Firms' Internal Networks and Local Economic Shocks*

Xavier Giroud[†] Holger M. Mueller[‡]

September 2017

Abstract

This paper shows that local economic shocks spill over to distant regions through firms' internal networks, and that such spillovers matter economically by affecting aggregate employment in those regions. Using confidential micro data from the U.S. Census Bureau, we find that establishment-level employment responds strongly to shocks in other regions in which the firm is operating. Consistent with theory, the elasticity of establishment-level employment with respect to shocks in other regions increases with firms' financial constraints. Also, establishments belonging to firm networks exhibit smaller employment elasticities with respect to (their own) local shocks. To account for the impacts of general equilibrium adjustments, we examine aggregate employment at the county level. Similar to what we found at the establishment level, we obtain large elasticities of county-level employment with respect to shocks in other counties linked through firms' internal networks.

*We thank Marianne Bertrand (editor), five anonymous referees, Scott Baker, Martin Beraja, David Berger, Nick Bloom, Eduardo Davila, Itamar Drechsler, Xavier Gabaix, Ben Keys, Pat Kline, Theresa Kuchler, Andres Liberman, Vojislav Maksimovic, Atif Mian, Ben Moll, Enrico Moretti, Daniel Paravisini, Thomas Philippon, Tomasz Piskorski, Alexi Savov, Ben Schoefer, Johannes Stroebel, Amir Sufi, Alireza Tahbaz-Salehi, Stijn van Nieuwerburgh, Joe Vavra, Vikrant Vig, Gianluca Violante, Danny Yagan, and seminar participants at Princeton, Berkeley, MIT, Northwestern, Columbia, NYU, Ohio State, Boulder, Fed Board, Zurich, St. Gallen, NBER Summer Institute, LBS Summer Finance Symposium, and LSE Workshop on Networks in Macro & Finance for helpful comments. Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed.

[†]Columbia Business School, NBER, and CEPR. Email: xavier.giroud@gsb.columbia.edu.

[‡]NYU Stern School of Business, NBER, CEPR, and ECGI. Email: hmueller@stern.nyu.edu.

1 Introduction

An important feature of resource allocation within firms is that individual business units must compete for scarce resources. As Williamson (1975, p. 147) writes when describing the advantages of the multidivisional (M-form) organization, "cash flows in the M-form firm are not automatically returned to their sources but instead are exposed to an internal competition." Such competition naturally creates an interdependence among otherwise unrelated business units. When a business unit experiences a negative shock to its cash flows, such as one arising from a drop in local consumer demand, corporate headquarters does not simply cut resources in the affected business unit. Rather, it optimally spreads the cash-flow shock across multiple business units so as to equate their marginal revenue products (normalized by factor prices).[1] As a result, local consumer demand shocks not only lead to employment declines in local business units but also in business units in other regions. Our paper empirically shows how local consumer demand shocks spill over to distant regions through firms' internal networks, and how such spillovers matter economically by affecting aggregate employment in those regions.

To examine how local consumer demand shocks propagate through firms' internal networks, we build a complete spatial network of the firm's internal organization using confidential data at the establishment level from the U.S. Census Bureau's Longitudinal Business Database (LBD). We obtain regional variation in local consumer demand shocks by focusing on the massive collapse in house prices during the Great Recession. As prior research has shown, the collapse in house prices caused a sharp drop in local consumer spending by households (Mian, Rao, and Sufi 2013; Stroebel and Vavra 2014; Kaplan, Mitman, and Violante 2016). This drop in consumer spending, in turn, has led to large employment losses in the non-tradable sector: across different U.S. regions, those with larger declines in housing net worth experienced significantly larger declines in non-tradable employment (Mian and Sufi 2014; Giroud and Mueller 2017).

[1] This is illustrated in a simple model in Section 2. As is shown there, financial constraints are crucial for local cash-flow shocks to spill over to other business units. See also Stein (1997) for a model in which financially constrained firms reallocate scarce resources towards business units whose investment opportunities have increased, and Inderst and Mueller (2003) for a model in which financially constrained firms smooth out cash-flow shocks to individual business units by withdrawing resources from other business units. Stein (2003) provides an overview of the literature on within-firm resource allocation.

A defining feature of non-tradable industries (e.g., restaurants, supermarkets, retail stores) is that they rely on local consumer demand. This makes non-tradable employment particularly well-suited to study the effects of local consumer demand shocks, such as those originating from falling house prices. The same feature also makes non-tradable employment particularly well-suited to study how local consumer demand shocks spill over to distant regions through firms' internal networks. While these shocks may directly affect non-tradable employment at the local level, they should *not directly* affect non-tradable employment in distant regions. Consequently, if a department store experiences a decline in employment in response to a local consumer demand shock in some other region in which the firm is operating, then it is unlikely that this employment decline is due to a *direct* demand effect from that other region.

We find that non-tradable establishment-level employment is highly sensitive to local consumer demand shocks in other regions in which the firm is operating. Controlling for changes in local house prices, the elasticity of establishment-level employment with respect to house prices in those regions is 0.028. Accordingly, a ten percent drop in house prices in other regions of the firm's network translates into a 0.28 percent decline in establishment-level employment. Importantly, what matters is that establishments are linked to other regions in which the firm is operating, not other regions in general. If we link establishments to other regions using equal weights, population weights, or income weights, or if we link them to randomly selected regions, their sensitivity of employment to house prices in other regions is close to zero and highly insignificant.

A key empirical challenge arises from separating regional spillovers through firms' internal networks from common shocks to regions in which the firms are operating. We account for such common shocks by including regional—precisely, ZIP code—fixed effects in our regressions. We thus compare non-tradable establishments in the same ZIP code that are exposed to the same regional shock but that belong to different firms and hence are exposed to different shocks in other regions. Our estimates drop only slightly, and they remain highly significant. A potential concern is that regional shocks may differentially affect establishments in different industries. We address this concern by including ZIP code $\times$ industry fixed effects, where industries are measured at the 4-digit NAICS level. Our estimates remain virtually unchanged.

Regional shocks may differentially affect establishments even within a single 4-digit NAICS industry. A classic example is clientele effects. A low-end department store may be affected differently by a regional shock than a high-end department store, even though both establishments are in the same 4-digit industry (NAICS 4522). In order to make a comparison between establishments catering to similar clienteles, we control for the average income, age, gender, race, and education in other ZIP codes in which the establishment's parent firm is operating. Effectively, we thus compare establishments in the same ZIP code and industry that belong to firms catering to similar segments of the population. Including these additional controls does not affect our estimates.

In addition, we account for clientele effects by estimating Placebo regressions using counterfactual firm networks. The underlying idea is that if two firms within the same industry mutually overlap in almost all of their locations, then they are likely to cater to similar clienteles. To illustrate, suppose two firms in the same 4-digit industry mutually overlap in 90 percent of their ZIP codes (2 to 10), but firm A is additionally present in ZIP code 1, whereas firm B is additionally present in ZIP code 11. If our estimates are confounded by clientele effects, then firm A's establishments—those in ZIP codes 1 to 10—should also be sensitive to changes in house prices in ZIP code 11, even though firm A itself has no presence in that ZIP code. Likewise, firm B's establishments should also be sensitive to changes in house prices in ZIP code 1. We find that this is not the case, suggesting that our estimates are unlikely to be confounded by common regional shocks that affect establishments differently due to their clienteles.

Consumers may go to restaurants and grocery stores in neighboring regions. Thus, another empirical challenge arises from separating regional spillovers through firms' internal networks from confounding *direct* demand effects from nearby regions. We find that direct demand spillovers have at best a modest effect. If we control for proximity-weighted house price changes in other ZIP codes, our estimates become only slightly weaker, and they remain highly significant. The same is true if we exclude all ZIP codes within a 50, 100, 250, or 500 mile radius or within the same state.

We conclude our establishment-level analysis with some additional tests. There are two sides to being part of a multi-region firm. One is that local firm units absorb some of the impacts of shocks in other regions. The flip side is that firm units in other regions absorb some of the impacts of local shocks. Hence, establishments of multi-region firms should be less sensitive to (their own) local shocks than local firms. Indeed, we find that the elasticity of employment with respect to *local* house prices is smaller for establishments belonging to multi-region firms and, more generally, for establishments belonging to more expansive regional firm networks. Second, theory predicts that the extent to which firms reallocate internal resources in response to local shocks should be increasing with firms' financial constraints. Consistent with this prediction, we find that establishments belonging to more financially constrained firms exhibit larger elasticities of employment with respect to house prices in other regions. In fact, for the least financially constrained firms in our sample, we find no evidence that firms reallocate internal resources in response to local shocks. Lastly, we examine if firm units in close proximity to headquarters are more insulated from economic shocks. This could be due to efficiency reasons, lobbying, or simply because management feels more responsible for these firm units. Consistent with being more insulated from economic shocks, we find that establishments which are located closer to headquarters exhibit smaller elasticities of employment with respect to both local house prices and house prices in other regions.

Regional spillovers through firms' internal networks may be irrelevant in general equilibrium if workers of multi-region firms that are laid off due to shocks in other regions are re-employed by (local) firms which are less exposed to those regions. To see whether the distribution of firm networks also matters in the aggregate, the final part of our paper examines aggregate non-tradable employment at the county level. Similar to what we found at the establishment level, we find sizable elasticities of non-tradable county-level employment with respect to house prices in other counties linked through firms' internal networks. That being said, relative to local elasticities, the magnitudes are somewhat smaller than in our preceding establishment-level analysis, possibly reflecting the impacts of general equilibrium adjustments.

Our paper contributes to several strands of literature. A growing literature in urban, macro-, and financial economics studies how shocks propagate throughout the economy. This literature focuses on input-output networks (e.g., Acemoglu et al. 2012; Caliendo et al. 2014; Acemoglu, Akcigit, and Kerr 2016; Barrot and Sauvagnat 2016), banking and financial networks (e.g., Peek and Rosengren 1997, 2000; Acemoglu, Ozdaglar, and

Tahbaz-Salehi 2012; Schnabl 2012; Cabrales, Gale, and Gottardi 2015), and social networks (Bailey et al. 2016). Little is known about whether, and how, firms' *internal* networks facilitate the propagation of local shocks, and how this affects macroeconomic aggregates. In this regard, an important aspect of using U.S. Census Bureau data is that we can capture the firm's entire network structure: the LBD includes the ZIP codes and firm affiliations of all (payroll) establishments in the U.S.

Second, our paper contributes to a recent literature that studies the collapse in house prices in the Great Recession and its implications for consumer spending (Mian, Rao and Sufi 2013; Stroebel and Vavra 2014; Kaplan, Mitman, and Violante 2016) and employment (Mian and Sufi 2014; Giroud and Mueller 2017).[2] Our paper shows that local consumer demand shocks not only affect local non-tradable employment but also non-tradable employment in other regions. Indeed, we find large elasticities of non-tradable employment with respect to local consumer demand shocks in other regions, echoing a point made in Beraja, Hurst, and Ospina (2016) that it is difficult to draw inferences about aggregate economic activity based on local elasticities alone. Importantly, local elasticities and those with respect to shocks in other regions have the same sign. Thus, accounting for spillovers from other regions strengthens the role of consumer demand in explaining the decline in U.S. employment during the Great Recession.

Lastly, a large literature focuses on the role of public policy in redistributing resources across regions through a federal system of tax and transfer policies, including "place-based" subsidy and investment programs (e.g., Glaeser and Gottlieb 2008; Farhi and Werning 2012; Kline and Moretti 2013, 2014a, 2014b; Moretti 2014; Nakamura and Steinsson 2014; Beraja 2016).[3,4] Our paper focuses on the role of *firms*, arguing that multi-region firms redistribute resources across regions through their internal networks as

[2]See Berger et al. (2015) for a model that produces large consumption responses to house price changes in line with estimates found in empirical studies.

[3]Regional transfers may be implicit. For instance, Hurst et al. (2016) show that lack of regional variation in mortgage rates on loans secured by government-sponsored enterprises (GSEs) constitutes an implicit transfer to regions that are more likely to be hit by adverse local shocks.

[4]Although factor mobility can, in principle, mitigate the adverse impacts of local shocks, there is mounting evidence that the movement of capital and labor across regions in the aftermath of shocks is sluggish and, at best, incomplete (e.g., Blanchard and Katz 1992; Notowidigo 2011; Autor, Dorn, and Hanson 2013, 2016; Autor et al. 2014; Yagan 2016).

part of an overall firm-wide optimizing behavior.

The rest of this paper is organized as follows. Section 2 presents a simple model. Section 3 describes the data, variables, empirical strategy, and summary statistics. Section 4 considers non-tradable employment at the individual establishment level. Section 5 studies aggregate non-tradable employment at the county level. Section 6 concludes.

