

# Online Appendices for “Outsourcing and the Rise in Services”

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## Appendix A

### A.1 Detailed Data Description

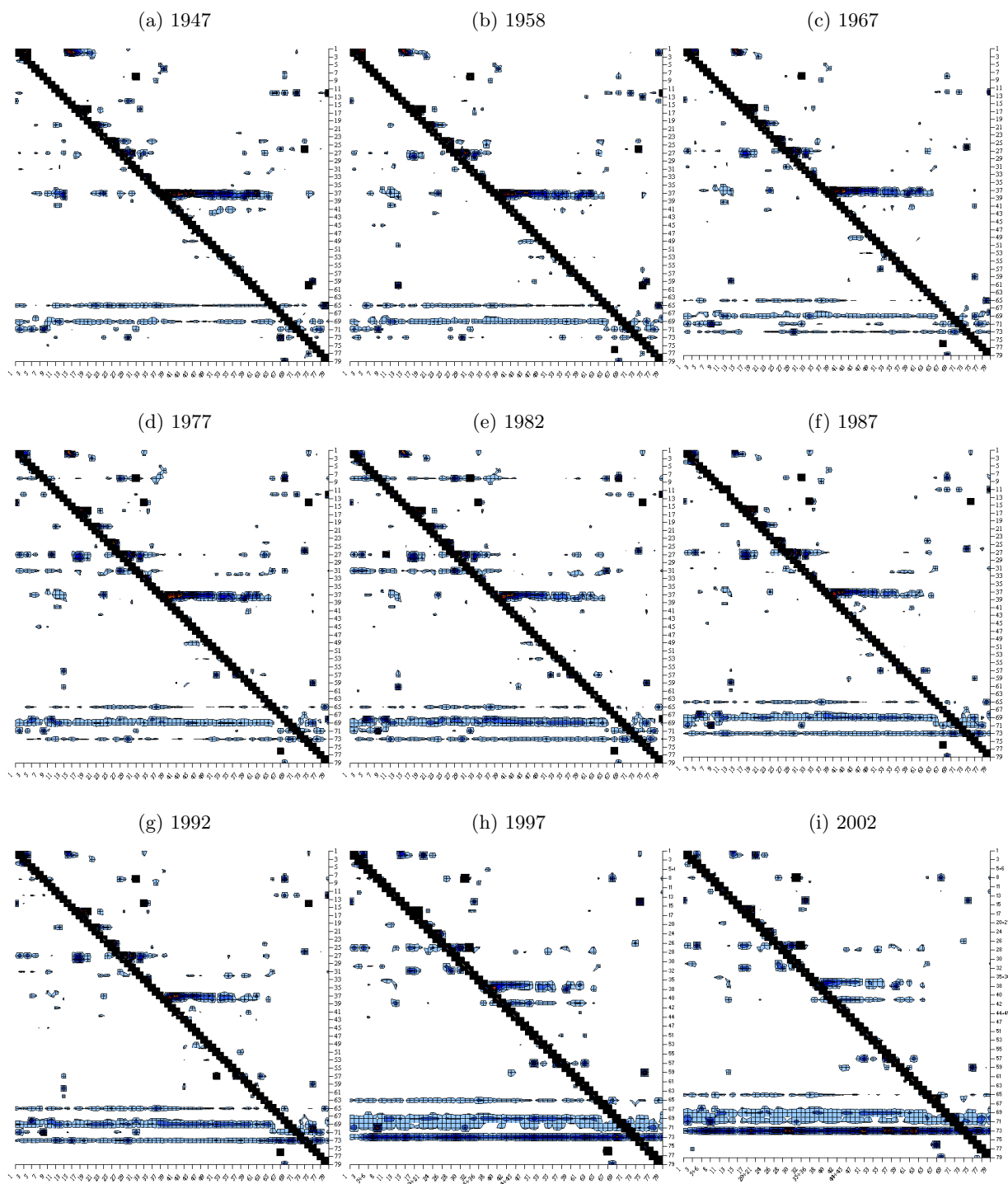
#### A.1.1 Industry and I-O Data

All the industry and I-O data come from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. Employment, value added and relative price indexes come from the Annual Industry Accounts, according to the December 2010 release; final uses price indexes come from the National Income and Product Accounts (NIPA) tables. The I-O data for years 1947, 1958, 1963, 1967, 1972, 1977, 1982, 1987, 1992, 1997 and 2002 come from the Benchmark Input-Output Accounts; while data for years 1998-2001 and 2003-2007 come from the Annual Industry Accounts, according to the December 2010 release. The supplementary version of the tables is used in the main text, while the standard version is adopted in Appendix B.2. The standard versions of the tables are available only for years starting from 1992; under this version, the output of industries corresponds to the published output in the Industry Accounts because the redefinitions for secondary products performed by the BEA are not present, as in the supplementary tables. The re-classifications of secondary products carried out by BEA to define commodities cannot be avoided however. I-O tables until 1992 are based on the SIC classification while they are based on NAICS for later years. Figure A.1 displays the total requirements tables for the benchmark years until 2002 using the same definition of industries over time (concordance tables available on request). They clearly show how the horizontal line corresponding to business services was almost absent in 1947 but becomes more and more visible over time.

The allocation of industries to the three main sectors under investigation is performed as follows:

- Agriculture: Agriculture, forestry, fishing and hunting
- Manufacturing: Mining, Construction, Manufacturing

Figure A.1: Total Requirements Tables in the U.S., 1947-2002



*Note:* The tables for years 1947 to 1967 show the 85-industry level total requirements coefficients, the tables for years 1972 to 1982 show the 85-industry level IxC total requirements coefficients; all data are readily available on the BEA website. The tables for years 1987 and 1992 are obtained from the Use and Make tables at the six-digit level. The tables for years 1997 and 2002 are obtained from the Use and Make tables at the summary level and transformed into I-O SIC codes using a concordance table available on request. A contour plot method is used, showing only shares greater than 2% of the total output multiplier (or backward linkage).

- Services: all other industries including Government (excluding Scrap, which is kept as a separate sector)

Given the high level of aggregation, the definition of the three main sectors is not heavily affected when the classification switches from SIC to NAICS because most of the changes take place within each aggregate sector. Only two sub-sectors switch from one main sector to another: publishing and auxiliary units. They were both classified within manufacturing under SIC, but are now classified within services under NAICS. Unfortunately it is not possible to perform this adjustment in an ideal way. In particular there is a problem with auxiliary units, which are classified within the sector 55 of NAICS, namely Management of Companies and Enterprises. This sector is composed by three sub-sectors: 551111 (Offices of Bank Holding Companies); and 551112 (Offices of Other Holding Companies); 551114 (Corporate, Subsidiary, and Regional Managing Offices). The latter was moved from manufacturing to PBS but the first two were not. In fact, they were already classified within services under SIC as well. The trouble is that I-O data are not disaggregated enough to distinguish these three sub-sectors, hence, by re-classifying the entire sector within manufacturing, the contribution of PBS is underpredicted. In the case of publishing the re-classification can be precisely performed by bringing industry 5111 - Newspaper, periodical, book, and directory publishers - back to manufacturing.<sup>1</sup> Yet this can be done for the benchmark years only, because in the case of the Annual I-O Accounts the level of disaggregation is not detailed enough to identify sector 5111; the re-classification has to be performed by moving the entire sector 511 - Publishing Industries (except Internet) - to manufacturing. This latter sector includes 5112 - Software Publishers - that is actually classified in PBS under SIC. This brings about an even more severe underprediction for Annual Accounts, not only for the overall service sector but more importantly for PBS, the main sector of interest in the paper.

