Firm Networks in the Great Depression*

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Abstract

We develop a model of within-firm financing networks to examine how firms facing working capital constraints channel resources in response to local shocks and then test this model in the context of the Great Depression. Using data from the Census of Manufactures consisting of establishments linked to their parent firms, we study the sensitivity of establishment-level employment to changes in local demand and financial conditions in single and multi-plant firms. Employment in establishments in a multi-plant firm is almost twice as correlated with demand than that of a SP establishment. In contrast, employment at multi-plant firms is less correlated with financial conditions. Furthermore, an establishment is affected by shocks to establishments in other regions making up the same firm.

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1 Introduction

Comovement in prices and quantities across industries and regions defines a business cycle. Changes in employment and output were highly correlated across industries and regions in the Great Depression, the most prominent business cycle event (Rosenbloom and Sundstrom, 1999). This comovement has led many people to posit an aggregate shock as the source of the downturn. Candidates for this shock include monetary policy (Friedman and Schwartz, 1971), the supply of credit (Bernanke, 1983), demand (Temin, 1976), uncertainty (Romer, 1990), and balance sheet effects from the stock market crash (Mishkin, 1978). The problem is that even aggregate shocks start somewhere. Our focus is on understanding one channel through which these localized shocks to demand or credit end up as aggregate ones: Transmission through geographically dispersed networks of establishments comprising a firm.

To motivate our analysis, consider the following concrete example: the Alpha Portland Cement Company. One of its nine constituent establishments was located in Alabama and another located in Illinois. During the Depression, there are region-specific shocks such as the banking panic in Chicago of July 1931. This presumably would directly affect the Alpha establishment located in Illinois.[1] This paper asks two related questions. First, will those Illinois specific events propagate to Alabama through the firm networks linking the Illinois establishment to the Alabama one? Second, will the presence of the firm network cause the Illinois establishment to respond differently to shocks in Illinois than a similar establishment in Illinois which is not in a firm network?

We first build a simple model of firms' internal financing decision when facing a working capital constraint to understand how these shocks are propagated through firm networks. The working capital constraint aggregates the pledgeability of revenue to finance

[1] A recent literature has studied the causal effect of bank failures on manufacturing outcomes in the Great Depression (Ziebarth, 2013; Jalil, 2014). These studies take advantage of plausibly exogenous differences in monetary policy, which, at least in part, were due to the particular leadership of the Atlanta Federal Reserve by Eugene Black.

labor costs across establishments. Going back to Coase (1937), a major question in economics has been what determines the boundaries of the firm. Benefits such as minimizing transaction costs (Williamson, 1981) and the ability to engage in "winner picking" for particularly productive projects (Stein, 1997) need to be balanced against costs associated with possible rent seeking (Scharfstein and Stein, 2000).[2] In our model, a firm's constituent network of establishments is valuable when this working capital constraint binds because it allows the firm to transfer resources between establishments in response to shocks to demand or the availability of credit in a local area. This idea is similar in spirit to work on the role of these firm work networks in other economic crises. For the case of the Great Recession, Matvos and Seru (2014) estimate a structural model to account for how internal capital markets can be a substitute for external ones.[3] Santioni et al. (2017) study the value of these networks for Italian firms during the recent Euro crisis and Almeida et al. (2015) for Korean *chaebol* in the Asian financial crisis of 1997. More generally, Hovakimian (2011) finds that recessions lead firms to redirect resources to the more productive divisions as measured by Tobin's q.[4]

We derive two sets of comparative statics results in the model. We first compare the response of single establishment (SP) establishments to ones that are part of a multi-plant (MP) firm to credit shocks and demand shocks in the establishment's own region. The

[2] An ample literature attempts to identify costs and benefits of conglomerate firms; the literature goes back to Shin and Stulz (1998); Lamont (1997); Rajan et al. (2000), and more recently, notably Schoar (2002); Maksimovic and Phillips (2002) and Gomes and Livdan (2004). This work has tended to be reduced form in nature though Gomes and Livdan (2004) and Matvos and Seru (2014) are notable exceptions. See Stein (2003), Phillips and Maksimovic (2007), and paper therein for a thorough literature review. Empirically, it seems that rather than allocating resources efficiently, internal capital markets appear to allocate resources towards low productivity projects, particularly when the company operates a diverse set of product lines Rajan et al. (2000). We do note that this claim that internal capital markets are inefficient is contested.

[3] For the same period, Kuppuswamy and Villalonga (2010) document a fall in the diversification discount, as evidence of an increase in the efficiency of internal capital markets. Rudolph and Schwetzler (2013) find a similar result looking across the world.

[4] One limitation of all this work and much of the empirical literature is the reliance on Compustat segment data to identify the extent of a particular firm's operations. As pointed out by Villalonga (2004), these self-reported "segments" not infrequently conflict with segments as categorized by the Census Bureau. One advantage of our setup is that we exploit time series variation to identify the functioning of these networks rather than cross-sectional variation, where omitted variables may blur relationships and which constitutes much of the finance literature.

key result is that the response to demand shocks depends crucially on whether the establishment's revenue is more or less pledgeable. The model predicts that the response of a MP establishment to a credit shock in its own area will be attenuated, but the response to a demand shock will be attenuated if and only if its revenue is less pledgeable than the other establishments in the firm. The second set of comparative statics results regards spillovers of shocks to other establishments in the same firm, and these again depend on relative plegeability in the case of demand shocks. Credit shocks to other establishments have the same sign as own shocks. For demand shocks, the sign on other shocks is the same as own shocks only when the establishment's revenue is less pledgeable.

To test the model, we use a sample of establishment schedules for 25 industries from the Census of Manufactures taken in 1929, 1931, 1933, and 1935. These industries represent just under 20% of all manufacturing establishments at this time. In addition, a number of these industries had firms with large networks of establishments. Following the setup of our model, our focus here is on "horizontal" networks of multiple establishments that are part of the same industry selling a similar product.[5] For example, in the cement industry, the average number of establishments of the the three largest firms to operate was more than ten and all of these establishments sold basically identical products to downstream businesses. In the automobile industry, that average was eighteen for the "Big Three". We link these establishments into their parent firms.

Our empirical approach estimates the difference between the response of MP and SP firms in quarterly employment in reaction to changes in the local economic environment. We focus on changes in local demand as measured by an index of retail sales and changes in local credit as proxied for by the regional Federal Reserve discount rate. The work closest to our is by Giroud and Mueller (2017), who study the role of these networks in response to housing price shocks in the Great Recession. Following the work of Mian et

[5]There are, of course, other types of network structures such as one where an establishment in some firm produces an intermediate good for another establishment in the same firm. This vertical dimension between establishments within a firm introduces a whole other set of bargaining and hold-up issues.

al. (2013), they interpret these shocks as local demand shocks. Our work extends theirs by not only going back in time but also considers these local credit market shocks. We exploit the geographic variation in the local availability of credit during the Depression, variation not readily observable in the Great Recession. This allows us to contribute to the large literature that has attempted to identify the effect of local credit shocks in the Great Depression.[6]

We find that employment at MP firms is more correlated with demand conditions than for SP firms. The point estimates range from a doubling of the sensitivity of SP firms to a 50% greater sensitivity depending on the specification. On the other hand, responses to changes in the discount rate are dampened in MP firms with respect to the SP ones. Here the point estimates suggest a reduction in the sensitivity by around 20%. We then examine whether these differences in sensitivity spillover to the other establishments that make up a particular firm located in distant regions. If firms reallocate funds across their establishments in response to local conditions, this should be reflected in spillover effects on the employment of other establishments unless the firm's supply of funds is perfectly elastic. For example, consider a firm with establishments in two separate regions with one of those establishments subject to a local demand spike. Given our previous results, the establishment in the region with relatively lower demand should see its employment fall. We document precisely this effect for changes in demand. The effect of "other" demand shocks is of roughly the same magnitude as the direct effect. We do not find strong evidence for spillovers in response to credit shocks which may be a function of the smaller direct effect in the first place. We interpret our empirical results as evidence of spillover effects that are present in MP firms.

Finally, our model implied that the effects of changes in local demand depend on whether that particular establishment's revenue is more or less pledgeable. We test these

[6]For example, Calomiris and Mason (2003) and Lee and Mezzanotti (2017) both identify negative effects from local credit market breakdowns. Benmelech et al. (2017) use variation in when a particular firm's long-term debt matures to isolate the effects of credit availability on employment.

implications by interacting a measure of relative pledgeability (whether or not the regional discount rate is high relative to firm average) with demand conditions. We find in line with the model, when an establishments is relatively less pledgeable revenue, changes in "other" demand conditions have *positive* effects on an establishment's employment. We only find evidence for part of the model implications for changes in "own" demand conditions in the data.

2 A Model of Firm Networks

Production Establishment i operates a decreasing returns to scale production function with labor as the sole input[7]

$$y_i = \frac{\sigma}{\sigma - 1} a_i l_i^{\frac{\sigma-1}{\sigma}}$$

for some $\sigma > 1$ and demand (or labor productivity) a_i. We will abuse notation and use the subscript i to refer to regions as well as establishments. This "abuse" reflects our interpretation of a_i as a local demand shock common to all establishments in region i. In a similar fashion, establishments in region i hire labor at wage rate w_i. For comparison with the case where our financing friction binds, we derive the first best level of production and labor demand, which is $y_i^{FB} = \frac{\sigma}{\sigma-1} w_i^{1-\sigma} a_i^{\sigma}$ and labor demand is $l_i^{FB} = \left(\frac{a_i}{w_i}\right)^{\sigma}$.

The Financing Friction We now introduce a working capital constraint that can be interpreted as requiring a firm to borrow its total wage bill up front securing that loan by posting collateral based on its revenue. We introduce the parameter κ_i to capture differences in the pledgeability of an establishment's revenue (Holmström and Tirole, 1998), and hence, the value of that establishment's revenue for the firm's liquidity position overall.

[7]This production structure is isomorphic to one with monopolistic competition and isoelastic demand curves.

If the firm owns N establishments, its liquidity constraint is given by

$$\sum_{i=1}^{N} w_i l_i \leq \sum_{i=1}^{N} \kappa_i y_i. \tag{1}$$

Denote profits $\pi_i(l_i) = \frac{\sigma}{\sigma-1} a_i l_i^{\frac{\sigma-1}{\sigma}} - w_i l_i$ where the subscript i emphasizes the fact that profits depend on local conditions a_i, w_i. Then the firm maximizes total profits

$$\max_{\{l_i\}_{i=1}^{N}} \sum_{i=1}^{N} \pi_i(l_i)$$

subject to the liquidity constraint (eqn. 1). It will be useful to rewrite this problem in terms of a *cashflow* function, $CF_i(l_i) = \kappa_i y_i - w_i l_i$. The labor choice l_i^{Max} that maximizes cashflow solves $\kappa_i MPL_i = w_i$ where $MPL_i = a_i l_i^{-\frac{1}{\sigma}}$ is the marginal product of labor for establishment i. In the interesting case when $\kappa_i < \frac{\sigma-1}{\sigma} < 1$, $l_i^{Max} = \kappa_i^{1/\sigma} l_i^{FB} < l_i^{FB}$, so there is a disconnect between maximizing an establishment's profits and its cashflow (which could be used to subsidize a different establishment's labor input). Note that it will never be optimal for a firm to set $l_i < l_i^{Max}$ since in this case, increasing l_i would increase both cash flow and profits of establishment i.

With this definition of the cashflow function, we can rewrite the firm's problem as

$$\max_{\{l_i\}_{i=1}^{N}} \sum_{i=1}^{N} \left[CF_i(l_i) + (1-\kappa_i) y_i\right]$$

subject to

$$\sum_{i=1}^{N} CF_i(l_i) \geq 0.$$

Rewriting the constraint in this way provides a straightforward check on whether a firm overall faces a binding liquidity constraint. To do this, we evaluate the cash flow functions at the first best labor choice $CF_i(l_i^{FB}) = w_i^{1-\sigma} a_i^{\sigma} \left(\frac{\sigma}{\sigma-1}\kappa_i - 1\right)$ and check whether total cash flow generated is non-negative. From this, a single establishment firm will be liquidity constrained if and only if $\kappa_i < \frac{\sigma-1}{\sigma}$. Hence, whether a single establishment firm's labor choice is distorted only depends on κ_i not "relative" local demand a_i/w_i. This condition can be rewritten for a firm with $N > 1$ as

$$\sum_{i=1}^{N} \alpha_i(0)\kappa_i \geq \frac{\sigma - 1}{\sigma} \tag{2}$$

where $\alpha_i(0) = \frac{w_i^{1-\sigma} a_i^{\sigma}}{\sum_{i=1}^{N} w_i^{1-\sigma} a_i^{\sigma}}$. In this case, whether a firm is liquidity constrained overall depends on a weighted average of κ_i where the weights depend on both a_i, w_i.

