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The Great Recession and Job Loss Spillovers

Impact of Tradable Employment Shocks on Supporting Services

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Abstract

This paper explores the spillover effects of job losses via input linkages during the Great Recession. Exploiting exogenous variation in tradable employment shocks across U.S. counties, the paper finds that job losses in the tradable sectors cause further job losses in local supporting services. The result is not due to reverse causation, construction job losses, or credit shortages. In addition, the paper finds that logistic supporting services are relatively more affected by local tradable job losses, while professional supporting services, such as information technology and management consulting, are more affected by the job losses in neighboring counties.

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The Great Recession and Job Loss Spillovers: Impact of Tradable Employment Shocks on Supporting Services

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1 Introduction

It is important to understand if, how, and to what extent unemployment spreads across sectors and geographic areas during a recession. Such propagation, if proven true, could provide a basis for government intervention in times of economic recession to prevent the ripple effect of adverse employment shocks from cascading across the economy.

The Great Recession is a unique context for studies on this issue. It was the most devastating economic event in the world economy since the 1930s. Unemployment in the U.S. reached as high as 10%. Employment in many industries, such as automobile, oil and gas, dropped as much as 30 to 40% between 2007 and 2010 (Nguyen, 2015). Economists are puzzled about many aspects of unemployment: Why was it so high? Did job losses propagate from one sector to another, and if so, how?

This paper examines how job losses propagated across sectors via input linkages during the Great Recession. Although many economists would agree that job losses could propagate, few have successfully captured the magnitude of this phenomenon given the difficulty of pinpointing an exogenous source of employment declines. Since employment across various industries is interrelated by spending and geography, this becomes a formidable obstacle to accurately measuring this effect.

The identification strategy we utilize in this paper is the following: we exploit exogenous variation in *the change in tradable employment* across U.S. counties and examine the subsequent spillover effect on *local supporting service industries*, i.e. those that provide support to tradable production, such as warehouse, transportation, human resource management, marketing and IT support.[2] An average U.S. county lost a staggering 16% of their tradable employment between 2007 and 2010. We find that counties with greater losses in tradable employment experienced more severe job losses in supporting service

[2] The detailed list of supporting service sectors is in section III.

industries. Quantitatively, a 10% decline in tradable employment leads to about 0.9% decline in local supporting service employment.

Furthermore, when we split the supporting services into industries dealing with logistics and those dealing with professional support, the local job loss spillover is much more significantly experienced by the former. A 10% decline in tradable employment causes a 1.8% decline in local logistic employment. As we will discuss in details later, this may be due to logistic industries' greater dependence on the success of local tradable sectors. In turn, we find that professional supporting industries are more affected by tradable job losses in neighboring counties, suggesting that the geographic coverage of professional supporting industries is larger.

The concept of job loss spillover via production linkages has not been a subject of many empirical studies. One reason for this may be the difficulty to distinguish job loss propagation pathways in the data, which do not readily point out causality. Said differently, given that job losses in any industry may affect employment in other industries, it becomes exceedingly difficult to determine the direction in which a spillover travels. For example, unemployment in the automobile industry could decrease the need for freight, causing workers in the freight industry to lose their jobs; however, laid-off workers in the freight industry may be less inclined to purchase new cars, therefore causing demand-driven unemployment in the automobile industry. As demonstrated by the aforementioned scenarios, job loss spillovers oftentimes occur simultaneously and in multiple directions, making the determination of causality within a particular spillover channel quite a challenge.

Our identification strategy, however, takes advantage of the exogeneity of tradable employment to a county to pinpoint the spillover from tradable industries to their supporting industries. It is important to note why we can utilize the change in tradable employment as an exogenous shock to a given county: demand for tradable goods overwhelmingly originates from *outside a county,* given that there are more than 3,000 counties in the U.S. The Great Recession is an excellent setup to study the consequences of the change in demand. Mian and Sufi and their co-authors, in a series of papers (Mian,

Rao and Sufi, 2013; Mian and Sufi, 2014) have documented that deleveraging households, driven by sharp drops in house prices, cut consumption sharply in the Great Recession. The consumption cuts caused massive job losses in both tradable and non-tradable sectors, where some tradable industries lost 30-40% of their workforces during the Great Recession (Nguyen, 2015). Since a county's demand for its own tradable goods is insignificant compared to the external demand, we may safely assume that tradable employment shocks to a county were driven externally. Our identification strategy is therefore similar in spirit to a seminal paper, Bartik (1991).

Nevertheless, we proceed with caution to rule out supply side factors- such as a credit shortage or local wages- that might drive job losses in both tradable and supporting sectors. We also find that the results are robust to the decline in the construction sector and households' deleveraging. Finally, we argue that credit issues are not driving the relationship.

The paper is organized in the following way: Section 2 gives a literature review; Section 3 presents the data; Section 4 describes our identification strategy in greater details; Section 5 examines the main results; Section 6 introduces an extension to our original results, in which we split the supporting sectors into logistics and professional industries; Section 7 proposes potential alternative hypotheses, and attempts to prove that they are unlikely; Section 8 concludes.