The treatment of imports deserves a separate discussion. Starting from 1972 the majority of imports is assigned directly to the relevant industry. That is, an import is accounted within the corresponding commodity and treated as any other input, with an entry for the industry that is importing and using it. A small portion remains unassigned and is accounted as a separate commodity (noncomparable imports). These are mainly services and hence I classify them into the service sector.<sup>2</sup> Unfortunately, before 1972, imports were unassigned and entirely classified as a separate commodity. Since the importance of services in imports of intermediates was likely to be small at that time, I classify the import commodity within manufacturing. In 1947, on the other hand, imports were treated with more precision and part of them were directly allocated to each commodity, similarly to recent years. However a large share remains unclassified (45%

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<sup>1</sup>In 2002, part of the 1997 sector 5111 is contained in the 2002 sector 5161 - Internet publishing and broadcasting. So also sector 5161 is moved back to manufacturing. The problem is that around 40% of this sector corresponds to the 1997 sector 5141, which should have been kept in services. Even more problematic is the fact that the sector 5141 should be re-classified into PBS (see details below), so by bringing it back to manufacturing the contribution of PBS will actually be underestimated.

<sup>2</sup>As reported by [Horowitz and Planting \(2006\)](#): “Before the 1992 benchmark I-O accounts, noncomparable imports also included certain imported goods, such as bananas and coffee, that were domestically consumed but were deemed to have no significant domestic counterparts.” But these imported goods are likely to be a small portion of the total, and, by affecting earlier years only, this issue has no impact on the main results of the paper.

of total imports); it is hard to find data on service imports for intermediate use but it is unlikely that services were playing a major role in 1947, hence I also assign noncomparable imports to manufacturing.<sup>3</sup>

The Professional and Business Services (PBS) industry in this study is identified with sector 73 of the SIC I-O classification (until 1992), which includes: 73A (Computer and data processing services ); 73B (Legal, engineering, accounting, and related services); 73C (Other business and professional services, except medical); and 73D (Advertising). In terms of the 1987 SIC classification, the sectors included are:

- 73: Business Services:
  - 731: Advertising
  - 732: Consumer Credit Reporting Agencies, Mercantile
  - 733: Mailing, Reproduction, Commercial Art and Photography, and Stenographic Services
  - 734: Services to Dwellings and other Buildings
  - 735: Miscellaneous Equipment Rental and Leasing
  - 736: Personnel Supply Services
  - 737: Computer Programming, Data Processing, and Other Computer Related Services
  - 738: Miscellaneous Business Services
- 76: Miscellaneous Repair Services
  - 769: Miscellaneous Repair Shops and Related Services
- 81: Legal Services
  - 811: Legal Services
- 87: Engineering, Accounting, Research, Management, and Related Services
  - 871: Engineering, Architectural, and Surveying
  - 872: Accounting, Auditing, and Bookkeeping Services
  - 873: Research, Development, and Testing Services (excluding sector 8733 - Noncommercial Research Organizations)
  - 874: Management and Public Relations Services
- 89: Miscellaneous Services
  - 899: Miscellaneous Services

The definition of the PBS according to the NAICS I-O data include sectors: 54 (Professional and Technical Services); 55 (Management of Companies and Enterprises); and 56 (Administrative and Waste Services). The codes coincide with the standard NAICS codes. This definition does not exactly match the one used under the SIC I-O classification and some adjustments are necessary in order to improve the consistency of the data over time. The re-classification

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<sup>3</sup>Despite not conveying much information on the nature of the inputs, it is revealing that 75% of these imports were used by manufacturing industries.

of the sector “Management of Companies and Enterprises” within manufacturing is the first obvious one, given what has just been discussed. Finer adjustments can only be performed for benchmark years because the Annual Accounts lack the needed level of detail; they involve the exclusion of some sub-sectors from the NAICS definition and the inclusion of others that were previously classified within PBS under the SIC definition. Unfortunately it is not possible to get a perfect match; a conservative approach has therefore been taken, by moving only sectors whose entire output or the vast majority of it needs to be re-classified. The NAICS I-O sub-sectors that have been excluded from the PBS definition under NAICS are:

- 5615: Travel arrangement and reservation services<sup>4</sup>
- 5620: Waste management and remediation services<sup>5</sup>

The sub-sectors that have been moved to PBS because they belong to it according to SIC are:

- 5112: Software publishers
- 5141 and 5142 (in 1997): Information Services; and Data Processing Services<sup>6</sup>
- 5180 (in 2002): Internet service providers, web search portals, and data processing
- 5324: Commercial and industrial machinery and equipment rental and leasing<sup>7</sup>

Note that the following SIC sectors cannot be correctly re-classified so they are completely missing from the new definition under NAICS: 7352 (Medical Equipment Rental and Leasing); 7377 (Computer Rental and Leasing); 7378 (Computer Maintenance and Repair); 7383 (News Syndicates); 7384 (Photofinishing Laboratories); and 8741 (Management Services). The vast majority of 769 (Miscellaneous Repair Shops and Related Services) and parts of few other sub-sectors are missing as well (e.g.: part of 7372, Prepackaged Software). Instead the NAICS sub-sectors that are kept while they should have been dropped because they were not in PBS under SIC are: 541191 (Title Abstract and Settlement Offices); 541213 (Tax Preparation Services); 541921 (Photography Studios, Portrait); 561730 (Landscaping Services); and 561740 (Carpet and Upholstery Cleaning Services). For the Annual I-O Account the previous finer adjustment cannot be carried out because they lack the level of disaggregation needed. It is only possible to correctly remove the I-O sector 562 (Waste management and remediation services) from PBS, and add back sector 514 (Information and data processing services).

Finally in years after 1972 I include in PBS also 40% of non-comparable imports for intermediate use. The share is based on 2002 data, when roughly 40% of total non-comparable imports for intermediates use were constituted by PBS.<sup>8</sup> This might slightly overestimate the PBS contribution in earlier years but it correctly estimates the contribution of PBS in 2002, which is the year used in all of the main results contained in the paper.

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<sup>4</sup>Part of the sector should have been kept because it corresponds to SIC sector 7389 (Business Services, NEC)

<sup>5</sup>Part of the sector should have been kept because it corresponds to SIC sectors 7359 (Equipment Rental and Leasing, NEC) and 7699 (Repair Shops and Related Services, NEC)

<sup>6</sup>This also includes NAICS sector 514120 (Libraries and archives), which corresponds to SIC sectors that were not in PBS. But it represents less than 8% of total sales of sector 5142 according to 1997 Census data.

<sup>7</sup>This also includes SIC sector 4741 (Rental of Railroad Cars), which was not in PBS; however, the vast majority of it corresponds to SIC sector 735 (Miscellaneous Equipment Rental and Leasing), which is in PBS.

<sup>8</sup>Author’s calculations based on [Yuskavage, Strassner and Medeiros \(2006\)](#) and the 2002 benchmark tables. A similar share is found for 1997 using data contained in [Horowitz and Planting \(2006\)](#) and the 1997 benchmark tables. All calculations are available upon request.

### A.1.2 Occupational Data

Occupational data come from the IPUMS-USA database. In order to compare occupations over time, the classification proposed by Meyer and Osborne (2005) is used.<sup>9</sup> The occupations associated with PBS are selected according to five different definitions using data in 1990. Definition 1 is the baseline case used in the main text and selects the occupations that have at least 9% of their workers employed in PBS. As a robustness check, I propose four alternative definitions. Definition 2 is very similar and simply uses a threshold of 10% instead of 9%. On the other hand, Definition 3 and Definition 4 are based on the analysis of the PBS industry itself; an occupation is included if at least 0.2% or 0.4% of total workers employed in PBS are classified within that particular occupation. Finally in the “Manual” Definition, I hand pick each occupation on the basis of its job description and whether it could fit in the PBS industry.

The list of occupation selected according to the 9% definition are listed in Table A.1. The table also shows the codes corresponding to the categories used to subdivide the occupations. They are:

- 1: Managers
  - 11: Top Managers
  - 12: Other managers
  - 13: Financial Managers
- 2: Professionals
  - 21: Lawyers
  - 22: Architects
  - 23: Engineers
  - 24: Accountants
  - 25: Advertisers
  - 26: Other professions
- 3: Computer related occupations
  - 30: Computer system analysts, software developers etc.
- 4: Clerks
  - 41: Administrative related occupations
  - 42: Service occupations
  - 43: Sales occupations
- 5: Technicians
  - 50: Technicians and repairers
- 6: Other occupations
  - 61: Construction and precision production occupations
  - 62: Operators and laborers

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<sup>9</sup>The corresponding variable is named OCC1990.

