^g}$, i.e., the share of the sector in total expenditures of goods-intermediates. Note further that given that $s_j = \frac{\tilde{I}_j}{\tilde{I}} = \frac{\tilde{I}_j}{p_V V_j} \frac{p_V V_j}{p_V V} \frac{p_V V}{\tilde{I}}$, then its growth bears a *size effect* that is measured by the value added share of the sector, $\frac{p_V V_j}{p_V V}$, and a *production technology effect* that is measured by the intensity of the sector in using intermediates for its final output production in comparison to the average/ aggregate economy, $\frac{\tilde{I}_j}{p_V V_j} / \frac{\tilde{I}}{p_V V}$.[42]

To illustrate how the size effect alone can drive a negative trend in the goods-intermediates expenditure share at the aggregate level consider the case that both sectors do not change their intensity in using goods-intermediates, i.e. $g_{\gamma_G^g} = g_{\gamma_S^g} = 0$. Since $\sum_{j\in\{G,S\}} s_j = 1$, then $g_{s_j} = -\frac{s_{j'}}{s_j} g_{sj'}$, $j' \neq j$, and $g_{\gamma_G} = -g_{sj'} \frac{s_{j'}}{\gamma_G} \left(\gamma_j^g - \gamma_{j'}^g\right)$. As a result, $g_{\gamma_G} < 0$ if $sgn\left[g_{s_{j'}} \left(\gamma_j^g - \gamma_{j'}^g\right)\right] > 0$, i.e., sectors that decline in their share in total expenditures of intermediates are the sectors that have the highest intensity in using goods-intermediates.

The aggregation issue is important also at the sector-level, since each sector j is an aggregate over K_j distinct industries. With an analogous argument, $\gamma_G^j = \sum_{k=1}^K \gamma_k s_k$; $\sum_{k=1}^K s_k = 1$ and the growth of the goods-intermediates expenditure share of sector j equals:

$$g_{\gamma_j^g} = \underbrace{\sum_{k=1}^{K_j} \frac{\gamma_k s_k}{\gamma_j} g_{\gamma_k}}_{\text{“within-industry effect”}} + \underbrace{\sum_{k=1}^{K_j} \frac{\gamma_k s_k}{\gamma_j} g_{s_k}}_{\text{“between-industry effect”}},$$

where the *within-industry effect* effectively captures the substitution effect and the between-industry effect the size effect.

[42] The results of Section 3 indicate that there are no trends in the latter, which implies that $s_j \propto \frac{p_V V_j}{p_V V}$.

As a final illustration how the aggregate trends can be confounded by composition effects, consider the share of total goods-intermediates expenditures in total gross output,

$$\begin{aligned}\frac{I^g}{Y} &= \frac{p_{I^g} I_G^g + p_{I^g} I_S^g}{Y} \\ &= \gamma_G^g \frac{\tilde{I}_G}{Y_G}\frac{Y_G}{Y} + \gamma_S^g \frac{\tilde{I}_S}{Y_S}\frac{Y_S}{Y}.\end{aligned}$$

It is apparent that trends in this share are not only driven by the actual substitution taking place in the goods and services-sector, captured by γ_G^g and γ_S^g. It is also affected by the production technology of each sector, $\frac{\tilde{I}_G}{Y_G}$ and $\frac{\tilde{I}_S}{Y_S}$, as well as from the evolution of the size of each sector, $\frac{Y_G}{Y}$ and $\frac{Y_S}{Y}$.

Alternatively, express $\frac{p_{I^g} I^g}{Y} = \gamma^g \delta$, where $\delta \equiv \frac{\tilde{I}}{p_Y Y}$ is the aggregate expenditure on intermediates in the economy's gross output production. Accordingly define $\delta^g \equiv \frac{p_{I^g} I^g}{Y}$, and note that $g_{\delta^g} = g_{\gamma^g} + g_\delta$. The forces driving the first component were analyzed afore. It becomes clear that changes in δ^g can be entirely driven by the same factors that drive changes in δ, given that $g_\delta = \frac{p_V V}{p_Y Y}(g_{\tilde{I}} - g_{p_V V})$. When there is growth of the value added of both sectors in the economy, i.e. $g_{V_G}, g_{V_S} > 0$, but $g_{\tilde{I}_j} = g_{\gamma_j^g} = g_{s_j} = 0$, $\forall j$, it follows that $g_{\tilde{I}} = 0 < g_{p_V V} = \sum_j \frac{p_V V_j}{p_V V} g_{p_V V j}$. As a result, $g_\delta, g_{\delta^g} < 0$. Hence, in the event that there is growth in the sectors, such that they use altogether fewer intermediate resources to produce output, then the share of the goods-intermediates expenditures out of gross-output would be declining, despite the absence of any substitution between the two types of intermediates in the economy.

