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JEL Classification: F16, L8

Keywords: Manufacturing employment, China shock, import competition, servicification, services input use



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June 12, 2020

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# 1 Introduction

The rapid rise in China's share of global trade since the early 1990s has generated significant adjustment pressures in countries around the world. Recent research on the impact of the steep rise in exports of manufactures from China to the United States on US manufacturing employment has documented the regionally differentiated effects of the "China shock" (Autor et al., 2013, 2020). Of particular note is the finding that the negative effects on manufacturing employment in local labor markets (commuting zones) are substantial and that during the time period that was investigated other economic sectors within commuting zones do not provide alternative employment opportunities to affected manufacturing workers (Acemoglu et al., 2016), which implies that much of the adjustment to the shock takes the form of exit from the labor market.

Aggregate employment and productivity growth in the US and other high-income advanced economies is increasingly intertwined with the performance of the service sector. The share of manufacturing in total employment has been falling since the late 1970s, with a concomitant steady increase in the services content of production, consumption and employment. At the level of the economy as a whole, competition from China and other emerging economies is just one – albeit important – factor that has induced shifts in employment away from manufacturing and towards services sectors.

These shifts in US comparative advantage are driven by technical change and investment responses to policies in both the US and in the rest of the world (China). Services account for an increasing share of US exports (34 percent in 2016, up from 27 percent in 2000); in 2016 the services trade balance registered a surplus of $248 billion, compared to a merchandise trade deficit of $752 billion.[1] US comparative advantage in services reflects human capital endowments and the ability to take advantage of services agglomeration externalities (Gervais and Jensen, 2019).

These broader features of structural transformation of the US economy are important in assessing the determinants of the impact of the China shock. In this paper we focus on one specific dimension of the 'servicification' of the US economy: the role of cross-sectoral variation in ser-

[1] Data are from US Bureau of the Census, at https://www.census.gov/foreign-trade/statistics/historical/index.html and reflect balance-of-payments figures. Thus they do not include services that are sold by foreign affiliates of US multinationals, which are an important additional channel for international provision of services by US-owned companies (Francois and Hoekman, 2010).

vices input use (arms-length purchases of services) by manufacturing sectors as a factor that influences the resilience of the latter to greater import competition from China. Given that the US has a revealed comparative advantage in services, downstream industries that are relatively intensive users of services may be better able to withstand import competition from China. We show that industries where production is relatively services intensive have fared better in terms of employment because their competitiveness has either prevented significant Chinese import penetration in their sector or secured them a distinct market segment even in the face of import penetration.

Given the worldwide trend of structural transformation, we propose a sector-level measure of services input intensity (SII), which is an internationally comparable statistic that broadly captures the variety of advantages that accrue to manufacturing industries that use services inputs. We know from previous literature that relative to intermediate parts and components, services are special inputs that enhance competitiveness through complex mechanisms: e.g., they coordinate increasingly fragmented global production processes; manage within-firm processes; coordinate between upstream suppliers and downstream customers in global value chains (GVCs) (Francois, 1990; Baldwin et al., 2015); and finally R&D, product development, innovation, and marketing help meet market demand and anticipate future preferences (Bloom et al., 2016). At our level of analysis we do not disentangle the relative importance of these services-dependent mechanisms, which are better studied using firm-level data.

It is helpful to illustrate the role of services inputs using the case of Carhartt: an apparel manufacturer that operates in an industry where Chinese import competition has largely substituted for US manufacturing. The company has been able to continue to operate factories in the US that, employ around 2200 workers. Carhartt has used advertising services successfully to differentiate itself, emphasising the quality and durability of its products; it has used external consulting services to optimise business processes; it has promoted consumer engagement on e-commerce platforms to build its brand; and it has captured additional value-added by branching into retail.

The latter elements of its strategy have been implemented through the use of cloud-based transportation management technology that has been sourced from specialized services consulting firms that led to efficiency gains through supply-chain optimization (GlobeNewswire, 2016). Use of such outsourced services inputs have helped Carhartt compete with imports by reducing costs, but more important is that these services inputs have allowed the company successfully to meet

market demand and respond to changing consumer tastes in a way that many other import-competing products have not been able to replicate.

The literature on services inputs into manufacturing highlights their special function in coordinating and logistics that support the process of production fragmentation and specialisation, which in turn improve industry-level efficiency and competitiveness. For instance, information and communications, transport, and logistics services are needed to connect labor and capital across space; and financial and insurance services allow firms to manage the risks of routine operations as well as the risks that are inherent in innovation and experimentation (Francois, 1990; Francois and Hoekman, 2010).