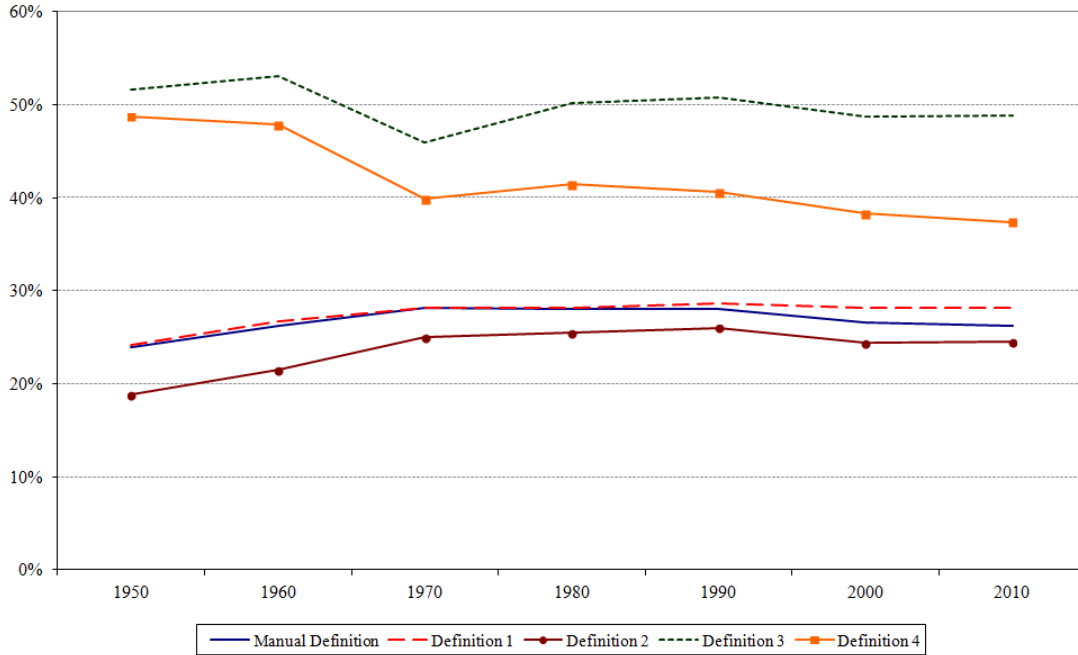
Table A.1: PBS Occupations - 9% Definition

<b>Occupation Description</b>	<b>OCC1990</b>	<b>Category</b>
Human resources and labor relations managers	8	11
Managers and specialists in marketing, advertising, and PR	13	25
Managers and administrators, n.e.c.	22	12
Accountants and auditors	23	24
Management analysts	26	12
Personnel, HR, training, and labor relations specialists	27	12
Business and promotion agents	34	12
Management support occupations	37	12
Architects	43	22
Civil engineers	53	23
Electrical engineer	55	23
Not-elsewhere-classified engineers	59	23
Computer systems analysts and computer scientists	64	30
Operations and systems researchers and analysts	65	30
Statisticians	67	26
Mathematicians and mathematical scientists	68	26
Physicists and astronomers	69	26
Chemists	73	26
Atmospheric and space scientists	74	26
Geologists	75	26
Physical scientists, n.e.c.	76	26
Agricultural and food scientists	77	26
Biological scientists	78	26
Medical scientists	83	26
Economists, market researchers, and survey researchers	166	26
Sociologists	168	26
Social scientists, n.e.c.	169	26
Urban and regional planners	173	26
Lawyers	178	21
Writers and authors	183	26
Technical writers	184	26
Designers	185	26
Art makers: painters, sculptors, craft-artists, and print-makers	188	26
Photographers	189	26
Art/entertainment performers and related	194	26
Editors and reporters	195	26
Electrical and electronic (engineering) technicians	213	50
Engineering technicians, n.e.c.	214	50
Mechanical engineering technicians	215	50
Drafters	217	50
Surveyors, cartographers, mapping scientists and technicians	218	50
Other science technicians	225	50
Computer software developers	229	30

Legal assistants, paralegals, legal support, etc	234	21
Technicians, n.e.c.	235	50
Advertising and related sales jobs	256	25
Sales demonstrators / promoters / models	283	43
Computer and peripheral equipment operators	308	30
Secretaries	313	41
Stenographers	314	41
Typists	315	41
Interviewers, enumerators, and surveyors	316	41
Receptionists	319	41
Information clerks, n.e.c.	323	41
File clerks	335	41
Bookkeepers and accounting and auditing clerks	337	24
Billing clerks and related financial records processing	344	24
Duplication machine operators / office machine operators	345	41
Mail and paper handlers	346	41
Office machine operators, n.e.c.	347	41
Other telecom operators	349	41
Mail clerks, outside of post office	356	41
Messengers	357	41
Customer service reps, investigators and adjusters, except insurance	376	41
Bill and account collectors	378	41
General office clerks	379	41
Proofreaders	384	41
Data entry keyers	385	41
Statistical clerks	386	41
Housekeepers, maids, butlers, stewards, and lodging quarters cleaners	405	42
Supervisors of guards	415	42
Guards, watchmen, doorkeepers	426	42
Supervisors of cleaning and building service	448	42
Janitors	453	42
Pest control occupations	455	42
Small engine repairers	509	50
Repairers of data processing equipment	525	50
Repairers of household appliances and power tools	526	50
Precision makers, repairers, and smiths	535	50
Locksmiths and safe repairers	536	50
Office machine repairers and mechanics	538	50
Mechanics and repairers, n.e.c.	549	50
Paperhangers	583	61
Precision grinders and filers	644	61
Furniture and wood finishers	658	61
Upholsterers	668	61
Photographic process workers	774	62
Welders and metal cutters	783	62
Hand painting, coating, and decorating occupations	789	62