2 Literature Review

Our paper is related to current literature on the collapse of demand during the Great Recession. Most prominently, Mian, Sufi and other co-authors have examined the effects of the decline in housing net worth on consumption and employment during the crisis. Mian, Rao and Sufi (2013) find that ZIP codes with higher pre-crisis household leverage (and steeper subsequent declines in housing net worth in the Great Recession) cut their consumption more sharply during this period. Similarly, Mian and Sufi (2014) find that housing net worth declines were driving consumption cuts and job losses. Nguyen (2015) examines job loss spillovers driven by the demand channel. In particular, he argues that

job losses in the tradable sector caused further job losses in local retail and restaurant industries, via the aggregate demand channel.

There are surprisingly few studies on cross-sectoral spillovers based on production linkage. Bodrin et al. (2013), using national data, examine job loss propagation from the construction sector to others. They argue that this channel has important effects on aggregate employment. Li and Martin (2015), also using national data at the sectoral level, find the financial sector to be the "epicenter" during the Great Recession, from which emanates job loss spillovers in other sectors. Unlike those two papers, we utilize *sectoral* data at the *county* level, and for that reason, we are less concerned about the endogeneity issue.

In a different context, using national employment data at the sectoral level, Acemoglu et al. (2016) study the transmission of trade shocks across U.S. manufacturing industries, via input-output linkages. The trade shock is the rising import competition from China. They find that inter-industry linkages do magnify the employment effects of trade shocks. Although in a similar spirit to Acemoglu et al. (2016), we do not employ the full input-output matrix. Rather, we focus on local supporting services. The reason is that at the county-industry employment level, upstream or downstream *tradable* industries may be located in a different county. For that reason, we may observe that a reduction in automobile assembly in one county, for example, may affect supply part producers in adjacent counties. This would contaminate our identification strategy. In contrast, if we carefully select a set of supporting service industries, we can be fairly confident that they serve only locally.

Our paper is also related to a growing literature on the labor market dynamics during the Great Recession. Ohanian (2011) argues that the decline in economic output and income in the Great Recession was due to severe distortions in the labor market, and not to declines in capital or productivity. Hoffman and Lemieux (2016) show that the collapse in construction employment was a major factor contributing to the fall in overall employment. Kroft et al. (2016) show that the massive 2008 employment collapse, combined with the slow recovery in demand prevents employment from picking up.

Similarly, Foster et al. (2016) find that job destruction in the 2008–09 period was accompanied by a very large drop in the job creation rate, which limited the scope for re-allocation and pushed many laid-off workers into long-term unemployment.

3 Data Analysis

The primary source of our data is the Census Bureau. We use employment data in March 2007 and March 2010 from the County Business Pattern (CBP) data set, given that these dates represent the lowest and highest points of the U.S. unemployment rate during the Great Recession. This data come with flags representing employment ranges, which we replace with average employment values. We use the NAICS codes obtained from the CBP data set at the six-digit level for supporting industries and at the four-digit level for tradable employment as provided by data from Mian and Sufi (2014). In later parts of the paper, we also use firm sizes from the CBP data set in order to examine potential problems related to credit.

What classifies an industry as tradable or supporting? For the purposes of this paper, we follow Mian and Sufi's (2014) classification of the tradable sector based on global trade data: a 4-digit NAICS industry is defined as *tradable* if it has imports plus exports equal to at least $10,000 per worker, or if total exports plus imports exceed $500M. Regarding the supporting industries, we base our categorization of a NAICS code on whether the industry aids the tradable sector, be it through professional or logistic support. In order to be identified as a supporting industry for our purposes, the given industry should work primarily at the intra-county level and cannot also deal with the residential population, for such an industry would contaminate our results. In determining the suitability of an industry, we examine each NAICS code provided on the NAICS Association's website (www.naics.com). Table 3.2 presents a full listing of supporting industries. A more detailed description of this methodology is provided in the Appendix.

Another factor prevents us from using the input-output table. We use six-digit NAICS codes to classify our industries, whereas the input-output table provided by the Bureau of

Economic Analysis (BEA) mainly uses NAICS codes up to two or three digits. For example, the BEA input-output table includes the code 562 (Waste management and remediation services). Note that this could mean residential or commercial waste management. Our focus only includes 562112 (Hazardous Waste Collection) and 526221 (Hazardous Waste Treatment and Disposal) from the broader 562 category, because we are more confident they serve tradable sectors rather than local residents.

Data for wages are from the Bureau of Labor Statistics (BLS). The BLS' Quarterly Census of Employment and Wages provides average weekly wages within a quarter for every NAICS 4-digit to 6-digit industry, across U.S. counties. For the analysis, we chose average weekly nominal wage for *Warehouse and Transportation* (NAICS codes 48-49). To be consistent with the timing of employment data, average weekly wages during quarter I, 2007 and during quarter I, 2010 were chosen.