In a world of global value chains (GVCs) where production involves the coordination across space and time of intermediate inputs that are produced by firms that are located in different regions or countries, this coordination function is particularly important. Baldwin et al. (2015) note that transport, telecommunications, logistics, and distribution services account for an increasing share of total value added in manufacturing because of the increasing fragmentation of the production process and the outsourcing of non-core activities. In the increasingly complex value chains that characterise modern manufacturing, parts have to be shipped and activities coordinated in ways that minimize the need for (cost of) storage.[2]

Services outsourcing as a driver of firm performance has been the subject of numerous papers, with research identifying a positive effect of services outsourcing on productivity at both the firm level (see for instance Görg et al., 2008; Hijzen et al., 2010) and at the sector level (see Amiti and Wei, 2009; Winkler, 2010). For example, Görg and Hanley (2011) identify a positive impact of outsourcing of services on innovation practices in a sample of Irish manufacturing firms. The use of ICT services in a broad range of industries has been a driver of US output and productivity growth since the mid-1990s (van Ark et al., 2008).

Our analysis extends the literature in several respects: The main contribution is to assess the role of services input intensity as a determinant of the local manufacturing employment response to greater import penetration. We complement Acemoglu et al. (2016) by showing that labor demand effects within a commuting zone are a function of the degree of sectoral exposure to Chinese imports, but that the services intensity of production is an additional factor that should

[2]Berlingieri (2015) finds that firms increase their services input intensity in order to manage coordination complexity (proxied by the number of contested export destination markets).

be considered.

More generally, our analysis contributes to the debate on the employment effect of services outsourcing. This literature has identified different theoretical channels with a net ambiguous effect on employment.[3] To the best of our knowledge the role of services outsourcing on the response of manufacturing employment to trade shocks has not been investigated. In doing so, we contribute to the broader debate on the role of services in aggregate economic performance and structural transformation (see Schettkat and Yocarini, 2006; Young, 2014; De Backer et al., 2015).

We analyze the heterogeneity of local manufacturing employment effects of the China shock, focusing specifically on the question of whether differences in the intensity of use of externally purchased services inputs across US manufacturing industries are associated with greater resilience of employment to import competition from China. We use the empirical approach that was developed by Autor et al. (2013) to identify the employment response of manufacturing sectors at the commuting zone level in the US.

We do not take a stance on whether it is appropriate to limit analysis of Chinese competition to a relatively short-run setting in which worker mobility is assumed to be very limited. Our goal is simply to deepen the understanding of the factors that determine the cross-sectoral variation in employment effects at the level of local labor markets. We find that more intensive use of producer services appears to be positively associated with resilience to import competition.

The remainder of the paper is organized as follows: Section 2 presents the data on services input intensity. Section 3 lays out the empirical strategy. Results are reported and discussed in Section 4. Section 5 concludes with some implications for further work.

## 2 Data

The analysis distinguishes between the two time periods analysed by Autor et al. (2013): 1990-2000 and 2000-2007, with the latter adjusted to be 10-year equivalent. For our dependent variable

[3] On the one hand, offshoring reduces input prices and increases profits, which in turn potentially increases manufacturing production and labor demand. On the other hand, higher quality and cheaper service inputs may substitute for labor that is used in production, decreasing labor demand (Amiti and Wei, 2006; Milberg and Winkler, 2010b and Winkler, 2010). Consistent with the theoretical ambiguity, empirical findings are mixed (Amiti and Wei, 2005, 2006; Schöller, 2007; Winkler, 2010; Michel and Rycx, 2012; Milberg and Winkler, 2010a, 2015; Eppinger, 2019). However, services offshoring tends to be associated with a higher demand for skilled labor at the firm level (Crinò, 2010; Andersson et al., 2016).

– changes in sectoral employment – we use County Business Patterns (CBP) data from the U.S. Census Bureau for the years 1990, 2000, and 2007. Data on working-age population are sourced from the Population Estimates Program (PEP) of the U.S. Census Bureau. We follow Autor et al. (2013) in controlling for unobserved demand shocks that affect – at the same time – changes in local employment levels and Chinese import competition. We also use their instrument: an exposure variable where bilateral trade flows from China to the US are replaced by trade flows from China to a basket of other advanced economies: Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. These data were made available by David Dorn. For the services input intensity measure we use US Input Output tables from the OECD STAN database for the mid-1990s.

We focus on the role of services input intensity in moderating the local labor market effects of exposure to imports of manufactured goods from China as assessed in the empirical framework that was developed by Autor et al. (2013). We do so by augmenting their empirical specification with a sectoral dimension in the spirit of Acemoglu et al. (2016). This allows us to introduce explicitly a measure of services input intensity that is used as a moderator of the effect of the treatment variable.