Figure A.2: Share of PBS Occupations in Total Employment

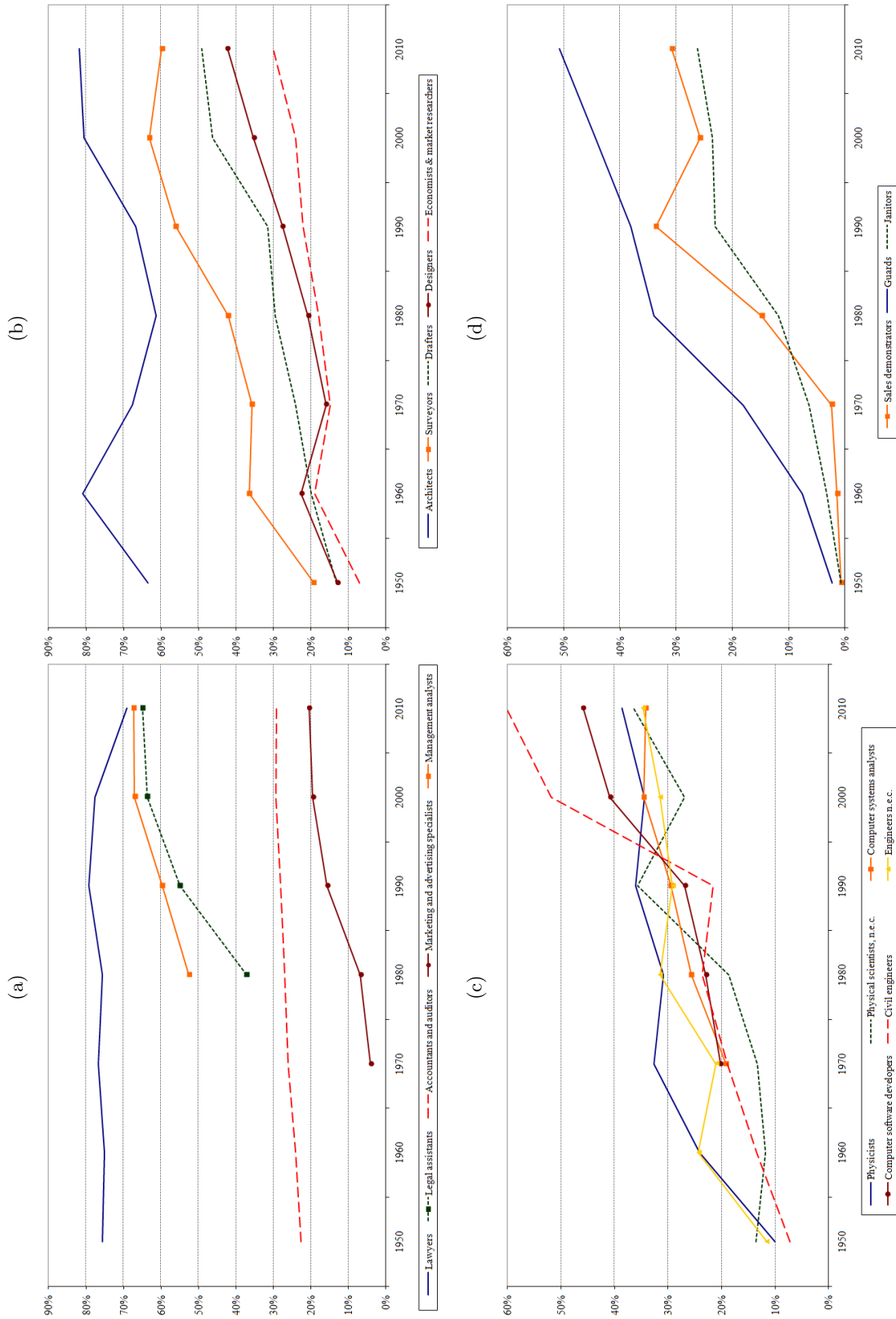


Note: PBS Occupations are selected according to five definitions, as described in the main text.

Figure A.2 compares the five definitions. Each line plots the share of the selected occupations in total employment over time, according to the different definitions. Interestingly, these shares are fairly constant over time. According to Definition 1, the share of workers classified within the PBS Occupations goes from 24.2% of total employment in 1950 to 28.2% in 2010 but stays essentially flat from 1970 onwards. According to Definition 2 and the Manual Definition, the share of PBS Occupations even falls in the second part of the period. The other two definitions are instead a bit more problematic: they include a share of the total work force that is too large. The trade-off between representativeness and over-inclusion becomes clear; Definition 3 includes almost 90% of workers employed in PBS, but at the same time it captures 50% of the total labor force. In the case of Definition 1 the trade-off looks better, in fact it accounts for 82% of the workers employed in PBS but captures just 29% of the total workers.

Figure A.3 replicates Figure 7a in the main text but for specific occupations. The pattern is quite similar across the board, with a constant increase in the share of workers employed in PBS over time. It is interesting to note that this is true for both high and low skilled occupations. For instance, a very similar growth is experienced by Civil Engineers displayed in panel A.3c and Guards in panel A.3d. This fact shows that the rise of PBS is not driven by a particular type of skill and is consistent with both an explanation that focuses on the importance of low-skilled jobs, like in Autor and Dorn (2012), and an explanation that hinges on the rise of high-skilled jobs, like in Buera and Kaboski (2012). At the same time, there are some interesting counter examples. For instance, the share for Lawyers (panel A.3a) did not change much over time, and was already over 75% in 1950.

Figure A.3: Selected Occupations - Participation in PBS



Source: IPUMS-USA.

## A.2 Construction of Aggregate I-O Tables

For the purpose of this study, I-O tables have to be aggregated in order to obtain the I-O linkages for the three main sectors: agriculture, manufacturing and services. The matrix  $\Omega$  in the model corresponds to an industry-by-industry total requirements table. The methodology to obtain this matrix is described by [Horowitz and Planting \(2006\)](#). In brief, there are two main methods to obtain the matrix corresponding to the different I-O conventions used before and after 1972. For the benchmark years until 1967, one symmetric industry-by-industry transaction matrix is published under the assumption that each industry only produces one commodity and that each commodity is only produced by one industry. The total requirements table is then simply obtained as a Leontief inverse. From 1972 onwards instead, the symmetry assumption has been dropped and two distinct tables have been published: the commodity-by-industry use table that shows the uses of commodities by industries and final consumers; and the industry-by-commodity make table that shows the production of commodities by industries. The methodology is slightly more involved, but again it is possible to obtain an industry-by-industry total requirements table. In this study, transaction, make and use tables are first aggregated and then inverted to obtain the total requirements table according to the two different methodologies. Moreover, following the documentation for benchmark years, the Commodity Credit Corporation adjustment is performed for years between 1963 and 1977; and the Scrap adjustment is carried out for years between 1972 and 1997. A very similar methodology is used to obtain the total requirements tables from 1972 onwards displayed in [Figure A.1](#). The tables are shown for illustrative purposes only, and they are not employed in the mains results of the paper.

## A.3 Construction of the Price Indexes

The aggregated value-added price indexes for agriculture, manufacturing and services have been computed from the chain-type price indexes for value added at the industry level, following the methodology described by [Whelan \(2002\)](#). The price index for agriculture is readily available and corresponds to the aggregate industry “agriculture, forestry, fishing, and hunting”. Manufacturing includes the industries “mining”, “construction” and “manufacturing”. Services include “private services-producing industries” and “government”.

The procedure to obtain the final uses price indexes is more involved. All data come from the NIPA tables and since all price indexes are chained, any manipulation described hereafter requires the methodology for chain-type indexes. The procedure involves three main steps: 1) identify the NIPA categories that better represent the I-O definition of commodities; 2) remove transportation, retail and wholesale margins to obtain producers’ price indexes; 3) add investment to the relevant sectors and obtain an aggregate price index for each sector that reflects the price of investment as well. The first two steps are described here, while the adjustment for investment is analyzed in [Appendix B.4](#). The first step consists in matching the personal consumption expenditures from the I-O side to the appropriate NIPA categories. Since the NIPA tables were extensively revised in 2009 to incorporate the results of the 2002 benchmark I-O accounts, I perform the match using the 2002 Bridge Table, which links the two data sources.

I cannot directly use the final consumption expenditure prices published by the BEA because they do not match the definition of final uses in the I-O data and they are published in purchasers' prices. For instance identifying agriculture with the NIPA category "food and beverages purchased for off-premises consumption" as in [Herrendorf, Rogerson and Valentinyi \(2013\)](#), would not be correct in the present setting because it also includes processed products, which are actually produced by the manufacturing sector and hence are classified as manufacturing commodities according to I-O data. Suffice to notice that, in 2002, the expenditures on food and beverage are seven times larger than the personal consumption expenditure associated with agriculture in I-O data. A finer definition is therefore needed. This is achieved by using the underlying NIPA tables, which contain categories at a more disaggregated level. The trouble is that the underlying tables are only available since 1959, hence it is not possible to keep the same exact definition for the three main sectors throughout the entire time period. After 1959, the personal and government consumption expenditures categories are allocated to the three main I-O commodities as follows:

- Agriculture: "Fish and seafood"; "Eggs"; "Fresh fruits and vegetables"; "Food produced and consumed on farms"; "Flowers, seeds, and potted plants"
- Manufacturing: "Durable goods" except "Net purchases of used motor vehicles", "Recording media", "Computer software and accessories" and "Corrective eyeglasses and contact lenses"; "Nondurable goods" except categories already included in Agriculture and "Net expenditures abroad by U.S. residents"; "Food furnished to employees (incl. military)"
- Services: "Services" except "Food furnished to employees (incl. military)"; "Recording media"; "Computer software and accessories"; "Corrective eyeglasses and contact lenses"; "Net expenditures abroad by U.S. residents"; "Government consumption expenditures"<sup>10</sup>

The match cannot be perfect because each NIPA category is often associated with more than one I-O commodity. For instance, "Cereals" are allocated in part to "Crop products", which fall in agriculture, and in part to "Food products", which fall in manufacturing. A conservative approach is used and a category is moved only if the majority of its expenditures falls in another sector. In the case of "Cereals", they are moved to manufacturing because only 1% of their expenditures are associated to agricultural commodities. Despite the imperfect match, the magnitudes are now much more in line with I-O data; for instance the personal consumption expenditures allocated to agriculture amount to 47.4 billions of dollars (at producers' prices) in 2002 while they are 48.2 billions of dollars in the I-O data. Unfortunately the same level of disaggregation is not available before 1959 and a much coarser match has to be used.<sup>11</sup> The

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<sup>10</sup>The treatment of government consumption expenditures changed in 1998. The reason is that the gross output for the general government industry did not include intermediate inputs before 1998 and they were accounted for as government consumption expenditures. Therefore the complete association of government consumption expenditures with services is correct only in recent years. Before 1998, one should allocate part of the government expenditures to agriculture and manufacturing; unfortunately the Bridge Tables are not available for government consumption expenditures and it is not clear which NIPA categories should be reallocated. In any case this is unlikely to have a major impact; in fact the government expenditures on agriculture were almost nil in all years and the expenditures on manufacturing commodities that should be reallocated were just 15% of the total in 1997.