Another case that the aggregate data would be misleading regarding the existence of a substitution among the different types of intermediates, is the one that while $g_{\gamma_j^g} = 0$, the two sectors experience a balanced growth for their value added and intermediates expenditures, i.e. $\frac{\tilde{I}^j}{p_V V_j}$ is constant , $\forall j$. In such case, since $\delta = \sum_j \frac{p_V V_j}{p_V V}\frac{\tilde{I}_j}{p_V V_j}$ it follows that $g_\delta = \sum_j \frac{\tilde{I}_j}{p_V V_j} g_{\frac{p_V V j}{p_V V}} = -g_{\frac{p_V V j}{p_V V}} \left(\frac{\tilde{I}_{j'}}{p_V V_{j'}} - \frac{\tilde{I}^j}{p_V V_j}\right)$, for $j' \neq j$. Thus, δ^g would be falling at the aggregate level as long as the growing sector is the sector with the lower expenditure on intermediates compared to its value added.

A.2 Intermediates prices data

Information on the relative prices of the two types of intermediates are available at the EMS detail, so that the EM were aggregated to the "goods-intermediates" prices according to the methodology outlined in Section 2.3.

At the economy level, two different measures of prices are available. The relative prices of the goods-sector gross output and the relative intermediates prices. The latter is based directly on information about intermediates. The gross output-based price data would suffice to capture the underlying trend in the intermediates' relative prices, under the assumption that the goods and services-sector deliver the intermediates they produce at the basic price of their gross output production. The direct intermediates prices measure is based directly on the information available for the intermediates. Figure A.2 presents the price index for these two measures and shows that consistent with the accounting principles they are almost identical. In either case, the relative price of the goods-intermediates falls over time.

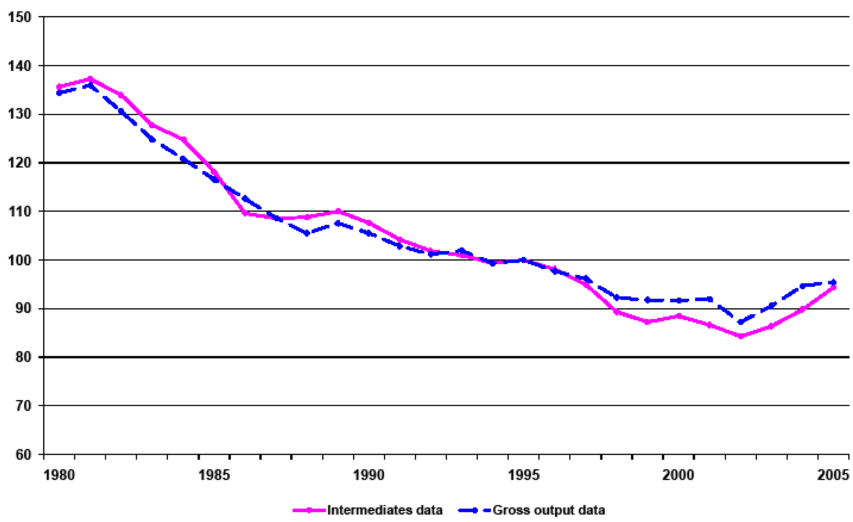

Figure 12: Relative prices of the goods-intermediates.

For the regressions of Section 3.2, two alternative measures of the relative prices of intermediates are considered: The first set of regressions (see Table 4) uses the relative prices of the goods-sector gross output (column (1)) and the sector-specific aggregated index of intermediates price data (columns (2)-(6)). For the purpose of the second set of regressions (see Table 5) the information for the intermediates value and volume growth at the industry level was used to infer the industry-specific growth in the relative prices of goods and services-intermediates. Different industries use different goods and services-intermediates products. As a result, the implied relative prices of the "basket" goods or services-intermediates differs across industries, if industries use different products with different intensities and when not all products within each intermediates type bear identical price shocks.