2 Resource Reallocation in Multi-Region Firms

This section presents a simple model illustrating how multi-region firms reallocate internal resources in response to local economic shocks. Consider a firm operating in n regions. Each regional firm unit produces output using labor input according to the production function $f_i(L_i)$ satisfying the regularity conditions $f_i{}'(L_i) > 0$, $f_i{}''(L_i) < 0$, $f_i(0) = 0$, $\lim_{x\to 0} f_i{}'(L_i) = \infty$, and $\lim_{x\to\infty} f_i{}'(L_i) = 0$, where $i = 1, ..., n$.[5] Regional firm units may differ in their labor productivity, as indicated by the subscript i in the production function, f_i. When transforming labor input into output, each regional firm unit takes output prices p_i and factor prices w_i as given. Labor input in period t generates output in period $t+1$, which is discounted using the per-period discount factor δ. Factor input costs are funded out of current-period cash flows. (See below for a discussion of external funds.) Importantly, factor input choices and and funding decisions are made centrally by the firm's headquarters, which has authority to move budgets across firm units so as to maximize overall firm value (e.g., Williamson 1975; Gertner, Scharfstein and Stein 1994; Stein 1997). Hence, the relevant budget constraint is at the overall firm level, not at the individual firm unit level. Let C_i denote the current-period cash flow generated by regional firm unit i. The firm's budget constraint is then $\sum_i w_i L_i \leq \sum_i C_i$.

The firm solves

$$\max_{L_i,\lambda} \delta \sum\nolimits_i p_i f_i(L_i) - \sum\nolimits_i w_i L_i + \lambda \left[\sum\nolimits_i C_i - \sum\nolimits_i w_i L_i \right], \tag{1}$$

[5]We focus on labor input given that our empirical analysis examines employment changes within multi-region firms. That said, the model can be extended to include both labor and capital input provided assumptions are made about the production function. See Section 8.1 of the Appendix for a model with both labor and capital input based on the Cobb-Douglas production function.

where λ denotes the Lagrange multiplier associated with the budget constraint.

The Kuhn-Tucker conditions are

$$\delta p_i f_i'(L_i) = (1 + \lambda)\, w_i \;\forall i, \tag{2}$$

$$\sum_i w_i L_i \leq \sum_i C_i, \tag{3}$$

and

$$\lambda \left[\sum_i C_i - \sum_i w_i L_i \right] = 0;\;\; \lambda \geq 0. \tag{4}$$

As a benchmark, suppose the firm is financially unconstrained, so that the budget constraint (3) is slack ($\lambda = 0$). In that case, (2) implies that headquarters allocates labor input to each regional firm unit up to the point where the (discounted) marginal revenue product of labor, $\delta p_i f_i'(L_i)$, equals the wage, w_i. Thus, in the absence of financial constraints, labor input in each regional firm unit is at the first-best optimum. Moreover, it follows from (2) that for any two regional firm units i and j, it must hold that

$$\frac{\delta p_i}{w_i} f_i'(L_i) = \frac{\delta p_j}{w_j} f_j'(L_j), \tag{5}$$

that is, a marginal dollar of funds has the same value at each regional firm unit.

Suppose next that the firm is financially constrained, so that the budget constraint (3) binds ($\lambda > 0$). In this case, the optimality condition (5) still holds—that is, a marginal dollar has the same value at each regional firm unit. However, this (shadow) value now strictly exceeds one—in contrast to the financially unconstrained firm, where it equals one—implying that the marginal revenue product of labor, $\delta p_i f_i'(L_i)$, strictly exceeds the wage, w_i. Accordingly, if the firm is financially constrained, labor input in each regional firm unit is below the first-best optimum.

Importantly, what matters is only whether the firm's budget constraint binds or is slack at the optimum, not whether the firm has access to external funds. The firm could have no access to external funds, yet the budget constraint could be slack if the firm's internal funds are sufficient to attain the first-best optimal level of production. Conversely, the firm could have access to external funds, yet the budget constraint could bind at the optimum if the sum of the firm's internal and external funds are insufficient to attain the first-best optimal level of production. Hence, access to external funds is neither necessary nor sufficient for the firm's budget constraint to be slack at the optimum.

Consider now a negative cash-flow shock in region j. The question we are interested in is whether and how this shock affects the firm's labor input choices in regions $i \neq j$. Intuitively, if the firm is financially constrained, headquarters will adjust production in each region to satisfy the optimality condition (5). Given that each regional firm unit exhibits decreasing returns to scale, this implies that labor input must decline in all regions, including regions $i \neq j$ that are not directly affected by the shock. Differentiating (2) and (3) with respect to C_j and solving yields

$$\frac{d\lambda}{dC_j} = \frac{1}{\sum_i \frac{w_i^2}{\delta p_i f_i''(L_i)}} < 0 \tag{6}$$

and

$$\frac{dL_i}{dC_j} = \frac{w_i}{\delta p_i f_i''(L_i)} \frac{d\lambda}{dC_j} = \frac{\frac{w_i}{\delta p_i f_i''(L_i)}}{\sum_i \frac{w_i^2}{\delta p_i f_i''(L_i)}} > 0 \; \forall i, \tag{7}$$

where the inequality signs follow from $f_i''(L_i) < 0$. Accordingly, a negative cash-flow shock in region j leads to a decline in labor input in all regions, including regions $i \neq j$. Moreover, this decline is larger the tighter is the firm's financial constraint, as expressed by the sensitivity of the shadow value of a marginal dollar to the cash-flow shock, $\frac{d\lambda}{dC_j}$.

Our analysis illustrates a key implication of centralized resource allocation: to ensure that the optimality condition (5) is satisfied, regional firm units must absorb some of the impacts of shocks in other regions. The flip side is that regional firm units become less sensitive to (their own) local shocks. Consider a single-unit firm operating in region j. Differentiating the firm's budget constraint with respect to C_j, we have

$$\frac{dL_j}{dC_j} = \frac{1}{w_j}. \tag{8}$$

By contrast, for a regional firm unit in region j that is part of a multi-region firm, the sensitivity of labor input to a local cash-flow shock is given by

$$\frac{dL_j}{dC_j} = \frac{1}{w_j} \frac{\frac{w_j^2}{\delta p_j f_j''(L_j)}}{\sum_i \frac{w_i^2}{\delta p_i f_i''(L_i)}}, \tag{9}$$

which is strictly less than the sensitivity given in (8).

Let us summarize the main predictions of our model. First, and most important, our model predicts that local cash-flow shocks spill over to other regions through a firm-level budget-constraint effect.[6] As a result, firm-level employment not only declines in affected regions but also in other regions. Financial constraints are crucial for this result. If the firm's budget constraint is slack, local cash-flow shocks do not propagate to other regions. Second, the magnitude of the regional spillover depends on how tight the firm's financial constraint is. The tighter is this constraint, the more sensitive is regional firm-level employment to cash-flow shocks in other regions. Third, while regional firm units absorb some of the impacts of shocks in other regions, the flip side is that firm units in other regions absorb some of the impacts of local shocks. Consequently, regional firm units that are part of multi-region firms are less sensitive to (their own) local shocks than are single-unit firms operating in the same region.

3 Data, Variables, and Summary Statistics

3.1 Data

We use confidential micro data at the establishment level from the U.S. Census Bureau's Longitudinal Business Database (LBD). An establishment is a "single physical location where business is conducted" (Jarmin and Miranda 2002; p. 5), e.g., a restaurant, gas station, grocery store, supermarket, or department store. The LBD covers all business establishments in the U.S. with at least one paid employee. Our data include information on employment, location, industry affiliation, and firm affiliation.

[6] Our model captures a salient feature of local consumer demand shocks: drops in local consumer spending affect firms' cash flows. An alternative view is one in which local consumer demand shocks reflect of local productivity shocks. Under this view, however, employment declines in affected regions would be associated with employment *increases* in other regions, which runs counter to the empirical evidence presented in this paper. See Section 8.2 of the Appendix for a theoretical analysis of local productivity shocks and their empirical implications for regional spillovers.

We focus on establishments in the non-tradable sector. A defining feature of non-tradable industries is that they rely on local consumer demand. As discussed previously, this makes non-tradable employment well-suited to study how local consumer demand shocks spill over to distant regions through firms' internal networks: while these shocks may directly affect non-tradable employment at the local level, they should not directly affect non-tradable employment in distant regions. We classify industries as non-tradable based on the classification scheme in Mian and Sufi (2014). Accordingly, there are 26 four-digit NAICS industries in the non-tradable sector. Among those, the largest ones in terms of U.S. employment shares are full-service restaurants (3.76%), limited-service eating places (3.40%), grocery stores (2.13%), department stores (1.36%), other general merchandise stores (1.12%), clothing stores (1.06%), automobile dealers (1.05%), health and personal care stores (0.89%), and gasoline stations (0.73%).

We match establishments to ZIP code-level house prices using house price data from Zillow. Our sample period is from 2006 to 2009.[7] Changes in house prices from 2006 to 2009 based on Zillow data are highly correlated with the "housing net worth shock" in Mian, Rao and Sufi (2013) and Mian and Sufi (2014), "Δ Housing Net Worth, 2006–2009." The correlation at the MSA level is 86.3 percent. They are also highly correlated with changes in house prices from 2006 to 2009 using data from the Federal Housing Finance Agency (FHFA). The correlation at the MSA level is 96.4 percent.

In our establishment-level analysis, we focus on firms operating in multiple ZIP codes ("multi-region firms"). Our sample consists of 385,000 non-tradable establishments accounting for 64.7% of non-tradable U.S. employment in 2006.[8] The high employment share of multi-region firms is reflective of the prominent role of national restaurant and retail chains in the non-tradable sector. In our county-level analysis, we examine *total* non-tradable employment at the county level, that is, we also include employment by single-region firms, such as "mom-and-pop shops." Our sample consists of 1,000 counties representing 85.8 percent of non-tradable U.S. employment in 2006.

[7]Zillow house price data have been used in, e.g., Keys et al. (2014), Mian, Sufi, and Trebbi (2015), Kaplan, Mitman, and Violante (2016), Bailey et al. (2016), and Giroud and Mueller (2017).

[8]All sample sizes are rounded to the nearest hundred following disclosure guidelines by the U.S. Census Bureau.

We obtain control variables from various data sources, including the 2000 Decennial Census (population), 2006 American Community Survey (age, education, race, gender), Internal Revenue Service (adjusted gross income per capita in 2006), Federal Reserve Bank of New York Consumer Credit Panel (household debt in 2006), and Facebook (Social Connectedness Index).[9] In addition, we compute measures of firms' financial constraints using data from Compustat (firm leverage, KZ index, WW index, all in 2006). To this end, we match establishments in the LBD to firms in Compustat using the Compustat-SSEL bridge maintained by the U.S. Census Bureau. Given that this bridge ends in 2005, we extend the match to 2009 using employer name and ID number (EIN) following the procedure described in McCue (2003).

3.2 Variables and Empirical Specification

We examine how non-tradable employment at the establishment level during the Great Recession responds to changes in local house prices in the establishment's own ZIP code as well as to changes in house prices in other ZIP codes in which the firm is operating. We estimate the following equation:

$$\Delta \text{ Log}(\text{Emp}_i)_{07-09} = \alpha + \eta_1 \ \Delta \text{ Log}(\text{HP}_k)_{06-09} + \eta_2 \ \sum_{l \neq k} \omega_{j,k,l} \ \Delta \text{ Log}(\text{HP}_l)_{06-09} + \varepsilon_i, \quad (10)$$

where Δ Log(Emp$_i$)$_{07-09}$ is the percentage change in employment from 2007 to 2009 in establishment i of firm j in ZIP code k, Δ Log(HP$_k$)$_{06-09}$ is the percentage change in house prices from 2006 to 2009 in ZIP code k, and $\sum_{l \neq k} \omega_{j,k,l}$ Δ Log(HP$_l$)$_{06-09}$ is the linkage-weighted percentage change in house prices from 2006 to 2009 in ZIP codes $l \neq k$. For brevity, we write Δ Log(HP)$_{06-09}$ (other) in lieu of $\sum_{l \neq k} \omega_{j,l,k}$ Δ Log(HP$_l$)$_{06-09}$. The elasticities of interest are η_1 and, especially, η_2. All regressions are weighted by establishment size (number of employees) and include either industry, ZIP code, or ZIP code $\times$ industry fixed effects. When ZIP code or ZIP code $\times$ industry fixed effects are included, Δ Log(HP$_k$)$_{06-09}$ is absorbed by the fixed effects. Industries are measured at the 4-digit NAICS level. Standard errors are clustered at the firm and county level.

[9] The Social Connectedness Index is described in Bailey et al. (2016). We thank Mike Bailey from Facebook for providing us with the data.

The establishment-level linkage weights $\omega_{j,k,l}$ specify the relative weight of changes in house prices in ZIP code l for an establishment of firm j in ZIP code k. We impose the minimal assumption that the linkage weights be proportional to firms' non-tradable employment in a given ZIP code:

$$\omega_{j,k,l} = \frac{\text{Emp}_{j,l}}{\sum_{m \neq k} \text{Emp}_{j,m,}}. \tag{11}$$

Accordingly, a local economic shock in ZIP code l matters more for an establishment of firm j in ZIP code k if the firm is more exposed to ZIP code l, as measured by its employment in ZIP code l relative to other ZIP codes $m \neq k$. Simply put, an individual establishment is more exposed to a given ZIP code if the establishment's parent firm is more exposed to that ZIP code. Naturally, a ZIP code has zero weight for an individual establishment if its parent firm has no employees in that ZIP code.

