Firm Networks in the Great Depression*

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Abstract

We study how firms allocate resources between their constituent establishments during the Great Depression. To do this, we construct an establishment-level dataset from the Census of Manufactures for a select set of industries and link the establishment into their parent companies. We examine the sensitivity of establishment-level employment to changes in local demand and financial conditions across single and multi-plant firms. We find that employment in establishments that are a part of a multi-plant firm is more highly correlated with demand than that of a single-plant. At the same time, employment at multi-plant firms is less correlated with financial conditions. We also find that shocks to establishment in one particular region spillover to plants that are part of the same firm but located in a different region. We develop a model of firm networks to interpret these results as evidence for the importance of internal firm networks in channeling resources across space in response to changes in local conditions. We also show how this model explains the empirical fact that employment at multiplant establishments and firms is more volatile than employment at single plant establishments (and firms).

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1 Introduction

A business cycle is defined by the comovement in outcomes across industries and regions. This is no less true in the Great Depression, the mother of all business cycle events. Outcomes across industry and region were highly correlated (Rosenbloom and Sundstrom, 1999). This has led many people to posit an aggregate shock as the source of these correlations, and there is no shortage of possible candidates: (1) monetary policy (Friedman and Schwartz, 1971); (2) demand shocks (Temin, 1976); (3) the Great Crash and its effects on uncertainty (Romer, 1990) or balance sheets (Mishkin, 1978).

Our focus is not on adjudicating between these possible explanations, but unpacking these so-called aggregate shocks. To do this, we study firms' geographically dispersed internal networks of establishments distributed and the role they play in propagating (or dampening) local shocks. We would argue that understanding these networks is important for understanding the aggregate nature of the Great Depression as well as the large differences in outcomes across space.[1] For example, Rosenbloom and Sundstrom (1999) document that while declines in manufacturing employment for regions in the North East and Middle Atlantic were highly similar, there is almost a 30 percentage point difference in the decline for the Mountain region versus the South Atlantic. This feature of the Depression, in some ways, motivated the original work by Bernanke (1983) that focused on the effects of declines in the local supply of credit due to bank failures and suspensions.

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. For example, in the cement industry, the average number of plants of the the three largest firms to operate was more than ten. In the automobile industry, that average was eighteen for the "Big Three". We link these es-

[1]There are, of course, other interesting types of networks between establishments that make up a firm such as between an establishment that produces an intermediate good for another establishment. This vertical differentiation between establishments introduces a whole other set of bargaining and hold-up issues.

tablishments into their parent firms. Our empirical approach estimates the difference between multiplant (MP) firms' and single plant (SP) firms' quarterly employment response 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.[2]

Now before discussing the main results, one might fairly wonder whether SP firms are a fair comparison group. We provide empirical evidence that the only consistent difference between the two is in terms of size not in terms of the production process. With this in place, we find that employment at MP firms is more correlated with demand conditions than for SP firms as proxied by a measure of local retail sales. The point estimates range from a doubling of the sensitivity of SP firms to a 50% greater sensitivity. On the other hand response to what we identify as a change to 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%.

A natural question is whether these differences in sensitivity "reverberate" to the other establishments that make up a particular firm. If firms reallocate funds across their establishments in response to local conditions, this should be reflected in spillover effects (unless the firm's supply of funds is perfectly elastic). Take for example a firm with establishments in two separate regions with one of those establishments subject to a local demand spike. Then given our previous results, the plant 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. These results provide supportive evidence for the value of these networks in that internal funds are channeled

[2]We also consider a wide variety of other credit supply variables such as deposits in and number of suspended or failing banks.

towards establishments that need it most be that need in terms high demand or lack of credit.

We also study specifically the boundary of the Atlanta Federal Reserve region following a long list of authors such as Richardson and Troost (2009), Ziebarth (2013), and Jalil (2014). The motivation here is that the Atlanta Federal Reserve was the leading practitioner of aggressive discount lending in the face of banking panics. Richardson and Troost (2009) showed that in Mississippi, which is divided into an Atlanta part of the state and a St. Louis part, the Atlanta part experienced a much smaller decline in the number of banks and deposits. Ziebarth (2013) showed that these differences extended to manufacturing outcomes and Jalil (2014) extended these results to *all* counties on the Atlanta border. These differences are due to the 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.

We use a triple difference framework to compare firms with establishments on both sides of the border to "synthetic" firms made up of non-MP establishments on both sides. Differences in mean employment between Atlanta located and non-Atlanta located establishments will capture not just differences in the discount rate but also differences in the availability of discount loans due to differences in standards for "good" collateral, for example.

A similar literature has begun to develop on the role of firms in the Great Recession. For example, Kuppuswamy and Villalonga (2010) document a fall in the diversification discount, as evidence of an increase in the efficiency of IC markets. Rudolph and Schwetzler (2013) find a similar result looking across the world. Matvos and Seru (2014) estimate a structural model to account for how IC markets can be a substitute for external ones. 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) studies the allocation of resources between high

q and low q divisions over the business cycle and finds that recessions lead firms to redirect resources to the more productive divisions.

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 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. For example, Calomiris and Mason (2003) and Lee and Mezzanotti (2017) both identify negative effects from local credit market breakdowns.[3] 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.

Our work also contributes to the literature in finance on internal capital markets, a broader term for these networks that encompasses not just geographically distinct establishments but also distinct product lines. Going back to Coase (1937), a major question in economics has been what determines the boundaries of the firm. One possible benefit to having an internal capital market as elucidated by a long tradition Williamson (1981) is minimizing transactions costs. Other possible benefits include the ability to engage in "winner picking" allowing for particularly productive projects to receive outsized amounts of resources Stein (1997), a benefit that plausibly varies with aggregate conditions. Other work in finance such as Scharfstein and Stein (2000) have identified possible costs to these internal markets in the form of possible rent seeking on the part of managers, to name one mechanism.

Empirically, it seems that rather than allocating resources efficiently, internal capital markets appear to put resources in low productivity projects particularly when the com-

[3]Others such as Cole and Ohanian (2000) argue that these bank failures are simply an epiphenomena.

pany 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. Empirically an ample literature attempts to identify costs and benefits of MP firms (or conglomerates), investigating the trade-off between benefits of diversification and its costs; 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.[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.

2 Data

We use data from 25 individual industries in this paper. The source as a whole is discussed in greater detail in Vickers and Ziebarth (2017). This rich data source allows us to study the Depression at a high level of disaggregation. The important limitations to this data are that it lacks information on investment (or the value of capital) and any information on the financial position of the plants or their parent firms. The first limitation makes the focus of this paper in terms of the outcome variable different than much of the literature. We will focus on monthly plant-level employment instead of on investment.

Besides the cement industry where directories from the Cement Institute were em-

[4]See Stein (2003) Phillips and Maksimovic (2007) and paper therein for a thorough literature review.

ployed, we link by hand plants into their parent firm using the name of the parent company. This can be a fraught process when firms change their names over the years. The process of linking particular plants over time, by way of comparison is much easier since we can use name of the plant as well as the location of the plants. There is no reason to think that the errors in matching plants to firms and the same firm over time are anything but random. That being said, almost surely the errors in the process of matching lead us to underestimate of the fraction of plants that are part of multi-plant firms. The reason for this is that it is much more likely to not find a match in error than in matching a plant that should not be. This will generate the usual attenuation bias. We should be clear that due to the fact that we do not have the whole universe of manufacturing establishments, we are not able to identify plants owned by a particular firm that fall outside of our industries of interest. In that way, it makes sense to think of this as a "conditional" analysis where the internal capital market operates at two levels, first allocating resources between different lines the business is in and second between plants in that particular line.

While originally collected for different purposes, the industries as shown in Table 1 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 or manufactured ice represented. In addition, we have differences in whether the industries are mainly consumer oriented like beverages versus business oriented like planing mills. In addition, as the table shows, there is considerable variation across the industries in the relative importance of establishments that are part of multi-plant (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.

Given our empirical strategy will rely on comparing MP to non-MP establishments, one might fairly 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 1 do bear

this out. 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 2 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 1 for most industries, MP establishments are larger along a number of dimensions. For revenue, the MP plants dominate by a real margin with even in the smallest case, 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 plants 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 plants having larger work forces, not surprising given they are producing so much more. One could interpret these differences as *prima facie* evidence for internal capital markets alleviating credit frictions and allowing plants that would be constrained to grow bigger. A different interpretation would be that for some reason, MP plants are more productive than non-MP plants 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 plants 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 plants are larger simply because they are more productive.

However along this labor share dimension, SP and MP plants do not appear that dissimilar across industries. MP plants may have a smaller ratio of wages to revenue, but the difference is neither large in the statistical nor economic sense. This suggests MP plants are not different in terms of technology, relative to single plants in their industry. There

is more direct evidence on this for some industries. For example, in cement and ice, differences between plants 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 MP firms.