A.3 Additional figures and tables

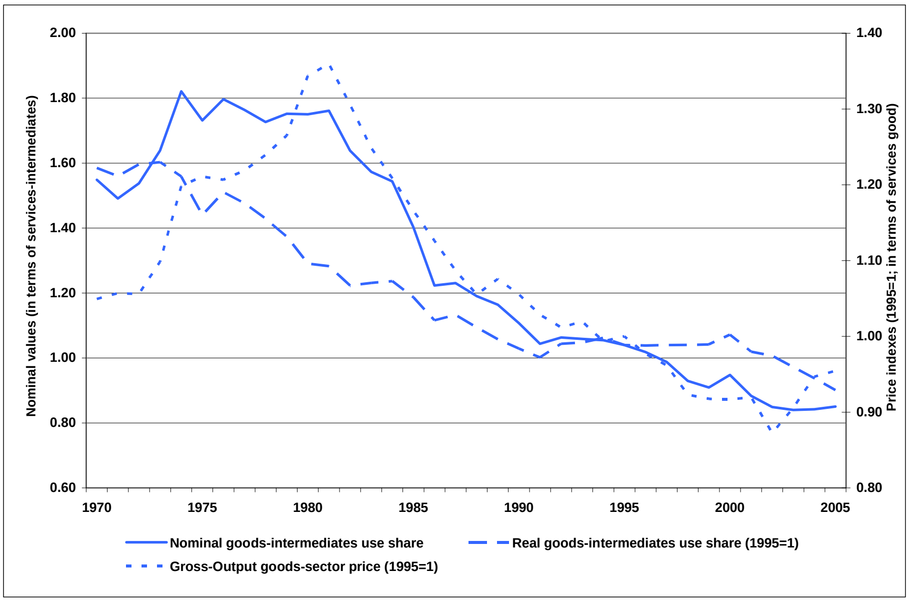

Figure 8: United States goods-intermediates relative nominal, real expenditures and prices of goods-intermediates.

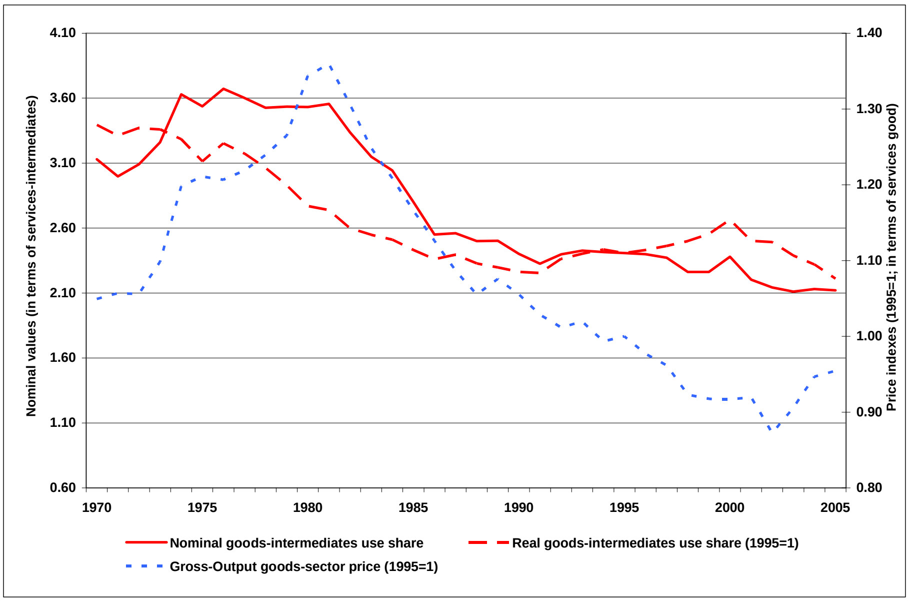

Figure 9: United States good-sector's goods-intermediates relative nominal, real expenditures and prices of goods-intermediates.