In the final part of our analysis, we consider aggregate non-tradable employment at the county level. Specifically, we examine how non-tradable county-level employment responds to changes in a county's own house prices as well as to changes in house prices in other counties linked through firms' internal networks. Similar to what we do in our establishment-level analysis, we estimate:

$$\Delta\ \text{Log}(\text{Emp}_i)_{07-09} = \alpha + \eta_1\ \Delta\ \text{Log}(\text{HP}_i)_{06-09} + \eta_2\ \sum_{j \neq i} \lambda_{i,j}\ \Delta\ \text{Log}(\text{HP}_j)_{06-09} + \varepsilon_i, \tag{12}$$

where Δ Log(Emp$_i$)$_{07-09}$ is the percentage change in non-tradable employment from 2007 to 2009 in county i, Δ Log(HP$_i$)$_{06-09}$ is the percentage change in house prices from 2006 to 2009 in county i, and $\sum_{j \neq i} \lambda_{i,j}\ \Delta\ \text{Log}(\text{HP}_j)_{06-09}$ is the linkage-weighted percentage change in house prices from 2006 to 2009 in counties $j \neq i$. We write Δ Log(HP)$_{06-09}$ (other) in lieu of $\sum_{j \neq i} \lambda_{i,j}\ \Delta\ \text{Log}(\text{HP}_j)_{06-09}$ for brevity. All regressions are weighted by county size (number of employees). Standard errors are clustered at the state level.

The county-level linkage weights $\lambda_{i,j}$ specify the relative weight of changes in house prices in county j for non-tradable employment in county i. They are computed as the employment-weighted average of individual establishment-level linkage weights $\zeta_{h,i,j}$

within a given county:

$$\lambda_{i,j} = \sum_h \frac{\text{Emp}_{h,i}}{\sum_k \text{Emp}_{k,i}} \zeta_{h,i,j}, \tag{13}$$

where $\sum_h \left(\text{Emp}_{h,i}/\sum_k \text{Emp}_{k,i}\right) = 1$. The establishment-level linkage weights $\zeta_{h,i,j}$ are constructed similarly to above, except that establishments are aggregated at the firm-county level and exposure is measured with respect to counties instead of ZIP codes. Hence, a local economic shock in county j matters more for county i if its establishments are more exposed to county j and these establishments have high employment shares within county i.

3.3 Summary Statistics

Table I provides basic summary statistics. In the top part of Panel (A), the sample consists of firms operating in multiple ZIP codes ("multi-region firms"), and the unit of observation is at the individual establishment level, consistent with our establishment-level analysis in Section 4. As can be seen, non-tradable establishments have on average 28.9 employees and are linked to 812.9 other ZIP codes through their firms' internal networks (based on 2006 figures). This is a sizable network, reflecting the prominent role of national restaurant and retail chains in the non-tradable sector. During the Great Recession, non-tradable employment at the establishment level declined by 3.1 percent, while house prices at the ZIP code level fell by 14.5 percent.

The bottom part of Panel (A) provides county-level summary statistics. The sample consists of all non-tradable firms within a county, including single-region firms, consistent with our county-level analysis in Section 5. As can be seen, the average county has 1,074 establishments and 18,490 employees in the non-tradable sector, accounting for 18.6 percent of total county-level employment. During the Great Recession, aggregate non-tradable county-level employment declined by 3.6 percent, which is slightly higher than the 3.1 percent decline reported above for multi-region firms.

To get a sense of whether, and how, firms' internal networks are correlated with demographic and other characteristics, Panel (B) of Table I shows correlations of the network-based linkage weights, ω and λ, with corresponding linkage weights based on proximity, population, income, education, age, and household debt. While most of these correlations are insignificant, those with proximity and population are significant. Both correlations are intuitive. For one, many non-tradable firms are regional firms. Second, national restaurant and retail chains are likely to have a stronger presence in regions with more potential customers. We address both correlations in our empirical analysis. As for population, we find that (counterfactual) networks based on population weights are unable to produce significant spillovers across regions (see Tables II and IX). As for proximity, we show that our estimates are robust to excluding proximate regions or controlling for proximity-weighted house price changes in other regions (see Tables V and X).

4 Firms' Internal Networks and Local Shocks

4.1 Main Establishment-Level Results

Figure I provides a visual impression by plotting the relationship between changes in establishment-level employment during the Great Recession and either changes in ZIP code-level house prices (top panel) or changes in house prices in other ZIP codes in which the firm has establishments (bottom panel). To filter out any confounding effects of Δ Log(HP)$_{06-09}$ (other) when plotting the relationship between Δ Log(Emp)$_{07-09}$ and Δ Log(HP)$_{06-09}$, we compute the residuals from a regression of Δ Log(Emp)$_{07-09}$ on a constant and Δ Log(HP)$_{06-09}$ (other). These residuals represent the component of Δ Log(Emp)$_{07-09}$ that is orthogonal to, and thus unexplained by, Δ Log(HP)$_{06-09}$ (other). For each percentile of Δ Log(HP)$_{06-09}$, the plot shows the mean values of the residuals and Δ Log(HP)$_{06-09}$, respectively. We proceed analogously in the bottom panel when plotting the relationship between Δ Log(Emp)$_{07-09}$ and Δ Log(HP)$_{06-09}$ (other).

As is shown in the top panel of Figure I, there is a positive relationship between changes in establishment-level employment and changes in local house prices at the ZIP code level. The elasticity of employment with respect to local house prices is 0.116, implying that a ten percent decline in local house prices is associated with a 1.16 percent decline in employment at the establishment level. (The average decline in house prices at the ZIP code level between 2006 and 2009 is 14.5 percent; see Table I.) The bottom panel shows the relationship between changes in establishment-level employment and changes in house prices in *other* ZIP codes in which the firm is operating. Here, the elasticity of employment with respect to house prices in other ZIP codes is 0.029, which is about 25 percent of the elasticity with respect to local house prices. Thus, employment at the establishment level is highly sensitive not only to local house price changes but also to house price changes in other regions in which the firm is operating.

Table II confirms this visual impression using regression analysis. All regressions include industry fixed effects. Industries are measured at the 4-digit NAICS level. In column (1), the elasticity of employment with respect to local house prices is 0.109, which is only slightly lower than in our graphical analysis. Accordingly, a ten percent decline in local house prices is associated with a 1.09 percent decline in employment at the establishment level. Column (2) includes the effect of changes in house prices in other ZIP codes in which the firm has establishments. While the coefficient associated with changes in local house prices, Δ Log(HP)$_{06-09}$, drops slightly, the coefficient associated with changes in house prices in other ZIP codes, Δ Log(HP)$_{06-09}$ (other), is highly significant. The elasticity of employment with respect to house prices in other ZIP codes is 0.028, which is about 30 percent of the elasticity with respect to local house prices. Consistent with our model in Section 2, both elasticities have the same sign: establishment-level employment declines in response to a drop in local house prices as well as a drop in house prices in other regions in which the firm is operating.

Importantly, what matters is that establishments are linked to other regions in which the firm is operating, not other regions in general. In column (3), we assign equal weight to all other ZIP codes. In columns (4) to (6), we replace the linkage weights ω with corresponding linkage weights based on population, income, and household debt.[10] Lastly, in column (7), we randomly select other ZIP codes. Precisely, for each establishment, we replace all ZIP codes the establishment is currently linked to ($\omega > 0$) with randomly selected ZIP codes. We then estimate equation (1) and store the coefficients and standard errors. We repeat this process 1,000 times. The results in column (7) display the average coefficients and standard errors, respectively, based on the 1,000 Placebo regressions. As can be seen, in all of these Placebo tests, the effect of house price changes in other regions

[10] Mian and Sufi (2011, 2014), Mian, Rao, and Sufi (2013), Keys et al. (2014), Berger et al. (2015), and Baker (2015) all emphasize the role of household debt in the Great Recession.

is small and insignificant.

4.2 Common Regional Shocks

A main empirical challenge arises from separating regional spillovers through firms' internal networks from common shocks to regions in which non-tradable firms have their establishments. Such common regional shocks—if they are correlated with house price changes—could potentially explain why the elasticity of employment with respect to local house prices has the same sign as the elasticity with respect to house prices in other regions in which the firm is operating.

Table III addresses confounding effects due to common regional shocks. In column (1), we include ZIP code fixed effects. These fixed effects account for any shock at the regional level as well as spillovers from one region to another, e.g., due to price or other general equilibrium adjustments. We thus compare non-tradable establishments in the same ZIP code that are exposed to the same regional shock but that belong to different firms and hence are exposed to different shocks in other regions.[11] As can be seen, the elasticity of employment with respect to house prices in other ZIP codes in which the firm is operating is almost identical to our previous estimate in column (2) of Table II. A potential concern with this estimate is that regional shocks may differentially affect establishments in different industries. In column (2), we address this concern by including ZIP code × industry fixed effects. Industries are measured at the 4-digit NAICS level. As can be seen, our results remain virtually identical.

Regional shocks may differentially affect establishments even within a single 4-digit NAICS industry. For instance, different establishments within the same ZIP code and 4-digit NAICS industry may have different clienteles (e.g., high- versus low-end retail stores). To account for clientele effects, we control in columns (3) to (6) for the weighted average income, age, and education in the *other* ZIP codes in which the firm is present. All regressions include ZIP code × industry fixed effects. Effectively, we thus compare

[11] Suppose employment in establishment j in region A declines in response to a shock in region B, where the establishment's firm has other operations. If the employment decline is due to a common shock to regions A and B, then employment should also decline in other establishments $i \neq j$ in region A whose firms do not have operations in region B.

establishments in the same ZIP code and industry that belong to firms catering to similar (demographic) segments of the population. As can be seen, including these additional controls does not affect our results.

In Table IV, we account for clientele effects by conducting Placebo tests based on counterfactual firm networks. The idea is that if two firms in the same industry mutually overlap in almost all of their locations, then they are likely to cater to similar clienteles. This is illustrated in Figure II. Firm A has establishments in locations 1 to 10, while firm B has establishments in locations 2 to 11. Suppose firms A and B are in the same industry. Given that the two firms overlap in 90% of their locations, the counterfactual assumption is that—based on the firms' common clienteles—firm A *could have been* in location 11, while firm B *could have been* in location 1. Thus, if our estimates are confounded by common shocks to firms' clienteles, then firm A's establishments—i.e., those in locations 1 to 10—should also be sensitive to changes in house prices in location 11, even though firm A itself has no presence in that location. Likewise, firm B's establishments should also be sensitive to changes in house prices in location 1.

In our Placebo tests, we identify all non-tradable firms in the same industry that mutually overlap in at least either 75% or 90% of their locations. Location is defined either at the ZIP code or county level. Industries are measured either at the 3- or 4-digit NAICS level.[12] In the spirit of the above example, we estimate the elasticity of employment at the establishment level with respect to house prices in (counterfactual) locations in which the firm *could have been*. As can be seen, regardless of which specification we use, this elasticity is small and insignificant. Hence, our estimates are unlikely to be confounded by common shocks to firms' clienteles.

4.3 Direct Demand Spillovers

Consumers may go to restaurants and grocery stores in neighboring regions. Thus, another empirical challenge arises from separating regional spillovers through firms' internal

[12]To obtain strong counterfactuals, we restrict our sample to "pure industry" firms that have *all* of their establishments in a single industry. As it turns out, this sample restriction does not impose a serious limitation. In the non-tradable sector, 94.6% (90.9%) of multi-region firms have all of their establishments in a single 3-digit (4-digit) NAICS industry (based on 2006 figures).

networks from potentially confounding *direct* demand effects from nearby regions.[13] That is, falling house prices in ZIP code j may affect non-tradable establishment-level employment in ZIP code i not because of firms' internal networks but rather because consumers in ZIP code j cut back on their restaurant visits and grocery shopping in ZIP code i.

Table V addresses potentially confounding direct demand effects from nearby regions. In column (1), we directly control for proximity-weighted changes in house prices in other ZIP codes. While the coefficient associated with this control is (marginally) significant, the coefficient associated with Δ Log(HP)$_{06-09}$ (other) drops only slightly and remains highly significant. Hence, direct demand spillovers have at best a modest effect. In columns (3) to (5), we exclude all ZIP codes within a 50, 100, 150, or 250 mile radius based on the ZIP codes' geographical centroids. As is shown, the coefficient associated with Δ Log(HP)$_{06-09}$ (other) remains highly significant in all regressions.

4.4 Scope of Firms' Regional Networks

There are two sides to being part of a multi-region firm. One is that local firm units absorb some of the impacts of shocks in other regions. The flip side is that firm units in other regions absorb some of the impacts of local shocks.[14] Hence, as predicted by our model in Section 2, establishments belonging to multi-region firms should be less sensitive to (their own) local shocks than local firms.

We test this prediction in Table VI using different measures of the scope of firms' regional networks. In column (1), we use a dummy indicating whether a firm operates in multiple ZIP codes ("multi-region firm"). In column (2), we use the number of ZIP codes in which the firm operates. Lastly, in column (3), we use a firm-level Herfindahl-Hirschman Index (HHI) measuring the firm's geographical concentration based on its employment at the ZIP code level. (We use one minus the HHI to allow all three measures to have

[13]Likewise, house prices may be spatially correlated.