SP Firm Case We derive the second best outcome in the case of a single establishment firm operating with a binding liquidity constraint. When the constraint does not bind, then $l_{SP}^{FB} = l^{FB}$. When the constraint binds, we can derive labor demand as

$$l_{SP}^{SB} = \left(\frac{\sigma}{\sigma - 1}\kappa \frac{a}{w}\right)^{\sigma} = \left(\frac{\sigma}{\sigma - 1}\kappa\right)^{\sigma} l^{FB}.$$

The subscript SP emphasizes that this is for a single establishment (SP) firm. We now derive our benchmark elasticities with respect to demand conditions a and with respect to pledgeability, κ.[8] From the expression above we immediately have

$$\frac{\partial \log l_{SP}^{SB}}{\partial \log \kappa} = \frac{\partial \log l_{SP}^{SB}}{\partial \log a} = \sigma. \tag{3}$$

MP Firm Case We now turn to the case of a firm owning multiple establishments. First, the liquidity or working capital constraint (WCC) can be rewritten as

$$CF_i(l_i) = -\sum_{j \neq i} CF_j(l_j). \tag{4}$$

This defines a negative relationship between employment at establishment i, l_i, and employment at some other establishment $-i$, holding fixed all the other establishments' labor

[8] Similar elasticities could be calculated with respect to w as well.

inputs. The first order condition (FOC) for the choice of establishment i's labor input is

$$\frac{(1-\kappa_i)MPL_i(l_i)}{CF_i'(l_i)} = \frac{1}{N-1}\sum_{j\neq i}\frac{(1-\kappa_j)MPL_j(l_j)}{CF_j'(l_j)}. \tag{5}$$

We can rewrite this in terms of units of the first best, $\bar{l} = l/l^{FB}$. In these units, the FOC (eqn. 5) becomes

$$\frac{(1-\kappa_i)\bar{l}_i^{-\frac{1}{\sigma}}}{\kappa_i\bar{l}_i^{-\frac{1}{\sigma}}-1} = \frac{1}{N-1}\sum_{j\neq i}\frac{(1-\kappa_j)\bar{l}_j^{-\frac{1}{\sigma}}}{\kappa_j\bar{l}_j^{-\frac{1}{\sigma}}-1}.$$

Note that in terms of $\bar{l}$, the FOC does not depend on a, w. Since the CF function is everywhere concave, this relationship determines a positive relationship between l_i and employment at some other establishment $-i$, holding fixed all the other establishments' labor inputs.[9]

One implication is that it will never be the case that one establishment is operating at the efficient scale while the others are not. Either all establishments operate at the efficient level or all have their input choices distorted. Assume for contradiction that one establishment was operating at its efficient scale while another was not. Then a marginal change in the labor use of the undistorted establishment would have second order effects on the profits that establishment earns while there would be a first order effect in reallocating some additional resources to the distorted establishments.

Another implication comes from considering the case where $\kappa_i = \kappa$ for all i. By symmetry, the only way for this to satisfy the resource constraint it must be that $CF_i(l_i) = CF_{-i}(l_{-i}) = 0$. Therefore, $l_i = l_i^0$ where $CF_i(l_i^0) = 0$ for all i. This means that in the case when credit conditions are the same across establishments, there is no cross-subsidization.

[9] For the case of two establishments, we can show that an unique solution exists. Note first that if $l_i = l_i^{FB}$, then the FOC implies that $l_{-i} = l_{-i}^{FB}$. However, on the other hand if $l_i = l_i^{FB}$, then $-CF_i(l_i^{FB}) > 0$ so $l_{-i} < l_i^{FB}$ by the WCC. Therefore, we know that the FOC curve is about the WCC curve when $l_i = l_i^{FB}$. For the case where $l_i = l_i^{Max}$, then the FOC implies that $l_{-i} = l_{-i}^{Max}$. From the WCC, we know that $-CF_i(l_i^{Max}) < 0$ so $l_{-i} > l_{-i}^{Max}$. Therefore, we know that the WCC curve is above the FOC curve when $l_i = l_i^{Max}$ and therefore, there is a unique solution to this problem.

So in this case as well as the abundant credit case, MP establishments will operate just like SP establishments in terms of their response to local demand shocks. This result has important implications for how we specify our regressions and provides a useful way to test the mechanisms outlined here.

Comparative Statics We now derive comparative statics with respect to "own" demand a_i and pledgeability κ_i as well as with respect to "other" conditions a_{-i}, κ_{-i}. To start, Figure 1 shows the the effect of an increase in demand for establishment (or region) i, a_i when initially establishment i is subsidizing establishment $-i$. When working in terms of $\bar{l}$, the FOC does not depend on relative demand at all so the FOC curve does change only the WCC curve, which rotates about the point where establishment i generates no cash flow. Figure 2 shows the effect of a credit tightening in region i, which is a decrease in κ_i again starting from a point where establishment i is subsidizing establishment $-i$. What these figures highlight is the extent to which the comparative statics depend on whether a particular establishment is initially subsidizing or being subsidized by the other establishments in the firm.

Let λ denote the Lagrange multiplier on the WCC (eqn. 4), which represents the shadow cost of liquidity within the firm. We can then calculate the optimal choice of l_i as a function of λ

$$l_i^* = \left((\kappa_i^{-1} + \lambda) \sum_{j=1}^{N} \frac{\alpha_j(\lambda)}{\kappa_j^{-1} + \lambda} \right)^{\sigma} l_{SP}^{SB} \tag{6}$$

where $\alpha_j(\lambda) = \frac{w_i l_i^*}{\sum_{i=1}^N w_i l_i^*}$ and l_i is implicitly a function of λ.[10] The form for $\alpha_j(\lambda)$ shows why in defining the condition for whether a firm is constrained overall (eqn. 2), we used the notation $\alpha_j(0)$ since it corresponds to evaluating $\alpha_j(\lambda)$ at $\lambda = 0$. Relative labor demand is

[10] An Appendix collects all of the proofs.

then given by

$$\frac{l_i^*}{l_{-i}^*} = \frac{1 + \kappa_i \lambda}{1 + \kappa_{-i}\lambda}.$$

Holding fixed λ, a decrease in κ_i making establishment i's revenue less pledgeable would decrease its relative labor input. This shows that establishments that face relatively tight financing constraints will be subsidized by other establishments that make up the firm relative to the SP firm case.

The fact that α_i changes with λ introduces complications into the comparative statics that we address by focusing on the case when the liquidity constraint is just binding, $\lambda = 0^+$.[11] First, we confirm that the shadow cost of internal funds is decreasing whenever the pledgeabilty of any one establishment's revenue κ_i increases. In particular,

$$\lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial \kappa_i} = -B^{-1} \frac{1}{1 - \alpha_i(0)},$$
$$\lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial a_i} = -B^{-1} \frac{\sigma}{a_i} \left(\kappa_i - \kappa_{-i}\right).$$

where $B > 0$ is a constant defined in the appendix. With these result for the derivatives of λ, we can calculate the elasticities of labor choices with respect to a_i, κ_i. For the effect of "own" and "other" (output) demand a on labor demand, we have

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log a_i} = \sigma \left(1 + \frac{\sigma}{B}(1 - \kappa_i)(\kappa_i - \kappa_{-i})\right), \tag{7}$$
$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log a_{-i}} = -\frac{\sigma^2}{B}(1 - \kappa_i)(\kappa_i - \kappa_{-i}). \tag{8}$$

For the "own" elasticity (eqn. 7), the sign of the second term $\kappa_i - \kappa_{-i}$, since by assumption, $1 - \kappa_i > 0$, determines whether the response of an establishment in a MP firm is greater or smaller than for a standalone firm, which is σ. In the case where $\kappa_i > \kappa_{-i}$, as establishment i grows because of higher demand, its share in the firm total wage bill increases. Hence the

[11] The Appendix also reports numerical simulations for more general values of λ and they confirm the qualitative patterns of these comparative statics.

shadow cost of internal funds decreases as its revenues are more pledgeable. Thus output for all establishments increases. On the other hand if $\kappa_{-i} > \kappa_i$, the weights in the wage bill shift towards the establishment with revenue that is less pledgeable and the shadow cost of funds rise, leading to a decline in its labor input.

Eqn. 8 gives the "other" demand elasticity which, by construction, for the single establishment case is zero. Given the comparative statics for λ above, a demand shock for an establishment $-i$ relaxes the overall firm financing constraint if $\kappa_{-i} > \kappa_i$, in which case output and labor demand increase for establishment i. These expressions also reconfirm our claim that whenever $\kappa_i = \kappa_{-i}$, MP establishments act like SP establishments with the same own elasticity with respect to demand and no spillovers of "other" demand conditions.

For the "own" and "other" comparative statics with respect to pledgeability κ, we have

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log \kappa_i} = \sigma \delta_i(0), \tag{9}$$

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log \kappa_{-i}} = \sigma \delta_{-i}(0). \tag{10}$$

where $\delta_i(0) = \frac{w_i^{1-\sigma} a_i^{\sigma} \kappa_i}{\sum_{i=1}^{N} w_i^{1-\sigma} a_i^{\sigma} \kappa_i}$. The first equation shows that there is a dampening of the effects of an "own" credit shock relative to the case of a firm consisting of a single establishment, in which case, this elasticity is σ. The size of this dampening depends on the establishment's relative size within the firm. The second equation, which is the elasticity with respect to an "other" credit shock, shows the link between establishments imposed by a binding liquidity constraint with the firm distributing the effects of the shock across all of its constituent establishments.

Giroud and Mueller (2017) study a similar model and show that there are *always* spillovers regardless of differences in local financial conditions.[12] The difference between those results and ours is that they study a slightly different "cash flow" shock that, while nominally attached to a particular establishment, only affects the firm-level financing con-

[12] In the appendix, we consider their setup in more detail.

straint. Therefore, cashflow shocks in their model are “shared” by all establishments within a firm with establishments sensitive to shocks in other regions, but less sensitive to shocks in their own region. These implications are exactly the same as ours for pledgeability shocks κ, but the sensitivity to regional demand (or productivity) shocks depends on whether there are differences in financial conditions across establishments. In fact as we showed, MP establishments can be more sensitive to fluctuations in local demand when their revenues are relatively more pledgeable $\kappa_i > \kappa_{-i}$.

3 Data

We use establishment-level data from the Census of Manufactures (CoM) covering 25 industries.[13] This data source provides a rich set of information about establishments during the first half of the the Depression including 1929, 1931, 1933, and 1935.[14] While providing in many respects more detailed information than the modern CoM, this source does have a few important limitations. First is the fact that it lacks information on investment (or the value of capital) and, second, it lacks any information on the financial position of the establishments or their parent firms. The first limitation makes the focus of this paper in terms of the outcome variable different from much of the literature. While much of the literature has focused on investment, we will instead focus on establishment-level employment.[15] The second limitation precludes us from examining whether our results differ based on these measures of financial dependence such as net worth or debt outstanding.[16]

While originally collected for different purposes, the industries as shown in Table 1

[13]The source as a whole is discussed in greater detail in Vickers and Ziebarth (2018).

[14]The CoM was also taken in 1937 but the establishment-level schedules do not still exist as far as we know. In fact, these 4 years are the only years between 1880 and 1963 that have establishment-level schedules available.

[15]That said, Giroud and Mueller (2017) use employment as their main variable of interest.

[16]Benmelech et al. (2017) use a dataset from Moody’s that has information on the composition of a firm’s debts outstanding to study the effects on employment of having to refinance during the Depression. The drawback of their dataset is that it only covers the largest firms that have floated bonds. Our dataset covers *all* establishments within an industry.

provide a cross-section of the manufacturing sector as a whole. We have "high tech" industries such as aircraft and radios. We also have durables such as cement and steel and non-durables such as ice cream and manufactured ice. In addition, we have differences in whether the industries are mainly consumer oriented like beverages versus business oriented like planing mills. The table also reports a geographic HHI that we will use as a measure of the tradeability of an industry's product. The one we report here uses city (effectively MSA) as the geographic unit and shares by city are based on total revenue.[17] Furthermore, there are differences in the degree of competition. The tacit collusion in the sugar and cement industries has been suspected by many authors.[18] Finally, the industries differ quite strikingly with regards to the importance of labor in production. The fraction of wages in gross output, a rough measure of the elasticity of production with respect to labor, ranges from 0.04 in sugar to 0.22 in agricultural implements. The diversity of the industries lends credence to the claim that the results reported below apply generally to the manufacturing sector. In terms of wage earners, the industries collected cover 17.6% of the total employment in the manufacturing sector and about 20% of revenue in 1929, both non-trivial fractions.[19]

In Figure 8, we plot by county the ratio of wage employment in our sample from 1929 to the number of people who report working in manufacturing in the 1930 Population Census. There are of course a number of reasons why this ratio could be different from 1 even if there were not measurement error. For one, we only consider wage employment, which is a fraction of total employment in manufacturing. In addition, the Census numbers are

[17] The idea of using this as a measure of tradeability is that industries with low concentration are ones where it makes sense to put production close to demand minimizing on shipping costs. This interpretation seems consistent with the fact that, for example, beverages and concrete products have the lowest values and both of these industries have low product value to shipping cost ratios. Results are consistent if we use the county as the geographic unit.

[18] For sugar, see Genesove and Mullin (1998). For cement, see Chicu et al. (2013) and the FTC's court case in 1931, *FTC v. Cement Institute*.

[19] As compared to the "weighted" measure, which are representative of manufacturing as a whole, the "unweighted" measure take a simple average of the ratio by county. We thank David Donaldson, Richard Hornbeck, and James Lee for providing the transcribed published tables that we use to benchmark our sample.

based on county of residence so if someone lives in a different county than he works, he will count as employed in the county of residence while in our data, he will count in the county where he works. Coverage rates are particularly high for the Carolinas and northern Georgia, areas in which the textile industry, one that we collected, comprises a large fraction of total manufacturing employment. Another area of relative overrepresentation is southern Louisiana, where virtually all employment in the sugar refining industry, another one we collected, is located.

One point to keep in mind is that the industries differ in their degree of "aggregation." The Census Bureau at the time did did not use a detailed hierarchal system like SIC codes to organize industries. Some of the industries such as ice, macaroni, cement, sugar refining, malt, bone black, and cane sugar are very narrowly defined and consistent over time with establishments tending to make only one product with little product differentiation. On the other hand, the remaining industries are closer to 3 digit SIC codes with many establishments producing a variety of products. For example, establishments in the agricultural implements industry made reapers, tractors, and thrashers, among other things.[20]

Unlike the modern CoM, our data source does not provide establishment or firm identifiers for linking establishments over time or groups of establishments that make up a firm in the cross-section. We have had to construct these ourselves. Besides the cement industry where directories from the Cement Institute were employed (Chicu et al., 2013), we link "by hand" establishments into their parent firm using the name of the parent company, which is all the information we have.[21] There are certainly errors involved in this process, but it is important to identify what types of errors will bias our results. Our regressions will use a repeated cross-sectional specification using quarterly variation in employment. So errors in linking establishments *within* a particular year are what is potentially problematic. This means that change in firm names over will not be problematic

[20] We actually created the radio industry ourselves identifying establishments that manufactured radios from the broader industry of producers of electrical equipment.