We can also examine the distribution of geographic locations of MP to non-MP establishments by Federal Reserve district. In Figure 3, we plot the marginal distribution of plants across the 13 Federal Reserve districts for SP and MP plants. 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 to us. If there are many MP plants in a region, there also tends to many SP plants 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 SP plants in one region with, say, high demand to MP plants in a different region with, say, low demand.

The industries collected represent the diversity of the manufacturing sector along a number of dimensions. Ice, sugar, and macaroni, for example, are consumer, non-durable products while both cement and agricultural implements are capital goods purchased by other businesses. The industries also differ to what extent they sell locally or to national markets. Because of high shipping costs, both ice and cement plants have limited geographic scope, while others such as automobiles and radios ship across the country. Furthermore, there are differences in the degree of competition. The tacit collusion in the sugar and cement industries has been suspected by many authors.[5] Finally, the industries differ quite strikingly with regards to the importance of labor in production. The fraction

[5]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*.

of wages to revenue (gross output), a rough measure of the elasticity of production with respect to labor, ranges from .04 in sugar to .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.

We also note that the industries differ in their degree of "aggregation." The CoM did not use things like 4 digit SIC codes to organize plants into industry groups. Instead they had categories that changed over time tending to become more narrowly defined. For example, the radio industry starts out in 1929 as also including phonograph producers before splitting these plants into a separate category (Scott and Ziebarth, 2013). At the same time, the industries of ice, macaroni, cement, sugar refining, malt, bone black, and cane sugar are very narrowly defined with plants tending to make only one product with little product differentiation. On the other hand, the remaining industries are closer 3 digit SIC codes with many plants producing a variety of products. This is particularly true for agricultural implements where plants made reapers, tractors, thrashers among other things. The concrete industry, while tending to have a particular plant only producing one product, covers all things made with concrete from concrete blocks to statues. The question of industry groupings is not particularly pressing for us since we are not interested questions of competition between these plants.

Because the establishments in this paper come from a non-random sample of industries, one concern is how representative they are of the entire manufacturing sector. Table 2 shows that 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.[6] As compared to the weighted, which are representative of manufacturing as a whole, the unweighted numbers take a simple average of the ratio by county.

In Figure 3, 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

[6]We thank Dave Donaldson, Richard Hornbeck, andJames Lee for providing the transcribed published tables.

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 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. Overall, our coverage rates are similar to 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 employment. Another area of relative overrepresentation is southern Louisiana, where virtually all employment in the sugar refining industry, another one we collected, is located.

3 Empirical Specification and Results

3.1 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 with respect 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. 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 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. There could also be production complementarities where one establishment or segment of a company produces a key input for another part of the company. Much of the existing literature, in our view, has not paid enough attention to the differences across firms in the relationships between their various segments.[7] On the other hand, in the case when a firm's internal network consists solely of geographically dispersed establishments producing similar products, 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. To be sure, 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.

With our geographic focus, we study the effects of regional economic conditions at the Federal Reserve district level. Now it would be preferred to have more narrowly defined regions or regions that more closely reflect a particular establishment's market. 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 in the estimation. We rely on the district level data simply due to data availability constraints.

The economic conditions we consider are the discount rate for the respective regional Fed and regional demand as proxied by the retail sales index collected by the Federal Reserve. With regards to the first variable, recall that this was 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 and the amount of discount lending. We should emphasize that we view the effect of changes in the discount rate as not directly falling on the establishments themselves but on credit for their wholesalers. We would argue that the role of trade credit has been somewhat missed in the literature on the role

[7] This is somewhat surprising since one of the most important empirical works in this literature by Lamont (1997) focused on just this distinction. In particular, he examined how non-oil subsidiaries of oil companies did following a sharp decline in the price of oil.

of the banking panics in the Great Depression. 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 Fed. The details regarding the second shock, the retail sales index, are discussed in Park and Richardson (2011). These measures of retail sales were collected by the Federal Reserve at the time. We aggregate the monthly employment and retail sales data to the quarterly level since this is the frequency of the discount rates. We will consider some other variables on banking outcomes that are at the county-level but are only at an annual frequency.

Not all of these industries sold their goods locally so to what extent this shock is a demand shock matters by industry. We will attempt to control for this by interacting demand with industry fixed effects. For some of the industries, we have modern information on weight of the product relative to its value, which is a proxy for tradeability of the product. We will use this variable as a way to proxy for how sensitive a particular industry is to local demand.

Let E_{it} be log quarterly employment and MP_{it} an indicator for MP status, then we estimate

$$\begin{aligned} E_{it} = \alpha_{\text{Own}} MP_{it} * Retail_{it} + \beta_{\text{Own}} MP_{it} * R_{it} + \gamma MP_{it} \\ + \text{Fed District} * \text{Quarter} + \text{Industry} * \text{Quarter} + \nu_{it} \end{aligned} \tag{1}$$

where R_{it} is the regional Fed discount rate, $Retail_{it}$ is an index of retail sales at Fed district level, Industry $*$ Quarter is a full set of industry specific seasonal trends, and Industry $*$ $Retail_{it}$ as well as Industry $* R_{it}$ are interactions of the local conditions and industry. We will experiment with how to further decompose ν_{it} by including things such as year fixed effects or Federal Reserve region specific year effects. Finally, we cluster the standard errors at the firm-year level following Giroud and Mueller (2017).

We test for the functioning of a firm's internal networks along two dimensions:[8]

1. Employment in MP establishments is more sensitive to local demand $Retail_{it}$ than SP establishments since they are able to tap internal resources, i.e. $\alpha_{\text{Own}} > 0$.

[8]See Maksimovic and Phillips (2002) for a typical neoclassical model of internal networks.

2. Employment in MP establishments is more sensitive to local credit conditions R_{it} than SP establishments since internal networks act as a transmission for external markets, i.e. $\beta_{\text{Own}} < 0$.

Note that the tests here are simply qualitative in that we do not have some theoretical baseline for how *much* more sensitive MP establishments should be to demand, for example. We use this less stringent standard since most of the rest of the literature has found evidence for clearly inefficient internal networks with resources moving going in the wrong direction. Furthermore, our choice of the word "sensitivity" is intentional since we do not mean to ascribe causality to the estimates.

We also experiment with specifications where we drop all MP firms where all of the establishments are located in the same Federal Reserve district. We do this mainly for comparability for some later regressions where we look for spillovers from establishments in other districts. This simply cannot be done when all the establishments are in the same district. This is one point where more disaggregated data would be very welcome.

3.2 Sensitivity to Local Economic Conditions

Table 3 reports the results across 3 different 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 investment. This is often how its effects are modeled where credit contractions lead to declines in aggregate demand and recessions. 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 view of credit's role, it is the case that 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 are located in the same region. Ben Bernanke made exactly this point in commenting on Cole and Ohanian (2000) on pg. 260: "If financial distress affects spending more than production, the lack of correlation between bank failures and production at the state level is not surprising, ... for example, if 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 local links? 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.

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 disaggregates this relationship by year. 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).

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 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.

3.3 Sensitivity to "Other" Local Economic Conditions

Now the question is whether this additional correlation is driven by reallocation of resources within the firm or that establishments in an MP firm are simply able to tap additional resources because of, say, slack borrowing constraints. To answer this, we look for evidence of spillovers of local shocks across establishments that make up the same firm. Start by taking a concrete example. Consider the Alpha Portland Cement Company and two of its constituent establishments: one located in Alabama and another located in Illinois. During the Depression, there are region-specific shocks like say the banking panic in Chicago of July 1931, which presumably would affect directly the Alpha establishment located in the state of Illinois. The question is will those Illinois specific events propagate all the way to Alabama through the internal capital markets linking this establishment in Illinois to the one in Alabama? Now if all MP firms had solely two establishments, this would be relatively simple to operationalize by including the other establishment's shock in the regression from before. The problem is what to do when there are more than 2. For example, the Alpha Portland Cement Company actually has 9 establishments total.

With more than 2 establishments, we have to decide on how to weight the local conditions at the various establishments. For each measure, we construct a revenue-weighted average of the measure for regions where other establishments part of the same firm are

located. Define the weighted "other" measure X_{it}^{Other} as

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

where Rev_j is the revenue of establishment j and the sum is overall establishments in firm f except for establishment i. We calculate this for our retail index as well as the credit measures. There is no particular reason for weighting by revenue. One could imagine weighting by distance to the other establishments. One could also consider more flexible approaches where the weights were estimated inside of the model. For the discount rate, one might consider using the minimum discount rate over all regions since if firms could borrow freely, then it would choose the least costly region to borrow in to fund all their operations. We explore some of these possibilities later.