We also use Mian and Sufi's (2014) data for several of our regressions. Most notably, we use several variables as pre-crisis controls: percentage white, median household income, percentage of homes occupied by owners, percentage of people with less than high school diplomas, percentage with only high school diplomas, unemployment rate, poverty rate, and percentage urban. Aside from this, we also use their data for the robustness checks we conduct later in the paper, in which we test the influence of the construction sector, credit constraints, presence of national banks and household leverage on the change in supporting sector employment.

Summary statistics for the variables used in our regressions are provided in Table 3.1. Approximately 1% and 5% of a county's population works in the supporting sector and tradable sectors, respectively. Supporting sector employment makes up 2.3% of total employment, while tradable employment makes up around 15%. Tradable sector employment declined by a striking 16.1%, while supporting sector employment declined by 4.4% between 2007 and 2010.

	N	mean	sd	p10	p90
Tradable employment/Population, 2007	3108	0.05	0.047	0.008	0.103
Supporting sector employment/Population, 2007	3056	0.008	0.017	0.002	0.017
Tradable employment/Employment, 2007	3102	0.145	0.107	0.03	0.288
Supporting sector employment/Employment ,2007	3055	0.023	0.031	0.006	0.045
Log change in tradable employment, 2007-2010	3103	-0.161	0.421	-0.58	0.186
Log change in supporting sector employment, 2007-2010	2989	-0.044	0.614	-0.693	0.682
% white	3135	86.997	15.017	65.834	98.827
Median household income, 2007	3135	35597	9147	26312	46608
% owner occupied,, 2007	3135	74.063	7.541	64.32	81.818
% with less than high school diploma, 2007	3135	22.565	8.705	12.584	34.965
% with only high school diploma, 2007	3135	34.706	6.571	26.398	42.903
Unemployment rate, 2007	3135	5.82	2.73	2.998	9.071
Poverty rate, 2007	3135	14.154	6.454	7.261	22.605
% urban, 2007	3135	39.318	30.881	0	84.608

Table 3.1: Summary statistics

NAICS	Industry Name
484110	General Freight Trucking, Local
488510	Freight Transportation Arrangement
488991	Packing and Crating
493110	General Warehousing and Storage
493120	Refrigerated Warehousing and Storage
493130	Farm Product Warehousing and Storage
493190	Other Warehousing and Storage
493190	Other Warehousing and Storage
541214	Payroll Services
541219	Other Accounting Services
541511	Custom Computer Programming Services
541512	Computer Systems Design Services
541513	Computer Facilities Management Services
541519	Other Computer Related Services
541611	Administrative Management and General Management Consulting Services
541612	Human Resources Consulting Services
541613	Marketing Consulting Services
541614	Process, Physical Distribution, and Logistics Consulting Services
561910	Packaging and Labeling Services
562112	Hazardous Waste Collection
562211	Hazardous Waste Treatment and Disposal

Table 3.2: Supporting service industries

4 Identification Strategy

We use the change in tradable employment in counties, which is exogenous, as a proxy for job losses in this sector. In using this identification strategy, we seek to demonstrate that counties with higher percentage changes in tradable employment experience more severe job losses in supporting industries. Therefore, we will use log changes to capture this percentage change, regressing the log change of supporting sector employment from 2007 to 2010 on the log change of tradable employment over the same time span.
This regression can be better understood as a derivative of simple production functions, which illustrate the relationship between inputs and outputs. These functions are the following:

$$L_{s,c} = \theta T_c^{\alpha} \quad (1)$$

$$T_c = \omega L_{T,c}^{\beta} \quad (2)$$

Where $L_{s,c}$ is supporting sector employment, $L_{T,c}$ is tradable employment, T_c is tradable output, the subscript c identifies a given county, and θ, ω, α and β are parameters. The underlying assumption in these equations is that employment in the supporting service sectors is directly determined by tradable output, which in turn is produced by tradable employment.

We can manipulate equations (1) and (2) in order to derive our desired regression. We can first combine the two equations by substituting T_c from equation (1) into equation (2) to get:

$$L_{s,c} = \theta \omega^{\alpha} L_{T,c}^{\alpha\beta} \quad (3)$$

If we take the log of both sides, equation (3) becomes:

$$\log(L_{s,c}) = \log(\theta \omega^{\alpha}) + \alpha\beta \log(L_{T,c}) \quad (4)$$

We can use equation (4) to derive the change in employment from 2007 to 2010:

$$\log(L_{s,c})_{2010} - \log(L_{s,c})_{2007} = \alpha\beta[\log(L_{T,c})_{2010} - \log(L_{T,c})_{2007}] \quad (5)$$

Equation (5) is obtained under the assumption that the proxy for productivity $\log(\theta\omega^{\alpha})$ does not change over time. It is true that unobserved county-specific productivity shocks could bias our results. However, it is generally agreed that the Great Recession was not driven by productivity shocks (see Ohanian, 2011 for example). Rather, it is argued to be driven by falling house prices and ensuing collapsing demand (Mian and Sufi, 2014) and uncertainty (Shoad and Veuger, 2015).