[21] In an appendix, we compare MP to non-MP establishments along a number of observable dimensions.

since we match on firm name only within a year. A potential source of errors that could effect our results would be very common sounding firm names that make it difficult for us to tell if two seemingly similar names are actually referring to the same firm. This type of error that leads us to "overgroup" establishments would make it more difficult for us to identify the effects of internal firm networks since, by assumption, none exists between these two establishments. We have attempted to be conservative in deciding what establishments to place in the same firm, which would lead us to underestimate the fraction of establishments that are part of MP firms.

We do not have the whole universe of manufacturing establishments, we are not able to identify establishments owned by a particular firm that fall outside of our industries of interest. For example, while we have information on establishments that do the final assembly of automobiles, we do not have information on all of the industries that produce inputs into the production of cars. Famously at this time, the Ford Motor Company was highly vertically integrated, even attempting to run its own rubber plantation in Brazil (Grandin, 2010). All of these other far-flung establishments owned by Ford will not be in our dataset and we will not be able to to allocate its resources across its establishments *within a particularly defined industry*. Understanding the decision of how a firm allocates its resources in the presence of these vertical relationships between upstream supplies and downstream users is something we leave for future work.

4 Empirical Specification

Our empirical strategy uses geographic and temporal variation in demand and credit conditions to identify the effects of internal firm networks by comparing the behavior of MP establishments relative to SP establishments. Besides the work of Giroud and Mueller (2017), who also emphasize the geographic dimension, most of the literature on internal networks considered another dimension of internal networks, the set of "segments" a firm operates. Relative to this "segments" approach, there are a number of benefits to our geographic strategy. First, as pointed out by Phillips and Maksimovic (2007), the measurement error due to the self reporting of these segments in the Compustat data, one of the most popular datasources for these studies, can severely bias results. An additional difficulty in working with segments is the fact that, in many cases, how well one segment does directly affects the performance of other segments. For example, Microsoft Office and Windows are treated as separate segments are hardly independent in how well they do. It seems nearly impossible to identify a shock that will solely effect the demand for Windows and not also affect the demand for Office. Besides demand complementarities as in the Microsoft case, there could also be production complementarities where one establishment or segment of a company produces a key input for another part of the company.

By focusing on the case where a firm's internal network consists solely of geographically dispersed establishments producing similar products, we eliminate these possible sorts of spillovers between establishments. There still might be spillovers stemming from the fact that all establishments within an industry tend to co-move together due to, say, variation in key input or output prices. We will show that the spillovers within a firm are greater than these spillovers due to industry-wide shocks. It is also important to keep in mind that our sample includes industries that are vertically integrated like automobile manufactures, but we only focus on the piece of those manufactures that is horizontally integrated, the final assemblers in the case of automobiles. Instead ,for us, the only reason why shocks to a particular MP establishment in one region should spill over to another establishment that is part of the same firm in another region is through the firm's internal network.

With our geographic focus, we study the effects of regional economic conditions at the Federal Reserve district level. It would be preferred to have more narrowly defined regions or regions that more closely reflect a particular establishment's market. The problem is that there is a tradeoff between geography and frequency. Datasets from this period with smaller geographic units tend to have lower frequency variation. For example, a commonly used FDIC dataset from the 1930s with information on bank failures is at the county-level but only at an annual frequency. [22] By using the discount rate for the respective regional Fed and regional demand as proxied by the retail sales index collected by the Federal Reserve, we are able to exploit quarterly variation to identify the effects of firm networks. Details regarding the construction of retail sales index are discussed in Park and Richardson (2011).

It is important to keep in mind that this was a period of time before authority over discount policy had been centralized at the Federal Reserve Board. This led to variation in discount rate policy across different regions, which we will take advantage of. Beyond the rate, regional Federal Research branches could also set their own conditions for what constituted high quality collateral and thereby affect the volume of discount lending (Richardson and Troost, 2009). For many branches, the Real Bills Doctrine was the controlling view of how monetary policy should operate. The doctrine stated that only "real bills," based on actual production, should be discounted, leading to a *pro-cyclical* monetary policy (as compared to say a Bagehot's Rule, which would suggest a more counter-cyclical policy stance). In some sense, the closest analog to the pledgeability parameter κ in our model is the haircut regional Federal Reserves applied to real bills presented by banks for discount. We will assume that the discount rate is positively correlated with the size of the haircuts (negatively correlated with κ). This is consistent with the behavior of the St. Louis and Atlanta banks during the Caldwell episode in the early 1930s (Richardson and Troost, 2009).

Discount loans made on this basis played an important role in the "correspondent" banking system at the time (Richardson, 2007). In this system, so-called county banks, which provided trade credit to local businesses, formed relationships by depositing funds

[22]The broad range of these regions also leads to cases where all establishments of a MP firms are contained in a single district, which brings up a question for how to handle these establishments in the empirical specifications. We return to this question later.

with so-called city banks, the correspondent who had access to the Federal Reserve. These relationships allowed county banks to in effect tap the discount window without having to become an actual member of the Federal Reserve. Due to this network structure, changes in the discount rate had effects beyond just banks that actually had access to the window affecting the local provision of trade credit. We view the effect of changes in the discount rate and trade credit as not directly falling on the establishments themselves but on credit for their wholesalers. So the question is whether the producers we study are able to substitute their own trade credit for these changes in availability of credit from the regional Federal Reserve.

Our first set of specifications considers the effect of changes in the retail index and discount rate on an establishment, without considering spillovers from other establishments in the firm. Letting E_{it} be log quarterly employment, we estimate the following equation:

$$E_{it} = \sum_{X=Retail,R} \left[\alpha_X^{Own} \cdot X_{it}^{Own} + \beta_X^{Own} \cdot MP_{it} \cdot X_{it}^{Own}\right] + \delta_{it} + \nu_{it}. \tag{11}$$

where MP_{it} is an indicator for whether or not an establishment is part of a MP firm, $Retail$ is the retail sales index, R is the regional discount rate, and δ_{it} is a set of fixed effects. These include, depending on the specification, Fed district seasonal effects, industry seasonal effects, Federal Reserve district fixed effects, year effects, Federal Reserve district specific time trends effects, seasonal effects, and industry effects. A fixed effect for being part of a MP firm is included as well. Obviously, not all of these industries sold their goods locally so to what extent this demand shock is really a shock matters by industry. We attempt to control for this by interacting demand with industry fixed effects.[23] Finally, we cluster the standard errors at the firm-year level following Giroud and Mueller (2017). This specification gives the baseline effects for the effect of a change in demand and a

[23] We also provide some robustness checks where we measure tradeability of an industry's product based on weight of the product relative to its value and the geographic concentration of the industry. We then interact this tradeability measure with the retail sales index.

change in the discount rate on employment. Changes in the retail index will be positively related to demand, with $\alpha^{Own}_{Retail} > 0$. Increases in the discount rate represent a tightening of financial conditions, with $\alpha^{Own}_{R} < 0$.

Our first testable implication of the model focuses on the effect of "own" shock for MP versus SP establishments. Assuming $\alpha^{\text{Own}}_{Retail} > 0, \alpha^{\text{Own}}_{R} < 0$ (though this is empirically the case), then from equation 9:

Prediction 1 The response of MP establishment to a *credit* shock relative to an SP establishment will be attenuated towards 0: $\beta^{\text{Own}}_{R} > 0$.

The superscript Own on the demand $Retail$ and credit R conditions in Equation 11 emphasizes that these are the conditions in an establishment's *own* location. We will contrast this our model's implications for how "other" demand or credit conditions–conditions affecting other establishments that make up the same firm–spillover. Therefore, we now discuss how we construct our "other" measures of the regional Federal Reserve discount rate and the retail sales index. With more than two establishments in a firm, we have to decide on how to weight the local conditions at the various establishments that make up a particular firm. For each measure, we construct a revenue-weighted average of the measure for regions where other establishments part of the same firm are located.[24] Define the weighted "other" measure X^{Other}_{it} as

$$X^{\text{Other}}_{it} = \sum_{j \in f, j \neq i} \frac{Rev_j}{\sum_{j \in f, j \neq i} Rev_j} X_{jt}$$

where Rev_j is the revenue of establishment j and the sum is over all establishments in firm f except for establishment i. We calculate this for our retail index $Retail_{it}$ as well as the credit measure R_{it}. There are other possible ways of weighting the other establishments such as geographic distance or based on wage bill. We explore some of these possibilities

[24] We also have robustness checks where we equally weight all establishments and another where we weight based on an establishment's wage bill.

later.

The implication for the effect of a *demand* shock on employment depends crucially on the relative pledgeability of the establishments. We create a measure of whether establishment i has revenue that is relatively more or less pledgeable than other establishments making up the firm. This variable ΔR_{it} is defined as

$$\Delta R_{it} = 1[R_{it} - R_{it}^{\text{Other}} > 0].$$

Based this definition, our implicit assumption is regions with $\Delta R_i = 1$ are places with less pledgeable revenue ($\kappa_i < \kappa_{-i}$). We then estimate the following equation:

$$\begin{aligned} E_{it} &= \sum_{X=Retail,R} \left[\alpha_X^{Own} \cdot X_{it}^{Own} + \beta_X^{Own} \cdot MP_{it} \cdot X_{it}^{Own} + \beta_X^{Other} \cdot X_{it}^{Other}\right] \\ &+ \sum_{Type=Own,Other} \left[\gamma_{Retail}^{Type} \cdot Retail_{it}^{Type} \cdot \Delta R_{it}\right] + \delta_{it} + \nu_{it}. \end{aligned}$$

The first line of the equation contains all of the variables from the first specification as well as the parameter β_X^{Other}, which captures the effect of changes in demand or credit conditions in the firm's other establishments on employment. Note that because $X^{Other} = 0$ as well as $\Delta R = 0$ is by definition zero for SP firms ($MP = 0$), these interactions are collinear and we therefore drop them from this regression specification. The second part of the equation captures the effect of shocks to own demand interacted with pledgeability and shocks to other demand interacted with plegeability.[25] The parameter γ_{Retail}^{Other} captures the differential effect of other shocks to the establishment in the firm with relatively less pledgeable assets. The idea of examining how "other" conditions spillover inside of a firm is similar in spirit to the specification of Giroud and Mueller (2017).

Given this specification and assuming the first set of results hold, our second set of testable implications of the model are as follows:

[25] We also include the "direct" effect of ΔR_{it} in the regression but omit it here for simplicity.

Prediction 2 The response of an MP establishment to a *demand* shock relative to an SP establishment will be amplified if and only if the establishment's revenue is relatively more pledgeable: $-\gamma_{Retail}^{Own} > \beta_{Retail}^{Own} > 0$.

Prediction 3 "Other" *demand* the opposite sign of "own" demand shocks if and only if the establishment's revenue is relatively more pledgeable: $-\gamma_{Retail}^{Other} < \beta_{Retail}^{Other} < 0$.

Prediction 4 "Other" *credit* shocks have the same sign as "own" credit shocks: $\beta_R^{\text{Other}} < 0$.[26]

One issue with this specification is how to handle a SP establishment or an MP firm with all of its establishments in the same region with regards to assigning a value for ΔR_{it} and other conditions. We choose to normalize both of these variables to 0 though any value would work. It is not literally the case that these establishments have an average other retail sales index of 0. In some sense, this information is missing. While this group of establishments will not provide information on identifying the effects of other conditions, we do not want to drop this group of establishments in all the specifications since they serve as a point of comparison for the MP establishments. That said, we will run the spillovers regressions on just the set of MP establishments putting aside trying to estimate whether MP establishments are more sensitive than SP establishments. We also experiment with specifications where we drop all MP firms where all of the establishments are located in the same Federal Reserve district.[27]

[26] The model also has implications for $\beta_R^{\text{Own}}/\beta_R^{\text{Other}}$, which should be related to the weight of establishment i in a total firm's wage bill.

[27] In an Appendix, we also estimate differences in overall employment volatility at the firm- and establishment-levels by MP status. Our model predicts that both MP establishments and firms will be more volatile, which is exactly what we find in the data.

5 Results

We begin by comparing the relative sensitivity of MP establishments to demand and credit shocks. The evidence here supports the general idea that firms are reallocating resources across their constituent establishments. We then move on to the regressions directly inspired by the model that have predictions for these sensitivities as a function of whether a particular establishment's revenue is more or less pledgeable than other establishments in the firm.

5.1 Sensitivity to Local Economic Conditions

Table 3 reports the results across a number of specifications that vary the set of additional fixed effects included. We first note that the baseline correlations between employment with the retail index and the discount rate have the "right" signs. Employment is positively correlated with higher retail sales and negatively correlated with discount rates. We go further and find that employment at MP establishments is much more correlated with demand conditions. In fact, in the first specification, the sensitivity is more than double the baseline effect and at a minimum is almost 50% larger. In the case of local discount rate, as hypothesized, sensitivity is lower for MP establishments though the relative effect is not as large as that for demand with a decline in magnitude of around 16% to 20%. Note that this still leaves employment at MP establishments sensitive to changes in discount rates.