With these variables defined, we estimate

$$\begin{aligned} E_{it} = \alpha_{\text{Own}} MP_{it} * R_{it} + \beta_{\text{Own}} MP_{it} * Retail_{it} + \alpha_{\text{Other}} Retail_{it}^{\text{Other}} + \beta_{\text{Other}} R_{it}^{\text{Other}} \\ + \gamma MP_{it} + \text{Fed District} * \text{Quarter} + \text{Industry} * \text{Quarter} + \nu_{it} \end{aligned} \tag{2}$$

The basic idea of the regression we estimate is similar in spirit to the specification of Giroud and Mueller (2017). They do not look at the effects of local shocks to economic conditions instead focusing on the plausibly exogenous introduction of an airline route to study the role of information in internal capital markets. So their paper is not interested in business cycles at all and the role of internal capital markets thereof. This comes with the benefit of having a clear causal interpretation. Like before, we refrain from using this causal language.

The next question is how should SP establishment or an MP firm will all of its establishments in the same region be handled. We choose to set both of these variables to 0 though any value would work. It is not literally the case that these establishments have an average other discount rate of 0. In some sense, this information is missing. However, we do not want to drop this group of establishments since they still provide useful informa-

tion for identifying effect of own discount rate and retail index. Let $\widetilde{MP}_{it}$ be an indicator for the group of establishments that do have establishments in other regions, then what we will estimate is the interaction between this indicator and the other discount rate and retail index variables. Note that $\widetilde{MP}_{it}$ is not exactly the indicator for being a multi-plant firm since it also requires the establishments to be located in separate Fed districts. We consider some regressions where we only use $\widetilde{MP}$ establishments for later. In these regression then, the relevant variables are excluded.

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 hgiher. 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.

Finally, we examine the effects across time in the right half of Figure 4. 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.

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.

4 Exploiting the Atlanta Fed Border Discontinuity

We provide some additional supporting evidence for the role of reallocation focusing on one border discontinuity. In particular, we focus on the Atlanta district. As noted by a number of authors such as Wicker (1966), Richardson and Troost (2009), and Carlson et al. (2011), Atlanta was very aggressive in extending short-term loans to struggling banks. Richardson and Troost (2009) showed how the district boundary that splits the state of Mississippi generated differences in bank failure rates across the two halves of the state. While Atlanta was loosening credit standards, St. Louis actually tightened its lending standards in response to the growing panics in the early part of the 1930s. Banks unfortunate enough to be located in the northern half of the state and covered by St. Louis failed at a much higher rate than those in the south. Ziebarth (2013) found that these higher bank failure rates translated into depressed business conditions in the northern half of the state.

In addition to the case of the St. Louis Fed, drawing on a number of other scholars, Jalil

argues that in general, all the regional banks less New York and Atlanta were opposed to expansionary initiatives. He then considers counties within 50 miles of the border and, given the Atlanta region borders four other regions, classifies the counties into four geographical regions: Atlanta-Richmond, Atlanta-St. Louis, Atlanta-Cleveland, and Atlanta-Dallas. His specification allows for including a set of time-invariant county controls as well as Fed region by year fixed effects (at least when there are more than 2 years of information). So rather than focus on just Mississippi, following Jalil (2014), we consider all counties on the border of the Atlanta district. This allows us to use a much larger sample of observations, but we still restrict attention to establishments on either side of the border.

There are five possible types of establishments: (1) SP in Atlanta, (2) SP not in Atlanta, (3) MP with all in Atlanta, (4) MP with none in Atlanta, and (5) MP with some on both sides. Now we want to isolate the effects of having access to internal networks. To do this, we focus on comparing SP establishments on either side of the boundary to MP ones *on both sides*. So we exclude all establishments in groups 3 and 4. This, of course, narrows the sample considerably but allows us to make the clearest comparisons. With this sample, we estimate a triple difference interacting a fixed effect for being in the Atlanta region with MP status and finally with after 1929:

$$E_{ift} = \sum_{MP} \sum_{t} \sum_{Atl} \beta_{MP,t,Atl} MP_f * T_t * Atl_i + \varepsilon_{ift}$$

where $Atlanta_i$ is an indicator for being in Atlanta district, T_t are time fixed effects, and MP_f is an indicator for being part of an MP firm. Our parameter of interest compares a hypotetheticl MP firm comprised of one establishment on either side of the boundary to a "synthetic" MP firm comprised of two SP establishments on either side where each of the establishments is of equal size. Then define the effect on firm employment in an MP firm $\bar{\beta}^{MP}$ as

$$\bar{\beta}^{MP} = \log \sum_{Atl} exp\left(\hat{\beta}_{MP,1,Atl} - \hat{\beta}_{MP,0,Atl}\right)$$

Similarly for a "synthetic" firm, define $\bar{\beta}^{nonMP}$ as

$$\bar{\beta}^{nonMP} = \log \sum_{Atl} exp\left(\hat{\beta}_{nonMP,1,Atl} - \hat{\beta}_{nonMP,0,Atl}\right)$$

Then our test statistic of interest is

$$\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$$

A negative (resp. positive) value of this statistic $\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$ means that the "synthetic" firm does relatively better after 1929 relative to a "true" MP firm. We ascribe these differences to access to these internal networks for the true MP firm in response to differences in monetary policy. Note that differences in monetary policy between Atlanta and all other bordering counties goes beyond simply differences in the discount rate. As discussed in detail by Richardson and Troost (2009), the Atlanta branch was aggressive in extending discount loans through expanding the types of "good" collateral and reducing the haircut applied to the collateral. On the other hand, the St. Louis branch, for example, actually *increased* collateral standards and the haircuts. In some cases, they required banks to pledge \$2 of collateral to get \$1 in discount loans (Richardson and Troost, 2009).

There are two important points to note abut this specification. First, to reemphasize, we do not include in the control group type 4 establishments since they will in principle be effected by the treatment through any internal capital market reallocation. Second, these differences only give the *total* effect of internal network reallocation. However, if the credit shock has spillover effects on local demand, then there will be countervailing effects for whether resources should flow towards or away from establishments in the stricken area. Recall our baseline results which found an amplified sensitivity to demand conditions and a dampened one to credit conditions for MP establishments. One way to isolate the pure credit effect would be to focus on industries where the good is highly tradeable so local demand is relatively unimportant, e.g. automobiles. Even if there are these opposing forces,

an effect significantly different from zero in either direction is evidence for active internal capital markets (as well as some limitation on the size of SP establishments) though we will not be able to comment on the efficiency of these flows.

Results using data just from 1929 and 1931 are reported in Table 8. In the table, we report the estimates from the triple difference model. Our statistic of interest $\bar{\beta}_{MP} - \bar{\beta}_{nonMP}$ along with its p-value is reported at the bottom of the table. It compares the relative performance of an MP firm with establishments on either side of the border to a "synthetic" non-MP firm with establishments on either side. We find a large negative effect which shows that the "synthetic" firms are doing worse significant at the 1% level in some of the specifications. Table 8 redoes the results but includes all post-1929 years. Here as well, we find a large negative effect significant at the 10% level. We interpret these results as reflecting the value of internal firm networks of establishments in the face of different monetary regimes and their effects on local credit markets.

There are a number of other possible contrasts that can be made not just between types of establishments but at different levels of aggregation. So far we have discussed comparing type 4 establishments stuck in the non-Atlanta region, but one could just as well make the other comparison focusing on the comparisons between type 4 establishments in the Atlanta region where the control group is all establishments in the non-establishment less those of type 4. In principle, this should give a similar answer. There are a number of other comparisons that could be made between the different types of establishments. For example, we would expect an ordering of the declines in employment with type 1 firms in Atlanta having the smallest followed by type 4 firms and finally type 1 firms not in Atlanta. We leave these other variations for later.

5 A Model of Firm Networks

We first develop a simple model to lay out the role of internal networks for firm and establishment volatilities. A firm operates N establishments. Each establishment operates a decreasing returns to scale production function in labor alone $y_i = \frac{L_i^{1-\eta}}{1-\eta}$ with $0 < \eta < 1$. Establishments maximize

$$\max_{L_i} P_i^{\eta} \frac{L_i^{1-\eta}}{1-\eta} - L_i$$

subject to $L_i \leq \epsilon_i \bar{L}_i$ where $\epsilon_i > 0$ is a credit shock and a demand shock P_i. We think of the credit constraint here as reflecting a constraint on trade credit for wholesalers that can be substituted for using internal funds $\bar{L}$. The solution is obvious with $L_i = \epsilon_i \bar{L}_i$ if $\bar{L}_i \epsilon_i \leq P_i$, the case of scarce credit, and $L_i = P_i$, the case of abundant credit, otherwise. Let total revenue for establishment i be denoted as $Rev_i = P_i^{\eta} \frac{L_i^{1-\eta}}{1-\eta}$.