<sup>11</sup>As a robustness exercise, in order to exclude this initial period, the main results of the paper are replicated

three main sectors are identified as follows:

- Agriculture: “Food and beverages purchased for off-premises consumption” except “Alcoholic beverages purchased for off-premises consumption”
- Manufacturing: “Durable goods” except “Net purchases of used motor vehicles”; “Non-durable goods” except categories already included in Agriculture; “Food furnished to employees (incl. military)”
- Services: “Services” except “Food furnished to employees (incl. military)”; “Government consumption expenditures”

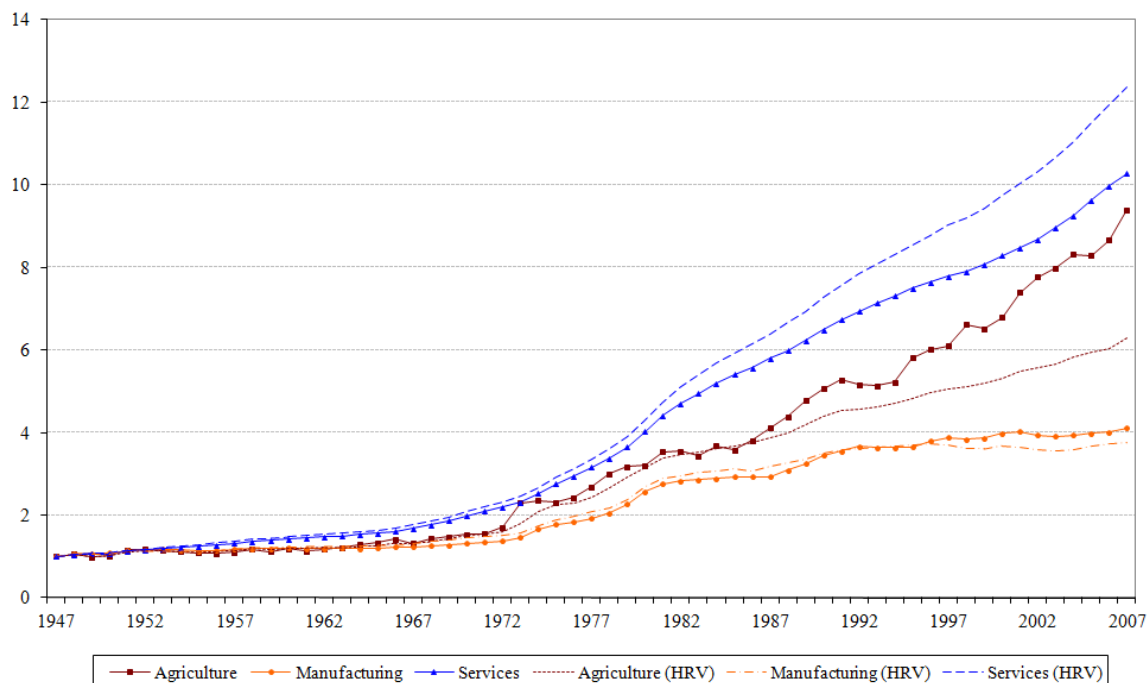
The price indexes obtained so far are in purchasers’ prices, however; this implies that part of their value reflects margins that actually belong to the service sector. The second step therefore consists in obtaining the transportation, retail and wholesale margins for agriculture and manufacturing from I-O tables. The data are available only for benchmark years starting from 1967; thus interpolated values are used in missing years and the margins for the 1947-1966 period are assumed to be equal to their value in 1967. The agriculture and manufacturing price indexes are adjusted to remove these margins, which are then moved within services. To achieve this, price indexes for transportation, retail and wholesale trade are needed. For transportation I take the price index for “Public Transportation” from NIPA tables. For retail and wholesale trade instead there is no direct counterpart in the NIPA tables (there is no final demand for retail trade as such). The obvious choice would be to take price indexes for gross output from the Industry Accounts; unfortunately gross output prices are available only since 1987, therefore value added price indexes are used instead.

Figure A.4 displays the obtained price indexes for final uses in the three main sectors and compares them to the price indexes used by [Herrendorf, Rogerson and Valentinyi \(2013\)](#). It is already clear from this figure that the predictions improve considerably when this alternative set of price indexes is used. In fact, the price index for services displays a higher growth rate, causing a stronger reallocation. Although this alternative set of price indexes is not correct in the current framework, it shows the direction of the bias on the results caused by the assumptions taken due to data limitations. For instance, the predicted change in the service sector employment share rises to 15.38 percentage points as opposed to 13.58 obtained with the preferred set of price indexes (see main text). This quantity amounts to 69% of the actual change and shows that the use of value added price indexes to control for transportation, retail and wholesale margins is likely to have introduced a lower bias in the results.

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starting from the benchmark table in 1958. They are very robust and essentially unchanged. In fact PBS outsourcing accounts for 2.35 percentage points of the change; given the shorter period this corresponds to 14% of the total increase in the share of services in total employment.

Figure A.4: Final Uses Price Indexes (1947=1)