[14]While both sides together are reminiscent of an insurance scheme, the question of whether multi-region firms provide insurance to their firm units depends on the net effect. Although there is some evidence that establishments of multi-region firms exhibit lower employment volatility than local firms—even after controlling for firm size and including ZIP code $\times$ industry fixed effects—it remains questionable whether the latter constitute a valid counterfactual given that firm affiliation is not randomly assigned. See Guiso, Pistaferri, and Schivardi (2005) and Ellul, Pagano, and Schivardi (2014) for empirical studies documenting how firms insure workers against output shocks by smoothing their wages intertemporally.

the same economic interpretation.) In column (1), our sample includes both multi- and single-region firms. In columns (2) and (3), we use our original sample of multi-region firms given that differences between single- and multi-region firms have already been captured in column (1). As is shown, regardless of how we measure the scope of firms' regional networks (RN), the interaction term Δ Log(HP)$_{06-09}$ $\times$ RN is always negative and highly significant. Thus, consistent with our model in Section 2, establishments belonging to firms with more expansive regional networks exhibit lower elasticities of employment with respect to local house prices.[15]

4.5 Financial Constraints

Our model in Section 2 predicts that the extent to which firms reallocate resources in response to local economic shocks should be increasing with firms' financial constraints. In Table VII, we take this prediction to the data using different measures of firms' financial constraints. In column (1), we use firm leverage. This measure is based on Giroud and Mueller (2017), who argue that firms with higher leverage in 2006, at the onset of the Great Recession, were more financially constrained during the Great Recession.[16] In columns (2) and (3), we use the Kaplan-Zingales index (Kaplan and Zingales 1997) and the Whited-Wu index (Whited and Wu 2006), respectively. Both indices are widely used in the finance literature. All three measures are only available for public firms. Accordingly, we restrict our sample to firms that have a match in Compustat.

As can be seen, regardless of how we measure firms' financial constraints (FC), the interaction term Δ Log(HP)$_{06-09}$ (other) $\times$ FC is always positive and highly significant. Hence, establishments of more financially constrained firms exhibit larger elasticities of

[15] Firms with more expansive regional networks tend to be larger. To account for the effects of firm size, we have re-estimated columns (1) to (3) controlling for firm size (number of employees) in 2006 as well as its interaction with Δ Log(HP)$_{06-09}$. While the coefficient associated with Δ Log(HP)$_{06-09}$ $\times$ RN drops slightly, it remains highly significant.

[16] Survey evidence by Campello, Graham, and Harvey (2010) emphasizes the importance of firms' financial constraints during the Great Recession. The authors asked 574 U.S. CFOs in 2008 whether their firms are financially constrained and what they are planning to do in 2009. Firms classified as financially constrained based on tangible measures—credit rationing, high costs of borrowing, and difficulties in initiating or renewing a credit line—said they would cut employment by 10.9 percent in the following year. By contrast, firms classified as financially unconstrained said they would cut employment only by 2.7 percent.

employment with respect to house prices in other ZIP codes in which the firm is operating. In fact, for the least financially constrained firms in our sample, we find no evidence that firms reallocate internal resources in response to local economic shocks. Finally, we find that establishments of more financially constrained firms exhibit larger elasticities of employment with respect to local house prices. Altogether, these results suggest that financial constraints matter, both for how firms respond locally to shocks and how they spread the impacts of these shocks across regions.

4.6 Proximity to Headquarters

An interesting question is whether firm units in close proximity to headquarters (HQ) are more insulated from economic shocks. For instance, it may be easier for such units to successfully lobby HQ, or management may simply interact more with, and hence feel more socially responsible for, units that are located closer to HQ. But proximity may also facilitate information flows and monitoring, leading to higher marginal returns.[17] Accordingly, it may be efficient to be "protective" of proximate firm units.

Table VIII examines if establishments that are located closer to HQ are less sensitive to house price changes. We use three different measures of proximity. In columns (1) and (2), we use a dummy indicating whether the establishment and HQ are located in the same ZIP code and county, respectively. In column (3), we use the (inverse) geographical distance between the establishment and HQ. Two results stand out. First, establishments that are located closer to HQ exhibit smaller elasticities of employment with respect to local house prices. Second, establishments that are located closer to HQ also exhibit smaller elasticities of employment with respect to house prices in other ZIP codes in which the firm has establishments. Together, these results suggest that firm units in close proximity to HQ are more insulated from local economic shocks.

[17] Using data on manufacturing plants from the U.S. Census Bureau, Giroud (2013) finds that proximity to HQ positively affects plant-level productivity.

5 Aggregate Employment at the County Level

Regional spillovers through firms' internal networks may be irrelevant in general equilibrium if workers of multi-region firms that are laid off due to shocks in other regions are re-employed by (local) firms which are less exposed to these regions. In principle, such general equilibrium adjustments may be impaired by wage and price stickiness. In addition, the extent of labor reallocation may depend on search and matching frictions in the labor market as well as labor adjustment costs. Empirical evidence suggests that labor market frictions were particularly severe during the Great Recession (e.g., Davis, Faberman, and Haltiwanger 2013; Şahin et al. 2014). Notably, Foster, Grim, and Haltiwanger (2014) find that the intensity of labor reallocation fell rather than rose during the Great Recession, in contrast to previous recessions. They conclude that "job reallocation (creation plus destruction) is at its lowest point in 30 years during the Great Recession and its immediate aftermath" (p. 10).

To see whether the distribution of firm networks also matters in the aggregate, we examine aggregate non-tradable employment at the county level. We consider non-tradable employment by *all* firms in a county, including single-region firms. Hence, our setting accounts for the possibility that workers laid off due to shocks in other regions are re-employed either by other multi-region firms or by (local) single-region firms. Linkages across counties are based on firms' internal networks as described in Section 3.2.

5.1 Main County-Level Results

Figure III provides a visual impression by plotting the relationship between changes in non-tradable county-level employment during the Great Recession and either changes in county-level house prices (top panel) or changes in house prices in other counties linked through firms' internal networks (bottom panel). As is shown in the top panel, the elasticity of employment with respect to a county's own house prices is 0.129. This is slightly larger than the corresponding elasticity in the top panel of Figure I as our sample now also includes small single-region firms. In the bottom panel, the elasticity of employment with respect to house prices in other counties linked through firms' internal networks is 0.030. Accordingly, non-tradable county-level employment is highly sensitive to changes in house prices in other counties, suggesting that spillovers through firms' internal networks also matter for aggregate employment.

Table IX confirms this visual impression using regression analysis. All regressions include demographic controls (income, age, education) as well as the county-specific employment shares of all 2-digit NAICS industries to account for the possibility that counties with exposure to certain industries are harder hit during the Great Recession (Mian and Sufi 2014). In column (1), the elasticity of non-tradable county-level employment with respect to a county's own house prices is 0.122, which is only slightly lower than in our graphical analysis. Column (2) includes the effect of changes in house prices in other counties linked through firms' internal networks. While the coefficient associated with changes in a county's own house prices, Δ Log(HP)$_{06-09}$, drops slightly, the coefficient associated with changes in house prices in other counties, Δ Log(HP)$_{06-09}$ (other), is highly significant. The elasticity of non-tradable county-level employment with respect to house prices in other counties is 0.024, which is about 20 percent of the elasticity with respect to a county's own house prices. This is somewhat less than in our establishment-level analysis, possibly reflecting the impacts of general equilibrium adjustments.

A quick back-of-the-envelope calculation suggests that consumer demand shocks can explain a significant portion of the drop in non-tradable employment during the Great Recession. As the summary statistics in Table I show, non-tradable employment at the county level dropped by 3.6 percent, while county-level house prices fell by 14.5 percent. Given the elasticities of 0.115 and 0.024 in column (2), a drop in house prices of 14.5 percent implies a drop in non-tradable employment of $(0.115 + 0.024) \times 14.5\% = 1.95\%$, which is more than half of the overall decline in non-tradable employment during the Great Recession. Notably, a substantial fraction of the decline in non-tradable employment explained by consumer demand shocks $(0.024/0.139 = 0.173)$ is due to shocks originating in other counties linked through firms' internal networks.

To address concerns that non-tradable county-level employment may be generically sensitive to house price changes in other counties, we perform the same Placebo tests as in Table II. In column (3), we assign equal weight to all other counties. In columns (4) to (6), we replace the linkage weights λ with corresponding linkage weights based on population, income, and household debt. Lastly, in column (7), we randomly select other counties. In all of these Placebo tests, the effect of house price changes in other counties is small and insignificant.

5.2 Common County-Level Shocks

As in our establishment-level analysis, a main empirical challenge arises from common shocks at the county level that are correlated with house price changes. In Table X, we account for this possibility by controlling for similarity-weighted house price changes in other counties. Similarity weights place more weight on other counties that are more "similar" (i.e., smaller absolute difference) to a given county. The underlying idea is that counties which are more similar are more likely to be exposed to similar county-level shocks. In columns (1) to (3), we examine similarities based on income, education, and age. In column (4), we examine similarities based on household debt. Lastly, in column (5), we examine similarities based on the share of non-tradable employment in a county. As is shown, in all of these regressions, the coefficient associated with house price changes in "similar" counties is small and insignificant. By contrast, our main coefficient of interest—that associated with Δ Log(HP)$_{06-09}$ (other)—is always highly significant. Thus, our estimates are unlikely to be confounded by common shocks at the county level that are correlated with house price changes.

In Table XI, we account for the possibility of common shocks at the county level in a different way. Precisely, we exploit the fact that not all counties experienced a collapse in house prices during the Great Recession. Linking such counties to other counties in which house prices fell sharply makes it unlikely that spillovers across counties are the result of common county-level shocks that are correlated with house price changes. In column (1), we focus on counties in which house prices *increased* during the Great Recession. In column (2), we focus on counties in which house prices changed only little, defined as changes of less than ± 2.5 percent. In both cases, the coefficient associated with Δ Log(HP)$_{06-09}$ (other) is highly significant. Thus, even though these counties did not experience house price shocks of their own, their employment is highly sensitive to house price changes in other counties linked through firms' internal networks.

5.3 Direct Demand Spillovers

Another empirical challenge arises from potentially confounding direct demand effects from nearby counties. Similar to our establishment-level analysis, we account for such direct demand effects by controlling for proximity-weighted changes in house prices in other counties and excluding counties within a certain radius. Table XII presents the results. In column (1), we control for promiximity-weighted changes in house prices in other counties. While the coefficient associated with this control is (marginally) significant, the coefficient associated with Δ Log(HP)$_{06-09}$ (other) drops only slightly, and it remains highly significant. Hence, direct demand spillovers from nearby counties have at best a small effect. In columns (2) to (5), we exclude all counties within a 50, 100, 150, or 250 mile radius based on the counties' geographical centroids. This rules out any direct demand spillovers from these counties by construction. As can be seen, the coefficient associated with Δ Log(HP)$_{06-09}$ (other) is always highly significant.

5.4 Trade Channel

We found no evidence that our results are driven by direct demand spillovers from nearby counties. However, local demand shocks may also *indirectly* affect non-tradable employment in other counties, namely, through the trade channel. Intuitively, falling house prices in county j may lead to employment losses in county i's *tradable* sector, which in turn may spill over to county i's non-tradable sector if workers that are laid off cut back on their local grocery shopping and restaurant visits.[18]

We approach the trade channel hypothesis in two ways. We first test a necessary condition for this (trade) channel to explain our results: changes in county-level house prices must affect tradable employment in other counties. Figure IV provides a visual impression. As can be seen, there is no association between changes in tradable county-level employment and either changes in a county's own house prices (top panel) or changes in house prices in other counties (bottom panel). Table XIII confirms this visual impression using regression analysis. As column (1) shows, neither changes in a county's own house

[18] An industry is classified as as tradable if imports plus exports exceed \$10,000 per worker or \$500M in total (Mian and Sufi 2014). Tradable industries are essentially manufacturing industries.

prices nor changes in house prices in other counties have a significant effect on tradable employment at the county level.

The second approach considers a slightly more complex variant of the trade channel hypothesis. Accordingly, falling house prices in county j may lead to employment losses in county j's tradable sector, which in turn may spill over to county i's tradable sector via *tradable* firms' internal networks, which eventually may spill over to county i's non-tradable sector if workers that are laid off cut back on their local grocery shopping and restaurant visits. We find no support for this hypothesis. As column (2) shows, changes in house prices in other counties linked through tradable firms' internal networks have no significant effect on tradable employment at the county level. Ultimately, all of the results in Table XIII are reflections of the "tradable Placebo" in Mian and Sufi (2014), which posits that regional variation in housing net worth shocks is unrelated to regional variation in tradable employment.

6 Conclusion

Using confidential micro data from the U.S. Census Bureau's Longitudinal Business Database and exploiting ZIP code-level variation in house price changes during the Great Recession, we show that local consumer demand shocks spill over to distant regions through firms' internal networks, and that such spillovers matter economically by affecting aggregate employment in those regions. At the establishment level, we find that the elasticity of non-tradable employment with respect to house prices in other ZIP codes in which the firm is operating is about one third of the elasticity with respect to local house prices. Similarly, at the county level, we find that the elasticity of non-tradable county-level employment with respect to house prices in other counties linked through firms' internal networks is about one fifth of the elasticity with respect to a county's own house prices. The slightly smaller magnitudes at the county level are likely a reflection of the impacts of general equilibrium adjustments. Overall, our results suggest that firms, through their networks of establishments, constitute an important channel through which local economic shocks propagate across U.S. regions.