A firm maximizes

$$\max_{\{\bar{L}_i\}} \sum_{i=1}^{N} \pi_i(\bar{L}_i)$$

subject to a working capital constraint

$$\sum_{i=1}^{N} \bar{L}_i \leq \sum_{i=1}^{N} Rev_i(\bar{L}_i)$$

The idea is that the firm can only provide internal funds to its constituent establishments up to its total revenue. One way to motivate this constraint is that it represents the "Real Bills Doctrine" that debt should be backed by real production or value. We emphasize that this constraint need not necessarily bind in all cases. We could also allow an additional credit shock at the level of the firm, which, say, limits the financial resources to some multiple of total revenue. However, this would be equivalent to scaling the establishment credit constraints by this multiple. Note as well that this problem is still well defined in the case when there is a SP establishment. As a function of $\bar{L}$ if credit is abundant, then $Rev_i(\bar{L}_i) = \frac{P_i}{1-\alpha}$ and, in the case where it is scarce, then $Rev_i(\bar{L}_i) = \frac{\bar{L}_i \epsilon_i}{1-\alpha} \left(\frac{P_i}{\bar{L}_i \epsilon_i} \right)^{\alpha}$.

It is useful to reformulate the problem in terms of $\bar{l} = \frac{\epsilon \bar{L}}{P}$ and to define a "cash flow" function

$$\bar{CF}(\bar{L}) = Rev(\bar{L}) - \bar{L}$$

This can be rewritten as

$$\bar{CF}(\bar{L}) = pCF(\bar{l})$$

where $CF(\bar{l}) = \frac{\bar{l}^{1-\eta}}{1-\eta} - \frac{\bar{l}}{\epsilon}$. With this notation, the firm's objective can be rewritten as

$$\max_{\{\bar{l}_i\}} \sum_{i=1}^{N} p_i \left[CF_i(\bar{l}_i) + \gamma_i \bar{l}_i \right]$$

with $p_i \equiv P_i/P_1$ and $\gamma_i = \frac{1-\epsilon_i}{\epsilon_i}$. We write the subscript i on CF to emphasize that it depends on i through its dependence on local credit conditions γ_i. This problem is subject to

$$0 \leq \sum_{i=1}^{N} p_i CF_i(\bar{l}_i)$$

We now note for later some properties of $CF(\bar{l})$. First $CF(\bar{l}) \leq 0$ if and only if $\bar{l} \leq \bar{l}^*$ where $\bar{l}^* = \left(\frac{\epsilon}{1-\eta}\right)^{1/\eta}$. Furthermore, $CF'(\bar{l}) \leq 0$ if and only if $\bar{l} \leq \bar{l}^{**}$ where $\bar{l}^{**} = \epsilon^{1/\eta}$. So $\frac{1}{1-\eta} - \frac{1}{\epsilon} = CF(1) \leq CF(\bar{l}) \leq CF(\bar{l}^{**}) = \frac{1}{\epsilon}\left[\frac{\epsilon^{1/\eta}}{1-\eta} - 1\right]$

The most interesting case is when $\bar{l}^* < 1$, or $\epsilon < 1 - \eta$, so that the efficient level of production does not generate positive cashflow. Notice as well that $CF'(\bar{l}^{**}) < 0$ and that it will never be efficient to have $\bar{l} < \bar{l}^*$ since in this case, a marginal change in $\bar{l}$ will increase cash flow and profits. So we can restrict attention to part of the domain where $CF'(\bar{l}) < 0$. If there were increasing returns to scale due to a fixed factor of production, then it might actually be optimal for a firm to close down an establishment altogether. We leave this to possible complexity to the side for now.

We now consider two cases: (1) credit is abundant; (2) credit is scarce. The first case corresponds to a situation where there is sufficient cashflow generated inside of the firm

to allow all the establishments to operate at the efficient scale,

$$\frac{\eta}{1-\eta} \geq \sum_i \frac{p_i}{\sum_i p_i}\gamma_i$$

This does not require that all establishments generate positive cashflow when operating at the efficient scale. In fact, this provides one possible motivation for forming MP firms, which is to pool together establishments that generate positive cash flow at the efficient scale with those that do not. We do not pursue this motivation here. Instead we use this condition as a way to think about a "fair" comparison between an MP firm and an SP firm, in effect, ruling out this pooling motive as a reason for the existence of MP firms. In particular, we will think about comparing an MP firm to an SP firm (or establishment) where $\gamma^{SP} = \sum_i \frac{p_i}{\sum_i p_i}\gamma_i$. In this case, the MP and SP firms will be unconstrained or constrained at exactly the same times. There will be no difference in terms of sensitivities to demand or credit conditions $\alpha_p \equiv \frac{\partial \bar{l}}{\partial p}, \alpha_\gamma \equiv \frac{\partial \bar{l}}{\partial \gamma}$ between SP and MP establishments when credit is abundant. Effectively, the establishments that make up the MP firm will operate like SP establishments.

Before discussing the case of scarce credit, we note that when credit is scarce the solution to the SP firm's (or establishment's) problem is trivial. The optimal choice of $\bar{l}_{SP}$ is determined by

$$CF_{SP}(\bar{l}_{SP}) = 0$$

So $\bar{l}_{SP} = \bar{l}^*$ since profits are strictly increase in $\bar{l}$ up to 1. Therefore,

$$\alpha_p^{SP} = 0$$

$$\alpha_\gamma^{SP} = -\frac{(1+\gamma)^{-\frac{\eta+1}{\eta}}}{\eta}$$

Now for an MP firm, the working capital constraint (WCC) implies for the optimal scale

of establishment in region $-i$

$$CF_{-i}(\bar{l}_{-i}) = -\sum_{i \neq -i} p_i CF_i(\bar{l}_i)$$

Since the solution is at a point where the cashflow functions are CF_i are decreasing, this relationship determines a negative relationship between l_i and employment at the other establishments. This relationship could be interpreted as a budget constrain for the firm.

The first order condition (FOC) will be

$$\frac{\gamma_{-i}}{CF'_{-i}(\bar{l}_{-i})} = \frac{1}{N-1} \sum_{i \neq -i} \frac{\gamma_i}{CF'_i(\bar{l}_i)}$$

Since the CF function is everywhere concave, this relationship determines a positive relationship between l_i, and employment at the other establishments. For the case of two establishments, we can show that an unique solution exists. Note first that if $\bar{l}_i = 1$, then the FOC implies that $\bar{l}_{-i} = 1$. However, on the other hand if $\bar{l}_i = 1$, then $-pCF_i(1) > 0$ so $\bar{l}_{-i} < 1$. Therefore, we know that the FOC curve is about the WCC curve when $\bar{l}_i = 1$. For the case where $\bar{l}_i = \bar{l}_i^{**}$, then $CF'_i(\bar{l}_i^{**}) = 0$ so the FOC implies that $\bar{l}_{-i} = \bar{l}_{-i}^{**}$. On the other hand, from the WCC, we know that $-pCF_i(\bar{l}_i^{**}) < 0$ so $\bar{l}_{-i} > \bar{l}_{-i}^{**}$. Therefore, we know that the WCC curve is above the FOC curve when $\bar{l}_i = \bar{l}_i^{**}$ and therefore, there is a unique solution to this problem.

One implication of these equations is that it will never be the case that one establishment is operating at the efficient scale while the other is not (See Figure 5). Both establishments will have their input choices distorted in this case. This simply follows from the following consideration. Assume that one establishment was operating at its efficient scale while the other was not. Then to a first order, a marginal change in its input use would have no effect on the profits that establishment earns while there would be a first order effect in reallocating some additional resources to the other establishment. It is interesting to consider first the case where $\gamma_i = \gamma_{-i}$. From the first order condition, this

implies that $\bar{l}_i = \bar{l}_{-i}$ and the only way for this to satisfy the resource constraint it must be that $CF(\bar{l}_i) = CF(\bar{l}_{-i}) = 0$. Therefore, $\bar{l}_i = \bar{l}_{-i} = \bar{l}^{**}$ since $\gamma_i = \gamma_{-i}$, $\bar{l}_i^{**} = \bar{l}_{-i}^{**}$. This means that in the case when credit conditions are the same across establishments, there is no cross-subsidization even if demand conditions are not the same, $p_i \neq p_j$ for some $i \neq j$. So in this case as well as the abundant credit case, MP establishments will operate just like SP establishments.

5.1 Implications: Sensitivities to Own and Other Economic Conditions

In our empirical analysis, we focus on comparing sensitivities to local shocks between SP and MP establishments as well as to what extent other conditions spillover. We can calculate the model analogs of these sensitivies by considering the comparative statics with respect to local demand and credit conditions. Continue to consider the two establishment case. Recall that an increase in p is a relative increase in demand for establishment i relative to establishment $-i$. If we differentiate the FOC with respect to p, we get

$$\frac{\partial \bar{l}_{-i}}{\partial p} \frac{CF''_{-i}}{CF''_i} = \frac{\partial \bar{l}_i}{\partial p}$$

Therefore, since CF is everywhere concave, it is the case that $\bar{l}_i$ and $\bar{l}_{-i}$ will co-move together in response to a change in p. It is easy to see that an increase in p will cause the WCC curve to shift to the right and therefore, both $\bar{l}_i, \bar{l}_{-i}$ will increase if and only if $\bar{l}_i > \bar{l}_i^*$. This is the case where establishment i is subsidizing establishment $-i$ (Figure 6). So at the current optimum, increases in the relative demand in region i increases firm cashflow and both establishments increase their size. This relationship also implies

$$\alpha_p^{MP} > \alpha_p^{SP} = 0$$

as well as the spillover effect $\beta_p^{MP} = \frac{\partial \bar{l}_{-i}}{\partial p}$

$$\beta_p^{MP} > \beta_p^{SP} \equiv 0$$

In the other case when establishment i is being subsidized by establishment $-i$, then employment in both establishments declines. Whether α_p^{MP} or β_p^{MP} are larger depends on whether the relative change comes from a change in own or other demand because changes in own demand also directly affect $\bar{l}$.