Understanding why MP establishments are less sensitive to changes in the discount rate requires understanding how credit mattered at this time. It is often assumed that the main channel through which credit matters is through the investment spending channel. For example, Bernanke et al. (1999) show in a quantitative business cycle model, how credit contractions lead to declines in aggregate demand and recessions through declines in investment. At least for the Depression, that theory is hard to square with the micro evidence that finds the *local* businesses are affected by *local* credit (Ziebarth, 2015). Under the investment theory, local businesses would decrease their investment immediately in response to a credit contraction, but there is no reason to believe that the businesses immediately affected by this reduction investment spending are located in the same region. Ben Bernanke made exactly this point in commenting on Cole and Ohanian (2000) on pg. 260: "[I]f financial distress reduces the demand for automobiles in Alabama, output in Michigan rather than in Alabama will be most affected." Of course in the long-run, a credit starved business which is not able to invest will experience a decline in output relative to the case with abundant credit, but it seems hard to build a business cycle theory around this long-run outcome. So why do people like Lee and Mezzanotti (2017) observe these links between local credit and local economic outcomes?[28] We would argue that this reflects the trade credit channel where banks play an important role in facilitating purchases of goods by local wholesalers. In fact, these so-called "real bills" were an important form of collateral at the discount window. This is the way in which firms' internal networks may be useful because internal financial resources can be used to substitute for a lack of external credit.

The results also still apply when we restrict attention to a different comparison group. These results are reported in Table 4. Besides MP firms that span multiple Fed districts, there is a group of firms and establishments that are concentrated in one Fed region. One may think that this group is not a fair comparison since for this group, a shock in the local region affects all the establishments at the same time independent of any internal capital market effects. So in this specification, we drop all of these establishments and firms. Still even with this restriction of the sample, the same patterns are present with only minor effects on the magnitudes.

Again we have tried to avoid using causal language, but one may wonder about the possibility of reverse causality here where changes in employment drive changes in retail

[28]Their results, which depend on the financial dependence of an industry, cast doubt on a version of the Friedman-Schwartz hypothesis that emphasizes the effects on bank failures on consumers and the ability to tap their deposits.

demand or changes in discount rates. While this is plausible though manufacturing is only part of a local economy, the difficulty is still how that would explain these *differences* between MP and non-MP establishments. It does not matter with regards to the effect on demand whether a person is employed by a MP or non-MP establishment. So while reverse causality is clearly a question in ascribing causal meaning to the baseline effects, we do not think it limits what we can say about the differences between these two type of establishments.

5.2 Sensitivity to "Other" Local Economic Conditions

Table 5 reports the results of this regression. We find that a establishment in a particular location responds to conditions of establishments in other locations that are part of the same firm. In particular, the response is of the same sign of the response to a shock in its own region. If demand is relatively high for other establishments, employment is higher. Similar results hold for discount rates. This is further evidence the firms are relaxing their total financing constraint and allocating efficiently the total amount of resources at their disposal. In other words, it is not the case that firms "keep their powder dry" whereby they could give more resources to one particular establishment without affecting another establishment. These spillover effects are not small. It is difficult to directly interpret the magnitude, but relative to the direct effects, these spillovers appear meaningful with almost equal magnitude for the retail index and about one fifth for the discount rate. Table 6 reports the results when we drop all the firms with all of its establishments in a single Fed region. Results are basically unaffected. Table 7 reports the results from equally weighting establishments in constructing other conditions.

We can go further by using temporal variation over the years of the Census to estimate the value of these internal networks as conditions in external capital markets collapse starting in 1931 and slowly begin to recover in 1935. This type of year by year analysis is similar in spirit to the exercise in Matvos and Seru (2014). A large part of the value of internal networks is derived from the presence of binding borrowing constraints. If firms are free to borrow as much as they like, then there is very little incentive to pool financial resources as in internal networks. We can test at least indirectly for these borrowing constraints by examining to what extent conditions in one region where an MP establishment is located spillover to an MP establishment part of the same firm in a different region. If the pool of internal resources is constrained by external credit, then increasing employment at one establishment in response to demand, say, should come at the cost of lower employment at the establishment with relatively lower demand. A similar effect should be present for changes in discount rates. The magnitude of this spillover can also be examined over time for evidence on the value of internal networks in the face of external credit collapses.

Figure 4 shows the relative MP "own" sensitivity in the 1929 and post-1929 time periods. Though the results are more noisy, there appears to be evidence that the value of these internal networks increases as external credit markets collapse. In particular, we find that the largest increase in sensitivity to demand conditions are in the later years of 1933 when credit markets are the most stressed. In fact, in 1929 before the Depression had even arrived, MP establishments are *less* sensitive to demand conditions, the opposite of what we noted in the full sample. When we turn to differences in sensitivity to discount rates over the years, we find a roughly similar picture picture with the largest declines in sensitivity coming during the Depression though unlike for demand, it does not appear to be present in 1933 (at least statistically).

Figure 5 shows the spillovers in the 1929 and post-1929 time periods. These provide further insights into how internal capital markets function in the presence of external credit market distress. One would expect that with limited outside credit opportunities, the spillover effects would be larger as firms would not be able to substitute using external finance. We find in particular for the retail index that the spillover effects are much larger during the Depression with basically no negative spillovers in 1929 before the Depression begins. The results for the discount rate are more nuanced. Unlike for the retail index, we still find positive spillover effects in 1929, but for most of the Depression years not only disappear but become negative with higher discount rates for other establishments negatively affecting an establishment's own employment as well. Our interpretation is that for these years, credit contractions were so severe that all establishments were forced to reduce their employment to accommodate the changes.

5.3 Sensitivities by Pledgeability of Revenue

We now turn to estimating equation 12, which includes interactions between other shocks and pledgeability. Table 8 reports the results of this regression. The magnitudes of the parameters estimated before remain broadly similar to the first specification. We then look specifically at the results using information from other establishments. The model predicted that credit shocks to other establishments had the same sign as own credit shocks: $\beta_R^{\text{Other}} < 0$. We find an insignificant effect here, although the point estimate is negative.

Another prediction concerned comparing the response of shocks to other establishment's demand across the establishments with more and less pledgeable assets. With regard to the prediction that $\beta_{Retail}^{Own} > 0$, this is not borne out in the data, with a point estimate that is negative although not statistically significant. However, the related prediction that $\beta_{Retail}^{Own} + \gamma_{Retail}^{Own} > 0$, or is confirmed, with a positive point estimate significant at the 1% level. We find that β_{Retail}^{Other} is negative, although not statistically significant. Moreover, the point estimate of $\beta_{Retail}^{Other} + \gamma_{Retail}^{Other}$ should be negative according to the model, where we find a positive effect, significant at the 5% level. Table 9 shows the results from equally weighting establishments within a firm when constructing other conditions.

Taken together the results show that firms faced binding credit constraints and, hence, had to reshuffle resources between establishments in response to changes in external conditions. This became even more extreme with the Depression with less ability to offset the necessary reshuffling with external credit and further declines in credit forcing all establishments to reduce employment. Still this is a story where internal capital markets are playing an essential role in mitigating these shocks in an efficient manner rather than in a distorted manner, seemingly implied by much of the previous empirical literature.

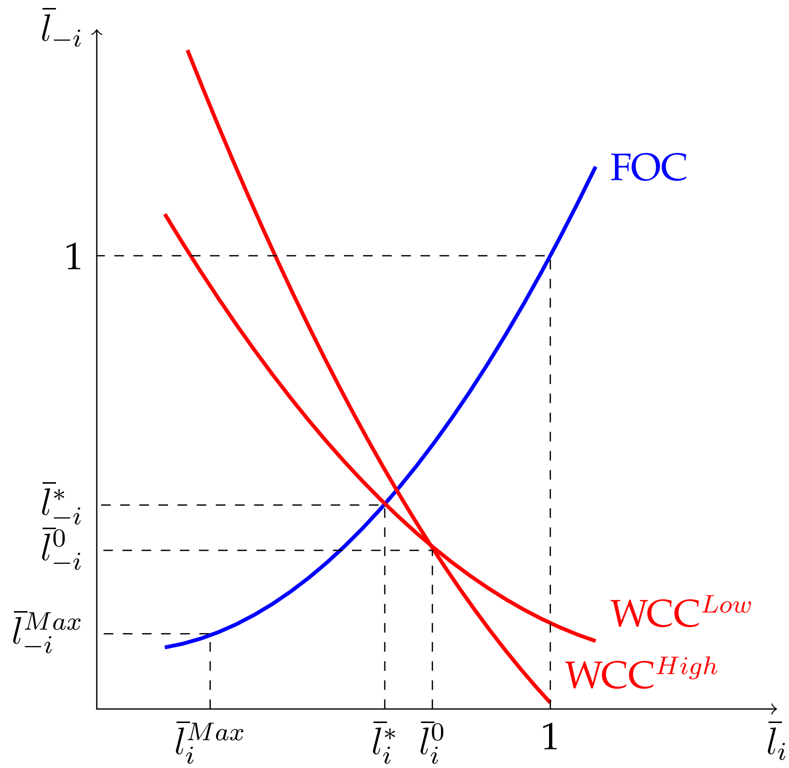
6 Conclusion

Big firms matter, and they matter in particular for business cycle fluctuations. For example, in 1937, there is evidence that a shock impacting labor costs driven by a unionization push in the automobile industry and, in particular, the Big 3 automakers caused the recession in that year (Hausman, 2016). So understanding business cycles is in many cases not about looking for aggregate shocks but particular shocks to "systemic" firms and understanding how those shocks propagate.

We have addressed the role of "big" firms as defined as firms that own multiple establishments in the Great Depression, by studying how resources are allocated inside of firms during this period of unprecedented stress in external credit markets. To do this, we collected a an establishment-level dataset from the Census of Manufactures and linked establishments to their parent firms. We then documented that employment at MP firms was more correlated with local "demand" conditions as proxied by a retail sales index but less so with regional Fed discount rates. We argued that this implicated differences in access to credit as the explanation for this "double difference." In addition, we found that shocks tended to spillover between establishments part of the same firm located in different regions as a function of differences in the pledgeability of revenue.

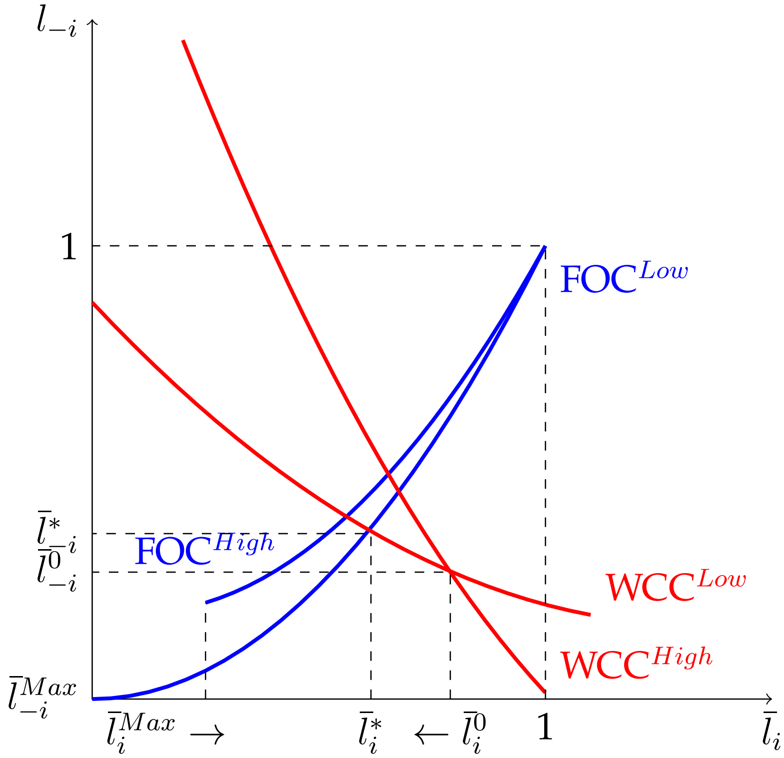
As we noted at the beginning, one salient feature of the Depression was the temporal synchronicity (with some differences) of regions all across the county. Identifying the reason for this synchronicity will provide important insights into the fundamental source of the Great Depression. So for future work, it would be useful to draw out implications of these findings for the geographic nature of the Depression and the role these networks played in aggregate in determining these geographic correlations in outcomes.

Figure 1: Comparative Statics of Increase in Demand for Region i



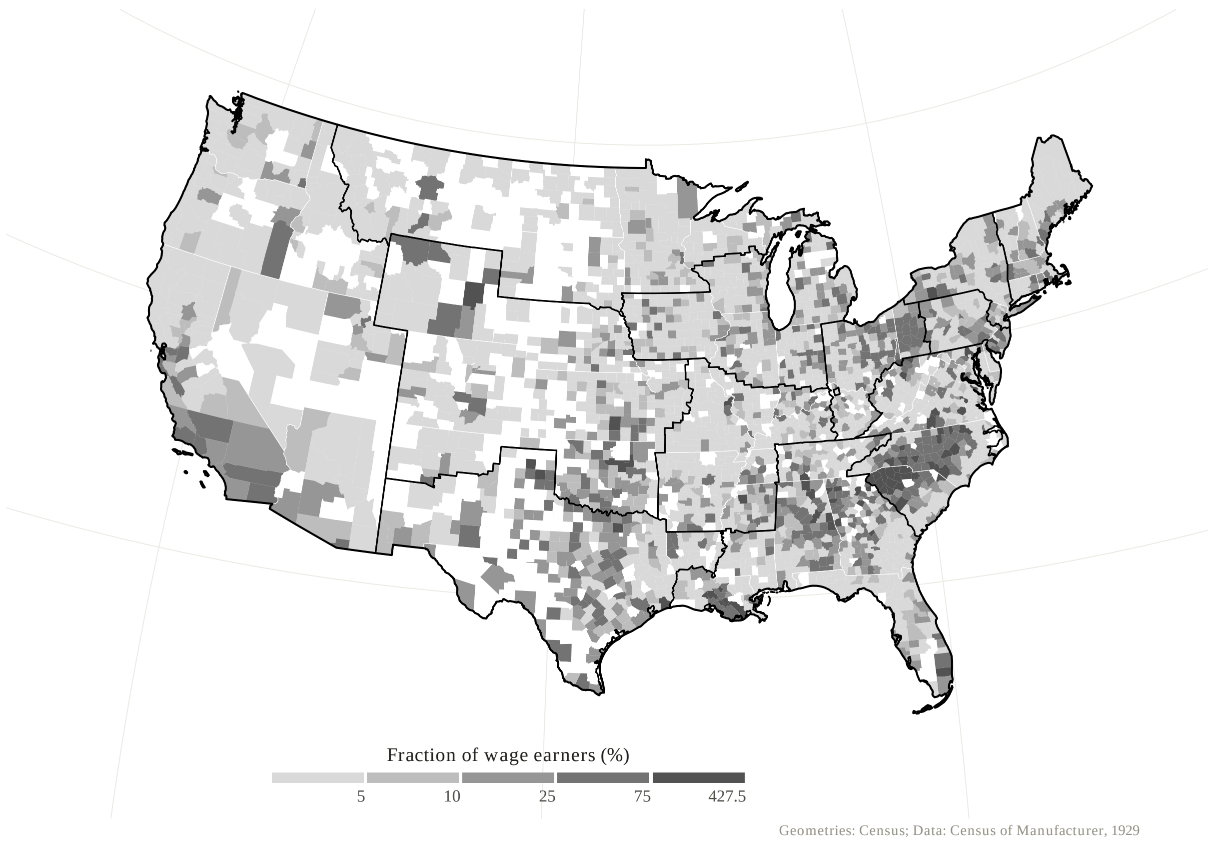
Notes: An increase in demand is an increase in a_i. Establishment i is subsidizing establishment $-i$ at the initial optimal choice. The WCC constraint rotates about the point $(\bar{l}_i^{Zero}, \bar{l}_{-i}^{Zero})$ where neither establishment generates any cashflow. The FOC curve is independent of demand so it remains fixed.