7 References

Acemoglu, Daron, Vasco Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, 2012, Network Origins of Aggregate Fluctuations, Econometrica, 80, 1977-2016.

Acemoglu, Daron, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, 2012, Systemic Risk and Stability in Financial Networks, American Economic Review 105, 564-608.

Acemoglu, Daron, Ufuk Akcigit, and William Kerr, 2016, Networks and the Macroeconomy: An Empirical Exploration, NBER Macroeconomics Annual 30, 276-335.

Autor, David, David Dorn, and Gordon Hanson, 2013, The China Syndrome: Local Labor Market Effects of Import Competition in the United States, American Economic Review 103, 2121-2168.

Autor, David, David Dorn, and Gordon Hanson, 2016, The China Shock: Learning from Labor Market Adjustment to Large Changes in Trade, forthcoming, Annual Review of Economics.

Autor, David, David Dorn, Gordon Hanson, and Jae Song, 2014, Trade Adjustment: Worker Level Evidence, Quarterly Journal of Economics 129, 1799-1860.

Bailey, Mike, Ruiqing Cao, Theresa Kuchler, and Johannes Stroebel, 2016, Social Networks and Housing Markets, NBER Working Paper No. 22258.

Baker, Scott, 2015, Debt and the Consumption Response to Household Income Shocks, mimeo, Northwestern University.

Barrot, Jean-Noël, and Julien Sauvagnat, 2016, Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks, Quarterly Journal of Economics 131, 1543-1592.

Beraja, Martin, 2016, Robust Policy Counterfactuals (with an Application to Fiscal Unions), mimeo, University of Chicago.

Beraja, Martin, Erik Hurst, and Juan Ospina, 2016, The Aggregate Implications of Regional Business Cycles, NBER Working Paper No. 21956.

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra, 2015, House Prices and Consumer Spending, NBER Working Paper No. 21667.

Blanchard, Olivier, and Lawrence Katz, 1992, Regional Evolutions, Brookings Papers on Economic Activity, 1-75.

Cabrales, Antonio, Douglas Gale, and Piero Gottardi, 2015, Financial Contagion in Networks, in: Oxford Handbook on the Economics of Networks, edited by Yann Bramoullé, Andrea Galeotti, and Brian Rogers. Oxford: Oxford University Press.

Caliendo, Lorenzo, Fernando Parro, Esteban Rossi-Hansberg, and Pierre-Daniel Sarte, 2014, The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy, NBER Working Paper No. 20168.

Campello, Murillo, John Graham, and Campbell Harvey, 2010, The Real Effects of Financial Constraints: Evidence from a Financial Crisis, Journal of Financial Economics, 97, 470-487.

Davis, Steven, Jason Faberman, and John Haltiwanger, 2013, The Establishment-Level Behavior of Vacancies and Hiring, Quarterly Journal of Economics 128, 581-622.

Ellul, Andrew, Marco Pagano, and Fabiano Schivardi, 2014, Employment and Wage Insurance within Firms: Worldwide Evidence, CEPR Discussion Paper No. 10711.

Farhi, Emmanuel, and Ivan Werning, 2012, Fiscal Unions, NBER Working Paper No. 18280.

Foster, Lucia, Cheryl Grim, and John Haltiwanger, 2014, Reallocation in the Great Recession: Cleansing or Not? NBER Working Paper 20427.

Gertner, Robert, David Scharfstein, and Jeremy Stein, 1994, Internal versus External Capital Markets, Quarterly Journal of Economics 109, 1211-1230.

Giroud, Xavier, 2013, Proximity and Investment: Evidence from Plant-Level Data, Quarterly Journal of Economics 128, 861-915.

Giroud, Xavier, and Holger Mueller, 2017, Firm Leverage, Consumer Demand, and Employment Losses during the Great Recession, Quarterly Journal of Economics 132, 271-316.

Glaeser, Edward, and Joshua Gottlieb, 2008, The Economics of Place-Making Policies, Brookings Papers on Economic Activity, 155-239.

Guiso, Luigi, Luigi Pistaferri, and Fabiano Schivardi, 2005, Insurance within the Firm, Journal of Political Economy 113, 1054-1087.

Hurst, Erik, Benjamin Keys, Amit Seru, and Joseph Vavra, 2016, Regional Redistribution through the U.S. Mortgage Market, American Economic Review 106, 2982-3028.

Inderst, Roman, and Holger Mueller, 2003, Internal versus External Financing: An Optimal Contracting Approach, Journal of Finance 58, 1033-1062.

Jarmin, Ron, and Javier Miranda, 2002, The Longitudinal Business Database, CES Working Paper 02-17.

Kaplan, Steven, and Luigi Zingales, 1997, Do Financing Constraints Explain Why Investment Is Correlated with Cash Flow? Quarterly Journal of Economics 112, 169-215.

Kaplan, Greg, Kurt Mitman, and Giovanni Violante, 2016, Non-durable Consumption and Housing Net Worth in the Great Recession: Evidence from Easily Accessible Data, NBER Working Paper No. 22232.

Keys, Benjamin, Tomasz Piskorski, Amit Seru, and Vincent Yao, 2014, Mortgage Rates, Household Balance Sheets, and the Real Economy, NBER Working Paper No. 20561.

Kline, Patrick, and Enrico Moretti, 2013, Place Based Policies with Unemployment, American Economic Review: Papers & Proceedings 103, 238-243.

Kline, Patrick, and Enrico Moretti, 2014a, Local Economic Development, Agglomeration Economies, and the Big Push: 100 Years of Evidence from the Tennessee Valley Authority, Quarterly Journal of Economics 129, 275-331.

Kline, Patrick, and Enrico Moretti, 2014b, People, Places and Public Policy: Some Simple Welfare Economics of Local Economic Development Programs, Annual Review of Economics 6, 629-662.

McCue, Kristin, 2003, Matching Compustat Data to the SSEL, mimeo, Center for Economic Studies.

Mian, Atif, and Amir Sufi, 2011, House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis, American Economic Review 101, 2132-2156.

Mian, Atif, and Amir Sufi, 2014, What Explains the 2007-2009 Drop in Employment? Econometrica 82, 2197-2223.

Mian, Atif, Kamalesh Rao, and Amir Sufi, 2013, Household Balance Sheets, Consumption, and the Economic Slump, Quarterly Journal of Economics 128, 1-40.

Mian, Atif, Amir Sufi, and Francesco Trebbi, 2015, Foreclosures, House Prices, and the Real Economy, Journal of Finance 70, 2587-2634.

Moretti, Enrico, 2014, Local Labor Markets, in: Handbook of Labor Economcis, edited by David Card and Orley Ashenfelter. Amsterdam: North-Holland.

Nakamura, Emi, and Jón Steinsson, 2014, Fiscal Stimulus in a Monetary Union: Evidence from US Regions, American Economic Review 104, 753-792.

Notowidigdo, Matthew, 2011, The Incidence of Local Labor Demand Shocks, NBER Working Paper No. 17167.

Peek, Joe, and Eric Rosengren, 1997, The International Transmission of Financial Shocks: The Case of Japan, American Economic Review 87, 495-505.

Peek, Joe, and Eric Rosengren, 2000, Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States, American Economic Review 90, 30-45.

Şahin, Ayşegül, Joseph Song, Giorgio Topa, and Giovanni Violante, 2014, Mismatch Unemployment, American Economic Review 104 3529-3564.

Schnabl, Philipp, 2012, The International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market, Journal of Finance 67, 897-932.

Stein, Jeremy, 1997, Internal Capital Markets and the Competition for Corporate Resources, Journal of Finance 52, 111-133.

Stein, Jeremy, 2003, Agency, Information and Corporate Investment, in: Handbook of the Economics of Finance, edited by George Constantinides, Milton Harris, and René Stulz. Amsterdam: North-Holland.

Stroebel, Johannes, and Joseph Vavra, 2014, House Prices, Local Demand, and Retail Prices, NBER Working Paper No. 20710.

Whited, Toni, and Guojun Wu, 2006, Financial Constraints Risk, Review of Financial Studies 19, 531-559.

Williamson, Oliver, 1975, Market and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.

Yagan, Danny, 2016, Is the Great Recession Really Over? Longitudinal Evidence of Enduring Employment Impacts, mimeo, UC Berkeley.

8 Appendix

8.1 Cobb-Douglas Production Function

This section presents a variant of the model in Section 2 in which regional firm units produce output using labor and capital input based on the Cobb-Douglas production function $f(\phi_i, L_i, K_i) = \phi_i L_i^\alpha K_i^\beta$, where $\alpha + \beta < 1$ implies decreasing returns to scale. When transforming labor and capital input into output, each regional firm unit takes output prices p_i and factor prices w_i and r_i as given.

The firm solves

$$\max_{L_i, K_i, \lambda} \delta \sum\nolimits_i p_i \phi_i L_i^\alpha K_i^\beta - \sum\nolimits_i (w_i L_i + r_i K_i) + \lambda \left[\sum\nolimits_i C_i - \sum\nolimits_i (w_i L_i + r_i K_i) \right], \tag{14}$$

where λ denotes the Lagrange multiplier associated with the budget constraint.

The Kuhn-Tucker conditions are

$$\delta p_i \phi_i \alpha L_i^{\alpha-1} K_i^\beta = (1+\lambda) w_i \ \forall i, \tag{15}$$

$$\delta p_i \phi_i \beta L_i^\alpha K_i^{\beta-1} = (1+\lambda) r_i \ \forall i, \tag{16}$$

$$\sum\nolimits_i (w_i L_i + r_i K_i) \leq \sum\nolimits_i C_i, \tag{17}$$

and

$$\lambda \left[\sum\nolimits_i C_i - \sum\nolimits_i (w_i L_i + r_i K_i) \right] = 0; \ \lambda \geq 0. \tag{18}$$

From (15) and (16) it follows that $\alpha r_i K_i = \beta w_i L_i$, implying that

$$\delta p_i \phi_i \left(\frac{w_i}{r_i} \frac{\beta}{\alpha} \right)^\beta \alpha L_i^{\alpha+\beta-1} = (1+\lambda) w_i \ \forall i \tag{19}$$

and

$$\delta p_i \phi_i \left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{\alpha} \beta K_i^{\alpha+\beta-1} = (1+\lambda)\, r_i \;\forall i. \tag{20}$$

As a benchmark, suppose the firm is financially unconstrained, so that the budget constraint (17) is slack ($\lambda = 0$). In that case, (15)-(16) imply that headquarters allocates labor (capital) input to each regional firm unit up to the point where the (discounted) marginal revenue product of labor (capital) equals the wage (rental rate of capital). Thus, in the absence of financial constraints, labor and capital input in each regional firm unit are at the first-best optimum. Furthermore, it follows from (19)-(20) that for any two regional firm units i and j, it must hold that

$$\begin{aligned} \frac{\delta p_i \phi_i}{w_i}\left(\frac{w_i}{r_i}\frac{\beta}{\alpha}\right)^{\beta} \alpha L_i^{\alpha+\beta-1} &= \frac{\delta p_i \phi_i}{r_i}\left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{\alpha} \beta K_i^{\alpha+\beta-1} \\ &= \frac{\delta p_j \phi_j}{r_j}\left(\frac{r_j}{w_j}\frac{\alpha}{\beta}\right)^{\alpha} \beta K_j^{\alpha+\beta-1} = \frac{\delta p_j \phi_j}{w_j}\left(\frac{w_j}{r_j}\frac{\beta}{\alpha}\right)^{\beta} \alpha L_j^{\alpha+\beta-1}, \end{aligned} \tag{21}$$

that is, a marginal dollar of funds has the same value at each regional firm unit regardless of whether it is used for labor or capital input.

Suppose next that the firm is financially constrained, so that the budget constraint (17) binds ($\lambda > 0$). In this case, the optimality condition (21) still holds—that is, a marginal dollar has the same value at each regional firm unit. However, this (shadow) value now strictly exceeds one—in contrast to the financially unconstrained firm, where it equals one—implying that the marginal revenue product of labor (capital) strictly exceeds the wage (rental rate of capital). Accordingly, if the firm is financially constrained, labor and capital input in each regional firm unit are below the first-best optimum.