Understanding the effects of a regional credit shock is more complicated since it will shift both the FOC and WCC curves (Figure 7). An increase in γ_i will lead to an inward shift in the WCC since it will reduce the cashflow for any level of $\bar{l}_i$. Turning to the FOC, we can write

$$\frac{CF_i'(\bar{l}_i)}{\gamma_i} = \frac{1}{\gamma_i}\left(\bar{l}_i^{-\eta} - 1\right) - 1$$

Now the term multiplying $1/\gamma_i$ is positive since $\bar{l}_i < 1$. Hence, increasing γ_i will cause an inward shift in the FOC curve as well. Therefore, $\bar{l}_i$ will decrease. We can also conclude from this that

$$\alpha_\epsilon^{MP} < \alpha_\epsilon^{SP} < 0$$

since for the MP case, there is an additional negative effect from the change in the FOC curve. However, it is ambiguous, on the face of it, as to the sign of the change in $\bar{l}_{-i}$. If we could show that WCC declines more than FOC, then $\beta_\epsilon^{MP} > \beta_\epsilon^{SP} = 0$, the desired result. These differences in sensitivities, own and other, between times when credit is scarce versus when it is abundant rationalize the difference in sensitivities we estimate in the data before and after the Depression begins.

5.2 Implications: Volatility of Establishment and Firm Employment

Related to the implications of the model for sensitivities to own and other shocks, the model has implications for the volatility of firm and establishment-level employment. Because of the non-linear nature of the model, it is not possible to calculate in closed form volatility. At the same time, it is relatively straightforward to simulate the model to understand its implications for volatility. To operationalize the simulations, we make the following assumptions about the joint distribution of the regional demand and credit shocks. First define $\log \gamma = [\log \gamma_1, ..., \log \gamma_N], \log P = [\log P_1, ..., \log P_N]$ as the vectors of local demand and credit conditions. First, we will assume that $\log \gamma, \log P$ are independent of each other. It would be easy to relax this assumption, but we want to focus on the role of geographic correlations in demand or credit conditions rather than the correlation in these separate economic shocks. In addition, we will assume that $\log \gamma, \log P$ are jointly normal with mean 0, common variance, and correlation. So the distributions of credit and demand shocks will be identical by region. To make the comparison "fair," we always set $\gamma^{SP} = \sum_i \frac{p_i}{\sum_i p_i} \gamma_i$ so SP and MP firms are unconstrained or constrained at same time. By setting the credit constraint in this particular way, we ignore possible effects on the variance due to differences in the probability of the firm-level credit constraint binding for MP versus SP firms. This approach to simulating the model also rules out any possible differences in how MP establishments are distributed across space relative to SP establishments, which would lead to difference in the distributions of shocks they face.

With these assumptions, we vary the regional correlation in demand and credit conditions and calculate at the firm-level the volatility in the average of $\log \bar{l}$, in other words, the geometric average of the level of $\bar{l}$. We prefer to use the geometric average since our sensitivities are in terms of $\log \bar{l}$ as well. Figure 8 shows the results of these simulations where we set $\eta = 0.25$. The volatilities are functions of both correlations, but to make it simpler to present, we present slices where we set the correlation of the other shock to 0.5. We report the relative log difference in volatility between MP and SP firms and establishments for

comparison to our regression results. Across both the establishment and firm levels of aggregation, we find that MP establishments and firms are more volatile. These differences are relatively independent of the correlation in demand shocks with differences around 0.4 log points. For the correlation in credit shocks, the volatility differences are decreasing over most of the range in correlations. This is intuitive since differences between MP and SP firms are due to the possibility of cross-subsidizing profitable establishments with negative cashflow. The existence of these opportunities depends on differences in credit conditions across regions. So the more highly correlated demand conditions there are, the fewer opportunities there are for moving resources between establishments and the more MP establishments (and firms) look like SP establishments (and firms).

So why are MP establishments and firms more volatile? The logic for this higher volatility at the establishment level is obvious since employment in MP establishments will be more sensitive to fluctuations in their own conditions than SP establishments as well as being sensitive to fluctuations in other conditions, which by construction do not affect SP establishments. At the level of the firm, there is a certain degree of risk sharing between establishments in response to credit shocks holding fixed any changes in the WCC. The changes in the FOC curve due to shifts in credit further amplify the declines in own employment while dampening the declines in employment for the other establishment. However, it is not possible that this would lead to overall declines in firm volatility relative to SP. On the other hand, for demand shocks, there is no risk sharing but rather co-movement as the firm moves along the upward sloping FOC curve. Taken together this explains why MP firms are more volatile that SP ones.

6 Testing Other Model Implications

6.1 Establishment and Firm 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 multi-plant 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 single-plant operation a multi-plant operation or vice verse where a multi-plant firm refocuses and becomes a single-plant operation. In principle, this would allow for the possibility of identifying the effects of being part of a multi-plant 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 report heteroskedasticity robust standard errors. Clustering at the firm-level produces only minor changes in the standard errors.

Table 9 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.

We now turn to the results at the firm-level with results reported in Table 10. 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.

Finally, we turn to the time series pattern of the multiplant 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.

7 Conclusion

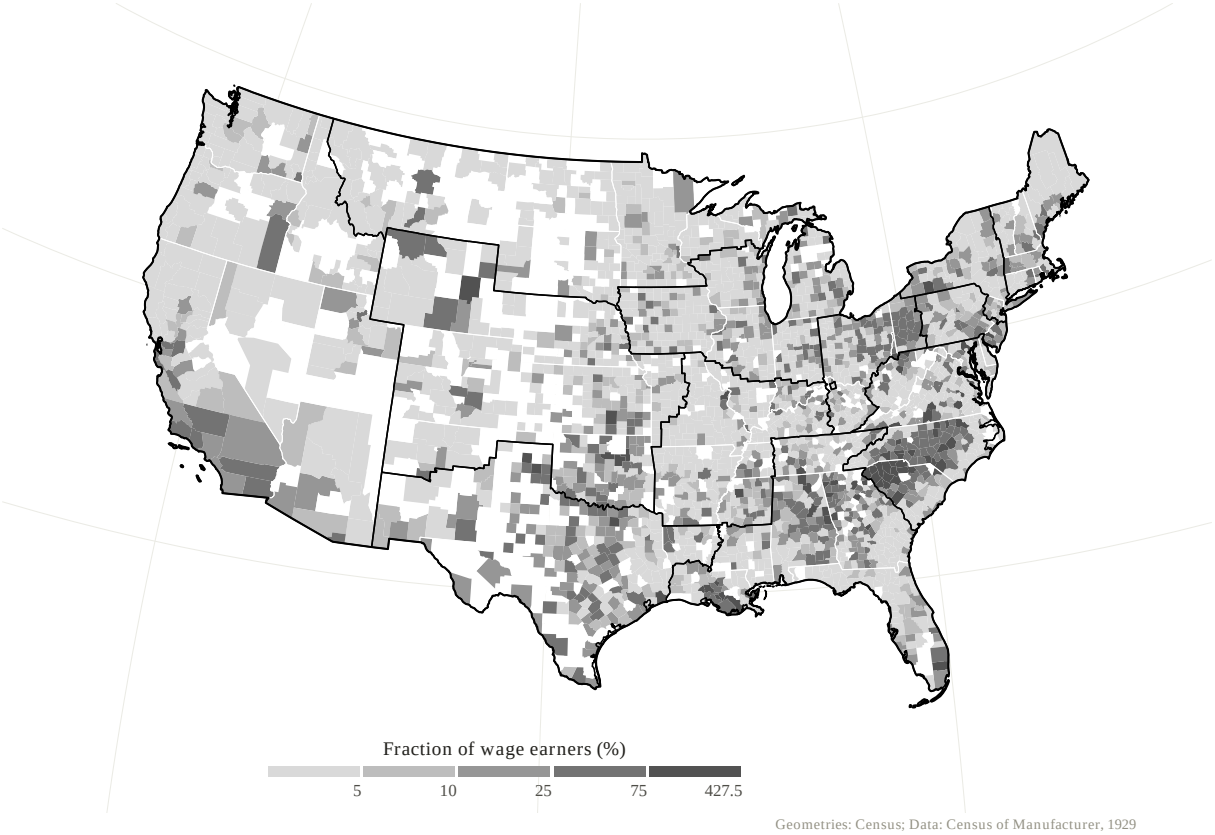
Big firms matter. They matter in particular for business cycle fluctuations. Take the modern case. Many downturns are, in part, driven by declines in automobile production. Yet there are only a handful of auto firms that matter. While the industry was more fragmented in 1937 though the Big 3 still dominated, there is evidence that a shock impacting labor costs in automobile industry 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. At the same time, big firms are not simply small firms scaled up. They different in kind having internal capital markets and incen-

tive problems.