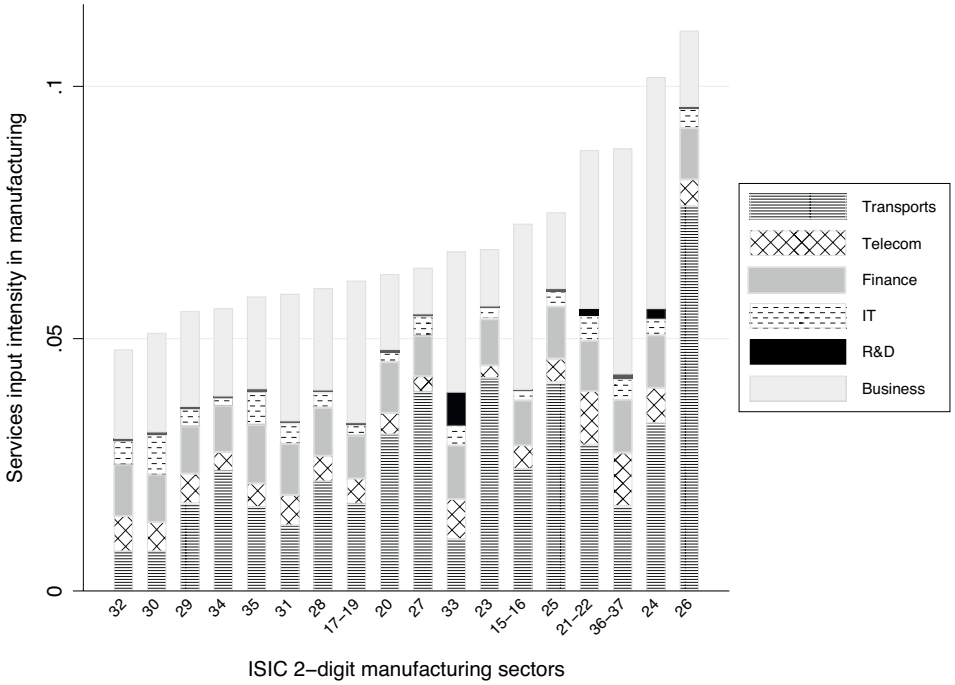
Autor et al. (2013) find that a local labor market's degree of exposure to imports of goods from China has a negative effect on the size of its manufacturing sector relative to geographic areas that are less exposed to imports. In what follows we hypothesize that the services input intensity of an industry will affect its response to changes in local trade exposure: For a given level of local labor market exposure to imports of manufactured goods, industries within that local labor market that are more intensive users of services are less affected.

Figure 1 ranks US manufacturing sectors (denoted by their two-digit ISIC Rev. 3 codes) in terms of their services input intensity as defined by the sum of technical input-output coefficients for six services sectors that are particularly salient intermediate inputs into production (so called 'producer services').[4] The pattern of services input intensity is relatively heterogeneous across manufacturing sectors. Transport, business and financial services tend to be relatively significant for most manufacturing industries. Conversely, R&D services tend to be small or absent in the

[4]Technical coefficients in Figure 1 capture the technical relationship between US industries that prevailed in the early 1990s. The coefficients comprise the elements of the square matrix $A$ defined as $A \equiv YM$, where $Y$ is a dimension $n$ square matrix of zeros, except along the main diagonal, that includes the inverse output of each industry and $M$ is the intermediate demand matrix. For each services-manufacturing sector pair $(s, j)$, the technical coefficient is the element $a_{sj}$ of $A$ and represents the cost of the intermediate inputs from services sector $s$ per dollar of total production of manufacturing sector $j$.

input bundle of downstream sectors – with the notable exception of medical, precision, and optical instruments (ISIC sector 33).

Figure 1: Services input intensity in manufacturing sectors




Notes: Manufacturing sectors are denoted on the horizontal axis with their 2-digit ISIC Rev. 3 codes. The identification of the ISIC 2-digit sectors can be found in the Appendix table A.1. For each services sector the vertical axis reports its technical coefficient in the respective manufacturing sector. Technical coefficients are computed from the earliest observation of the US input-output table that was sourced from the OECD IO STAN that captures the technical relationship between industries prevailing at the beginning of the 1990s.

# 3 Empirical strategy

To investigate the role of differences in services input intensity in moderating the impact of an increase in import competition on manufacturing employment, we interact the change in import exposure at the commuting zone (CZ) level with a measure of services input intensity across sectors:[5]

$$\Delta E_{ist} = \delta_{st} + \beta \Delta IP_{it} + \mu(\Delta IP_{it} \times SII_s) + \kappa(\Delta IP_{it} \times Exposure_s) + \gamma' \mathbf{X}_{ist-1} + \epsilon_{ist}\,, \qquad (1)$$

where: $\Delta E_{ist}$ is the change in employment of sector $s$ in CZ $i$ at time $t$, expressed in percentage

[5]We define local labor markets according to Autor et al. (2013) to be 722 non-overlapping commuting zones which represent areas with a high degree of labor mobility within and very little mobility across zones. Our empirical specification follows closely Section 6 of Acemoglu et al. (2016). We refer the reader to these papers for an in-depth discussion of identification and instrumentation strategies.

points of working–age population. The index $t$ distinguishes the two time periods we cover: 1990-2000 and 2000-2007, where the latter period is adjusted to be 10-year equivalent. $\Delta IP_{it}$ is the change in import penetration (exposure) to Chinese competition at the local labor market level as defined in Autor et al. (2013). $SII_s$ is a measure of the services input intensity of sector $s$. More precisely, $SII_s$ is the manufacturing sector-specific sum over services sectors of their technical coefficients.