Figure 2: Comparative Statics of Credit Tightening in Region i



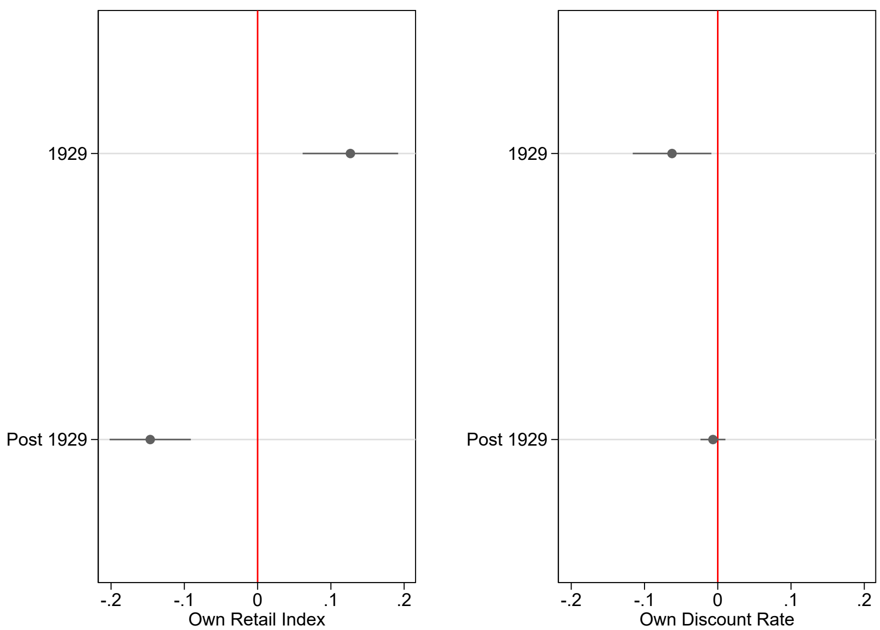
Notes: A credit tightening is a decrease in κ_i.Establishment i is subsidizing establishment $-i$ at the initial optimal choice. The WCC constraint rotates about the point where establishment i generates no cash flow. There are two effects on the FOC curve. First, the domain over which it is defined shrinks since $\bar{l}^{Max}_i$ increases. In addition, for all values of $\bar{l}_i$ where both FOC curves are defined, the new FOC curve is higher.

Figure 3: Percent of Manufacturing Workers Covered by Our Industries



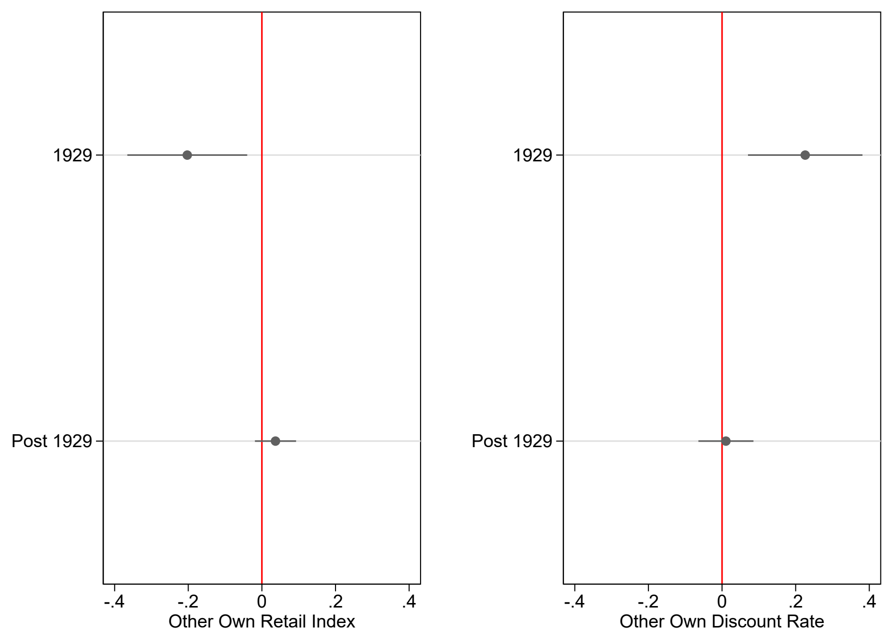
Notes: The percentage here is based on number of workers in the 1930 reporting that they work in manufacturing relative to the employment in our sample of industries for 1929. There are reasons why this percentage could be greater or smaller than 100%. For example, if a worker lives in a county different from where he works, this will lead us to underestimate coverage rates in his county of residence and overestimate in his county of work.

Figure 4: Sensitivity to "Own" Conditions: Pre and Post 1929



Notes: Regressions include Federal Reserve district fixed effects and industry specific seasonal trends as well as an indicator for MP status. Standard errors are clustered at the firm-level.

Figure 5: Sensitivity to “Other” Conditions: Pre and Post 1929



Notes: Regressions include Federal Reserve district fixed effects and industry specific seasonal trends as well as an indicator for MP status. Standard errors are clustered at the firm-level. Note that these results are from the regressions in Figure 4.

Table 1: Summary Statistics of the Industries in Sample

Industry	Establishments	Log Employees	Durable
Beverages	5155	1.128	0
Ice cream	3159	1.313	0
Ice, manufactured	3600	1.418	0
Macaroni	317	2.023	0
Malt	28	2.635	0
Sugar, cane	70	4.332	0
Sugar, refining	21	6.219	0
Cotton goods	1280	5.064	0
Linoleum	7	6.384	1
Matches	21	4.588	0
Planing Mills	4845	2.208	1
Bone black	65	2.977	0
Soap	283	2.033	0
Petroleum refining	389	3.995	0
Rubber tires	90	4.795	1
Cement	173	4.750	1
Concrete products	2432	1.467	1
Glass	265	4.891	1
Blast furnaces	105	5.089	1
Steel works	486	5.661	1
Agricultural implements	281	3.121	1
Aircraft and parts	133	3.220	1
Motor vehicles	245	4.516	1
Cigars and cigarettes	49	3.544	0
Radio equipment	336	3.813	1

Notes: All statistics are calculated for 1929. Establishments is the total number of establishments, Log Employees is the average number of log employees across establishments. Geog. HHI is the HHI where the shares are calculated by city for total revenue. Durable is whether we coded an industry's product as durable.

Table 2: Relative Importance of MP Establishments by Industry

	Percentage in MP of...		
Industry	Revenue	Employment	Establishments
Beverages	21.532	16.915	12.706
Ice cream	51.825	48.521	24.850
Ice, manufactured	65.717	59.679	49.639
Macaroni	.	.	0
Malt	20.659	27.745	32.143
Sugar, cane	26.287	38.294	12.857
Sugar, refining	62.779	59.385	52.381
Cotton goods	59.388	58.677	45.078
Linoleum	18.675	24.899	28.571
Matches	48.140	46.550	28.571
Planing Mills	17.433	16.768	10.320
Bone black	72.545	68.799	64.615
Soap	96.444	95.167	65.371
Petroleum refining	81.372	82.429	53.985
Rubber tires	91.786	89.664	72.222
Cement	68.323	72.226	61.272
Concrete products	17.985	14.761	8.923
Glass	60.479	54.669	37.358
Blast furnaces	78.128	74.744	58.095
Steel works	85.953	83.568	64.198
Agricultural implements	74.824	76.010	14.235
Aircraft and parts	32.916	37.469	18.797
Motor vehicles	80.077	70.429	31.837
Cigars and cigarettes	52.049	41.489	26.531
Radio equipment	38.030	42.260	8.036

Notes: These numbers are percentages of industry totals in 1929 by MP status. The "Establishments" column is the percentage of establishments that are part of an MP firm. Note that the values for the macaroni industry are missing because there are no MP establishments.

Table 3: Sensitivity to Local Demand and Credit Conditions

	Log Wage Earners			
	(1)	(2)	(3)	(4)
Retail Index	0.311***		0.264***	0.196***
	(0.021)		(0.022)	(0.042)
Discount Rate		-0.050***	-0.026***	-0.000
		(0.004)	(0.004)	(0.010)
MP * Retail Index	0.232***		0.292***	0.293***
	(0.047)		(0.048)	(0.049)
MP * Discount Rate		-0.005	-0.032***	-0.031***
		(0.011)	(0.011)	(0.011)
Multiplant	-0.464**	0.585***	-0.620***	-0.630***
	(0.205)	(0.053)	(0.202)	(0.204)
Fed District Seasonal Effects	Yes	Yes	Yes	Yes
Industry Seasonal Effects	Yes	Yes	Yes	Yes
Year x Fed District Effects	Yes	Yes	Yes	No
Fed District Effects	Yes	Yes	Yes	Yes
Year Effects	No	No	Yes	Yes
Seasonal Effects	Yes	Yes	Yes	Yes
Industry Effects	Yes	Yes	Yes	Yes
Observations	265231	265231	265231	265231

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level.

Table 4: Sensitivity to Local Demand and Credit Conditions: Drop All in One Region

	Log Wage Earners	
	(1)	(2)
Retail Index	0.277***	0.230***
	(0.021)	(0.043)
Discount Rate	-0.027***	0.002
	(0.004)	(0.010)
MP * Retail Index	0.313***	0.311***
	(0.061)	(0.061)
MP * Discount Rate	-0.040***	-0.039***
	(0.014)	(0.014)
Multiplant	-0.626**	-0.617**
	(0.251)	(0.252)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	243986	243986

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level. Here we drop firms that have all their establishments in one Fed district.

Table 5: Sensitivity to Local and Other Demand and Credit Conditions

	Log Wage Earners	
	(1)	(2)
Own Retail Index	0.265***	0.199***
	(0.021)	(0.043)
Own Discount Rate	-0.026***	-0.001
	(0.004)	(0.010)
MP * Own Retail Index	0.266***	0.266***
	(0.049)	(0.049)
MP * Own Discount Rate	-0.030*	-0.027*
	(0.016)	(0.016)
MP	-0.627***	-0.640***
	(0.202)	(0.204)
Other Retail Index	0.044**	0.047**
	(0.022)	(0.022)
Other Discount Rate	-0.004	-0.007
	(0.022)	(0.022)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	265231	265231

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level.

Table 6: Sensitivity to “Other” Conditions: Only MP Establishments

	Log Wage Earners	
	(1)	(2)
Own Retail Index	0.450***	0.297***
	(0.048)	(0.100)
Own Discount Rate	-0.024**	-0.028
	(0.011)	(0.027)
Other Retail Index	0.051***	0.056***
	(0.019)	(0.019)
Other Discount Rate	-0.039*	-0.045**
	(0.021)	(0.020)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	72384	72384

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level. We restrict attention to establishments that are part of a MP firm and therefore drop the MP indicator and its interactions with own and other conditions.

Table 7: Sensitivity to Local and Other Conditions: Equally Weighting Establishments

	Log Wage Earners	
	(1)	(2)
Own Retail Index	0.262***	0.198***
	(0.022)	(0.043)
Own Discount Rate	-0.026***	-0.001
	(0.004)	(0.010)
MP * Own Retail Index	0.276***	0.276***
	(0.049)	(0.049)
MP * Own Discount Rate	-0.031*	-0.028*
	(0.016)	(0.016)
MP	-0.671***	-0.685***
	(0.202)	(0.204)
Other Retail Index	0.043*	0.046**
	(0.022)	(0.022)
Other Discount Rate	-0.003	-0.006
	(0.022)	(0.022)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	265231	265231

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level. Other conditions are based on an equally weighted average across all establishments within a firm.

Table 8: Sensitivity by Pledgeability of Revenue

	Log Wage Earners	
	(1)	(2)
Own Retail Index	0.261***	0.192***
	(0.022)	(0.043)
Own Discount Rate	-0.027***	-0.003
	(0.004)	(0.010)
MP * Own Retail Index	0.457**	0.425**
	(0.188)	(0.188)
MP * Own Discount Rate	-0.030*	-0.028*
	(0.016)	(0.016)
Other Own Retail Index	-0.094	-0.067
	(0.179)	(0.180)
Other Own Discount Rate	-0.003	-0.006
	(0.023)	(0.023)
Less Pledgeable? * Other Retail	0.142	0.118
	(0.181)	(0.182)
Less Pledgeable? * Own Retail	-0.210	-0.171
	(0.185)	(0.186)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	265231	265231
$\hat{\beta}^{\text{Own}}_{Retail} + \hat{\gamma}^{\text{Own}}_{Retail}$	0.246***	0.254***
$\hat{\beta}^{\text{Other}}_{Retail} + \hat{\gamma}^{\text{Other}}_{Retail}$	0.048**	0.051**

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level.. "Less pledgeable" is an indicator for whether the "own" discount rate is greater than the "other" discount rate.