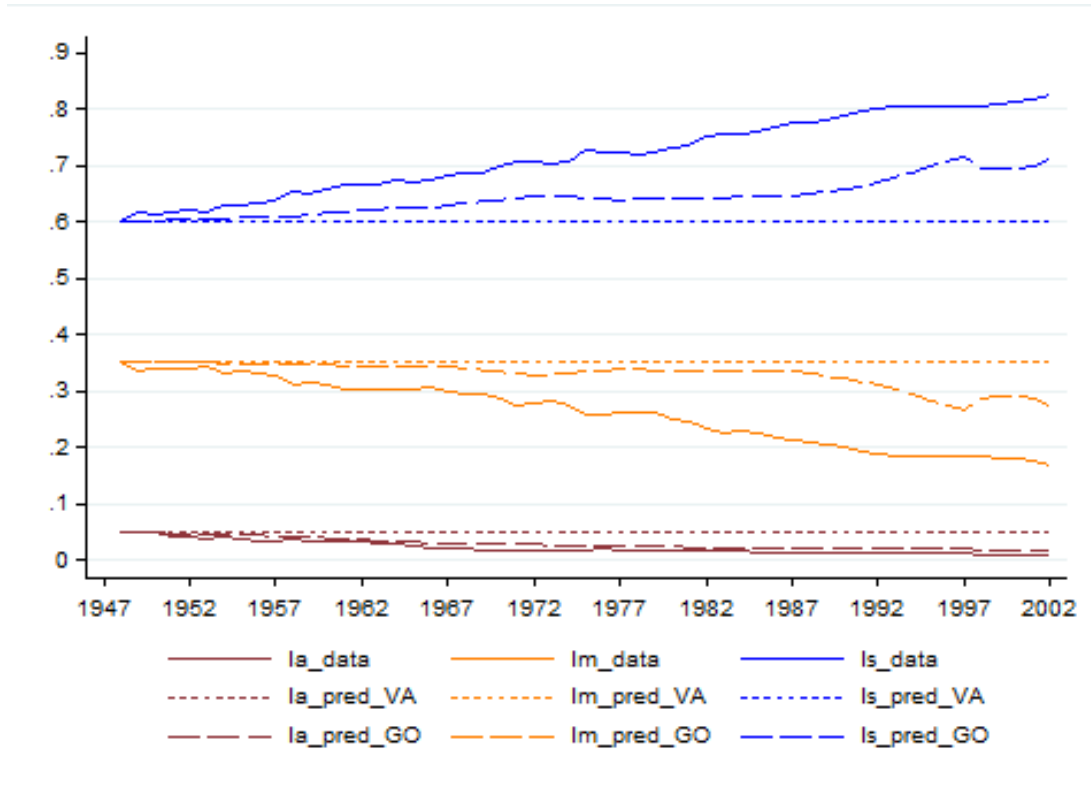
## Appendix B

### B.1 Results without the I-O Data Re-classification

As pointed out in the main text, the classification of I-O data changes in 1997 and unfortunately it is not possible to re-classify the I-O data in the ideal way. The results in the main text might be subject to a lower bias. In this section I re-obtain the main results using the I-O data as they are published by the BEA, that is without performing the re-classification of publishing and auxiliary units. Figure B.1 shows the results of the exercise. As expected, the predictions substantially improve. As shown in Table B.1, the decrease in the manufacturing share is 7.69 percentage points of total employment and the increase in services is 10.98, half of the actual change until 2002. This amount can be considered as an upper bound given the problems caused by the different treatment of auxiliary units between SIC and NAICS. But the change in the treatment of publishing can be regarded as an actual shift of the characteristics of this activity over time, and the re-classification performed in the main text was overly cautious. Hence the results reported here provide a useful benchmark and the correct prediction probably lies in between the two. A factor that pushes the predictions upwards is the differential treatment of imports over time (see Appendix A.1.1). If imports are entirely classified in the service sector before 1967, the ratios for manufacturing and services are reduced to 46% and 38%, respectively. The vast majority of imports was constituted by goods so these results are certainly a lower bound, but it is true that part of the imports should have been classified in services and the main results would be partially affected by this.

The results on the contribution of outsourcing also improve, but to a smaller extent. As

Figure B.1: Predicted vs. Actual Employment Shares in the U.S.



Source: BEA Benchmark and Annual Industry Accounts (release: December 2010) and author's calculations.

Note: The figure shows the data and the predictions obtained using the published I-O tables. The predicted changes in labor shares for agriculture (la), manufacturing (lm) and services (ls) are obtained using the proposed Gross Output model. The Value Added benchmark model predicts no change since the elasticity of substitution  $\epsilon = 1$ .

Table B.1: Predicted vs. Actual Changes in Employment Shares - No Reclassification

Sector	Data	Prediction	Ratio
Agriculture	-3.99	-3.30	83%
Manufacturing	-18.46	-7.69	42%
Services	22.45	10.98	49%

Note: The actual and predicted changes in the employment share are expressed as percentage points of total employment. The predicted changes are obtained using the proposed Gross Output model. Period: 1948-2002.

Table B.2: Effect of Outsourcing on Manufacturing and Services Employment Shares - No Re-classification

Counterfactual	Manufacturing			Services		
	Predicted Change	Diff. wrt Baseline	Ratio to Data	Predicted Change	Diff. wrt Baseline	Ratio to Data
Baseline	-7.69	-	-	10.98	-	-
1: No Service Outsourcing	-4.93	-2.76	15%	4.28	6.70	30%
2: No PBS Outsourcing	-3.87	-3.82	21%	7.02	3.96	18%
3: No Finance Outsourcing	-7.61	-0.08	0%	10.90	0.08	0%
4: No PBS Offshoring	-7.66	-0.03	0%	10.96	0.03	0%

*Note:* The predicted change and the difference with respect to the baseline setting are expressed in percentage points of total employment. The ratio to data is the quantity predicted by the counterfactual exercises expressed as percentage share of the actual change in the data. Period: 1948-2002.

shown in Table B.2, service outsourcing potentially accounts for almost two-thirds of the total prediction of the rise in services; and if the contribution is more plausibly narrowed to PBS only, outsourcing accounts for a change of 3.96 percentage points of total employment. Given the actual change of 22.5 percentage points, PBS outsourcing alone can explain 18% of the total increase in the share of services in total employment. In the case of manufacturing, PBS outsourcing alone can explain 21% of the total fall in the manufacturing employment share, corresponding to an absolute fall of 3.82 percentage points.

Finally note that the results on outsourcing are not affected by the treatment of imports over time. If imports are entirely classified within services before 1967, the results published in the main text almost do not move, they even marginally improve. PBS outsourcing accounts for an increase of 3.11 percentage points in the services employment share, and for a fall of 3.01 percentage points in the manufacturing share.

## B.2 Results with Standard I-O Tables

This appendix shows the results obtained using the standard I-O tables. In these tables output of industries corresponds to the published output in the Industry Accounts because the redefinitions for secondary products performed by the BEA are not present. As a robustness exercise, I report the estimates obtained using these tables for the change in the employment share until 2002. Tables B.3 and B.4 show the results of the exercise, which is performed according to the setting of Section 4 where the elasticity was fixed to one in order to isolate the forces under study. The tables that replicate results of other sections of the paper are available on request; they are not reported here because they do not add any extra evidence. As expected, there is almost no impact on the results. The proposed gross output model is capable of explaining a change in the services share equal to 7.95 percentage points of total employment in 2002, versus the 8.07 percentage points found when supplementary tables are used. In absolute terms, PBS outsourcing accounts for 2.9 percentage points, just 0.1 percentage points less than before. For manufacturing there is an analogous marginal reduction in the predictions, with a predicted fall in the share of manufacturing equal to 4.48 percentage points against the 4.62 of the main text,



and PBS outsourcing accounting for -2.82 percentage points, almost two-thirds of the prediction and just 0.1 percentage points less than before.

Table B.3: Predicted versus Actual Changes in Employment Shares - Standard Tables

Sector	Data	Prediction	Ratio
Agriculture	-3.99	-3.47	87%
Manufacturing	-18.28	-4.48	25%
Services	22.28	7.95	36%

*Note:* Period: 1948-2002. See also notes in Table B.1.

Table B.4: Effect of Outsourcing on Manufacturing and Services Employment Shares - Standard Tables

Counterfactual	Manufacturing			Services		
	Predicted Change	Diff. wrt Baseline	Ratio to Data	Predicted Change	Diff. wrt Baseline	Ratio to Data
Baseline	-4.48	-	-	7.95	-	-
1: No Service Outsourcing	-1.60	-2.88	16%	3.25	4.70	21%
2: No PBS Outsourcing	-1.67	-2.82	15%	5.04	2.91	13%
3: No Finance Outsourcing	-4.29	-0.19	1%	7.75	0.19	1%
4: No PBS Offshoring	-4.45	-0.03	0%	7.92	0.03	0%

*Note:* Period: 1948-2002. See also notes in Table B.2.

The redefinitions of the output of industries are not the only changes carried out by the BEA. In fact, although in the standard tables the BEA constructs I-O tables using the same definition of industries adopted in the Industry Accounts, it still applies some modifications in the case of commodities. As for industry data, the BEA classifies establishments according to their primary activity; occasionally, however, it identifies some secondary products and re-classifies them into other commodities, in contrast with the Economic Census that classifies everything in the industry of the primary product. These re-classifications might pose some problems for the identification of outsourcing with the rise in PBS use, and unfortunately tables before re-classifications are not published. Nevertheless, the re-classifications only affects small single-establishment firms with one single secondary product (but large enough to keep separate records).<sup>12</sup> In fact, whenever two or more support activities cross six-digit NAICS industries, they are treated as auxiliary units and classified in NAICS sector 55 (Management of Companies and Enterprises), which I exclude. This is the case for medium and large multi-establishment enterprises that usually internally produce more than one support activity.