We restrict the focus to the six categories of producer services in Figure 1: (1) transport and storage; (2) telecommunications; (3) finance; (4) computer and related services (IT); (5) R&D; and (6) business services.[6] To rule out the possibility that the change in exposure to Chinese import competition affects the degree of service input intensity, we measure $SII_s$ using data that reflects the industrial linkages in the early 1990s.

Controlling for the interaction between $\Delta IP_{it}$ and $Exposure_s$ (predicted exposure at the sectoral level) allows us to control for the possibility that the differential impact of $\Delta IP_{it}$ on $\Delta E_{ist}$ with respect to $SII_s$, may be driven by differences in other relevant characteristics: that service intensive industries are also less exposed to Chinese competition. To establish exogeneity, $Exposure_s$ is predicted from a regression of sectoral import penetration in the US on the sectoral import penetration in other countries.

$\mathbf{X}_{ist-1}$ is a vector of other controls, which include lagged variables that vary at the CZ-time level and census geographic division dummy variables that are interacted with sector fixed effects.[7] $\delta_{st}$ are sector-time fixed effects, which flexibly capture any sector specific time effect. $\epsilon_{ist}$ is the error term.

The marginal effect of changes in exposure to Chinese import competition on local employment is given by:

$$ME_s = \beta + \mu \times SII_s + \kappa \times Exposure_s. \tag{2}$$

Summary statistics for the main variables used in the estimation are reported in Table 1. Changes in both import penetration and sectoral employment are on average larger in the later period, and also exhibit greater variability.

[6]The business services category includes professional services such as legal, accounting, management consulting, and engineering.

[7]The nine census divisions are identified by eight dummy variables that group together subsets of CZs.

Table 1: Summary statistics for the main variables

| Variable | Mean | Median | sd | Min | Max |
|---|---|---|---|---|---|
| $\Delta E_{ist}$ | -0.099 | -0.001 | 0.706 | -18.570 | 14.035 |
| $\Delta E_{is\mathbf{1990}}$ | -0.032 | 0.000 | 0.663 | -16.467 | 13.005 |
| $\Delta E_{is\mathbf{2000}}$ | -0.165 | -0.017 | 0.741 | -18.570 | 14.035 |
| $\Delta IP_{it}$ | 1.906 | 1.179 | 2.582 | -0.629 | 43.085 |
| $\Delta IP_{i\mathbf{1990}}$ | 1.176 | 0.746 | 1.781 | -0.075 | 25.405 |
| $\Delta IP_{i\mathbf{2000}}$ | 2.636 | 1.935 | 3.016 | -0.629 | 43.085 |
| $Exposure_s$ | 0.661 | 0.613 | 0.261 | 0.300 | 1.226 |
| $SII_s$ | 0.069 | 0.063 | 0.017 | 0.048 | 0.111 |

Notes: The data span two time periods: 1990-2000 and 2000-2007, and each period is indexed by the year it begins. The latter period is adjusted to be 10-year equivalent.

# 4 Results

## 4.1 Benchmark case

Table 2 reports the results of 2SLS estimation of versions of equation (1) where columns (3) to (5) progressively include treatment variables. The same instruments and controls as Autor et al. (2013) are used. Results in column (1) confirm at a sector-local labor market level previously established findings of a negative relative effect of import exposure on employment share. These results are invariant to progressively adding control variables that capture relevant features of the local labor markets.[8] Note that we observe effects in terms of percentage point changes, not levels, of employment share, and that the methodology permits analysis of relative effects: the performance of more exposed local sectors versus less exposed ones.

This first result in column (1) is obtained from a stacked first differences specification used by Autor et al. (2013) that uses data from two time periods: 1990-2000 and 2000-2010. We test for a structural break between these two time periods using a Chow test and reject the null hypothesis of no structural break (Chow F-statistic: 15.07). Column (3) reveals that the pooled results are driven by the later (2000-2010) period. Column (2) shows that import exposure is not significant in the first period (1990-2000). For this reason, and given that the earliest data for our $SII_s$ variable is from the 1990s, in what follows we focus out analysis exclusively on the later period, but note that our findings are robust to pooling the time periods as in Autor et al.

[8] Our controls are not shown; they are the standard ones in the literature: the lags of local manufacturing employment share; college-educated share of population; foreign-born share of population; female employment share; share of routine occupations; and share of outsourcable occupations.

(2013).

Table 2: Services input intensity and sectoral exposure mediate the effect of Chinese import competition

| | 2SLS | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Change in Import Exposure per worker | -0.032*** | -0.005 | -0.021** | -0.073** | 0.126** |
| | (0.007) | (0.013) | (0.008) | (0.029) | (0.050) |
| Change in Import Exposure per worker × SII | | | | 0.756** | -0.305 |
| | | | | (0.328) | (0.411) |
| Change in Import Exposure per worker × Sectoral Exposure | | | | | -0.189*** |
| | | | | | (0.038) |
| Observations | 25,992 | 12,996 | 12,996 | 12,996 | 12,996 |
| Sanderson–Windmeijer F stat | 48 | 22 | 30 | 63 | 110 |
| Controls | YES | YES | YES | YES | YES |
| Sector × Decade FE | YES | YES | YES | YES | YES |