We have addressed part of this question by studying how resources are allocated inside of firms during a time of great stress in external capital markets, the Great Depression. To do this, we collected a 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. We would emphasize again that these results contrast with much of the literature which has strained to find any positive effects from internal capital markets with Matvos and Seru (2014) being the one exception. We also provided some additional specifications that exploited Federal Reserve district boundaries in two separate ways.

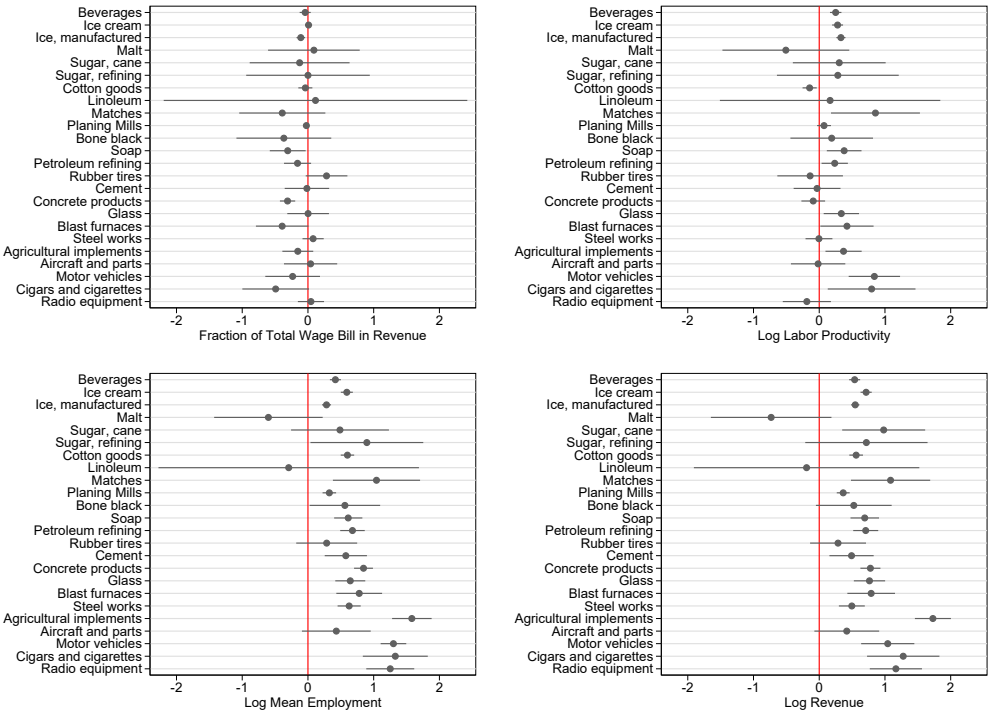
As we noted at the beginning, one salient feature of the Depression was the temporal synchronicity (with some differences) of regions all across the county. Identifying the reason for this synchronicity will provide important insights into the fundamental source of the Great Depression. So for future 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: Percent of Manufacturing Workers Covered by Our Industries



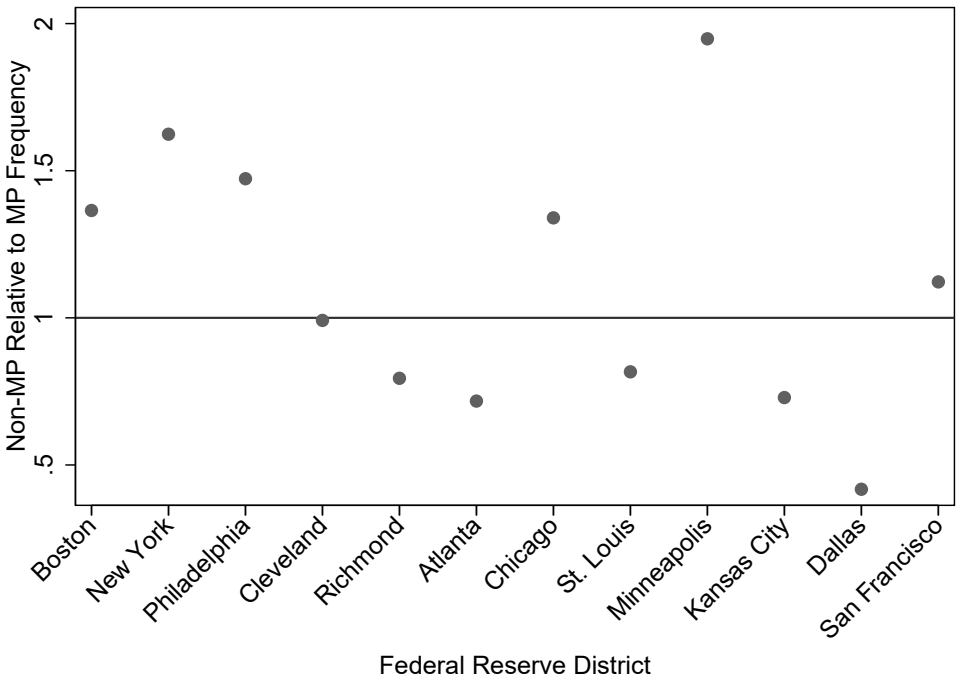
Notes: The percentage here is based on number of workers in the 1930 reporting that they work in manufacturing relative to the employment in our sample of industries for 1929. There are reasons why this percentage could be greater or small than 100%. For example, if a worker lives in a county different 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 2: Comparison of MP to non-MP Establishments in 1929



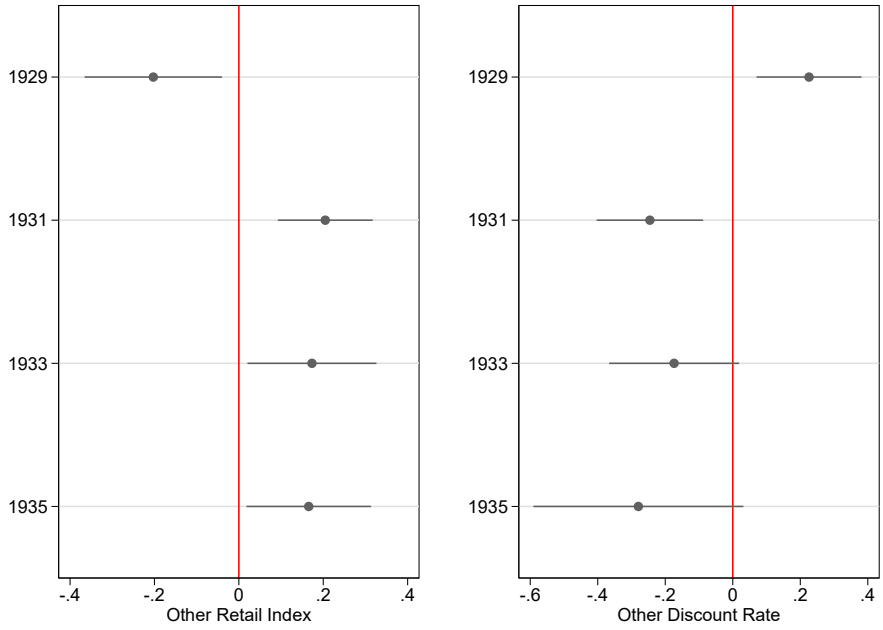
Notes: The table reports the mean difference in the variable between MP and non-MP establishments. All variables besides the labor ratio are in terms of logs. The labor fraction is the ratio of total wage bill to total revenue. Coefficients and standard errors are scaled by the standard deviation of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

Figure 3: MP Status by Federal Reserve District



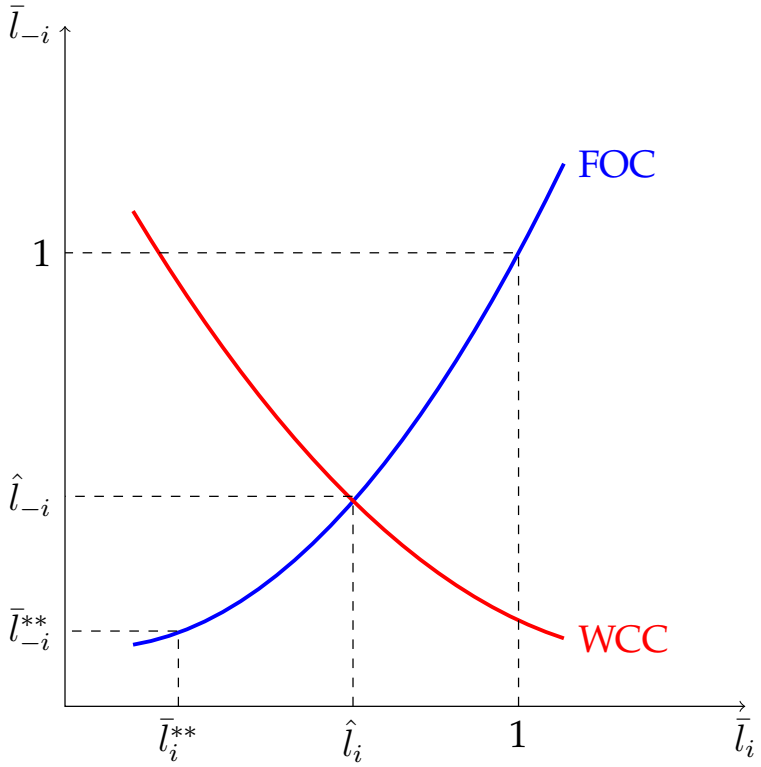
Notes: The relative frequency is the number of MP establishments to non-MP establishments in 1929 scaled by the aggregate ratio of MP to non-MP establishments. So a value of 1 means that the ratio in a given district is equal to the national average.