Table 9: Sensitivity by Pledgeability of Revenue: Equally Weighting Establishments

	Log Wage Earners	
	(1)	(2)
Own Retail Index	0.262***	0.193***
	(0.022)	(0.043)
Own Discount Rate	-0.027***	-0.002
	(0.004)	(0.010)
MP * Own Retail Index	0.399**	0.366**
	(0.175)	(0.174)
MP * Own Discount Rate	-0.032*	-0.030*
	(0.017)	(0.017)
Other Own Retail Index	-0.035	-0.007
	(0.161)	(0.161)
Other Own Discount Rate	-0.001	-0.004
	(0.024)	(0.024)
Less Pledgeable? * Other Retail	0.079	0.054
	(0.163)	(0.163)
Less Pledgeable? * Own Retail	-0.154	-0.113
	(0.173)	(0.173)
Fed District Seasonal Effects	Yes	Yes
Industry Seasonal Effects	Yes	Yes
Year x Fed District Effects	Yes	No
Fed District Effects	Yes	Yes
Year Effects	Yes	Yes
Seasonal Effects	Yes	Yes
Industry Effects	Yes	Yes
Observations	265231	265231
$\hat{\beta}^{\text{Own}}_{Retail} + \hat{\gamma}^{\text{Own}}_{Retail}$	0.245***	0.253***
$\hat{\beta}^{\text{Other}}_{Retail} + \hat{\gamma}^{\text{Other}}_{Retail}$	0.044**	0.047**

Notes: These data are at a quarterly frequency. The retail index is defined at the Federal Reserve district level as is the discount rate. The variable MP is an indicator for whether an establishment is part of a multi-plant firm. Standard errors are clustered at the firm-level.. "Less pledgeable" is an indicator for whether the "own" discount rate is greater than the "other" discount rate. Other conditions are based on an equally weighted average across all establishments within a firm.

A Appendix: Model Details

A.1 Proof of Result for Optimal Labor Choice

Lemma A.1 *The Lagrange multiplier on the working capital constraint λ solves*

$$\frac{\sigma-1}{\sigma(1+\lambda)} = \sum_{i=1}^{N} \frac{\alpha_i(\lambda)}{\kappa_i^{-1}+\lambda}$$

where $\alpha_i(\lambda) = \frac{w_i l_i(\lambda)}{\sum_{i=1}^{N} w_i l_i(\lambda)}$.

Proof To show this, we start with the FOC for l_i

$$(1+\lambda\kappa_i)a_i l_i^{-1/\sigma} = (1+\lambda)w_i.$$

Multiply both sides by l_i and factor out a κ_i to get

$$\frac{\sigma-1}{\sigma}\kappa_i y_i = (1+\lambda)\frac{w_i l_i}{\kappa_i^{-1}+\lambda}.$$

Now sum over i and use the fact that $\sum_{i=1}^{N}\kappa_i y_i = \sum_{i=1}^{N} w_i l_i$ to get

$$\frac{\sigma-1}{\sigma(1+\lambda)}\sum_{i=1}^{N} w_i l_i = \sum_{i=1}^{N}\frac{w_i l_i}{\kappa_i^{-1}+\lambda}.$$

Divide through by $\sum_{i=1}^{N} w_i l_i$ and define $\alpha_i = \frac{w_i l_i}{\sum_{i=1}^{N} w_i l_i}$ to arrive at the claim.

We can now prove the result in the paper for the optimal labor choice as a function of λ.

Proof The FOC for l_i can be written as

$$l_i = l_{SP}^{SB}\left(\frac{\kappa_i^{-1}+\lambda}{1+\lambda}\frac{\sigma-1}{\sigma}\right)^{\sigma}$$

Now substitute for $\frac{\sigma-1}{\sigma(1+\lambda)}$ using the lemma and multiply through by $\kappa_i^{-1}+\lambda$ to arrive at our result.

A.2 Proofs of Comparative Statics Results

From the FOC for l_i, we have

$$l_i = \left(\frac{a_i}{w_i}\right)^{\sigma}\left(\frac{1+\lambda\kappa_i}{1+\lambda}\right)^{\sigma}.$$

Replacing l_i in the working capital constraint with this expression, we get

$$\frac{\sigma}{\sigma-1}\sum_{i=1}^{N}\kappa_i w_i^{1-\sigma}a_i^{\sigma}\left(\frac{1+\lambda\kappa_i}{1+\lambda}\right)^{\sigma-1}=\sum_{i=1}^{N}w_i^{1-\sigma}a_i^{\sigma}\left(\frac{1+\lambda\kappa_i}{1+\lambda}\right)^{\sigma}.$$

Recall that $\alpha_i(\lambda)=\frac{w_i l_i}{\sum_{i=1}^{N}w_i l_i}=\frac{w_i^{1-\sigma}a_i^{\sigma}(1+\lambda\kappa_i)}{\sum_{i=1}^{N}w_i^{1-\sigma}a_i^{\sigma}(1+\lambda\kappa_i)}$ where we noted the dependence of α_i on λ. Then by the lemma, we know

$$\sum_{i=1}^{N}\frac{\kappa_i}{1+\kappa_i}\alpha_i(\lambda)=\frac{\sigma-1}{\sigma}\frac{1}{1+\lambda}.$$

This equation defines the value for λ and we will use it to derive the comparative statics. We can then use the implicit function theorem to calculate the derivative of λ with respect to the various parameters a_i,κ_i. For the case of two establishments and taking the limit of the derivative as $\lambda\to 0^+$:

$$\lim_{\lambda\to 0^+}\frac{\partial\lambda}{\partial\kappa_i}=-B^{-1}\left(1+\frac{w_i^{1-\sigma}a_i^{\sigma}}{w_{-i}^{1-\sigma}a_{-i}^{\sigma}}\right),$$
$$\lim_{\lambda\to 0^+}\frac{\partial\lambda}{\partial a_i}=-\sigma B^{-1}\frac{\kappa_i-\kappa_{-i}}{a_i}$$

where $B=\sum_{i=1}^{2}\kappa_i(1-\kappa_i)\left(\frac{w_i^{1-\sigma}a_i^{\sigma}}{w_{-i}^{1-\sigma}a_{-i}^{\sigma}}+1\right)+\sigma(\kappa_1-\kappa_{-i})^2>0$. So if κ_i increases, the financing constraint is relaxed and λ falls. If a_i increases, the financing constraint is relaxed if and only if $\kappa_i>\kappa_{-i}$, i.e. establishment i's are relatively more pledgeable.

Once we have expressions for the derivative of the multiplier with respect to the various parameters, it is relatively straightforward to derive the comparative statics for the labor choices. From the above expression for l_i, we have

$$l_i=\left(\frac{a_i}{w_i}\right)^{\sigma}\left(\frac{1+\lambda\kappa_i}{1+\lambda}\right)^{\sigma}.$$

Differentiating with respect to a_i

$$\frac{\partial l_i}{\partial a_i}=\sigma\frac{l_i}{a_i}\left(1-\frac{1-\kappa_i}{(1+\lambda)(1+\lambda\kappa_i)}a_i\frac{\partial\lambda}{\partial a_i}\right).$$

Taking the limit as $\lambda\to 0^+$ again and using the result for $\lim_{\lambda\to 0^+}\frac{\partial\lambda}{\partial a_i}$, we have

$$\lim_{\lambda\to 0^+}\frac{\partial\log l_i}{\partial\log a_i}=\sigma^2\left[\sigma^{-1}+B^{-1}(\kappa_i-\kappa_{-i})(1-\kappa_i)\right].$$

We derive the elasticity with respect to "other" demand shocks in a similar way:

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log a_{-i}} = -\sigma^2 B^{-1}(\kappa_i - \kappa_{-i})(1-\kappa_i).$$

The process to calculate the comparative statics with respect to κ is similar, but involves a bit more algebra. First, we have

$$\frac{\partial \log l_i}{\partial \log \kappa_i} = \kappa_i \sigma \left(\frac{\lambda + \kappa_i \frac{\partial \lambda}{\partial \kappa_i}}{1+\lambda\kappa_i} - \frac{\partial \lambda}{\partial \kappa_i} \frac{1}{1+\lambda} \right).$$

Taking the limit as $\lambda \to 0^+$, we get

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log \kappa_i} = -\sigma\kappa_i(1-\kappa_i) \lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial \kappa_i}.$$

Substituting in for $\lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial \kappa_i}$ gives our result. Now for the "other" shock, we start with

$$\frac{\partial \log l_i}{\partial \log \kappa_{-i}} = \sigma \kappa_{-i} \frac{\partial \lambda}{\partial \kappa_{-i}} \left(\frac{\kappa_i}{1+\lambda\kappa_i} - \frac{1}{1+\lambda} \right)$$

Taking the limit as $\lambda \to 0^+$, we get

$$\lim_{\lambda \to 0^+} \frac{\partial \log l_i}{\partial \log \kappa_{-i}} = \sigma\kappa_{-i}\kappa_i \lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial \kappa_{-i}}$$

Substituting in for $\lim_{\lambda \to 0^+} \frac{\partial \lambda}{\partial \kappa_{-i}}$ gives our result.

A.3 Microfoundation for the Financing Constraint

Here we layout a very simple way to microfound the financing constraint. Assuming the firm faces a limited enforcement constraint, the firm solves

$$\max \sum_{i=1}^{N} y_i - w_i l_i$$

subject to both technological and contractual constraints:

$$y_i = a_i \frac{\sigma}{\sigma-1} l_i^{\frac{\sigma-1}{\sigma}},$$
$$\sum_{i=1}^{N} (1-\kappa_i) y_i \leq \sum_{i=1}^{N} y_i - w_i l_i.$$

The firm may only pledge κ_i of revenues to pay their suppliers, such that if it defaults the firm keeps a fraction $(1-\kappa_i)$ of revenues. The second constraint is thus an incentive constraint stating the fraction they get under default is smaller than their profit. Rearranging the contractual constraint we find $\sum_{i=1}^{N} w_i l_i \leq \sum_{i=1}^{N} \kappa_i y_i$.

A.4 Comparison to GM Model

Here we derive the results from the model in GM and compare to our model. The key difference between our model and their's is the type of shocks studied. They focus on "cashflow" shocks that simply relax the firm-level cashflow constraint symmetrically for all establishments. There is no direct analog to this shock in our model. In the language of consumer demand theory, they study the effects of a pure wealth shock where labor input at each establishment is a normal good. Hence, this kind of shock will generate co-movement in employment across all establishments that make up a firm

Fixing ideas, a firm maximizes its profits from a set of N establishments given by

$$\max \sum_{i=1}^{N} p_i y_i - w_i l_i$$

where the constraint is simply

$$\sum_{i=1}^{N} w_i l_i \leq \sum_{i=1}^{N} C_i.$$

The term C_i is the "cashflow" generated by establishment i and the total cashflows across all establishments limits the the total wage bill of the firm. In their model, each C_i and, hence, the total cashflow is taken as exogenous. This is where our model differ than theirs. Our working capital constraint is determined endogenously based on the revenue of each establishment. It is immediate in their setup that the effects of a shock to C_i on employment across establishments does not depend on i.

Continuing with their setup and taking prices and wages as exogenous, the first order condition for l_j is

$$p_j y_i'(l_j) = (1 + \lambda) w_j$$

where λ is the Lagrange multiplier on the cashflow constraint. We can now do comparative statics on C_k by differentiating the FOC and the working capital constraint to find

$$\frac{\partial \lambda}{\partial C_k} = \tilde{w}_j \frac{\partial l_j}{\partial C_k},$$
$$\sum_{i=1}^{N} w_i \frac{\partial l_i}{\partial C_k} = 1$$

where $\tilde{w}_j = \frac{p_j}{w_j} y_j''(l_j)$. Then

$$\frac{dl_j}{dC_k} = \omega_j$$

where $\omega_j = \frac{\tilde{w}_j}{\sum_{i=1}^{N} \tilde{w}_i} > 0$ is a weight that does not depend on k. This shows that it does not matter the source of the cashflow shock. An establishment "shares" in its effects proportional to its size as measured by ω_j. So the magnitude of the effect does depend on the characteristics of the establishment. This implication on the relative magnitudes of the effects is not tested in GM. As a point of comparison, this cashflow shock is closest to our financing shock in terms of the qualitative predictions. On the other hand, GM interpret their main shock–variation in housing prices–as reflecting variation in local demand, which in our model has different effects depending on whether a particular establishment's revenue is more or less pledgeable.

A.5 Extension to General CES Production Function

Here we consider an extension to allow for a general CES production function. The production function takes the form of

$$y = a \cdot (\alpha l^{\rho} + (1-\alpha) k^{\rho})^{\frac{1}{\rho}\eta}$$

such that α is the labor share and $\varepsilon = 1/(1-\rho)$ is the elasticity of substitution across inputs. Finally $\eta < 1$ is the level of decreasing returns to scale. It is equivalent to $\frac{\sigma-1}{\sigma}$ in the previous Cobb-Douglas case.