Consider now a negative cash-flow shock in region j. Analogous to the main model, differentiating (17), (19), and (20) with respect to C_j and solving yields

$$\frac{d\lambda}{dC_j} = \frac{\delta(\alpha+\beta-1)}{\sum_i \left(\frac{w_i^2}{p_i\phi_i}\frac{L_i^{2-\alpha-\beta}}{\alpha}\left(\frac{w_i}{r_i}\frac{\beta}{\alpha}\right)^{-\beta} + \frac{r_i^2}{p_i\phi_i}\frac{K_i^{2-\alpha-\beta}}{\beta}\left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{-\alpha}\right)} < 0, \tag{22}$$

$$\frac{dL_i}{dC_j} = \frac{\frac{w_i}{p_i\phi_i}\frac{L_i^{2-\alpha-\beta}}{\alpha}\left(\frac{w_i}{r_i}\frac{\beta}{\alpha}\right)^{-\beta}}{\sum_i \left(\frac{w_i^2}{p_i\phi_i}\frac{L_i^{2-\alpha-\beta}}{\alpha}\left(\frac{w_i}{r_i}\frac{\beta}{\alpha}\right)^{-\beta} + \frac{r_i^2}{p_i\phi_i}\frac{K_i^{2-\alpha-\beta}}{\beta}\left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{-\alpha}\right)} > 0 \;\forall i, \tag{23}$$

and

$$\frac{dK_i}{dC_j} = \frac{\frac{r_i}{p_i\phi_i}\frac{K_i^{2-\alpha-\beta}}{\beta}\left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{-\alpha}}{\sum_i\left(\frac{w_i^2}{p_i\phi_i}\frac{L_i^{2-\alpha-\beta}}{\alpha}\left(\frac{w_i}{r_i}\frac{\beta}{\alpha}\right)^{-\beta}+\frac{r_i^2}{p_i\phi_i}\frac{K_i^{2-\alpha-\beta}}{\beta}\left(\frac{r_i}{w_i}\frac{\alpha}{\beta}\right)^{-\alpha}\right)} > 0\ \forall i. \tag{24}$$

Lastly, as in the main model, we can compare the sensitivity of single-unit firms and regional firm units that are part of multi-region firms to local cash-flow shocks. For a single-unit firm in region j, the sensitivity of labor and capital input to a local cash-flow shock is given by

$$\frac{dL_j}{dC_j} = \frac{\alpha}{\alpha+\beta}\frac{1}{w_j} \tag{25}$$

and

$$\frac{dK_j}{dC_j} = \frac{\beta}{\alpha+\beta}\frac{1}{r_j}, \tag{26}$$

respectively. By contrast, for a regional firm unit in region j that is part of a multi-region firm, the sensitivity of labor and capital input to a local cash-flow shock is given by

$$\frac{dL_j}{dC_j} = \frac{\alpha}{\alpha+\beta}\frac{1}{w_j}\frac{\frac{w_j^2}{p_j\phi_j}L_j^{2-\alpha-\beta}\left(\frac{w_j}{r_j}\right)^{-\beta}}{\sum_i\left(\frac{w_i^2}{p_i\phi_i}L_i^{2-\alpha-\beta}\left(\frac{w_i}{r_i}\right)^{-\beta}\right)} \tag{27}$$

and

$$\frac{dK_j}{dC_j} = \frac{\beta}{\alpha+\beta}\frac{1}{r_j}\frac{\frac{r_j^2}{p_j\phi_j}K_j^{2-\alpha-\beta}\left(\frac{r_j}{w_j}\right)^{-\alpha}}{\sum_i\left(\frac{r_i^2}{p_i\phi_i}K_i^{2-\alpha-\beta}\left(\frac{r_i}{w_i}\right)^{-\alpha}\right)}, \tag{28}$$

respectively, which is strictly less than the sensitivities in (25)-(26).

8.2 Local Productivity Shocks

This section presents a variant of the model in Section 2 in which each regional firm unit produces output using labor input according to the production function $f_i(L_i) = \phi_i f(L_i)$, where ϕ_i is a region-specific productivity parameter.

The firm solves

$$\max_{L_i,\lambda} \delta \sum\nolimits_i p_i\phi_i f(L_i) - \sum\nolimits_i w_iL_i + \lambda\left[\sum\nolimits_i C_i - \sum\nolimits_i w_iL_i\right], \tag{29}$$

where λ denotes the Lagrange multiplier associated with the budget constraint.

The Kuhn-Tucker conditions are

$$\delta p_i \phi_i f'(L_i) = (1+\lambda)\, w_i \ \forall i, \tag{30}$$

$$\sum_i w_i L_i \leq \sum_i C_i, \tag{31}$$

and

$$\lambda \left[\sum_i C_i - \sum_i w_i L_i\right] = 0; \ \ \lambda \geq 0. \tag{32}$$

Consider a negative productivity shock in region j. If the firm is financially unconstrained, so that the budget constraint (31) is slack ($\lambda = 0$), (the first-best optimal) labor input in region j declines. There are no implications for regions $i \neq j$. Formally, setting $\lambda = 0$ and differentiating (30) with respect to ϕ_j, we obtain

$$\delta p_j \left[f'(L_j) + \phi_j f''(L_j)\frac{dL_j}{d\phi_j}\right] = 0, \tag{33}$$

implying that

$$\frac{dL_j}{d\phi_j} = \frac{-f'(L_j)}{\phi_j f''(L_j)} > 0, \tag{34}$$

and

$$\delta p_i \phi_i f''(L_i)\frac{dL_i}{d\phi_j} = 0 \ \forall i \neq j, \tag{35}$$

implying that

$$\frac{dL_i}{d\phi_j} = 0 \ \forall i \neq j. \tag{36}$$

Suppose next that the firm is financially constrained, so that the budget constraint (31) binds ($\lambda = 0$). There are two effects at work. First, as in the financially unconstrained case, labor input in region j declines. However, this frees up scarce funds, which can be used for labor inputs in regions $i \neq j$ given that labor input in these regions is below the first-best optimum. As a consequence, labor input in regions $i \neq j$ *increases*. Differentiating (30)-(31) with respect to ϕ_j and solving yields

$$\frac{d\lambda}{d\phi_j} = \frac{\frac{w_j f'(L_j)}{\phi_j f''(L_j)}}{\sum_i \frac{w_i^2}{\delta p_i \phi_i f''(L_i)}} > 0, \tag{37}$$

$$\frac{dL_j}{d\phi_j} = \frac{w_j f'(L_j)}{\phi_j f''(L_j)} \left[\frac{-\sum_{i \neq j} \frac{w_i}{\delta p_i \phi_i f''(L_i)}}{\sum_i \frac{w_i^2}{\delta p_i \phi_i f''(L_i)}} \right] > 0, \tag{38}$$

and

$$\frac{dL_i}{d\phi_j} = \frac{w_j f'(L_j)}{\phi_j f''(L_j)} \frac{\frac{w_i}{\delta p_i \phi_i f''(L_i)}}{\sum_i \frac{w_i^2}{\delta p_i \phi_i f''(L_i)}} < 0 \; \forall i \neq j. \tag{39}$$

Thus, if the firm is financially constrained, a negative productivity shock in region j leads to a decline in labor input in region j and an *increase* in labor input in regions $i \neq j$.

Figure I
Non-Tradable Establishment-Level Employment

This figure plots the relationship between changes in non-tradable establishment-level employment, Δ Log(Emp)$_{07\text{-}09}$, and either changes in house prices in the establishment's ZIP code, Δ Log(HP)$_{06\text{-}09}$, or changes in house prices in other ZIP codes in which the firm has establishments, Δ Log(HP)$_{06\text{-}09}$ (other). To filter out any confounding effects of Δ Log(HP)$_{06\text{-}09}$ (other) when plotting the relationship between Δ Log(Emp)$_{07\text{-}09}$ and Δ Log(HP)$_{06\text{-}09}$, we compute the residuals from a regression of Δ Log(Emp)$_{07\text{-}09}$ on a constant and Δ Log(HP)$_{06\text{-}09}$ (other). For each percentile of Δ Log(HP)$_{06\text{-}09}$, the plot in the top panel shows the mean values of the residuals and Δ Log(HP)$_{06\text{-}09}$, respectively. We proceed analogously in the bottom panel when plotting the relationship between Δ Log(Emp)$_{07\text{-}09}$ and Δ Log(HP)$_{06\text{-}09}$ (other).

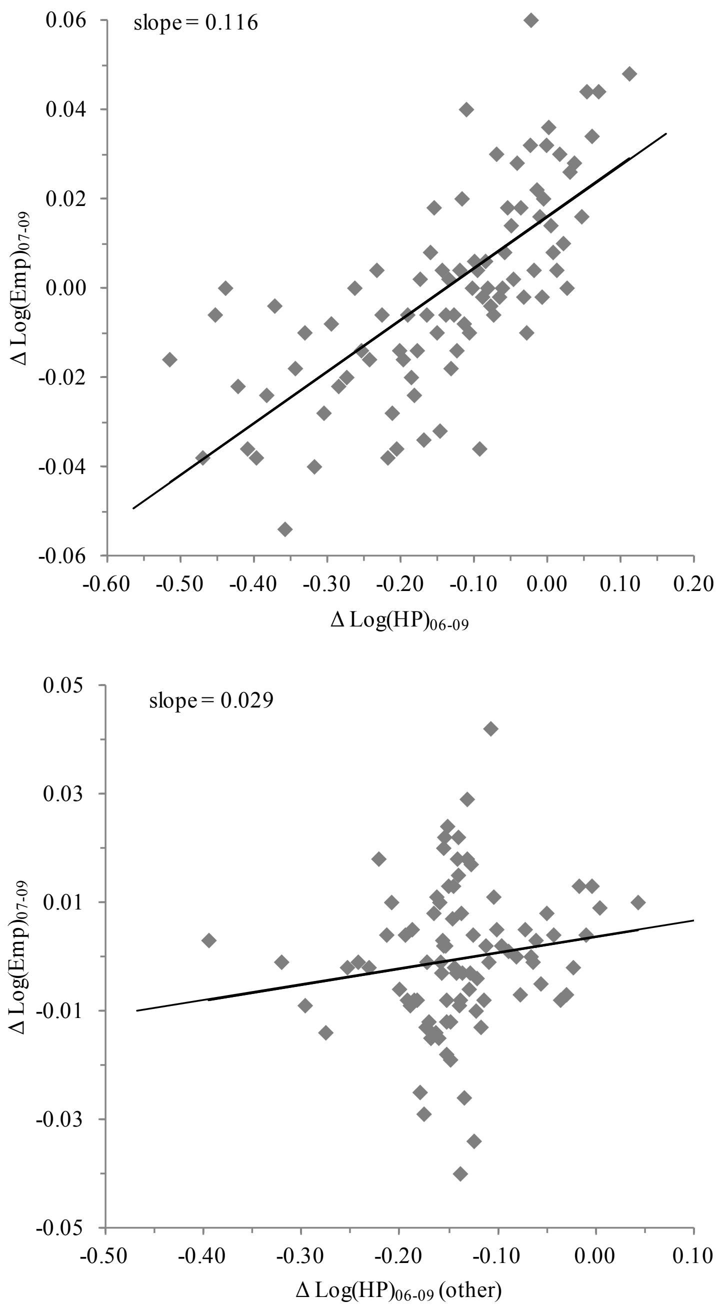


Figure II
Counterfactual Firm Networks

This figure illustrates the counterfactual firm networks used in the Placebo tests in Table IV. Firm A has establishments in locations 1 to 10, while firm B has establishments in locations 2 to 11. Moreover, firms A and B are in the same industry. Given that the two firms overlap in 90% of their locations, the counterfactual assumption is that, based on the firms' common clienteles, firm A *could have been* in location 11, while firm B *could have been* in location 1.