Since the supporting industries are directly affected by tradable output, we will use the log change in tradable employment. From equation (5), we arrive at our basic regression:

$$\boldsymbol{\Delta \log(L_{s,c}) = \beta_0 + \beta_1 \Delta \log\left(L_{T,c}\right) + controls_c + \varepsilon_c} \quad \textbf{(6)}$$

where $\Delta\log(L_{s,c})$ is the log change in supporting sector employment in county c from 2007 to 2010, $\Delta\log\left(L_{T,c}\right)$ is the log change in tradable employment in county c during the same period, and $controls_c$ are all of the control variables previously mentioned. Note all the regressions are weighted by the county number of households, and the standard errors are clustered at the state level.

Reverse causation might appear to pose a threat to our identification. Some might question whether a drop in supporting sector employment causes a decrease in tradable employment, which is the reverse of what we argue. For example, if this were the case, the shutting down of a warehouse would cause a manufacturing company to shut down factories. This claim, however, is empirically unsound, as we prove later in the Alternative Hypotheses section.

Similar to reverse causation, others may believe that the relationship we find is biased due to the omission of other variables. They may argue that households' deleveraging, the decline in construction sector or problems related to credit supply during the crisis are significantly influential variables whose omission biases our results. We find, however, these arguments to be invalid, as we test in greater detail in the Alternative Hypotheses section.

5 Main Results

This section explores the relationship between job losses in a county's tradable and supporting service sectors, showing that the two are positively correlated. This finding is robust to the pre-crisis controls, such as percentage white, median household income, percentage of homes that are owner occupied, percentage of population with less than high school diploma, percentage of population with only high school diploma, unemployment rate, poverty rate, and percentage urban.

Table 5.1 below presents the baseline results underlying the job loss spillover effect from the tradable sector to supporting industries. It includes two regressions, the first revealing the relationship between supporting sector employment and tradable sector employment; and the second including the controls. There is no difference in value of our explanatory variable after adding all of our control variables, suggesting that these controls do not impact the relationship we seek to isolate. The positive coefficient of our explanatory variable indicates that a greater decrease in tradable employment leads to a greater decline in employment in supporting industries. Across counties, a 1% decrease in tradable employment on average causes a 0.086% decrease in supporting sector employment between 2007 and 2010. This relationship is significant at a 5% significance level with and without control variables. Note that in this paper, the change of every variable of interested x is measured as $\log(x)_{2010} - \log(x)_{2007}$.

VARIABLES	Log change in supporting employment, 2007-2010	
	[1]	[2]
Log change in tradable employment, 2007-2010	0.086**	0.086**
	[0.038]	[0.035]
% white		0.192**
		[0.090]
Median houshold income		0
		[0.000]
% owner occupied		-0.385***
		[0.131]
% with less than high school diploma		-0.015
		[0.219]
% with only high school diploma		-0.288
		[0.250]
Unemployment rate		1.362**
		[0.667]
Poverty rate		-0.795
		[0.592]
% urban		-0.056
		[0.059]
Constant	-0.003	0.323
	[0.010]	[0.200]
Observations	2,897	2,897
R-squared	0.002	0.013

Robust standard errors in brackets (***p<0.01, **p<0.5, *p<0.1).
All regressions in this paper are weighted by number of households. Standard errors are clustered at the state level.

Table 5.1: Baseline results

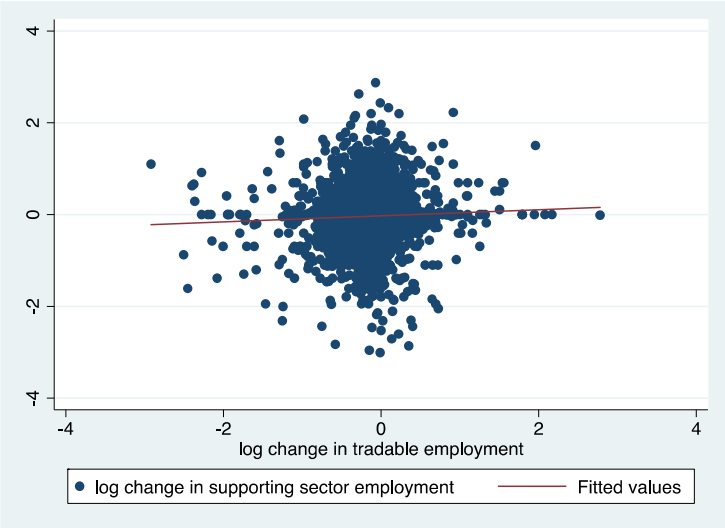

Figure 5.1: Scatterplot of regression [1] in Table 5.1

Figure 5.1 shows the scatter plot between log change in supporting sector employment and log change in tradable employment. It shows that the positive relationship is quite robust and not driven by any outliers.