We first begin with the case of a standalone or single establishment firm. Without any constraints the first best level of output is

$$y = (a\eta^{\eta} \cdot \zeta^{\eta})^{\frac{1}{1-\eta}} . \tag{12}$$

The working capital constraint now limits the total cost of inputs: $wl + rk \leq \kappa y$. Assuming this constraint binds, the second best level of output for a single firm is:

$$y = \mu^{\frac{\eta}{1-\eta}} (a\eta^{\eta} \cdot \zeta^{\eta})^{\frac{1}{1-\eta}} , \tag{13}$$

where $\mu < 1$ measures distortion in output due to the binding working capital constraint. Its value in this case we define as μ^{SB} is

$$\mu^{SB} = \frac{\kappa}{\eta} \cdot \left(\frac{\zeta}{\xi}\right)^{\frac{\rho}{1-\rho}} \tag{14}$$

where

$$\zeta = \left[\alpha \left(\frac{1-\alpha}{r}\right)^{\frac{\rho}{1-\rho}} + (1-\alpha)\left(\frac{\alpha}{w}\right)^{\frac{\rho}{1-\rho}}\right]^{\frac{1-\rho}{\rho}},$$
$$\xi = \left[(1-\alpha) \left(\frac{1-\alpha}{r}\right)^{\frac{\rho}{1-\rho}} + \alpha\left(\frac{\alpha}{w}\right)^{\frac{\rho}{1-\rho}}\right]^{\frac{1-\rho}{\rho}}.$$

Now we extend to the case of a MP firm where now the working capital constraint applies to the firm's total input costs

$$\sum_{i=1}^{N}(w_i l_i + r_i k_i) \leq \sum_{i=1}^{N} \kappa_i y_i.$$

Like in the Cobb-Douglas case, we can relate κ_i to the output distortion μ_i and the Lagrange multiplier on the working capital constraint λ as $\mu_i = (1+\lambda\kappa_i)/(1+\lambda)$. Then λ solves the following equation:

$$\sum_{i=1}^{N} \mu_i^{\frac{1}{1-\eta}} a_i^{\frac{1}{1-\eta}} \cdot \left(\frac{\kappa_i}{\mu_i \eta} \cdot \zeta_i^{\frac{\eta}{1-\eta}} - \zeta_i^{\frac{\eta-\rho}{(1-\rho)(1-\eta)}} \cdot \xi_i^{\frac{\rho}{1-\rho}}\right) = 0.$$

We can show that this equation can be written as

$$\sum_{i=1}^{N} y_i \cdot \left(\frac{\xi_i}{\zeta_i}\right)^{\frac{\rho}{1-\rho}} \cdot \left(\mu_i^{SB} - \mu_i\right) = 0. \tag{15}$$

To see this, first rewrite the total cost of input factors and the pledgeable revenue for establishment i

$$\begin{aligned} w_i l_i + r_i k_i &= \mu_i^{\frac{1}{1-\eta}} \cdot (\eta a_i)^{\frac{1}{1-\eta}} \cdot \zeta_i^{\frac{\eta-\rho}{(1-\rho)(1-\eta)}} \cdot \xi_i^{\frac{\rho}{1-\rho}}, \\ \kappa_i y_i &= \kappa_i \cdot (\eta^\eta a_i)^{\frac{1}{1-\eta}} \cdot \zeta_i^{\frac{\eta}{1-\eta}} \cdot \mu_i^{\frac{\eta}{1-\eta}}. \end{aligned}$$

Putting these together we have the working capital constraint:

$$\sum_{i=1}^{N} \mu_i^{\frac{1}{1-\eta}} a_i^{\frac{1}{1-\eta}} \eta^{\frac{1}{1-\eta}} \cdot \left(\frac{\kappa_i}{\mu_i \eta} \cdot \zeta_i^{\frac{\eta}{1-\eta}} - \zeta_i^{\frac{\eta-\rho}{(1-\rho)(1-\eta)}} \cdot \xi_i^{\frac{\rho}{1-\rho}}\right) \leq 0.$$

In the case, when this constraint binds, we can write

$$\begin{aligned}\sum_{i=1}^{N} \mu_i^{\frac{1}{1-\eta}-1} a_i^{\frac{1}{1-\eta}} \zeta_i^{\frac{\eta}{1-\eta}} \left[\frac{\kappa_i}{\eta} - \left(\frac{\xi_i}{\zeta_i}\right)^{\frac{\rho}{1-\rho}} \cdot \mu_i\right] &= \sum_{i=1}^{N} y_i \left[\frac{\kappa_i}{\eta} - \left(\frac{\xi_i}{\zeta_i}\right)^{\frac{\rho}{1-\rho}} \cdot \mu_i\right] \\ &= \sum_{i=1}^{N} y_i \cdot \left(\frac{\xi_i}{\zeta_i}\right)^{\frac{\rho}{1-\rho}} \cdot \left[\frac{\kappa_i}{\eta} \cdot \left(\frac{\zeta_i}{\xi_i}\right)^{\frac{\rho}{1-\rho}} - \mu_i\right] \\ &= \sum_{i=1}^{N} y_i \cdot \left(\frac{\xi_i}{\zeta_i}\right)^{\frac{\rho}{1-\rho}} \cdot \left(\mu_i^{SB} - \mu_i\right) \\ &= 0.\end{aligned}$$

Recall that μ_i^{SB} is the output distortion of a standalone establishment with pledgeability parameter κ_i. A few results are immediate from equation (15). First, If $\mu_i > \mu_i^{SB}$ i.e., establishment i is less constrained within the MP firm than on its own, then it must be the case that there is an establishment $j \neq i$ such that $\mu_j < \mu_j^{SB}$. Second, if all establishments are equally constrained: $\forall i, j \ \mu_i = \mu_j$, then there are no transfers across establishments within the MP firm and $\forall i, \ \mu_i = \mu_i^{SB}$ Note in this case, it need not be true that all the other establishment specific parameters w_i, r_i, a_i are the same.[29]

In the CES case, as compared to the Cobb-Douglas case, movements in interest rates r_i distort relative factor choices whenever firms are against their working capital constraints. This is already visible in the benchmark case where higher interest rates lead to lower labor demand and output. The question is how changes in interest rates spillover to other establishments. To answer this question, we conduct some numerical experiments for a two establishment firm in the case when $\kappa_1 > \kappa_2$ and when $\kappa_2 > \kappa_1$:

Figure 6 shows that when r_1 is small and $\kappa_1 > \kappa_2$, then there is a transfer from establishment 1 to establishment 2. Hence, labor demand in establishment 1 is below its SP benchmark and demand is above its benchmark in establishment 2. This is true up to a value of $r_1 = r_1^\star$ such that $r_1^\star > r_2$, where interest rate faced by firm 1 becomes so high that the shadow cost is higher now for firm 1 than for firm 2. When $\kappa_1 < \kappa_2$: there are only transfers for only small values of r_1. Actually the flows reverse for a value of $r_1 = r_1^\star$ such that $r_1^\star < r_2$. Note in both cases, how the labor inputs in the MP case (the solid lines) are "squeezed" between those of the standalone case (the dotted lines). This highlights the insurance value of MP firms when establishments are heterogeneous in the ability to pledge their revenue.

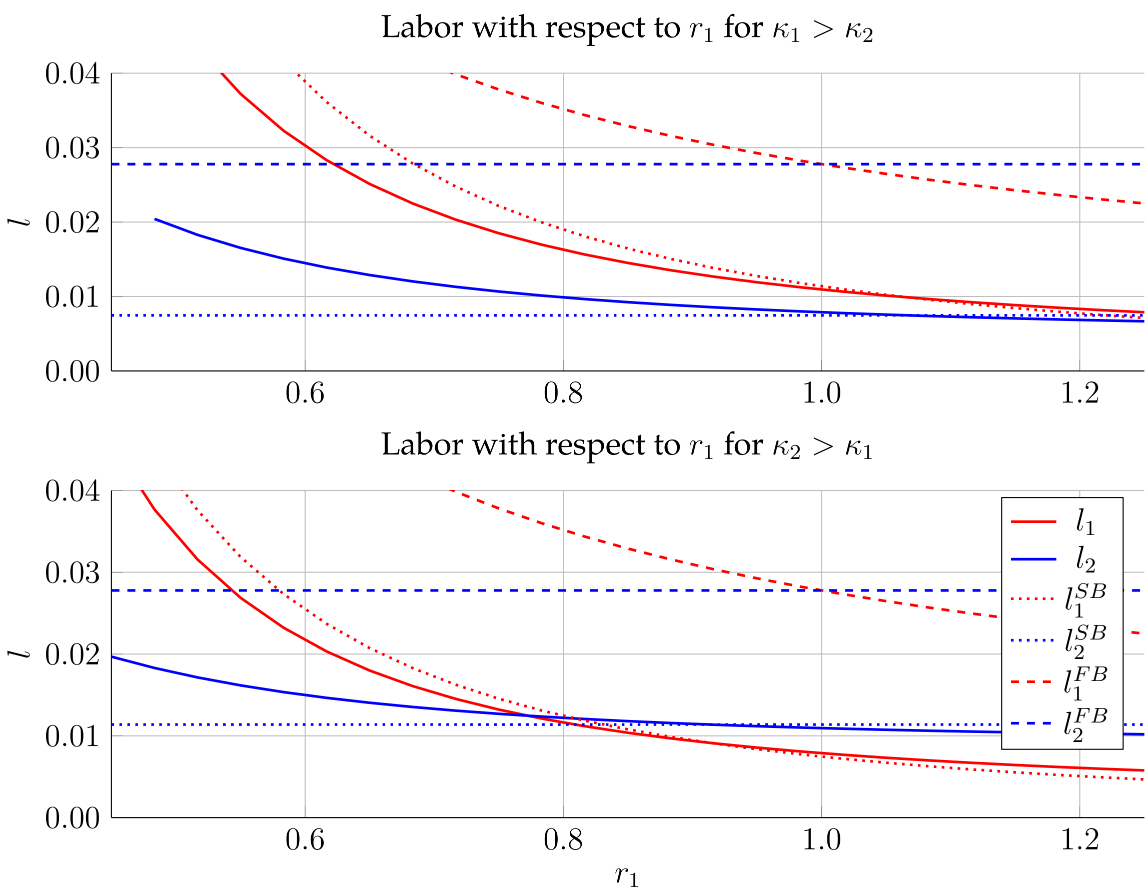
In our regression specifications, we interpreted the regional Federal Reserve discount rate as (minus) the pledgeability of an establishment's revenue in that region. A perhaps more obvious interpretation is that variation in the discount rate drives variation in the

[29] In the case when $w_i = w_j = \bar{w}, r_i = r_j = \bar{r}$ for all i, j, differences in μ_i distorts the allocation of resources across establishments, in that marginal factor products are not equalized.

$$\text{MPK}_i = \bar{r}/\mu_i; \qquad \text{MPL}_i = \bar{w}/\mu_i.$$

This means that there are productivity losses from these financing frictions since even holding fixed total factor inputs, output could be increased by reallocating factors of production to establishments with higher marginal products .

Figure 6: Comparative Statics for Interest Rates: CES Case



Notes: Optimal labor choices are plotted for no-constraint benchmark (dashed), SP with a binding working capital constraint (dotted), and a MP firm with a binding working capital constraint.

cost of capital for an establishment in a particular region.[30] Under either interpretation, the testable implications are the same with effects of changes in the discount rate for a particular establishment depending crucially on whether that establishment is relatively constrained.

B Appendix: Comparing MP to Non-MP Establishments

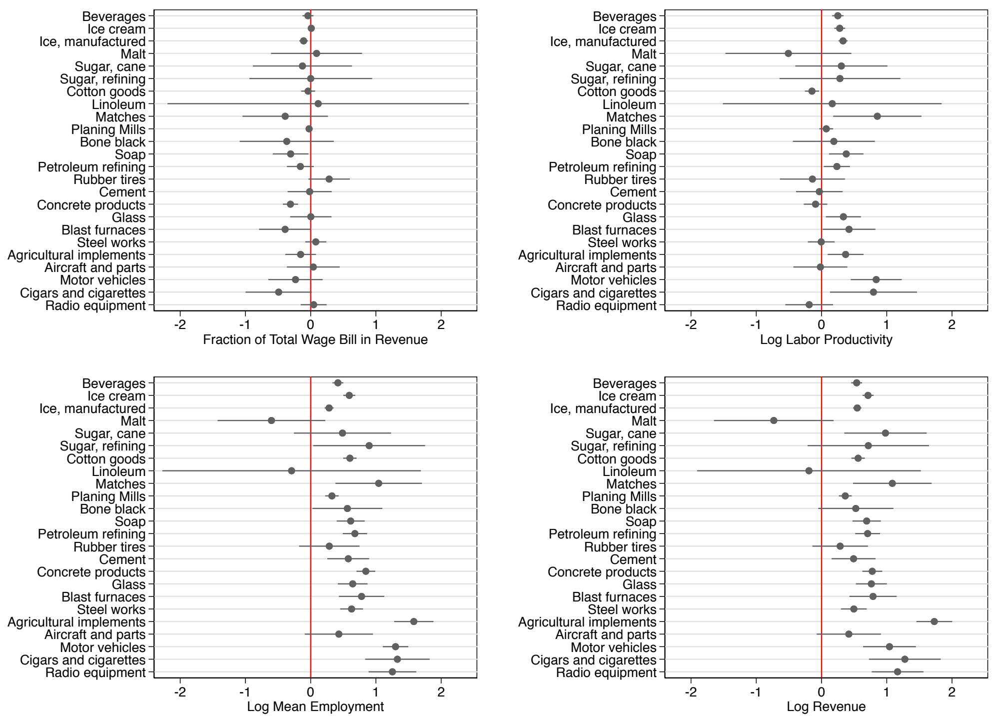
Given that our empirical strategy will rely on comparing MP to non-MP establishments, one might wonder whether the comparison between these two types of firms is a fair one. The summary statistics across our set of industries as reported in Table 2 suggest differences, there is considerable variation across the industries in the relative importance of establishments that are part of MP firms. The fraction of MP establishments ranges from 0% in macaroni all the way to 72% in rubber tires. The range is even larger if we consider revenue or employment where we go from 0% in macaroni almost all the way to 100% in soap. MP establishments command more than a proportional share of employment and revenue relative to their share in total establishments.