Figure 4: Sensitivity to Local and "Other" Demand and Credit Conditions by Year



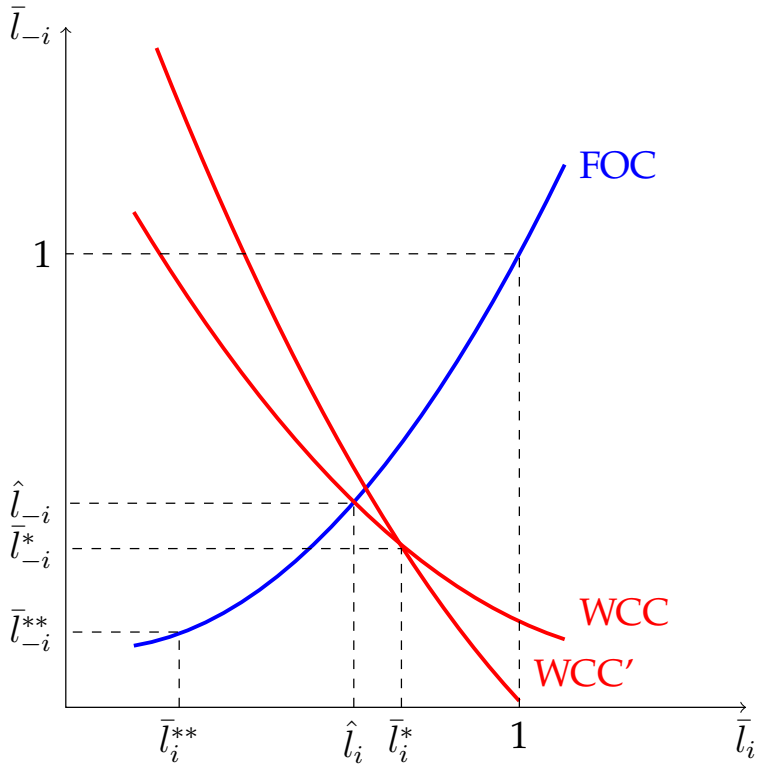
Notes: Regressions include Federal Reserve district fixed effects and industry specific seasonal trends as well as a multiplant indicator. Standard errors are clustered at the firm-level.

Figure 5: Optimal Choices of $\hat{l}_i, \hat{l}_{-i}$ When Credit is Scarce



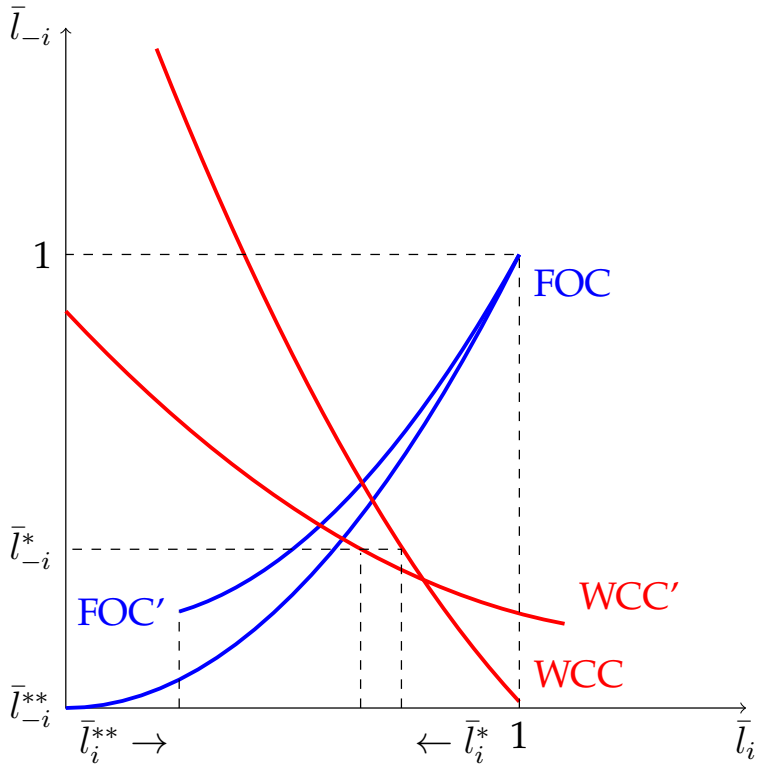
Notes: The solution is determined as the intersection of the WCC and FOC curves.

Figure 6: Comparative Statics of Increase in Relative Demand for Region i



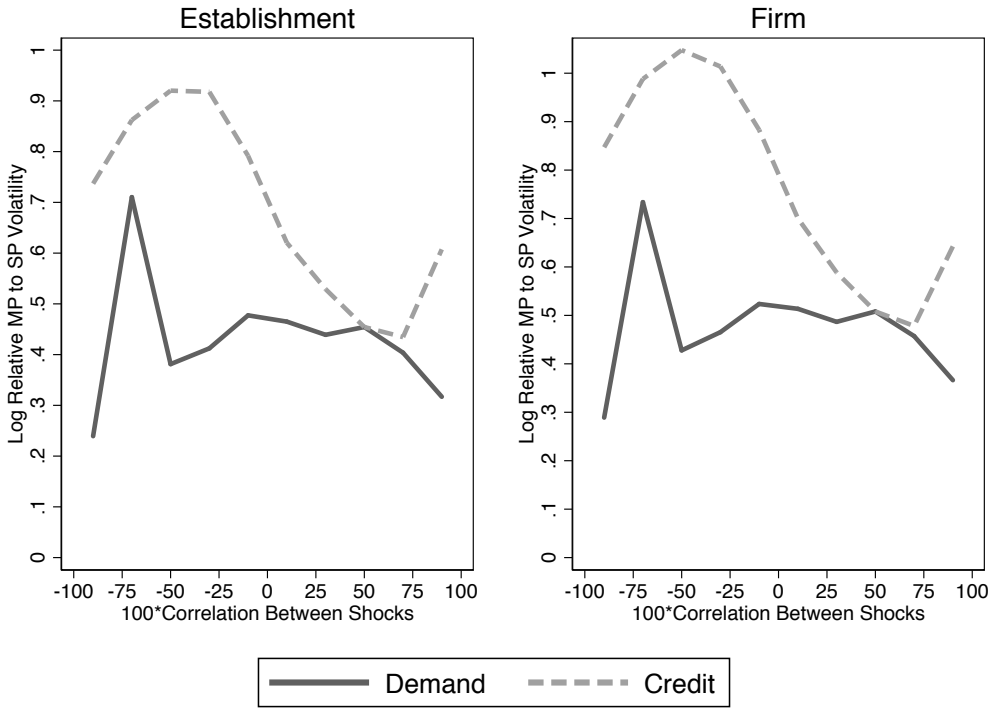
Notes: Establishment i is subsidizing establishment $-i$ at the initial optimal choice. The WCC constraint rotates about the point $(\bar{l}^*_i, \bar{l}^*_{-i})$ where neither establishment generates any cashflow. The FOC curve is independent of demand so it remains fixed.