6. Extension

6.1 Splitting up the supporting sectors

In this section, we will further arrange supporting industries into two separate subgroups. As can be seen in Table 3.2, the supporting sector includes a diverse array of industries, which may behave differently to a change in tradable employment given that the nature of their workforces—the supply of workers available, the skillsets necessary, etc.—is inherently different. For example, a worker responsible for packing and crating goods would have qualities very different from a consultant, consequently affecting their job stability in response to an exogenous shock. For the purposes of this exercise, we split the supporting sector into two subcomponents, which we name logistical and professional industries. The reclassification of each industry in the supporting sectors is shown in Table 6.1a below. Jobs involving warehousing, transportation, storage and waste management are classified as logistics industries, whereas jobs requiring a particular skill

set (such as payroll management, computer systems design, accounting, and so forth) are considered professional industries.

NAICS	Industry Name	Logistics (l) or Professional (p)
484110	General Freight Trucking, Local	l
488510	Freight Transportation Arrangement	l
488991	Packing and Crating	l
493110	General Warehousing and Storage	l
493120	Refrigerated Warehousing and Storage	l
493130	Farm Product Warehousing and Storage	l
493190	Other Warehousing and Storage	l
561910	Packaging and Labeling Services	l
493190	Other Warehousing and Storage	l
562112	Hazardous Waste Collection	l
562211	Hazardous Waste Treatment and Disposal	l
541214	Payroll Services	p
541219	Other Accounting Services	p
541511	Custom Computer Programming Services	p
541512	Computer Systems Design Services	p
541513	Computer Facilities Management Services	p
541519	Other Computer Related Services	p
541611	Administrative Management and General Management Consulting Services	p
541612	Human Resources Consulting Services	p
541613	Marketing Consulting Services	p
541614	Process, Physical Distribution, and Logistics Consulting Services	p

Table 6.1a: Supporting industries classified as logistics or professional

Summary statistics for the logistics and professional industries are provided in Table 6.1b. Roughly half of the supporting workforce works in each subset, both of which make a bit over 1% of the total employment in 2007.

VARIABLES	N	mean	sd	p10	p90
Logistics Employment/Employment, 2007	2882	0.012	0.023	0.001	0.026
Logistics Employment/Population, 2007	2883	0.004	0.0105	0.0004	0.008
Professional Employment/Employment, 2007	2917	0.012	0.016	0.003	0.024
Professional Employment/Population, 2007	2920	0.004	0.007	0.0008	0.009

Table 6.1b: Summary statistics

Table 6.1c shows the regression results when the supporting sector is split into logistics and professional industries. The first two regressions depict the relationship between the change in tradable employment and logistics employment ([2] including pre-crisis control variables as in Table 5.1), while the last two regressions depict the relationship between the change in tradable employment and professional employment. Adding control variables slightly increases the magnitude of each baseline regression, but it does not considerably impact significance.

The positive coefficients of tradable employment in each regression indicate that a greater drop in tradable employment leads to a greater decrease in employment in logistics and professional industries. Across counties and holding control variables constant, a 1% decrease in tradable employment causes a 0.176% decrease in logistics employment and a .058% decrease in professional employment. The relationship is highly significant for the logistics sector (i.e.: is significant at a 1% significance level); however, the coefficient on the log change in tradable employment is not significant in neither regression [3] nor [4], which means that an exogenous tradable employment shock does not possess a significant spillover effect for professional industries that support the tradable sectors. Various factors could contribute to this difference in significance. One possibility is that logistic industries are more tightly linked to the local tradable sector, whereas professional industries do not rely as heavily on tradable employment within the domestic county. If this were true, a decrease in tradable employment within a county would more significantly impact logistic industries than professional ones.

VARIABLES	Log change in L employment		Log change in P employment	
	[1]	[2]	[3]	[4]
Log change in tradable employment	0.169***	0.176***	0.055	0.058
	[0.050]	[0.057]	[0.049]	[0.045]
Constant	-0.031*	0.770***	0.027**	0.112
	[0.015]	[0.224]	[0.013]	[0.305]
Controls	No	Yes	No	Yes
Observations	2,582	2,582	2,708	2,708
R-squared	0.004	0.023	0.001	0.006

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 6.1c: Impacts on logistics and professional employment

6.2 The impact of the domestic county's versus neighboring counties' tradable job losses

In this subsection, we will discuss the results of Table 6.1c in greater detail, outlining empirical evidence for how tradable employment affects the logistics and professional industries differently. As discussed previously, a change in tradable employment within a county significantly impacts the logistic industries, but does not have the same effect on the professional ones. In other words, this relationship is significant for logistic industries' employment at more than a 1% significance level, but it is not significant for professional industries' employment even at a 10% level.

This finding has interesting implications for how different supporting industries react to exogenous shocks in tradable employment. Table 6.1c seems to suggest that certain industries experience spillovers, while others do not. In order to further investigate this finding, we examine the impact on the supporting sectors of not only local tradable employment (or tradable employment within a county), but also tradable employment of other counties within the state. We generate a new variable called neighboring counties' tradable employment, which is the tradable employment of all counties in the state *except* the county of interest. We then include this in our regressions to examine the impact of tradable employment in the rest of the state on supporting industries.