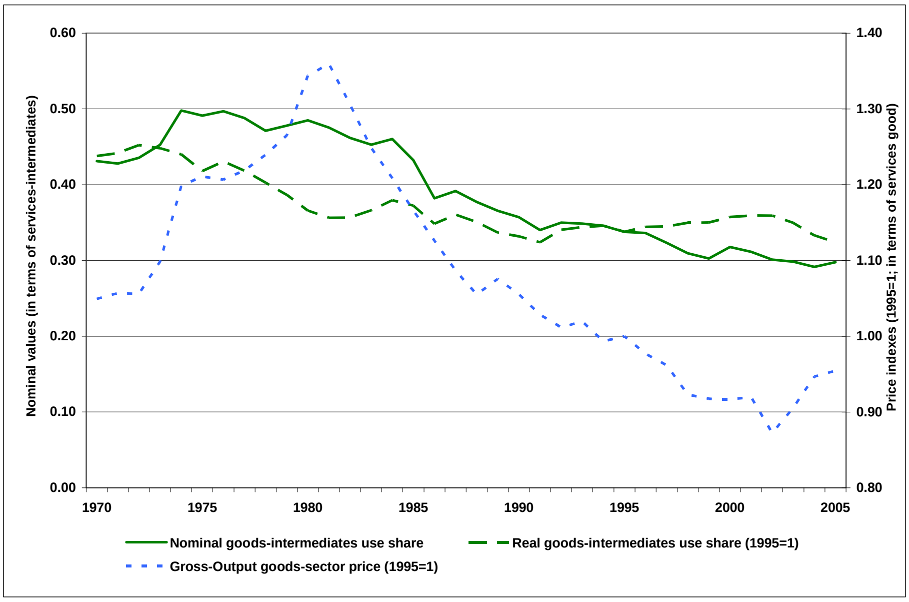

Figure 10: United States services-sector's goods-intermediates relative nominal, real expenditures and prices of goods-intermediates.

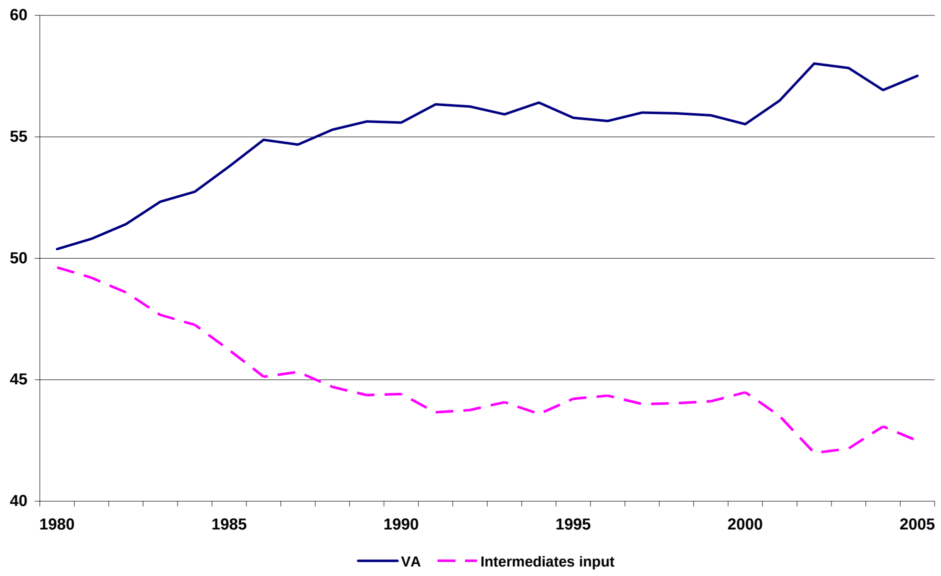

Figure 11: United States gross output composition in terms of value added and intermediates.

Notes: In 1983 the old, 1970-1995, and the new, 1983-2000, BLS-EMP datasets were linked using the iterative proportional fitting process (RAS) (see Chapter 4 in Jorgenson, Ho, and Stiroh (2005)). The spike in the data present in 1983 is likely because the two datasets are consistent with a different industry classification system that affected the ratio of value added to intermediates in several industries (e.g. oil and gas mining). The year 1987 is another important breakpoint, since data for the period 1983-1987 is based on the SIC 1972, whereas for the 1987-2000 is based on SIC 1987 industry classification. Finally, year 2000 is the point where the SIC data are extrapolated forward using NAICS.