Figure 7: Comparative Statics of Credit Tightening in Region i



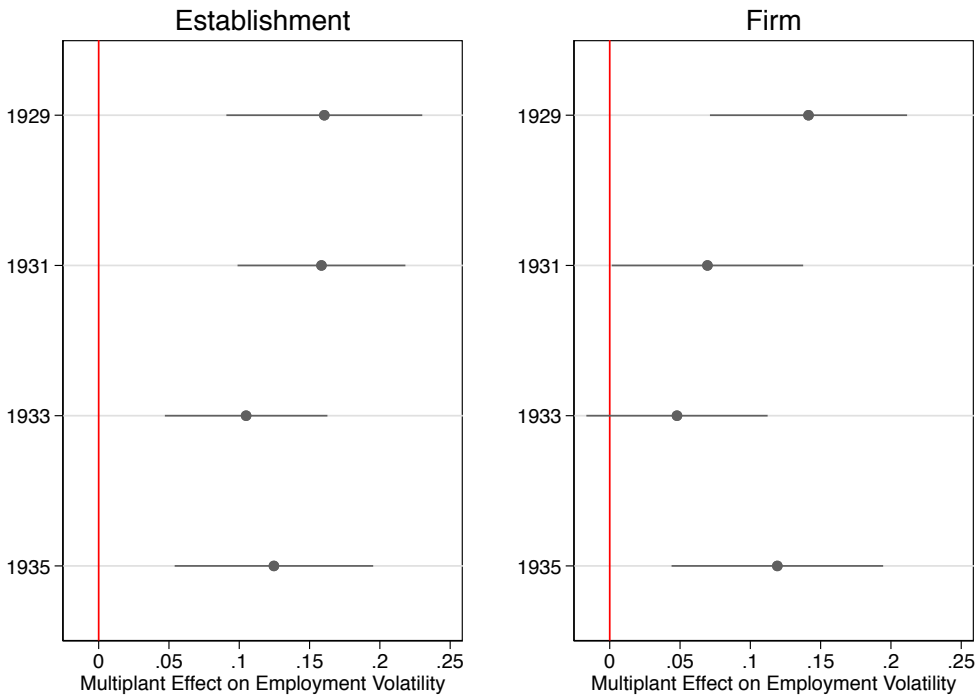
Notes: Establishment i is subsidizing establishment $-i$ at the initial optimal choice. The WCC constraint rotates about the point $\bar{l}^*_i$ where $CF_i(\bar{l}^*_i) = 0$. There are two effects on the FOC curve. First, the domain over which it is defined shrinks since $\bar{l}^{**}_i$ increases. In addition, for all values of $\bar{l}_i$ where both FOC curves are defined, the new FOC curve is higher.

Figure 8: Simulated Firm and Establishment level Volatility Effects by Year



Notes: Let $\log \gamma = [\log \gamma_1, ..., \log \gamma_N], \log P = [\log P_1, ..., \log P_N]$. We assume $\log \gamma, \log P$ are independent of each other. In addition, $\log \gamma, \log P$ are jointly normal with mean 0, common variance 0.2, and a correlation that we vary. We set $\gamma^{SP} = \sum_i \frac{p_i}{\sum_i p_i} \gamma_i$ so SP and MP firms are unconstrained at same time. The figures here are fixing the correlation of the other shock at 0.5. In both cases, we set $\eta = 0.25$.

Figure 9: Estimated Firm and Establishment level Volatility 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.

Table 1: Relative Importance of MP Establishments by Industry

Industry	Fraction in MP of... 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.

Table 2: Coverage of Our Sample

	Percentage of Aggregate Manufacturing	
	Weighted	Unweighted
Total wages	17.062	20.247
Establishments	18.548	10.955
Monthly Employment	15.193	17.505
Value of product	19.448	20.990

Notes: The "Aggregate" column is the share in the national totals for manufacturing. The "Unweighted" column averages the share at the county level equally weighting each county.

Table 3: Sensitivity to Local Demand and Credit Conditions

	Log Wage Earners			
Retail Index	0.311***		0.264***	0.196***
	(0.0213)		(0.0216)	(0.0425)
Discount Rate		-0.0504***	-0.0260***	-0.000326
		(0.00398)	(0.00415)	(0.00966)
MP * Retail Index	0.232***		0.292***	0.293***
	(0.0466)		(0.0484)	(0.0487)
MP * Discount Rate		-0.00536	-0.0325***	-0.0315***
		(0.0107)	(0.0112)	(0.0112)
Multiplant	-0.464**	0.585***	-0.620***	-0.630***
	(0.205)	(0.0535)	(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
N	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. All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends. 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	
Retail Index	0.277***	0.230***
	(0.0212)	(0.0427)
Discount Rate	-0.0268***	0.00200
	(0.00414)	(0.00970)
MP * Retail Index	0.313***	0.311***
	(0.0608)	(0.0610)
MP * Discount Rate	-0.0400***	-0.0394***
	(0.0137)	(0.0138)
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
N	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. All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends. 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	
Retail Index	0.265***	0.199***
	(0.0214)	(0.0426)
Discount Rate	-0.0261***	-0.000703
	(0.00419)	(0.00980)
MP * Retail Index	0.266***	0.266***
	(0.0486)	(0.0488)
MP * Discount Rate	-0.0302*	-0.0272*
	(0.0159)	(0.0158)
Multiplant	-0.627***	-0.640***
	(0.202)	(0.204)
Other Retail Index	0.0443**	0.0469**
	(0.0216)	(0.0217)
Other Discount Rate	-0.00425	-0.00744
	(0.0217)	(0.0218)
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
N	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. All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends. Standard errors are clustered at the firm-level.All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends.

Table 6: Sensitivity to "Other" Conditions: Only MP Establishments

	Log Wage Earners	
Retail Index	0.450***	0.297***
	(0.0479)	(0.100)
Discount Rate	-0.0235**	-0.0283
	(0.0111)	(0.0274)
Other Retail Index	0.0514***	0.0558***
	(0.0189)	(0.0190)
Other Discount Rate	-0.0387*	-0.0446**
	(0.0208)	(0.0205)
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
N	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. All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends. Standard errors are clustered at the firm-level.All regressions include Federal Reserve specific seasonal trends and industry specific seasonal trends.We restrict attention to only establishments that are part of a MP firm.

Table 7: Effects Using Atlanta Region Border Discontinuity: 1929 and 1931

	Log Wage Earners		
Multiplant=0, Atlanta=0, Year=1931	-0.257**	-0.250*	-0.223*
	(0.0941)	(0.0974)	(0.0983)
Multiplant=0, Atlanta=1, Year=1929	0.329	0.825***	0.868***
	(0.263)	(0.171)	(0.0723)
Multiplant=0, Atlanta=1, Year=1931	-0.00867	0.476**	0.542***
	(0.260)	(0.174)	(0.0721)
Multiplant=1, Atlanta=0, Year=1929	0.125	-0.0403	-0.0280
	(0.620)	(0.571)	(0.618)
Multiplant=1, Atlanta=0, Year=1931	-0.794	-0.896*	-1.041**
	(0.405)	(0.377)	(0.355)
Multiplant=1, Atlanta=1, Year=1929	1.581	1.809*	1.746*
	(0.884)	(0.706)	(0.696)
Multiplant=1, Atlanta=1, Year=1931	-0.133	0.216	0.405
	(0.584)	(0.526)	(0.510)
County Demographics	Yes	No	No
State Fixed Effects	Yes	Yes	No
Fed District Fixed Effects	Yes	Yes	Yes
N	1575	1607	1607
$\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$	-0.943	-0.860	-0.890
Wald Test P-value of $\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$	0.013	0.017	0.015

Notes: All regressions include industry fixed effects. Our parameter of interest $\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$ compares "true" MP firms that straddle the boundary to "synthetic" ones created by randomly pairing establishments in the same industry on either side of the boundary. Standard errors are clustered at the firm-level.

Table 8: Effects Using Atlanta Region Border Discontinuity: All Years

	Log Wage Earners		
Multiplant=0, Atlanta=0, Year>1929	-0.0849	-0.0785	-0.0584
	(0.0787)	(0.0806)	(0.0838)
Multiplant=0, Atlanta=1, Year=1929	0.512**	0.909***	0.868***
	(0.190)	(0.156)	(0.0722)
Multiplant=0, Atlanta=1, Year>1929	0.324	0.719***	0.704***
	(0.187)	(0.153)	(0.0631)
Multiplant=1, Atlanta=0, Year=1929	0.0606	-0.0976	-0.0545
	(0.624)	(0.586)	(0.635)
Multiplant=1, Atlanta=0, Year>1929	-0.422	-0.480	-0.720*
	(0.359)	(0.361)	(0.331)
Multiplant=1, Atlanta=1, Year=1929	1.736*	1.895**	1.746*
	(0.849)	(0.702)	(0.695)
Multiplant=1, Atlanta=1, Year>1929	0.488	0.744	0.818
	(0.731)	(0.726)	(0.724)
County Demographics	Yes	No	No
State Fixed Effects	Yes	Yes	No
Fed District Fixed Effects	Yes	Yes	Yes
N	2807	2861	2861
$\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$	-0.659	-0.562	-0.679
Wald Test P-value of $\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$	0.100	0.141	0.085

Notes: All regressions include industry fixed effects. Our parameter of interest $\bar{\beta}^{MP} - \bar{\beta}^{nonMP}$ compares "true" MP firms that straddle the boundary to "synthetic" ones created by randomly pairing establishments in the same industry on either side of the boundary. Standard errors are clustered at the firm-level.

Table 9: 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
N	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.

Table 10: Firm Level Employment Volatility by MP Status

	Standard Deviation of Employment			
Mean Employment	-0.882***	-0.856***	-0.262***	-0.289***
	(0.0940)	(0.0941)	(0.0704)	(0.0701)
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
N	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.

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