VARIABLES	Log change in Logistics employment		Log change in Professional employment	
	[1]	[2]	[3]	[4]
Log change in tradable employment	0.165***	0.178***	0.031	0.035
	[0.052]	[0.058]	[0.045]	[0.043]
Log change in neighboring counties' tradable employment	0.130	-0.029	0.675**	0.701***
	[0.299]	[0.254]	[0.261]	[0.219]
Constant	-0.008	0.782***	0.141***	0.188
	[0.054]	[0.215]	[0.043]	[0.309]
Controls	No	Yes	No	Yes
Observations	2,581	2,581	2,707	2,707
R-squared	0.005	0.023	0.006	0.012

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 6.2: Including neighboring county tradable employment

The coefficients of the log change in tradable employment in Table 6.2 are very similar to those in Table 6.1c: the coefficient in [1] is highly significant and similar in magnitude to its Table 6.1c counterpart, and the coefficient in [2] is still insignificant. What is more notable, however, is the impact of a change in neighboring counties' tradable employment. Across counties, a 1% decrease in neighboring counties' tradable employment causes a large 0.701% decrease in professional employment, a relationship that is also very statistically significant.

As these results demonstrate, logistics industries experience more severe job losses from a tradable employment shock originating within the county and are not significantly affected by shocks in neighboring counties. On the contrary, professional industries are not significantly affected by a tradable employment shock occurring solely in the local county, but do experience a decline in employment from tradable job loss happening in other counties within the state. This entails that logistics supporting industries have a greater dependence on tradable employment within the same county, whereas professional supporting industries assist a geographically broader range of tradable industries. Said differently, local supporting industries are more *locally* oriented, while

professional supporting industries have a reach that is *more spread out* across various counties within the state.

This result is not only empirically valid, but it also makes a great deal of intuitive sense. As currently classified, the logistics subsector includes industries responsible for the physical movement and storage of goods. In order to work most efficiently, it would behoove these industries to work close to the factories producing tradable goods (to minimize transport time, for example). By contrast, the nature of work with which the professional subsector is involved does not necessitate the same proximity to the tradable industries they support, allowing these industries to work more remotely. As a result, it makes more intuitive sense for professional supporting industries to serve clients in neighboring counties and for logistics supporting industries to deal with tradable industries in the same county.

Finally, the result helps to strengthen our argument for job loss spillovers via production linkages. If the spillovers were to be via other channels, credit for example, we would not expect differential impacts of tradable job losses on logistic and professional employment.

7 Alternative Hypotheses

In this section, we will examine alternative hypotheses that, if true, could potentially disprove the results we have found. We will examine each of the following competing hypotheses in greater detail: reverse causation, the influence of the construction sector, households' deleveraging, and credit supply constraints.

7.1 Reverse Causation

It is possible that a fall in supporting sectors' employment could have caused a decrease in tradable employment instead of the other way around. If this were the case, exogenous closings of car storage facilities, for example, would cause a decrease in tradable employment at automobile factories.

Since credit is the most prominently discussed factor in the Great Recession, we will first examine the validity of credit shocks to the supporting services. We do this as follows: if credit shocks indeed drove declines in supporting service employment, we should see that the impacts were heavier for smaller supporting service firms, who supposedly have weaker access to finance (Mian and Sufi, 2014). Greater job losses in smaller firms would affirm the potential of this reverse causation channel; however, as Table 7.1a reveals, this trend is clearly not supported in the data. Between 2007 and 2010, the number of large supporting service firms (e.g. that have 20-49 workers, 50-99 workers and more than 100 workers) dropped more than the number of smaller firms (see the *Mean* row for the average changes in the number of firms across firm sizes). This indicates that credit shocks do not pose a probable threat.

Table 7.1b provides an additional test. We regress log change in supporting sector against the National Bank dummy. The dummy takes the value of 1 for a county if that county has more national banks, and 0 if that county has more local banks. The idea is that if credit shocks posed a problem to supporting industries, these industries would be less affected in counties with national banks than they would in counties with local banks, on the ground that national banks would get help from their headquarters. Yet, as Table 7.1b demonstrates, there is no significant difference between job losses in counties with national and local banks. If anything, supporting sector in counties with more national banks saw a stronger (albeit not significant) decline in employment. Thus, it is not very likely for reverse causation—driven by credit shocks-- to be an issue.

	4 to 9	5 to 9	10 to 19	20 to 49	50 to 99	100 plus
Number of observations	2861	2467	2329	2259	1675	1704
Mean	-0.149	-0.129	-0.083	-0.178	-0.213	-0.232
sd	0.402	0.544	0.515	0.5	0.592	0.457
p10	-0.631	-0.762	-0.719	-0.777	-0.981	-0.734
p90	0.288	0.515	0.533	0.405	0.56	0.292

Table 7.1a: Log change in number of firms based on firm size

	Log change in supporting sector employment, 2007-2010
National Bank	-0.017
	[0.023]
Constant	-0.008
	[0.018]
Observations	2,923
R-squared	0

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7.1b: Examining national banks vs. local banks

In addition, we examine the hypothesis that higher local input prices, such as wages, cause the shrinkage of the supporting sectors, which in turn affects the tradable sector. We do so by testing if the supporting sectors' employment and wages move in the opposite directions. If the sector's wages went up while employment went down, this means that supporting services might have been hurt by higher wages, a supply side factor. Conversely, if the sectors' wages went down with employment, this points to the possibility of a demand-driven decline of the supporting service sectors.