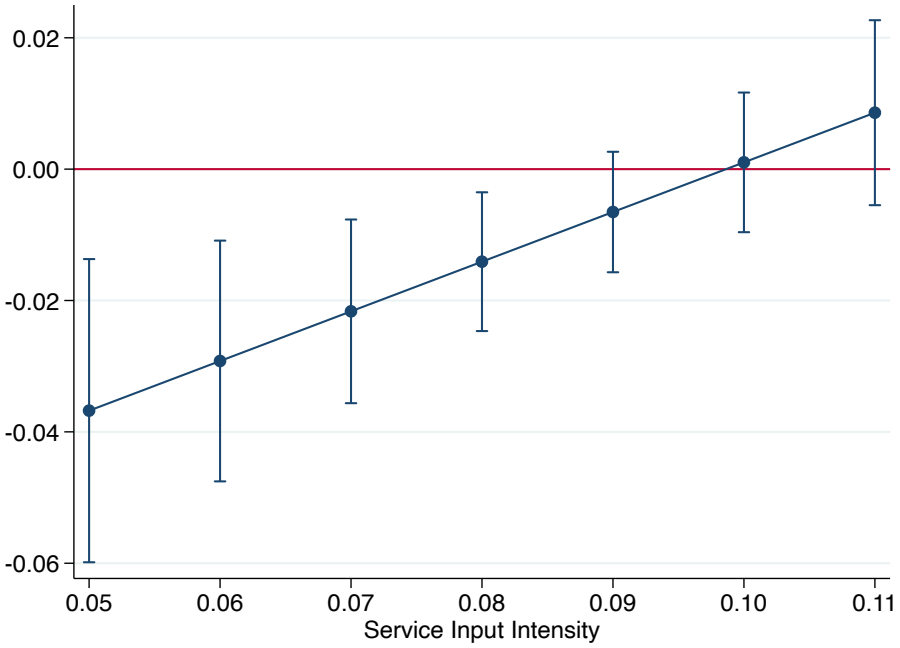
Notes: Estimates from equation $\Delta E_{ist} = \delta_{st} + \beta \Delta IP_{it} + \mu(\Delta IP_{it} \times SII_s) + \kappa(\Delta IP_{it} \times Exposure_s) + \gamma' \mathbf{X}_{ist-1} + \epsilon_{ist}$ Commuting zone $i$, sector $s$, time $t$. The dependent variable is the 10-year equivalent change in manufacturing employment/working-age population in percentage points. All models are estimated using 2SLS. SII is a measure of services input intensity in the downstream sector. The controls – $\mathbf{X}_{ist-1}$ – are the shares of: lagged employment in manufacturing; college-educated; foreign-born; female employed; employment in routine occupations; and census division dummy variables that are interacted with sector fixed effects. Standard errors in parentheses are clustered by state.

A novel finding from our analysis is the significant positive coefficient on the interaction between import exposure and services input intensity of the local manufacturing sector in column (4). This supports the hypothesis that greater use of services inputs may act to moderate adverse employment effects of an increase in import penetration.[9] Once we introduce a control for the interaction between local import exposure and sectoral exposure in column (5) we see that this interaction term becomes significant and the interaction of local exposure and SII becomes insignificant. This means that high SII is also associated with low sectoral exposure, which suggests that at this level of aggregation the mechanism through which SII functions is by reducing import competition.

To illustrate this finding graphically, Figure 2 plots the marginal effect of the treatment on the dependent variable as a linear function of the moderator variable $SII$. The estimated marginal effect of exposure to manufactured imports is less negative when the sector makes greater use of service inputs. For the highest values of service input use observed in the sample the effect is not statistically different from zero.

[9]Controlling for endogeneity due to potential unobserved demand shocks with the use of the instrumentation strategy is important as the OLS point estimates (not reported) of $\beta$ and $\mu$ are $-0.0378^{***}$ and $0.379^{*}$, respectively, which significantly underestimate this impact.

Figure 2: Marginal effect of trade shock as a function of services input intensity




Notes: The figure plots the estimates from column (4) in Table 2 and the corresponding 90% confidence intervals computed for different values of services input intensity.

The point estimates show that, at the mean value of $SII$ of 0.069, a \$1,000 exogenous decadal rise in CZ's import exposure per worker reduces sectoral manufacturing employment per working-age population by approximately 0.021 percentage points ($= -.0730 + 0.756 \times 0.069 = -0.021$). The same increase in import competition generates different effects depending on the sectoral $SII$. At the highest level of $SII$ (0.111) the same \$1,000 increase in import exposure leads to a 0.011 percentage point increase in sectoral manufacturing employment share, although this increase is not significantly different from zero. At the lowest level of $SII$ (0.048) the same \$1,000 increase in import exposure leads to a reduction in sectoral manufacturing employment share of 0.037 percentage points.