Table 10: United States goods and services-sector value added and gross output shares

Sector shares in	Value added		Gross output	
year	Goods	Services	Goods	Services
1980	42.8	57.2	55.5	44.5
1985	37.0	63.0	51.9	48.1
1990	33.0	67.0	46.9	53.1
1995	31.2	68.8	42.5	57.5
2000	30.4	69.6	40.5	59.5
2005	28.3	71.7	38.0	62.0

Table 11: United States goods and services-sector intermediates use and production shares

Share of intermediates	produced by		used by	
year	Goods	Services	Goods	Services
1980	63.6	36.4	68.4	31.6
1985	58.4	41.6	64.8	35.2
1990	52.5	47.5	59.2	40.8
1995	51.0	49.0	56.7	43.3
2000	48.7	51.3	53.0	47.0
2005	46.0	54.0	51.1	48.6

Table 12: Industry NACE classication and grouping into goods and services-sector

GOODS-sector		SERVICES-sector	
Sector-level analyis			
Industry name	NACE code	Industry name	NACE code
AGRICULTURE, HUNTING, FORESTRY AND FISHI	AtB	WHOLESALE AND RETAIL TRADE	G
MINING AND QUARRYING	C	HOTELS AND RESTAURANTS	H
TOTAL MANUFACTURING	D	TRANSPORT AND STORAGE AND COMMUNICATION	I
ELECTRICITY, GAS AND WATER SUPPLY	E	FINANCE, INSURANCE, REAL ESTATE AND BUSINESS S	JtK
CONSTRUCTION	F	EDUCATION	M
		HEALTH AND SOCIAL WORK	N
		OTHER COMMUNITY, SOCIAL AND PERSONAL SERVIC	O
		PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	P
		EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES	Q
64-Industry-level analysis			
Industry name	NACE code	Industry name	NACE code
Agriculture	1	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50
Forestry	2	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
FISHING	B	Retail trade, except of motor vehicles and motorcycles; repair of household goods	52
Mining of coal and lignite; extraction of peat	10	HOTELS AND RESTAURANTS	H
Extraction of crude petroleum and natural gas and services	11	Other Inland transport	60
Mining of metal ores	13	Other Water transport	61
Other mining and quarrying	14	Other Air transport	62
Food and beverages	15	Other Supporting and auxiliary transport activities; activities of travel agencies	63
Tobacco	16	POST AND TELECOMMUNICATIONS	64
Textiles	17	Financial intermediation, except insurance and pension funding	65
Wearing Apparel, Dressing And Dying Of Fur	18	Insurance and pension funding, except compulsory social security	66
Leather, leather and footwear	19	Real estate activities	70
WOOD AND OF WOOD AND CORK	20	Renting of machinery and equipment	71
Pulp, paper and paper	21	Computer and related activities	72
Publishing	221	Research and development	73
Printing and reproduction	22x	Legal, technical and advertising	741t4
Coke, refined petroleum and nuclear fuel	23	Other business activities, nec	745t8
Pharmaceuticals	244	EDUCATION	M
Chemicals excluding pharmaceuticals	24x	HEALTH AND SOCIAL WORK	N
Rubber and plastics	25	Sewage and refuse disposal, sanitation and similar activities	90
OTHER NON-METALLIC MINERAL	26	Activities of membership organizations nec	91
Basic metals	27	Media activities	921t2
Fabricated metal	28	Other recreational activites	923t7
MACHINERY, NEC	29	Other service activities	93
Office, accounting and computing machinery	30		
Insulated wire	313		
Other electrical machinery and apparatus nec	31x		
Electronic valves and tubes	321		
Telecommunication equipment	322		
Radio and television receivers	323		
Scientific instruments	331t3		
Other instruments	334t5		
Motor vehicles, trailers and semi-trailers	34		
Building and repairing of ships and boats	351		
Aircraft and spacecraft	353		
Railroad equipment and transport equipment nec	35x		
Manufacturing nec	36		
Electricity supply	40x		
Gas supply	402		
CONSTRUCTION	F		