Table 7.1c shows that wages move in the same direction of logistics employment: counties that have higher logistics job losses also saw larger wage drops. The change in wages is measured as the log of warehouse and transportation average weekly wage during the first quarter of 2010 *minus* that during the first quarter of 2007. This evidence strengthens the argument that tradable job losses reduce demand for supporting services.

VARIABLES	Log change in logistic employment, 2007-2010	
Δlog(wage)	0.265***	0.270**
	[0.097]	[0.103]
Constant	-0.060**	0.757***
	[0.024]	[0.281]
Controls	No	Yes
Observations	1,640	1,640
R-squared	0.003	0.031

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7.1c: The relationship between wage and supporting sectors' job losses

7.2 Construction

Some might believe that the spillover to the supporting industries was not caused by an exogenous shock in tradable employment, but rather a decline in employment in construction-related industries—an important problem in the crisis. The construction sector collapsed during the Great Recession, and so it is possible that this influenced employment in the supporting service sectors.

VARIABLES	Log change in supporting sector employment	
Log change in tradable employment	0.085**	0.093**
	[0.037]	[0.038]
Log change in construction employment	0.022	0.024
	[0.057]	[0.056]
Constant	0.001	0.321
	[0.016]	[0.223]
Controls	No	Yes
Observations	2,896	2,213
R-squared	0.002	0.013

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7.2: Including construction sector employment

As Table 7.2 reveals, this hypothesis is not empirically true. After including the change in construction employment, the coefficient of the change in tradable employment is still very significant at approximately the same magnitude. On the other hand, the change in construction employment is not significant at the 10% significance level, meaning it does not plausibly influence the supporting sectors' job losses.

7.3: Households' cuts in non-tradable consumption

Cuts in household consumption present another competing hypothesis. Mian, Sufi and Rao (2013) find that pre-crisis household leverage serves as a strong proxy for household cuts in consumption. They show that counties with higher pre-Recession household leverage witnesses larger drops in non-tradable employment (such as retails and restaurants), which could also affect supporting services. We need to examine if our results is robust to the declines in non-tradable employment (proxied by pre-crisis household leverage). As shown by Table 7.3, including household leverage into the regression does not affect our results. Since this proxy for consumption cuts is not significant at a 10% significance level, consumption cuts in non-tradable consumption (such as retails and restaurants) are not likely a driving factor.

VARIABLES	Log change in supporting sector employment	
	[1]	[2]
Log change in tradable employment	0.093**	0.094**
	[0.041]	[0.038]
Leverage 2006	0.008	0.002
	[0.015]	[0.014]
Constant	-0.015	0.326
	[0.029]	[0.221]
Controls	No	Yes
Observations	2,213	2,213
R-squared	0.002	0.013

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7.3: Including pre-Recession household leverage

7.4: Credit-led spillovers

Spillovers from the tradable sectors to supporting industries could occur by means of credit channels. For instance, when an underwater tradable firm is late in repaying, it affects bank lending to firms in supporting industries. If this were the case, supporting industries that are smaller in size could experience greater declines in employment when faced with an exogenous tradable employment shock, given that they have less access to credit.

We find, however, that this is not the case. To test this hypothesis, we use an approach similar to that introduced in Mian and Sufi (2014). We divide supporting firms based on firm size (4 to 9 workers, 5-9 workers, 10-19 workers, 20-49 workers, 50-99 workers and more than 100 workers). We regress the change in the number of firms (by firm size) against the change of tradable employment over six regressions, examining logistics, professional, and total industries separately. If credit constraints were a problem, the coefficients of change in tradable employment would decrease as the firm size increased, signifying that smaller supporting service firms (i.e.: those with presumably less access to credit) would be hit harder by the tradable employment shock. Table 7.4 shows that this is not the case. The dependent variable is change in the number of firms with different size. Many of the coefficients are not significant. When they are, they do not decrease in magnitude as assumed under the credit constraint hypothesis.