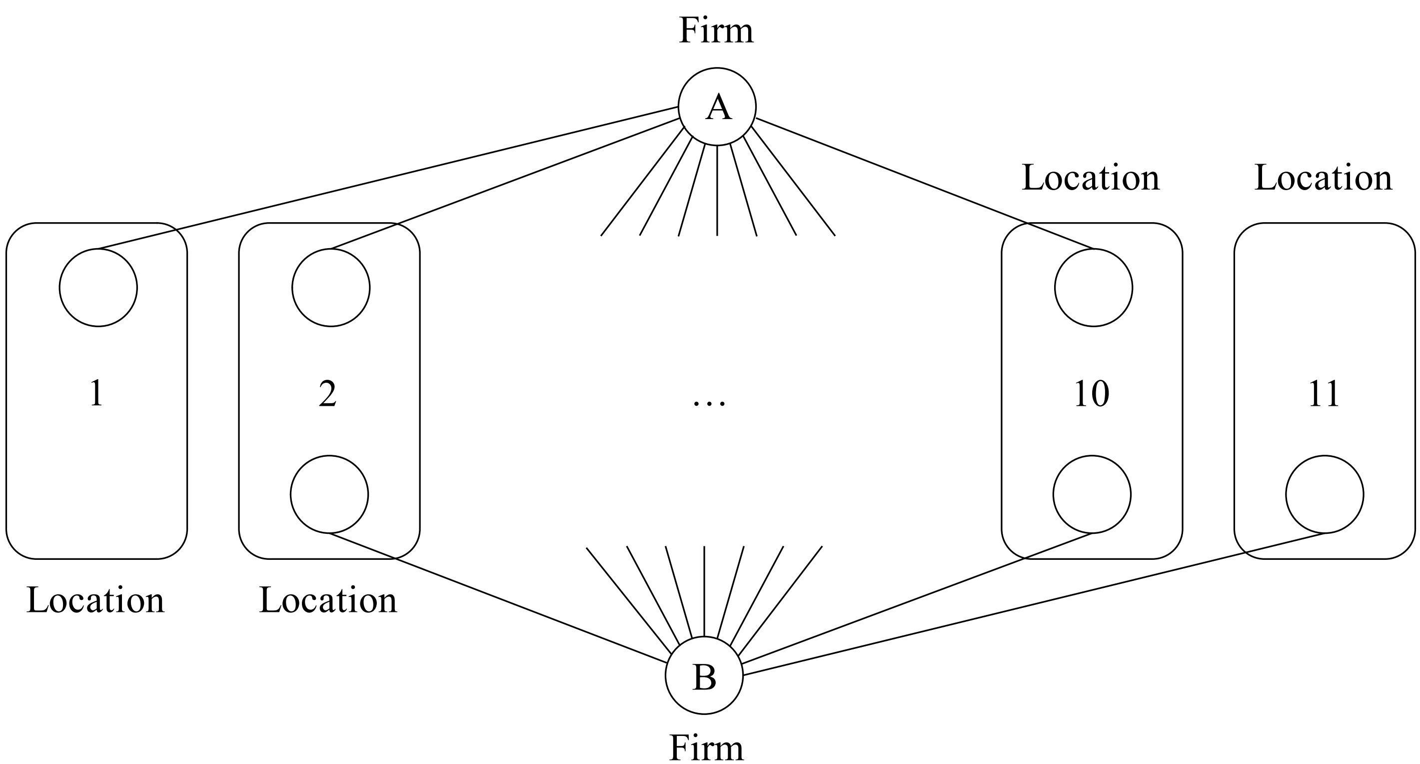
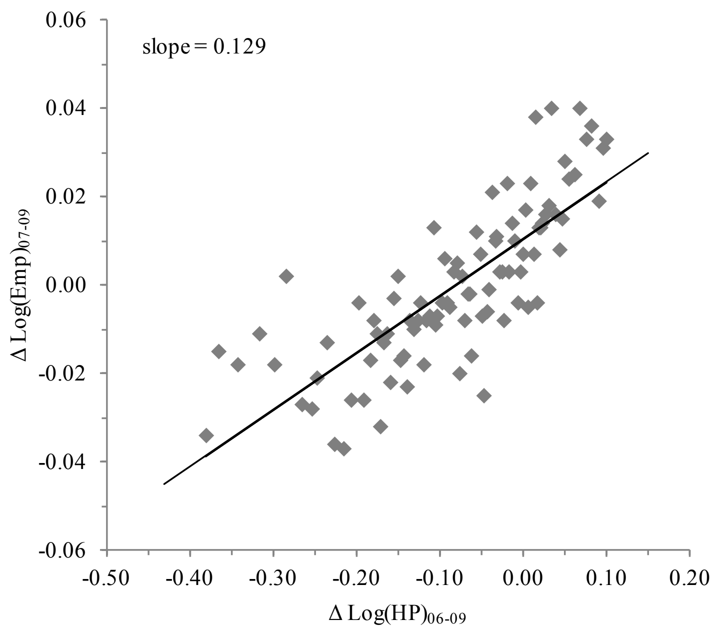


Figure III
Non-Tradable County-Level Employment

This figure is similar to Figure I, except that it plots the relationship between changes in non-tradable county-level employment, Δ Log(Emp)$_{07\text{-}09}$, and either changes in county-level house prices, Δ Log(HP)$_{06\text{-}09}$, or changes in house prices in other counties linked through firms' internal networks, Δ Log(HP)$_{06\text{-}09}$ (other).



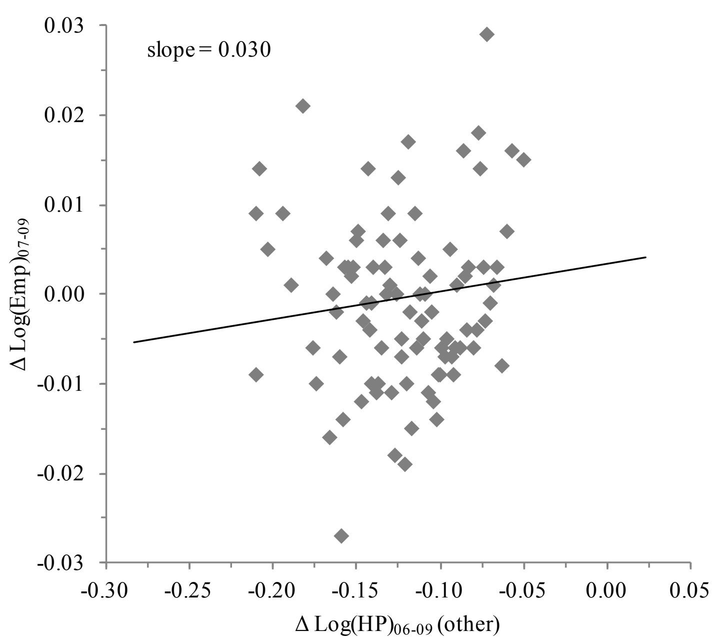
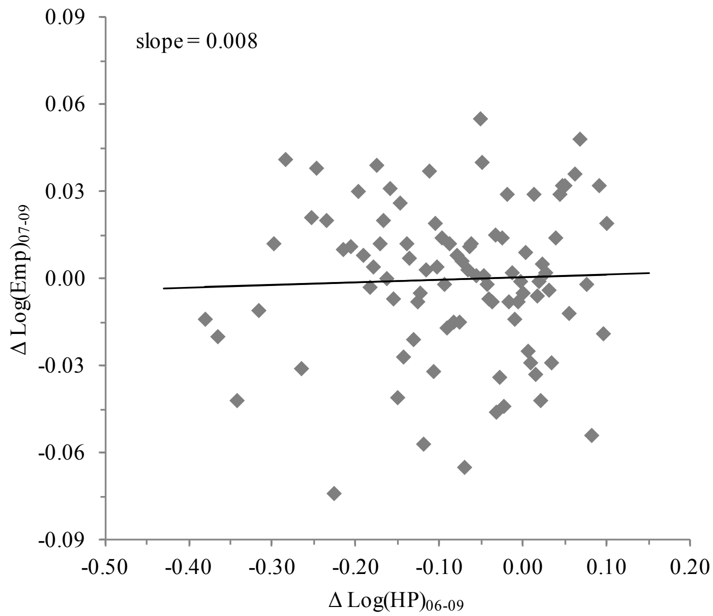


Figure IV
Tradable County-Level Employment

This figure is similar to Figure III, except that it pertains to tradable county-level employment.



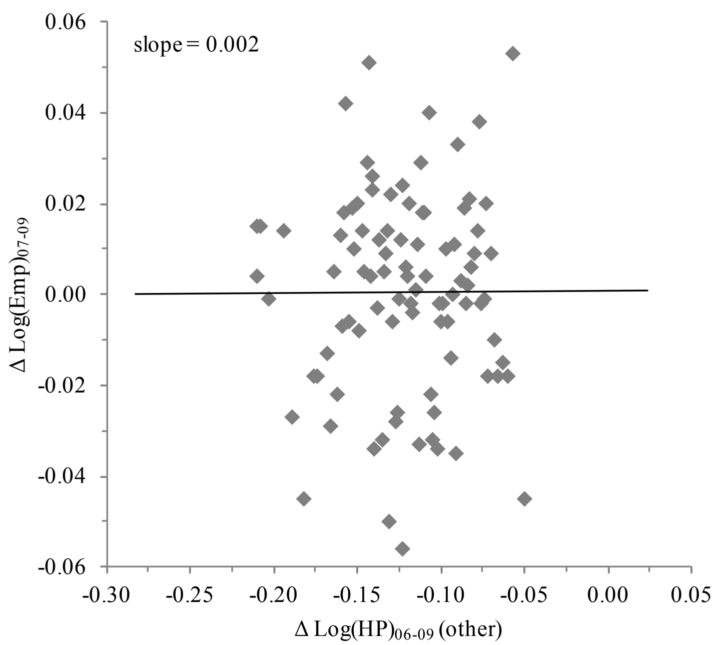


Table I
Summary Statistics

Panel (A) provides basic summary statistics. The establishment-level statistics pertain to non-tradable firms operating in multiple ZIP codes ("multi-region firms"). Employees is the number of employees in 2006. Δ $Log(Emp)_{07\text{-}09}$ is the percentage change in employment from 2007 to 2009. Δ $Log(HP)_{06\text{-}09}$ is the percentage change in house prices in the establishment's ZIP code from 2006 to 2009. # Linkages is the number of other ZIP codes in which the firm has establishments. The county-level statistics pertain to all non-tradable firms in a county, including single-region firms. Establishments and Employees is the number of establishments and employees, respectively, in 2006. Employment share is the ratio of non-tradable county-level employment to total county-level employment in 2006. Δ $Log(Emp)_{07\text{-}09}$ is the percentage change in non-tradable county-level employment from 2007 to 2009. Δ $Log(HP)_{06\text{-}09}$ is the percentage change in county-level house prices from 2006 to 2009. All percentage changes are employment-weighted. Panel (B) reports pairwise correlations of the network-based linkage weights ω and λ with corresponding linkage weights based on proximity, population, income, education, age, and household debt. The network-based linkage weights are described in Section 3.2. Proximity is the inverse of the geographical distance between regions' centroids. Population is recorded in 2000. Income is adjusted gross income per capita in 2006. Education is the percentage of adults in a county with a bachelor's degree or higher in 2000. Age is the median age among county residents in 2000. Household debt (mortgage, auto, and credit card debt) is per capita in 2006. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Panel (A): Basic summary statistics

	N	Mean	Std. Dev.
Establishment level (multi-region firms)			
Employees	385,000	28.9	47.0
Δ $Log(Emp)_{07\text{-}09}$	385,000	-0.031	1.614
Δ $Log(HP)_{06\text{-}09}$	385,000	-0.145	0.193
# Linkages	385,000	812.9	1,085.9
County level (all firms)			
Establishments	1,000	1,074	2,174
Employees	1,000	18,490	38,227
Employment share	1,000	0.186	0.531
Δ $Log(Emp)_{07\text{-}09}$	1,000	-0.036	0.883
Δ $Log(HP)_{06\text{-}09}$	1,000	-0.145	0.189

Table I
(continued)

Panel (B): Correlation with network-based linkage weights

	Correlation with establishment-level linkage weights ω (*p* -value)	Correlation with county-level linkage weights λ (*p* -value)
Proximity	0.106***	0.103***
	(0.000)	(0.009)
Population	0.061***	0.073*
	(0.001)	(0.068)
Income	0.018	0.028
	(0.283)	(0.210)
Education	-0.027	-0.030
	(0.139)	(0.201)
Age	-0.019	-0.027
	(0.195)	(0.220)
Household debt	-0.006	-0.024
	(0.419)	(0.467)

Table II
Main Establishment-Level Results

The dependent variable is the percentage change in non-tradable establishment-level employment from 2007 to 2009, Δ Log(Emp)$_{07\text{-}09}$. Δ Log(HP)$_{06\text{-}09}$ is the percentage change in house prices in the establishment's ZIP code from 2006 to 2009. Δ Log(HP)$_{06\text{-}09}$ (other) is the linkage-weighted percentage change in house prices from 2006 to 2009 in the other ZIP codes in which the firm has establishments. The establishment-level network-based linkage weights ω are described in Section 3.2. In column (3), these linkage weights are replaced with equal weights. In columns (4) to (6), they are replaced with Placebo weights based on population, income, and household debt. In column (7), ZIP codes are randomly assigned using 1,000 bootstrap samples. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$						
			Placebo tests				
			Equal weights	Population weights	Income weights	HH debt weights	Random ZIP codes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Log(HP)$_{06\text{-}09}$	0.109***	0.091***	0.109***	0.109***	0.110***	0.109***	0.107***
	(0.020)	(0.023)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Δ Log(HP)$_{06\text{-}09}$ (other)		0.028***					
		(0.006)					
Δ Log(HP)$_{06\text{-}09}$ (other, placebo)			0.001	-0.001	-0.003	0.001	0.003
			(0.017)	(0.014)	(0.014)	(0.015)	(0.010)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Observations	385,000	385,000	385,000	385,000	385,000	385,000	385,000

Table III
Common Regional Shocks

This table presents variants of the specification in column (2) of Table II with alternative fixed effects and demographic controls. Average income (education, age) is the weighted average income (education, age) in the other ZIP codes in which the firm has establishments. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(HP)$_{06\text{-}09}$ (other)	0.026***	0.025***	0.024***	0.024***	0.025***	0.024***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Average income			0.004*			0.004*
			(0.002)			(0.002)
Average education				0.006*		0.005
				(0.004)		(0.004)
Average age					0.001	-0.001
					(0.003)	(0.004)
Industry fixed effects	Yes	–	–	–	–	–
ZIP code fixed effects	Yes	–	–	–	–	–
ZIP code × industry fixed effects	No	Yes	Yes	Yes	Yes	Yes
R-squared	0.09	0.29	0.29	0.29	0.29	0.29
Observations	385,000	385,000	385,000	385,000	385,000	385,000