We formally test whether that are differences in the means across these groups not just in terms of size as measured by revenue or employment but also in terms of labor productivity and labor share in revenue. Figure 7 shows these differences in mean by industry. We scale the coefficients by the standard deviation of the dependent variable (and adjust the standard errors accordingly). Not surprisingly given Table 2 for most industries, MP establishments are larger along a number of dimensions. For revenue, the MP establishments are larger even in the smallest case by industry, the difference reflecting a move from the 47th percentile to the 53rd in cement. For sugar, the difference in size between MP and non-MP establishments reflects a move from the 41st percentile of the output distribution to the 59th. Broadly speaking, the same flavor of results hold for wage earners with MP establishments having larger work forces, not surprising given they are producing so much more.

On the other hand, along the labor share dimension, non-MP and MP establishments do not appear that dissimilar across industries. MP establishments may have a smaller ratio of wages to revenue, but the difference is neither large in the statistical nor economic sense. This suggests MP establishments are not different in terms of technology (at least in terms of the role of labor) relative to non-MP establishments in their industry. There is more direct evidence on this for some industries. For example, in cement and ice, differences between establishments were not due to fundamentally different production processes. It was simply a function of the scale of the machinery employed. In cement, it was the size of the kiln. For ice, the horse power of the compressors. On the other hand, there is qualitative evidence from various sources that in some particular industries there were differences in technology such as automobiles (Bresnahan and Raff, 1991) and macaroni (Alexander, 1997). These papers are silent on whether these technology choices were correlated with whether an establishment was part of an MP firm.

[30] For this interpretation to make sense empirically, it must be that markets for working capital are segmented geographically.

Figure 7: Comparison of MP to non-MP Establishments in 1929

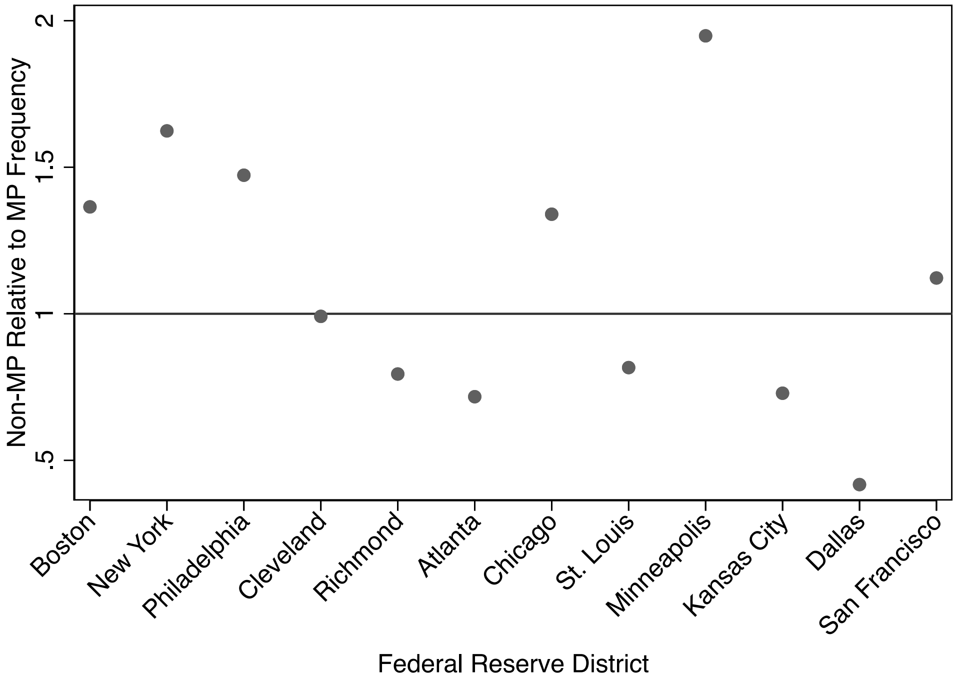


Notes: The figure reports the mean difference between MP and non-MP establishments. Each variable is log transformed besides the labor ratio are in terms of logs, which is the ratio of total wage bill to total revenue. Coefficients and standard errors are scaled by the standard deviation of the dependent variable in the given industry. Standard errors are clustered at the firm-level.

One could interpret these differences as *prima facie* evidence for the role of firm networks in alleviating credit frictions and allowing establishments that would be constrained to grow bigger. A different interpretation would be that for some reason, MP establishments are more productive than non-MP establishments and this explains, then, why they are larger, as suggested by Foster et al. (2008). There is modern evidence in a paper by Schoar (2002) that finds MP establishments or, more precisely, conglomerate firms are more productive on average than stand alone firms, but some of this benefit is dissipated when a stand along chooses to diversify. She does not, however, consider whether this difference in productivity explains any of the size differential as measured by output present in her data as well. Instead, in the spirit of Foster et al. (2008), we would argue MP establishments are larger simply because they are more productive.

We can also examine the distribution of geographic locations of MP to non-MP establishments by Federal Reserve district. In Figure 8, we plot the marginal distribution of establishments across the 13 Federal Reserve districts by MP status. A ratio of 1 means that the ratio of the number of non-MP to MP establishments is equal to the national ratio. These distributions do not appear to be significantly different. If there are many MP establishments in a region, there also tends to many non-MP establishments as well. This will allow us to identify the effects of changes in demand and credit conditions using within region variation rather than having to compare non-MP establishments in one region with, say, high demand to MP establishments in a different region with, say, low demand.

Figure 8: MP Status by Federal Reserve District



Notes: The relative frequency is the number of MP establishments to non-MP establishments in 1929 scaled by the aggregate ratio of MP to non-MP establishments. So a value of 1 means that the ratio in a given district is equal to the national average.

C Appendix: Employment Volatility

Given the empirical results on sensitivity to own conditions as well as other establishments and the theoretical results, we now consider where MP establishments more volatile than non-MP establishments *controlling* for size as measured by employment? Furthermore, if we aggregate to the level of the firm, are MP firms more volatile again controlling for size? Note that size is an important control here not only because there are differences in the average size between MP and non-MP establishments, but that size appears to be correlated with sensitivity to the business cycle, at least in modern data Moscarni and Postel-Vinay (2012). We examine these volatility differences across industries and over time as well. The latter we think provides some interesting insights into the interaction between external and internal capital markets.

We now introduce some notation to specify the regression. Establishment i part of firm j has average log monthly employment in year t of

$$\bar{E}_{ijt} = \frac{1}{12} \sum_{\tau=1}^{12} \log E_{ijt}.$$

Its (monthly) standard deviation in log employment is denoted by $\bar{\sigma}^{E}_{ijt}$. For firms, we sum over all i that are a member from firm j before applying the log transform. Firm variables are denoted with a tilde. Using the standard deviation of log makes the interpretation of the results more transparent as a one standard deviation shock represents some percentage variation in the employment variable. To be precise, the employment variable is solely wage earners excluding salaried employees.

The regression specification at the establishment-level is

$$\sigma^E_{ijt} = \alpha_0 + \alpha_1 \bar{E}_{ijt} + \alpha_2 MP_{jt} + \text{Industry} * \text{Year} + \varepsilon_{ijt}.$$

where MP_{jt} is an indicator whether firm j is a MP firm and Industry $*$ Year represents a full set of industry-specific time trends. Note that MP_{jt} is not necessarily fixed over time. It may be the case that new establishments join a particular firm making an originally SP firm into an MP one or vice verse where a MP firm refocuses and becomes a SP operation. In principle, this would allow for the possibility of identifying the effects of being part of a MP operation using *within* establishment variation. Unfortunately, the number of establishments that this applies to is vanishingly small. Because of this, we cannot control for firm and establishment fixed effects separately from the MP indicator. We cluster standard errors at the firm-level.

Table 10 reports the results from these regressions. All three regression show that MP establishments have more volatile employment counts from month to month. This is consistent across all the specifications, which range from including a full set of industry-specific time trends to no fixed effects at all. The magnitude of the effect in our preferred specification taking out industry specific time trends is quite significant being approximately 13% of the average volatility. The results are also robust to the inclusion state fixed effects as well. The overall effect from size of the establishment as measured by total revenue is also interesting as there appears to be very little relationship between size and volatility. The coefficient is statistically significant but economically not very meaningful.

Table 10: Establishment Level Employment Volatility by MP Status

	Standard Deviation of Employment			
Mean Employment	-1.257***	-1.246***	-0.707***	-0.740***
	(0.149)	(0.150)	(0.165)	(0.159)
Multiplant	2.891***	2.926***	5.982***	6.146***
	(0.495)	(0.495)	(0.755)	(0.757)
Industry Fixed Effects	Yes	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	No
Industry x Year Fixed Effects	Yes	No	No	No
Observations	68205	68205	68205	68205
Mean Y	20.966	20.966	20.966	20.966

Notes: Volatility is measured as the standard deviation in monthly employment in a given year at the respective level of aggregation, establishment or firm. Coefficients and standard errors are scaled by the mean of volatility. These regressions control for mean employment at the same level of aggregation in a given year as well as industry fixed effects. Standard errors are clustered at the firm-level.

We now turn to the results at the firm-level with results reported in Table 11. As at the establishment-level, MP *firms* are consistently more volatile than non-MP firms even after controlling for size. One might have thought that the higher volatility at the establishment-level would have been offset by an averaging across a number of different establishments that do not share perfectly correlated local conditions to get lower volatility at the firm-level. This does not appear to be the case. The effect is reasonably large as well around 8.5% of the average level of volatility. The differences here do tend to be smaller than the establishment-level differences. So there does appear to be some risk sharing across establishments but simply not enough to undo the higher level of unconditional volatility at the MP establishments.

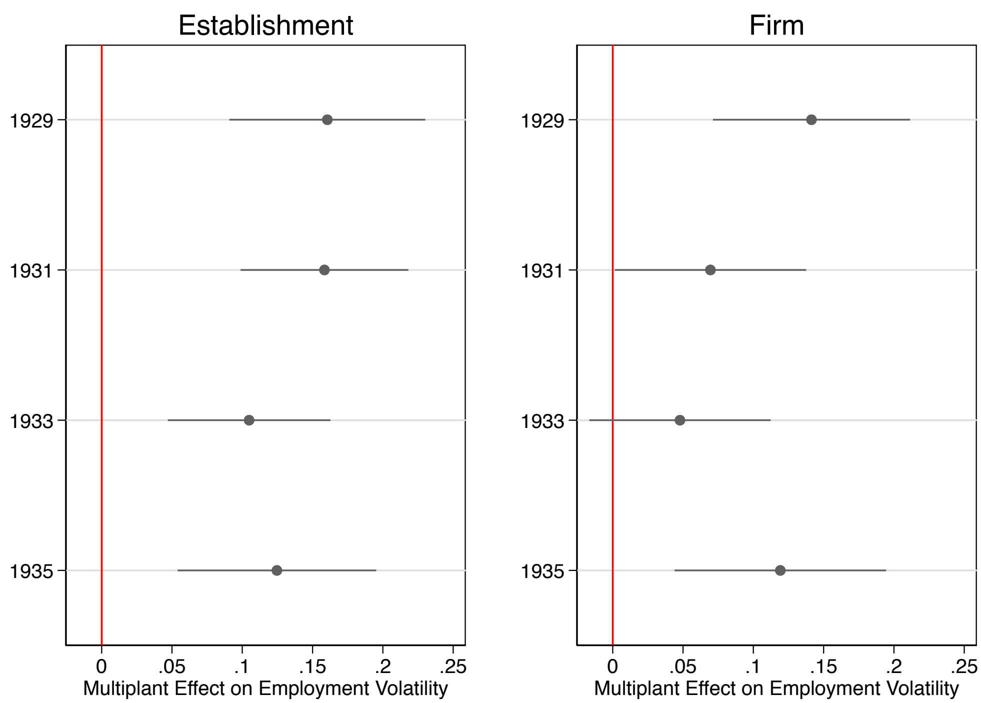
Table 11: Firm Level Employment Volatility by MP Status

	Standard Deviation of Employment			
Mean Employment	-0.882***	-0.856***	-0.262***	-0.289***
	(0.094)	(0.094)	(0.070)	(0.070)
Multiplant	1.806***	1.742***	2.941***	3.037***
	(0.424)	(0.426)	(0.454)	(0.456)
Industry Fixed Effects	Yes	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	No
Industry x Year Fixed Effects	Yes	No	No	No
Observations	53938	53938	53938	53938
Mean Y	19.689	19.689	19.689	19.689

Notes: Volatility is measured as the standard deviation in monthly employment in a given year at the respective level of aggregation, establishment or firm. Coefficients and standard errors are scaled by the mean of volatility. These regressions control for mean employment at the same level of aggregation in a given year as well as industry fixed effects. Standard errors are clustered at the firm-level.

Finally, we turn to the time series pattern of the MP effect for establishments and firms. Figure 9 reports this effect at the establishment and firm levels for each year of 1929, 1931, 1933, and 1935. The MP effect for 1931 and 1933 are severely attenuated and statistically indistinguishable from 0 in 1933 at both the establishment and firm level. We find it highly suggestive that the Depression does not begin in earnest until the middle to end of 1929 and the banking panics do not start until 1930, peak in 1933, and are over by 1935. This pattern exactly matches the effects with 1935 showing again a large MP effect. Now this banking pattern is also the pattern for the broader economy. So it is difficult to know whether this is a financial markets effect or a general business cycle effect. One can think of this approach as similar in spirit to both Matvos and Seru (2014) and Kuppuswamy and Villalonga (2010) who exploit the 2008 Financial Crisis as an exogenous shock to external capital markets. The former paper is closer in that they are interested in resource allocation within firms as well. They find that with the costs of external finance increasing, internal networks provide a substitute.

Figure 9: Firm and Establishment Employment Volatility MP Effects by Year



Notes: Volatility is measured as the standard deviation in monthly employment in a given year at the respective level of aggregation, establishment or firm. Coefficients and standard errors are scaled by the mean of volatility. These regressions control for mean employment at the same level of aggregation in a given year as well as industry fixed effects. Standard errors are clustered at the firm-level.

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