	4 to 9	5 to 9	10 to 19	20 to 49	50 to 99	100 plus
	Logistics					
	[1]	[2]	[3]	[4]	[5]	[6]
Log change in tradable employment, 2007-2010	0.019	0.108***	0.019	0.182***	0.144*	0.585***
	[0.017]	[0.037]	[0.036]	[0.043]	[0.073]	[0.040]
Constant	-0.042***	-0.100***	-0.092***	-0.111***	-0.139***	-0.086***
	[0.006]	[0.011]	[0.010]	[0.010]	[0.012]	[0.009]
Observations	2,861	2,469	2,332	2,306	1,871	2,156
R-squared	0	0.005	0	0.016	0.005	0.194
	Professional					
	[7]	[8]	[9]	[10]	[11]	[12]
Log change in tradable employment, 2007-2010	-0.023	0.001	0.009	-0.001	0.043	0.031
	[0.015]	[0.012]	[0.013]	[0.015]	[0.028]	[0.024]
Constant	-0.052***	-0.011	0.002	-0.055***	-0.085***	-0.083***
	[0.006]	[0.007]	[0.007]	[0.008]	[0.011]	[0.018]
Observations	3,044	3,025	3,007	2,867	2,250	1,907
R-squared	0.003	0	0	0	0.001	0.001
	Total					
	[13]	[14]	[15]	[16]	[17]	[18]
Log change in tradable employment, 2007-2010	-0.008	0.104**	0.031	0.176***	0.176**	0.596***
	[0.022]	[0.039]	[0.036]	[0.044]	[0.079]	[0.050]
Constant	-0.095***	-0.112***	-0.087***	-0.166***	-0.225***	-0.175***
	[0.009]	[0.016]	[0.012]	[0.016]	[0.017]	[0.018]
Observations	2,860	2,467	2,330	2,259	1,676	1,705
R-squared	0	0.004	0	0.013	0.006	0.109

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7.4: Testing credit supply constraints

8 Conclusion

The Great Recession was a painful period in world economic history. Behind the dry numbers are actual people and communities that suffer from job losses and the resulting hardship. It is important to understand the impacts of the Great Recession, among them, how shocks transmit across economic sectors.

This paper is an effort to understand better the transmission of job losses during Great Recession. We focus only on the transmission via input linkages. Using an identification strategy similar to Bartik (1991), we show that counties with higher tradable job losses experience greater declines in supporting service employment. These results are statistically significant and are robust across numerous control variables.

Additionally, disaggregating the supporting sectors into two separate subsectors—logistics and professional—reveals that the impact of the exogenous shock was much greater and more significant for the logistics industries than the professional ones. We argue that this is due to logistics industries' dependence on local tradable employment and professional industries' relationship with neighboring county tradable employment. Furthermore, we find that these results are not influenced by reverse causation, exposure to the construction sector, household leverage or credit supply constraints. We are therefore confident that our results reveal the impact of cross-sectoral job loss spillovers during the Great Recession.

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Appendix

In defining supporting industries, we rigorously examined all of the NAICS codes provided on the NAICS Association's website. We made our decisions based on the descriptions of each industry described under a given NAICS. If the code potentially supported the tradable sectors, we then asked if any industries under the code a) dealt with the residential population (such as 561720, which includes housekeeping services) or b) functioned far from the tradable industries (such as 484121 and 484122, which deal with long-distance freighting and trucking). If either was thought to be true, the code was removed. The following are descriptions of all the industry NAICS codes that we included in the supporting sectors:

484110 General Freight Trucking, Local: carries freight locally, generally with a one-day return. This industry fulfills the need of transportation for tradable industries, as their goods require freight trucks to move from factory to warehouse, stores, etc. Note: we do not include the industries 484121 (General Freight Trucking, Long-Distance, Truckload) and 484122 (General Freight Trucking, Long-Distance, Less Than Truckload) because these industries are not stationed locally, which would therefore contaminate our results.

488510 Freight Transportation Arrangement: This industry negotiates with the freight transportation process, therefore making it supporting for reasons similar to the aforementioned code.

493110 General Warehousing and Storage: Industry responsible for storing goods in warehouses. This is considered supporting because this industry stores tradable goods.

493120 Refrigerated Warehousing and Storage: Same reasons as the previous code except this deals with tradable goods that require refrigeration.

493130 Farm Product Warehousing and Storage: Industry responsible for storage of farm products. Because farm products are tradable goods, this industry falls under the supporting category.

493190 Other Warehousing and Storage: Storage for specific industries, such as lumber, whiskey, etc.

541214 Payroll Services: Deals with accounting, billing, and bookkeeping. This is a supporting industry given that the tradable industries require its service

541219 Other Accounting Services: Supporting for same reasons as previous code.

541511 Custom Computer Programming Services, *541512* Computer Systems Design Services, *541519* Other Computer Related Services: Included because many tradable industries utilize software and computers for their businesses.

562211 Hazardous Waste Treatment and Disposal and *562112* Hazardous Waste Collection: Tradable industries include manufacturing, which could create harmful byproducts that require disposal.

541611 Administrative Management and General Management Consulting Services; *541612* Human Resources Consulting Services; *541613* Marketing Consulting Services; *541614* Process, Physical Distribution, and Logistics Consulting Services: Tradable companies require these industries in order to deal with back-end challenges.

561910 Packaging and Labeling Services and *488991* Packing and Crating: Packaging and Labeling, Packing and Crating: These industries are an integral part of the transportation of tradable goods.