Table IV
Counterfactual Firm Networks

The dependent variable is the percentage change in non-tradable establishment-level employment from 2007 to 2009, Δ Log(Emp)$_{07\text{-}09}$. Δ Log(HP)$_{06\text{-}09}$ (other, placebo) is the average percentage change in house prices from 2006 to 2009 in (counterfactual) locations in which peer firms have establishments but the given firm has no establishments. Location is defined either at the county or ZIP code level. Peer firms are in the same 3- or 4-digit NAICS industry as the given firm and mutually overlap with the given firm in at least 75% or 90% of their locations. See Section 3.2 for a full description of the Placebo test. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$							
	County				ZIP code			
	≥ 75% county overlap & same 3-digit NAICS	≥ 75% county overlap & same 4-digit NAICS	≥ 90% county overlap & same 3-digit NAICS	≥ 90% county overlap & same 4-digit NAICS	≥ 75% ZIP code overlap & same 3-digit NAICS	≥ 75% ZIP code overlap & same 4-digit NAICS	≥ 90% ZIP code overlap & same 3-digit NAICS	≥ 90% ZIP code overlap & same 4-digit NAICS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log(HP)$_{06\text{-}09}$ (other, placebo)	0.002	-0.002	0.002	0.001	-0.002	0.001	0.001	0.002
	(0.009)	(0.011)	(0.011)	(0.016)	(0.015)	(0.017)	(0.018)	(0.020)
ZIP code × industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.40	0.65	0.57	0.62	0.77	0.79	0.65	0.65
Observations	39,900	28,600	16,200	9,900	4,500	2,900	2,500	1,200

Table V
Direct Demand Spillovers

This table presents variants of the specification in column (2) of Table III. Δ $Log(HP)_{06\text{-}09}$ (other, proximity) is similar to Δ $Log(HP)_{06\text{-}09}$ (other), except that the network-based linkage weights ω are replaced with weights based on the geographical distance between ZIP codes' centroids. Δ $Log(HP)_{06\text{-}09}$ (other, ZIP ≥ X miles) is similar to Δ $Log(HP)_{06\text{-}09}$ (other), except that the network-based linkage weights ω are set to zero for ZIP codes within an X-mile radius. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ $Log(Emp)_{07\text{-}09}$				
	(1)	(2)	(3)	(4)	(5)
Δ $Log(HP)_{06\text{-}09}$ (other, proximity)	0.011*				
	(0.007)				
Δ $Log(HP)_{06\text{-}09}$ (other)	0.020***				
	(0.006)				
Δ $Log(HP)_{06\text{-}09}$ (other, ZIP ≥ 50 miles)		0.022***			
		(0.005)			
Δ $Log(HP)_{06\text{-}09}$ (other, ZIP ≥ 100 miles)			0.022***		
			(0.005)		
Δ $Log(HP)_{06\text{-}09}$ (other, ZIP ≥ 200 miles)				0.020***	
				(0.004)	
Δ $Log(HP)_{06\text{-}09}$ (other, ZIP ≥ 250 miles)					0.019***
					(0.004)
ZIP code × industry fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared	0.29	0.29	0.29	0.29	0.29
Observations	385,000	385,000	385,000	385,000	385,000

Table VI
Scope of Firms' Regional Networks

This table presents variants of the specification in column (2) of Table III in which Δ Log(HP)$_{06\text{-}09}$ is interacted with measures of the scope of firms' regional networks (RN) in 2006. In column (1), RN is a dummy variable indicating whether the firm operates in multiple ZIP codes ("multi-region firm"). The sample consists of all non-tradable firms in a county, including single-region firms. In column (2), RN is the number of ZIP codes in which the firm operates. In column (3), RN is one minus the Herfindahl-Hirschman index (HHI) measuring the extent of the firm's geographical concentration based on its non-tradable employment at the ZIP code level. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$		
	Multi-ZIP	# ZIP	RN-HHI
	(1)	(2)	(3)
Δ Log(HP)$_{06\text{-}09}$ × RN	-0.027***	-0.013***	-0.522***
	(0.008)	(0.002)	(0.063)
RN	0.008***	0.005***	0.058**
	(0.001)	(0.001)	(0.024)
ZIP code × industry fixed effects	Yes	Yes	Yes
R-squared	0.20	0.29	0.29
Observations	910,300	385,000	385,000

Table VII
Financial Constraints

This table presents variants of the specification in column (2) of Table III in which Δ $Log(HP)_{06\text{-}09}$ and Δ $Log(HP)_{06\text{-}09}$ (other) are each interacted with measures of firms' financial constraints (FC) in 2006. In column (1), FC is firm leverage, which is the ratio of the sum of debt in current liabilities and long-term debt to total assets. In column (2), FC is the financial constraints index of Kaplan and Zingales (1997). In column (3), FC is the financial constraints index of Whited and Wu (2006). Both indices are net of their minimum values. In all columns, the sample consists of firms that have a match in Compustat. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ $Log(Emp)_{07\text{-}09}$		
	$Leverage_{06}$	$KZ\text{-}index_{06}$	$WW\text{-}index_{06}$
	(1)	(2)	(3)
Δ $Log(HP)_{06\text{-}09}$ × FC	0.130***	0.003**	0.051***
	(0.045)	(0.001)	(0.014)
Δ $Log(HP)_{06\text{-}09}$ (other)	0.009	0.008	0.010
	(0.012)	(0.010)	(0.016)
Δ $Log(HP)_{06\text{-}09}$ (other) × FC	0.038**	0.001**	0.013**
	(0.015)	(0.000)	(0.006)
FC	-0.038***	-0.003**	-0.008**
	(0.006)	(0.001)	(0.004)
ZIP code × industry fixed effects	Yes	Yes	Yes
R-squared	0.42	0.42	0.42
Observations	124,100	124,100	124,100

Table VIII
Proximity to Headquarters

This table presents variants of the specification in column (2) of Table III in which Δ $Log(HP)_{06\text{-}09}$ and Δ $Log(HP)_{06\text{-}09}$ (other) are each interacted with measures of geographical proximity to headquarters (HQ). In columns (1) and (2), Proximity to HQ is a dummy variable indicating whether the establishment and HQ are located in the same ZIP code and county, respectively. In column (3), Proximity to HQ is one divided by one plus the geographical distance between the establishment's and HQ's ZIP codes' centroids. All regressions are weighted by establishment-level employment. Standard errors (in parentheses) are double clustered at the firm and county level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ $Log(Emp)_{07\text{-}09}$		
	Same ZIP code	Same county	Inverse distance
	(1)	(2)	(3)
Δ $Log(HP)_{06\text{-}09}$ × Proximity to HQ	-0.022**	-0.020**	-0.019**
	(0.010)	(0.010)	(0.009)
Δ $Log(HP)_{06\text{-}09}$ (other)	0.031***	0.032***	0.029***
	(0.008)	(0.008)	(0.010)
Δ $Log(HP)_{06\text{-}09}$ (other) × Proximity to HQ	-0.013**	-0.011**	-0.013**
	(0.006)	(0.006)	(0.005)
Proximity to HQ	0.017***	0.014***	0.023***
	(0.003)	(0.003)	(0.002)
ZIP code × industry fixed effects	Yes	Yes	Yes
R-squared	0.29	0.29	0.29
Observations	385,000	385,000	385,000

Table IX
Aggregate Employment at the County Level

The dependent variable is the percentage change in non-tradable county-level employment from 2007 to 2009, Δ Log(Emp)$_{07\text{-}09}$. Δ Log(HP)$_{06\text{-}09}$ is the percentage change in county-level house prices from 2006 to 2009. Δ Log(HP)$_{06\text{-}09}$ (other) is the linkage-weighted percentage change in house prices from 2006 to 2009 in other counties linked through firms' internal networks. The county-level network-based linkage weights λ are described in Section 3.2. The placebo tests in columns (3)-(7) are analogous to those in Table II. Demographic controls include income, education, and age at the county level. Industry controls are the county-specific employment shares of all 23 two-digit NAICS industries in 2006. All regressions are weighted by county-level employment. Standard errors (in parentheses) are clustered at the state level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$						
			Placebo tests				
			Equal weights	Population weights	Income weights	HH debt weights	Random counties
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Log(HP)$_{06\text{-}09}$	0.122***	0.115***	0.123***	0.118***	0.122***	0.122***	0.122***
	(0.006)	(0.012)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Δ Log(HP)$_{06\text{-}09}$ (other)		0.024***					
		(0.007)					
Δ Log(HP)$_{06\text{-}09}$ (other, placebo)			0.007	0.009	0.002	0.001	0.002
			(0.041)	(0.010)	(0.015)	(0.013)	(0.028)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Observations	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Table X
Common County-Level Shocks

This table presents variants of the specification in column (2) of Table IX. Δ Log(HP)$_{06\text{-}09}$ (other, *) is similar to Δ Log(HP)$_{06\text{-}09}$ (other), except that the network-based linkage weights λ are replaced with "similarity weights" that place more weight on counties that are more similar to the given county. Similarity is the absolute difference in either income, education, age, household debt, or the county-level share of non-tradable employment. All regressions are weighted by county-level employment. Standard errors (in parentheses) are clustered at the state level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$				
	(1)	(2)	(3)	(4)	(5)
Δ Log(HP)$_{06\text{-}09}$	0.112***	0.114***	0.108***	0.115***	0.114***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)
Δ Log(HP)$_{06\text{-}09}$ (other)	0.025***	0.024***	0.029***	0.024***	0.022***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.006)
Δ Log(HP)$_{06\text{-}09}$ (other, income)	0.003				
	(0.015)				
Δ Log(HP)$_{06\text{-}09}$ (other, education)		0.004			
		(0.010)			
Δ Log(HP)$_{06\text{-}09}$ (other, age)			0.003		
			(0.013)		
Δ Log(HP)$_{06\text{-}09}$ (other, household debt)				0.001	
				(0.013)	
Δ Log(HP)$_{06\text{-}09}$ (other, non-tradable share)					0.003
					(0.012)
Demographic controls	Yes	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes	Yes
R-squared	0.17	0.17	0.17	0.17	0.17
Observations	1,000	1,000	1,000	1,000	1,000

Table XI
Counties in Which House Prices Did Not Fall

This table presents variants of the specifications in columns (1) and (2) of Table IX in which the sample is restricted to counties in which house prices either increased (columns (1) and (2)) or changed only little, defined as changes of less than ±2.5 percent (columns (3) and (4)). All regressions are weighted by county-level employment. Standard errors (in parentheses) are clustered at the state level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ Log(Emp)$_{07\text{-}09}$			
	Δ Log(HP)$_{06\text{-}09}$ > 0		Δ Log(HP)$_{06\text{-}09}$ ± 0.025	
	(1)	(2)	(3)	(4)
Δ Log(HP)$_{06\text{-}09}$	0.018	0.014	0.003	0.003
	(0.050)	(0.051)	(0.012)	(0.012)
Δ Log(HP)$_{06\text{-}09}$ (other)		0.020**		0.022**
		(0.010)		(0.010)
Demographic controls	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes
R-squared	0.18	0.19	0.22	0.23
Observations	200	200	200	200

Table XII
Direct Demand Spillovers

This table presents variants of the specification in column (2) of Table IX. Δ $Log(HP)_{06\text{-}09}$ (other, proximity) is similar to Δ $Log(HP)_{06\text{-}09}$ (other), except that the network-based linkage weights λ are replaced with weights based on the geographical distance between counties' centroids. Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ X miles) is similar to Δ $Log(HP)_{06\text{-}09}$ (other), except that the network-based linkage weights λ are set to zero for counties within an X-mile radius. All regressions are weighted by county-level employment. Standard errors (in parentheses) are clustered at the state level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ $Log(Emp)_{07\text{-}09}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ $Log(HP)_{06\text{-}09}$	0.110***	0.115***	0.116***	0.116***	0.116***	0.116***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Δ $Log(HP)_{06\text{-}09}$ (other, proximity)	0.012*					
	(0.007)					
Δ $Log(HP)_{06\text{-}09}$ (other)	0.019***					
	(0.007)					
Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ 50 miles)		0.019***				
		(0.006)				
Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ 100 miles)			0.019***			
			(0.006)			
Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ 150 miles)				0.018***		
				(0.006)		
Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ 200 miles)					0.018***	
					(0.006)	
Δ $Log(HP)_{06\text{-}09}$ (other, counties ≥ 250 miles)						0.017***
						(0.006)
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.17	0.17	0.17	0.17	0.17	0.17
Observations	1,000	1,000	1,000	1,000	1,000	1,000

Table XIII
Trade Channel

This table presents variants of the specification in column (2) of Table IX. In column (1), the dependent variable is the percentage change in tradable county-level employment from 2007 to 2009, Δ $Log(Emp)_{07-09}$. In column (2), Δ $Log(HP)_{06-09}$ (other, tradable network) is similar to Δ $Log(HP)_{06-09}$ (other), except that the network-based linkage weights λ are replaced with corresponding linkage weights based on tradable firms' internal networks. All regressions are weighted by county-level employment. Standard errors (in parentheses) are clustered at the state level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Δ $Log(Emp)_{07-09}$	
	Tradable	Non-tradable
	(1)	(2)
Δ $Log(HP)_{06-09}$	0.011	0.120***
	(0.010)	(0.006)
Δ $Log(HP)_{06-09}$ (other)	0.003	
	(0.014)	
Δ $Log(HP)_{06-09}$ (other, tradable network)		0.004
		(0.010)
Demographic controls	Yes	Yes
Industry controls	Yes	Yes
R-squared	0.13	0.17
Observations	1,000	1,000