## 4.2 Services input intensity and sectoral import exposure

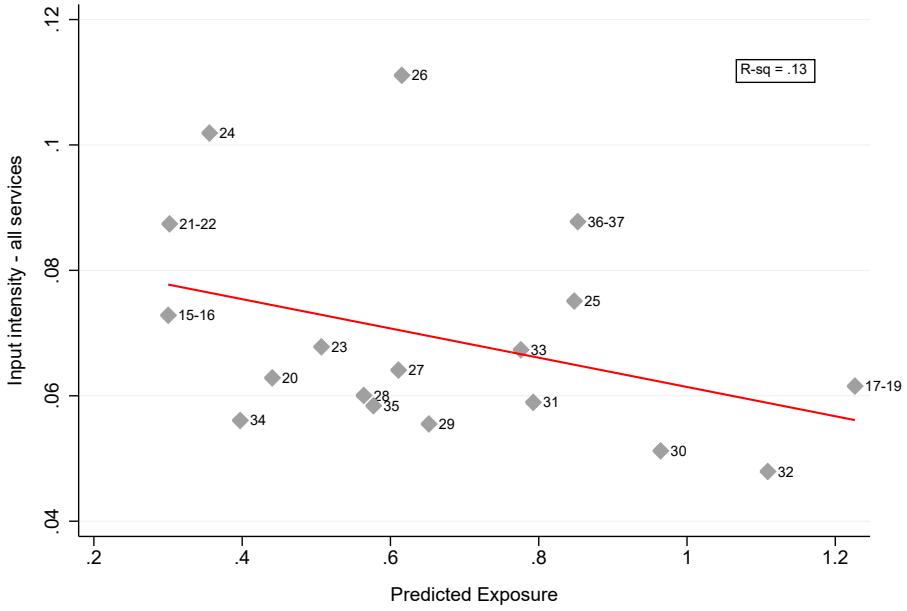
The foregoing demonstrates that services input intensity is a moderator of the China shock. $SII$ is a "pre-treatment" sector-level characteristic of manufacturing sectors that potentially affects not only a sector's employment response to import competition but also the extent to which it is subject to exposure. As discussed previously, the employment effect of a trade shock will be sector-specific, depending on the degree of exposure, which is determined in part by the services

intensity of different manufacturing industries. $SII$ moderates the employment effect of the trade shock through its influence on the degree to which it attenuates the level of import competition with which it is confronted, which is reflected in the magnitude of the shift of the labor demand curve.

Given the degree of sectoral exposure to import competition, services intensity may also affect a sector's response to greater import competition. This effect can operate both through a further shift in sector-specific labor demand and/or through variations across sectors in the elasticity of labor supply. In cases where labor supply is more elastic the net result may be a further reduction in labor demand.

Our empirical framework allows us to identify a sector's response to the China shock as long as services input intensity and sectoral import exposure are uncorrelated. In the spirit of Acemoglu et al. (2016), to guarantee exogeneity, we use predicted sectoral exposure computed by regressing US sectoral exposure on the sectoral exposure of other high-income advanced economies. As Figure 3 shows, the estimated correlation between $SII$ and predicted sectoral exposure is negative and equal to -0.36 (see Table 3). This suggests that the moderating effect of $SII$ is at least partly driven by the lower values of sectoral exposure that are associated with higher $SII$.

Figure 3: Correlation between exposure and service input intensity




Notes: The line shows the fitted values of the univariate regression of $SII$ on our measure of predicted exposure. Both variables are measured at the sectoral level, and manufacturing sectors are denoted with their 2-digit ISIC Rev. 3 codes. The identification of the ISIC 2-digit sectors can be found in the Appendix table A.1.

Table 3: Correlation between service input intensity and exposure

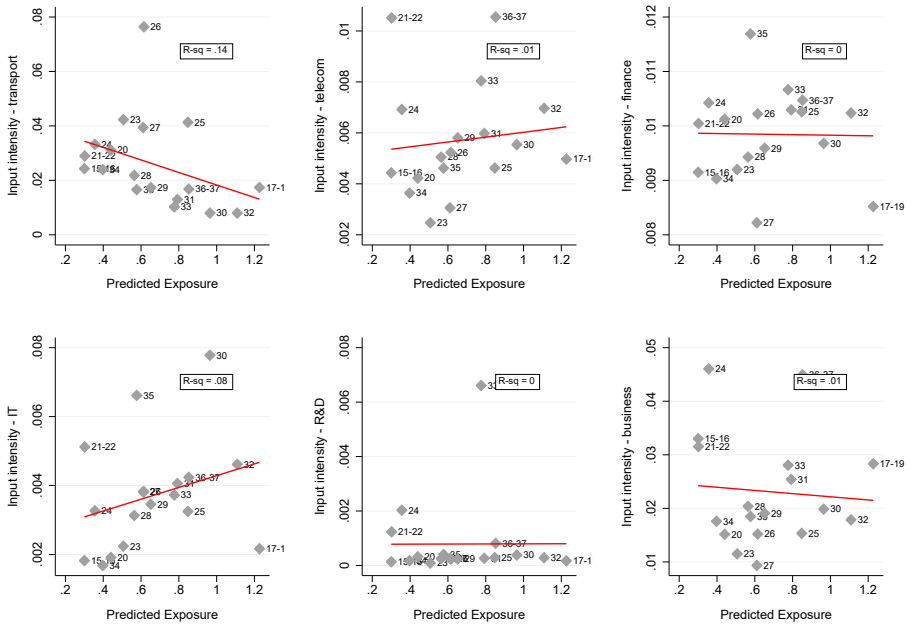
| | Predicted Exposure |
|---|---|
| Input intensity - all services | -0.362 |
| | (0.140) |
| Input intensity - transport | -0.371 |
| | (0.129) |
| Input intensity - telecom | 0.115 |
| | (0.650) |
| Input intensity - finance | -0.017 |
| | (0.948) |
| Input intensity - IT | 0.284 |
| | (0.253) |
| Input intensity - R&D | 0.003 |
| | (0.990) |
| Input intensity - business | -0.076 |
| | (0.764) |
| Observations | 18 |