The problem of internal transactions therefore only remains for those small firms whose secondary products are re-classified by the BEA from manufacturing to PBS. These transactions are small in absolute terms and they are unlikely to drive the results. This statement is consistent with the evidence for goods provided by [Atalay, Hortaçsu and Syverson \(2012\)](#) for the domestic operations of U.S. multi-plants firms, and by [Ramondo, Rappoport and Ruhl \(2014\)](#) for intra-

<sup>12</sup>An example is a small newspaper publisher that produces advertising as its single secondary product. For further details see [Horowitz and Planting \(2006\)](#).

firm trade of U.S. multinational firms. Both papers show that shipments between establishments owned by the same firm are surprisingly low and extremely skewed towards large plants: the internal shipments of the median plant are zero or very low in both studies. Hence, by controlling for the internal transactions of medium and large plants, I am likely to capture the vast majority of internal service production recorded in the data. Moreover, the negligible impact that the industry redefinitions have on the magnitude of the results offers another reason why the commodity re-classifications will have a small effect. In fact, the redefinitions are performed using exactly the same logic of the re-classifications, they are just applied to the definition of industries and not commodities. The very small impact of these redefinitions on the magnitude of the results is reassuring; it proves that what is observed in the data is mainly driven by outsourcing since the re-classifications are likely to have a similar very marginal impact.

Finally, there are three extra reasons to believe that the results will provide a robust estimate for outsourcing. First, any re-classification that takes place within manufacturing does not matter for the analysis; only the re-classifications from manufacturing to services, and PBS in particular, are a source of concern. The only examples provided by the BEA that fall into this category are advertising and data processing services. Second, only the difference in service outsourcing matter in the analysis. If the internal production of secondary products stays constant in relative terms over time, these internal transactions cannot possibly drive the result. The constant share accounted by auxiliary units, as shown in Table 2 of Section 3.2, confirms this view. Third, I only consider PBS outsourcing, while there is much evidence that many other types of services have been outsourced, especially bearing in mind the long time frame of the analysis: transportation and warehousing are good examples.<sup>13</sup> Even though a small fraction of the change in PBS use accounted as outsourcing might come from internal transactions, many other types of services are not included, possibly causing an even larger bias in the opposite direction. I do not include them in the baseline results to be more conservative. In fact other services like transportation and wholesale trade are not classified within auxiliary units, hence contrary to PBS I would not be able to properly control for internal transactions.

### B.3 Results until 2007

In recent years, the I-O tables are available annually and not only for the benchmark years. Unfortunately, the annual tables are computed using more aggregate data and do not match the statistical quality of tables in benchmark years. In particular, the intermediate inputs at the detail level are estimated assuming the industry technology to be constant, undermining the precise aim of this study. Moreover, the annual tables are revised periodically over time, when new information becomes available, while the benchmark tables are usually published with a 5-year lag and are not subject to further updates. Also the correction for the classification change cannot be performed as precisely as for benchmark years, as pointed out in Appendix A.1.1. The finer adjustment for PBS cannot be done precisely; and, in the case of publishing, I have to re-classify a larger sector that includes Software Publishers, causing an even bigger

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<sup>13</sup>See footnote 14 in the main text.

underprediction of the overall service sector. For all these reasons, the data for years after 2002 are particularly inaccurate, and the results should be therefore treated with care.

Table B.5: Predicted versus Actual Changes in Employment Shares

Sector	Data	Prediction	Ratio
Agriculture	-4.05	-3.29	81%
Manufacturing	-19.35	-3.82	20%
Services	23.41	7.11	30%

*Note:* Period: 1948-2007. See also notes in Table B.1.

Table B.6: Effect of Outsourcing on Manufacturing and Services Employment Shares

Counterfactual	Manufacturing			Services		
	Predicted Change	Diff. wrt Baseline	Ratio to Data	Predicted Change	Diff. wrt Baseline	Ratio to Data
Baseline	-3.82	-	-	7.11	-	-
1: No Service Outsourcing	-1.85	-1.97	10%	2.15	4.96	21%
2: No PBS Outsourcing	-1.26	-2.56	13%	4.46	2.65	11%
3: No Finance Outsourcing	-3.55	-0.27	1%	6.83	0.28	1%

*Note:* Period: 1948-2007. See also notes in Table B.2.

I replicate the results of Section 4 over the period 1948-2007. As expected, given the warning on data quality, the predictions drop slightly in recent years. As shown in Table B.5, the predicted change in the services share is equal to 7.11 percentage points of total employment, which corresponds to 30% of the actual change. An extra reason for the drop in the estimate is that, after having somewhat leveled in the '90s, the employment share of services experienced a sharp increase in the last decade. Looking at the contribution of outsourcing in Table B.6, PBS account for 2.65 percentage points of total employment, not far from the 3 percentage point change obtained in the main results. Despite the data quality issues, PBS outsourcing still accounts for a sizable share of the total labor reallocation.

In January 2014, the 2007 benchmark table has been published after a comprehensive revision of the industry economic accounts. The revision was aimed at making the benchmark table fully consistent with the NIPAs and the annual industry accounts. The drawback is that the methodology has been deeply revised and unfortunately the new table is not entirely consistent with the previous benchmark tables. For instance the expenditures on research and development are now treated as capital and not as intermediate inputs as before. This “capitalization” of R&D increased GDP by \$330.9 billion but reduced intermediate inputs, for industries in manufacturing in particular. This and other changes affect the present study because directly affect the measure of PBS. It is hard to undo these changes because the industries that were using these inputs are unknown. Overall the new methodology made the 2007 benchmark table more consistent with the recent annual tables but less consistent with the 2002, 1997 and previous benchmark tables. For this reason, it is not possible to use the tables published with the new methodology and all results are based on the 2010 release.

## B.4 Results with Investment

Despite being by far the largest component (85.6% in 2002), personal and government consumption expenditures do not account for the total of final uses, and a further extra adjustment in the price indexes is needed in case investment is to be considered as well. This adjustment involves the allocation of private fixed investment and government gross investment to the three main sectors. The agriculture sector is not a recipient of investment, so no further modification is needed. Unfortunately the NIPA tables are again not detailed enough, and the allocation is quite coarse. All of investment apart from investment in software is allocated to manufacturing; hence the investment allocated to services are just software plus the transportation, retail and wholesale margins associated with investment in manufacturing.<sup>14</sup> The share of investment allocated to services is therefore lower than the actual one. For instance, part of the investment in structures should be allocated to Real Estate, which is in services; PBS is another recipient of investment, which cannot be clearly identified.

The results of the paper are re-obtained here to show the robustness to the inclusion of investment. Clearly the relevant results are those of Section 5 where the final uses expenditure shares are allowed to vary, since with a unitary elasticity the choice of the price indexes has no impact. An extra step is required to allow for investment in the value added model, otherwise the comparison between the two models would not be correct. The treatment of investment in the value added model is performed as in [Ngai and Pissarides \(2004\)](#); they assume that all of investment is performed in manufacturing and set the aggregate investment rate to 20% of output, matching the average investment rate for the period 1929-1998. Note that this is similar to the adjustment performed for the gross output prices, since, also in that case, the share of investment performed in the service sector cannot be properly accounted for.

Table B.7: Predicted vs. Actual Changes in Employment Shares - Investment

Sector	Data	Gross Output		Value Added	
		Prediction	Ratio	Prediction	Ratio
Agriculture	-3.99	-3.55	89%	-2.90	73%
Manufacturing	-18.28	-8.61	47%	-3.01	16%
Services	22.28	12.16	55%	5.90	26%

*Note:* The predicted changes are obtained using both the proposed Gross Output model and the Value Added benchmark model. Period: 1948-2002. The elasticity of substitution  $\epsilon = 0.5$ . See also notes in [Table B.1](#).