Notes: The table reports the Pearson correlation coefficient between sectoral service input intensity and sectoral exposure with the associated p-value in parenthesis. The first row refers to all service sectors, whereas each of the remaining rows refers to one of the 6 service sectors.

In order to investigate this question further, we unpack $SII$ at the level of each individual producer service component, generating six different services-specific measures of input intensity, denoted as $SII^k$, where $k$ is the index for different categories of producer services inputs. Figure 4 plots the estimated correlation between manufacturing sector import exposure and the relevant $SII^k$ variable. There is substantial heterogeneity across individual services sectors. For Finance and R&D we find that the correlation is equal to 0. In these two cases all of the moderating effect of $SII^k$ can be attributed solely to the manufacturing sectors' capacity to respond to import competition.

When the correlation is different from 0, we cannot distinguish between the effect of services intensity on import exposure and the effect on the employment response. Thus in these cases controlling for sectoral exposure is important in order to isolate the component of services input intensity that is orthogonal to predicted sectoral exposure. As shown in Table 4, column (1) the moderating properties of $SII^{Transport}$ are completely absorbed by the portion of its variability that co-moves with sectoral exposure to imports. In this case we replicate the result obtained using the aggregate $SII$ variable: higher services intensity reduces the negative impact on labor demand, but we cannot disentangle the mechanism through which this works.

Figure 4: Correlation between import exposure and services sector-specific $SII$




Notes: The lines show the fitted values of the univariate regressions of the separate components of $SII$ on our measure of predicted exposure. Both variables are measured at the sectoral level, and manufacturing sectors are denoted with their 2-digit ISIC Rev. 3 codes. Each graph refers to one of the six types of services. The identification of the ISIC 2-digit sectors can be found in the Appendix table A.1.

In the case of telecommunications (column 2) and business services (column 6), higher values of $SII^{Telecom}$ and $SII^{Business}$ are associated with larger negative employment effects of the China shock. This is consistent with a situation where the supply-side (elasticity) effect augments the demand-side impact, which results in a greater decline in manufacturing employment. In the case of telecommunications, these properties are again completely absorbed by the portion of the variation that co-moves with sectoral exposure. In contrast, in the case of business services, this effect is at least partly driven by variation that is orthogonal to predicted sectoral import exposure.

These results suggest that there are services sector-specific differences that are masked by the finding that at the aggregate level greater services intensity is associated with a smaller decline in manufacturing labor demand (employment) following the trade shock. This aggregate result is driven by transport, finance, and R&D, with the last two service categories representing cases where the effect is independent of variation across manufacturing industries in exposure to import competition. Our unpacking of $SII$ also reveals that for some types of services – business services in particular – higher levels of $SII^{Business}$ are associated with a greater decline in labor

Table 4: Services input intensity and sectoral exposure mediate the effect of Chinese import competition - 2000

| | 2SLS – 6 services-specific measures of input intensity | | | | | |
|---|---|---|---|---|---|---|
| | (1) Transport | (2) Telecom | (3) Finance | (4) IT | (5) R&D | (6) Business |
| Change in Import Exposure per worker | 0.091*** | 0.125*** | -0.097 | 0.080*** | 0.093*** | 0.137*** |
| | (0.028) | (0.033) | (0.128) | (0.024) | (0.019) | (0.037) |
| Change in Import Exposure per worker × SII | 0.217 | -4.926 | 19.958 | 7.672 | 8.604** | -1.480* |
| | (0.478) | (4.065) | (13.331) | (8.316) | (3.870) | (0.804) |
| Change in Import Exposure per worker × Sectoral Exposure | -0.177*** | -0.178*** | -0.181*** | -0.195*** | -0.182*** | -0.187*** |
| | (0.032) | (0.032) | (0.033) | (0.037) | (0.033) | (0.035) |
| Observations | 12,996 | 12,996 | 12,996 | 12,996 | 12,996 | 12,996 |
| Sanderson–Windmeijer F stat | 105 | 64 | 74 | 68 | 66 | 64 |
| Controls | YES | YES | YES | YES | YES | YES |
| Sector × Decade FE | YES | YES | YES | YES | YES | YES |