Tables [B.7](#) and [B.8](#) report the results of the exercise. The overall predicted sectoral reallocation is reduced in both models; this result comes from the fact that most of the investment is accounted for in manufacturing, hence this sector experiences a lower drop in total employment. In fact, according to the gross output model, the change in the share of manufacturing is equal to -8.61 percentage points of total employment in 2002, a lower drop compared to the 9.99 points

<sup>14</sup>Margins for fixed private investment and government gross investment are again obtained from benchmark I-O tables and interpolated in missing years. Unfortunately the first year in which these margins are available is 1982; hence in all previous years the margins are assumed to be equal to their value in 1982. This does not seem to be a particular source of concern given that the margins are quite constant over time.

Table B.8: Effect of Outsourcing on Manufacturing and Services Employment Shares - Investment

Counterfactual	Manufacturing			Services		
	Predicted Change	Diff. wrt Baseline	Ratio to Data	Predicted Change	Diff. wrt Baseline	Ratio to Data
Baseline	-8.61	-	-	12.16	-	-
1: No Service Outsourcing	-6.20	-2.41	13%	7.75	4.40	20%
2: No PBS Outsourcing	-6.03	-2.58	14%	9.50	2.66	12%
3: No Finance Outsourcing	-8.43	-0.17	1%	11.98	0.18	1%
4: No PBS Offshoring	-8.58	-0.02	0%	12.13	0.03	0%

*Note:* Period: 1948-2002. The elasticity of substitution  $\epsilon = 0.5$ . See also notes in Table B.2.

predicted in the main text without accounting for investment. Also the predicted increase in services is lower, amounting to 12.16 percentage points versus the 13.58 points predicted without investment. But the contributions of the change in the I-O structure and of outsourcing are very robust, displaying even higher values compared to the results without investment. In fact, accounting for intermediates improves the prediction of the rise in the services share by 6.26 percentage points. For what concerns the contribution of outsourcing the results are also robust, if not stronger. Service outsourcing potentially accounts for 4.4 percentage points of total employment; and if the contribution is more plausibly narrowed to PBS only, outsourcing accounts for 2.66 percentage points of total employment compared to 2.53 points predicted without including investment. Also the results for manufacturing slightly improve, with PBS outsourcing accounting for a drop of 2.58 percentage points (against -2.45 in the main text), which is 14% of the total fall in the manufacturing employment share.

## Appendix C

### C.1 Determinants of PBS Outsourcing: Census data

The measure of purchased PBS used in Section 6.2 is obtained from I-O tables. As argued in the main text, this measure of PBS outsourcing is reliable once auxiliary units are excluded; in fact, the problem of internal transactions only remains for those small companies whose secondary products are re-classified by the BEA from manufacturing to PBS. These transactions are likely to account for a very small share of the total. In any case, to dispel any doubt on this issue I perform a robustness exercise and use a second more precise measure of service outsourcing. It comes from the quinquennial Census of Manufactures, which directly asks firms the cost of services purchased from other companies. The problem of internal transactions is therefore completely eliminated. Unfortunately the first year in which data are available is 1992, and only a limited range of services is available: legal, accounting, advertising, software and data processing, and refuse removal. These inputs constitute a subset of the services contained in the PBS sector.

The industry classification employed is NAICS, and I convert the data in 1992 from SIC to

NAICS using the weighted concordance table available on the U.S. Census Bureau website. The measure of coordination complexity is obtained using the Occupational Employment Statistics published by the U.S. Bureau of Labor Statistics. The data are available at a 4-digit NAICS level only from 2002, therefore I cannot exploit the within variation and the analysis only focuses on the cross-sectional variation by adding year fixed effects. A further reason for this choice is that the measure of service outsourcing is not completely consistent across the different Censuses; in fact the 2002 Census also includes purchases of computer hardware, which cannot be excluded.<sup>15</sup>

Table C.1 shows the results of the regressions. Coordination complexity again has a strongly positive and significant effect on PBS outsourcing. The adoption of new technologies, measured by the number of patents used by the industry, has a positive effect but not robust to the inclusion of all controls. Allowing for cross-industry variation only, I can include other determinants of outsourcing, whose measure is only available in a given year. They include: a measure of productivity dispersion as in Yeaple (2006); the ratio of R&D expenditures to sales from the FTC Line of Business Survey; the measure of contract intensity proposed by Nunn (2007); and the measure of routine introduced by Costinot, Oldenski and Rauch (2011). Analyzing the control variables, human-capital intensity again has a positive effect, and this time is strongly significant. Capital intensity is instead negative and significant, in contrast with the results in the main text that gave a positive estimate. The positive and significant effect of the contract intensity variable can be interpreted as another support, albeit indirect, to the complexity and core-competencies story. Under a standard transaction costs economics interpretation, as also pointed out by Corcos et al. (2013), a firm in-sources more contract intensive inputs. Given that all of the inputs used to construct this variable are goods, the positive impact on service outsourcing can be rationalized by arguing that a manufacturing firm with more contract intensive inputs will focus on its core-competencies by producing more goods in-house and outsourcing more of the non-core services.

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<sup>15</sup>Data in 2002 also include the cost for management consulting and administrative services. Since the time variation is not exploited, they are not excluded because they are contained in PBS.

Table C.1: Determinants of PBS Outsourcing - Census data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Complexity	1.909 <sup>a</sup> (0.544)	1.478 <sup>b</sup> (0.627)	1.564 <sup>b</sup> (0.636)	3.554 <sup>a</sup> (0.484)	2.590 <sup>a</sup> (0.475)	2.426 <sup>a</sup> (0.468)	2.386 <sup>a</sup> (0.475)	2.357 <sup>a</sup> (0.474)	2.538 <sup>a</sup> (0.474)	2.783 <sup>a</sup> (0.497)
Num Patents		0.071 <sup>a</sup> (0.021)	0.062 <sup>a</sup> (0.021)	0.090 <sup>a</sup> (0.018)	0.049 <sup>a</sup> (0.019)	0.053 <sup>a</sup> (0.019)	0.043 <sup>b</sup> (0.020)	0.035 <sup>c</sup> (0.020)	0.028 (0.020)	0.031 (0.020)
Num Inputs			0.151 (0.113)	0.229 <sup>b</sup> (0.097)	0.201 <sup>b</sup> (0.099)	0.219 <sup>b</sup> (0.102)	0.223 <sup>b</sup> (0.102)	0.236 <sup>b</sup> (0.103)	0.194 <sup>c</sup> (0.105)	0.217 <sup>b</sup> (0.105)
K/L				-0.406 <sup>a</sup> (0.031)	-0.406 <sup>a</sup> (0.031)	-0.330 <sup>a</sup> (0.057)	-0.322 <sup>a</sup> (0.059)	-0.308 <sup>a</sup> (0.063)	-0.245 <sup>a</sup> (0.067)	-0.241 <sup>a</sup> (0.067)
S/L					0.302 <sup>a</sup> (0.049)	0.290 <sup>a</sup> (0.048)	0.261 <sup>a</sup> (0.054)	0.277 <sup>a</sup> (0.055)	0.254 <sup>a</sup> (0.056)	0.280 <sup>a</sup> (0.060)
Scale						-0.052 (0.034)	-0.058 (0.036)	-0.074 <sup>c</sup> (0.042)	-0.079 <sup>c</sup> (0.042)	-0.076 <sup>c</sup> (0.042)
R&D/Sales							0.038 (0.027)	0.042 (0.027)	0.024 (0.027)	0.035 (0.029)
Dispersion								0.054 (0.057)	0.058 (0.055)	0.051 (0.055)
Contract Int									0.151 <sup>a</sup> (0.053)	0.148 <sup>a</sup> (0.053)
Routine										0.407 (0.302)
Observations	1,386	1,383	1,383	1,376	1,376	1,376	1,367	1,352	1,352	1,352
R-squared	0.043	0.062	0.064	0.229	0.263	0.265	0.268	0.279	0.286	0.287
Fixed effects	year	year	year	year	year	year	year	year	year	year

*Note:* The dependent variable is the share of purchased professional and business services from other companies over total sales. All variables are expressed in logs. Data are from the Census of Manufactures for years 1992, 1997 and 2002. Industry-clustered standard errors in parentheses; (a, b, c) indicate 1, 5, and 10 percent significance levels.

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