Notes: Estimates from equation $\Delta E_{ist} = \delta_{st} + \beta \Delta IP_{it} + \mu(\Delta IP_{it} \times SII_s) + \kappa(\Delta IP_{it} \times Exposure_s) + \gamma' \mathbf{X}_{ist-1} + \epsilon_{ist}$
Commuting zone $i$, sector $s$, time $t$. The dependent variable is the 10-year equivalent change in manufacturing employment/working-age population in percentage points. All models are estimated using 2SLS. SII is a measure of services input intensity in the downstream sector. The controls – $\mathbf{X}_{ist-1}$ – are the shares of: lagged employment in manufacturing; college-educated; foreign-born; female employed; employment in routine occupations; and census division dummy variables that are interacted with sector fixed effects. Standard errors in parenthesis are clustered by state.

demand. Higher services input intensity from services that increase firms' flexibility in their use of labour inputs may increase the elasticity of supply of labor in the potential labour pool and thus exacerbate the employment effects of a given trade shock.

The aggregate labor-supply elasticity in a sector is higher when there are fewer barriers and fixed costs to employment: e.g. training, educational attainment, certification, or firm- or sector-specific experience. This is also the case when a sector has a larger local pool of potential workers to draw from, or is able to benefit from geographic mobility of workers or technologies that permit workers to provide their services remotely. Companies that provide business services in particular facilitate the outsourcing of tasks by manufacturing firms that require relatively little firm- or industry-specific skills.

Because there is a large market for such workers that spans many industries, these workers have relatively more employment opportunities than do workers who perform tasks that require a high level of firm-specific knowledge capital. An implication is that the business services input intensity of a sector is associated with a more wage-sensitive labor force. The upshot is a higher labor supply elasticity, so that a given downward shift in demand will result in a greater decrease in employment by manufacturing establishments in equilibrium. This second mechanism can account for the heterogeneity of the results that we obtain when we decompose different types of services. While the aggregate result strongly supports our main hypothesis of services input

intensity being a technological feature capable of attenuating the negative employment response to import competition, the findings from a more disaggregated analysis add a layer of complexity that points at heterogeneity across services sectors. However, it should be noted that we cannot disentangle the supply and demand effects with the available data.

# 5 Conclusions

The evidence presented in this paper suggests that services intensity is a factor that differentiates local US manufacturing employment responses to the China shock. We find that the manufacturing sectors that have borne the brunt of the adjustment costs that are associated with import competition from China are those that are less services-intensive, whereas those that use services inputs more intensively experienced less reductions in employment.

The decline in US manufacturing employment has been ongoing for decades, which largely reflects continued technological change. The share of services has expanded as a result of a mix of: inter-industry productivity differences; inter-industry shifts in the division of labor (outsourcing); and increasing final demand for services as per capita incomes rise (Schettkat and Yocarini, 2006).

For the future, manufacturing jobs will continue to become more skill-intensive and sophisticated and be associated with further servicification of production. The implications of servicification of the economy has long been a subject of research. Less well understood is how the rise in services input intensity affects the employment responses of manufacturing industries to trade shocks. We provide evidence that services input intensity is a factor that moderates the negative employment impacts of the China shock, but our evidence also shows that it is important to "unpack" this result. Different services play different roles and functions in making manufacturing employment more or less resilient to trade shocks.

More generally, our findings point to a broader research agenda on the properties of different types of services inputs and the role that they play in the production functions of firms and their employment adjustment dynamics. Crucial to that end are rich labor statistics that allow assessment of heterogeneous effects across services tasks that differ in skill content (see Autor et al., 2003, for a taxonomy of skill types based on the dictionary of occupational titles) and to analyze the role of services in shaping the effect of trade shocks as a function of the skill content across industries or firms (Lu and Ng, 2012). While such an analysis is beyond the scope of the

present paper, we hope our findings will stimulate analysis employing more detailed data of the role of services in structural transformation.

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# Appendix

Table A.1: Mapping between sectors 2-digit ISIC Rev. 3 codes and labels

| Codes | Labels |
|---|---|
| 15-16 | food products, beverages, and tobacco |
| 17-19 | textiles, textile products, leather, and footwear |
| 20 | wood and products of wood and cork |
| 21-22 | pulp, paper, paper products, printing, and publishing |
| 23 | coke, refined petroleum products, and nuclear fuel |
| 24 | chemicals and chemical products |
| 25 | rubber and plastics products |
| 26 | other non-metallic mineral products |
| 27 | basic metals |
| 28 | fabricated metal products except machinery and equipment |
| 29 | machinery and equipment n.e.c |
| 30 | office, accounting, and computing machinery |
| 31 | electrical machinery and apparatus n.e.c |
| 32 | radio, television, and communication equipment |
| 33 | medical, precision, and optical instruments |
| 34 | motor vehicles, trailers, and semi-trailers |
| 35 | other transport equipment |
| 36-37 | manufacturing n.e.c. and recycling |