Misallocation and Productivity during the Great Depression

Nicolas L. Ziebarth*
Northwestern University

November 23, 2011

Abstract

Aggregate productivity fell by 18% between 1929 and 1933. Existing explanations for this decline have focused on unobserved shifts in factor inputs such as labor hoarding. I develop a new hypothesis that focuses on the role of resource misallocation between heterogeneous plants. Using a novel plant-level dataset, I study two industries: manufactured ice and cement. I decompose the overall change in industry-level productivity into efficient productivity shifts and misallocation as in Hsieh and Klenow (2009). Increases in misallocation between 1929 and 1931 can explain at a minimum 50% of the decline in productivity for cement, around 20% between 1931 and 1933, and 10 to 15% for 1933 to 1935. I estimate that increases in misallocation can explain 50% of the total decline in industry productivity for manufactured ice between 1929 and 1935. In order to explain these findings, I develop a model of financial frictions that relates misallocation to dispersion in working capital interest rates. If banks are unwilling to take on additional leverage to fund the most productive plants, credit becomes misallocated resulting in factor misallocation and lower aggregate productivity. My model therefore explains the empirically observed increase in misallocation through an increase in the marginal cost of leverage. I argue that these empirical and theoretical results provide another role for the non-monetary effects of the banking crisis during the Depression (Bernanke, 1983a): the collapse of aggregate productivity.

1 Introduction

Why did productivity decline so much during the Great Depression? Measured aggregate TFP fell by 18% relative to trend from 1929 to 1933 before beginning to recover in 1935 (See Figure 1). Amaral and MacGee (2002) find a decline closer to 20% when the government and agricultural sectors are excluded. Ohanian (2001) estimates that only 1/3 of the fall can be explained by

*E-mail: nlz@u.northwestern.edu. I thank my dissertation committee members: Joel Mokyr, Jonathan Parker, and Joe Ferrie for detailed comments and for funding part of the data collection. I also received useful feedback from Bob Gordon, Paul Grieco, Josh Hausman, Matthias Kehrig, Erik Loualiche, Ryan Marsh, Giorgio Primiceri, Chris Vickers, Thijs van Rens, and seminar participants at the Northwestern Macro Lunch, Economic History, EHA Annual Meeting, and the NBER Summer Institute DAE. Other portions of the data collection were funded by the Graduate School and the Center for the Study of Industrial Organization. William Creech at the National Archives provided useful information on the data. Stephen Karlson kindly provided some data on the cement industry. Mary Hansen helped organize data collection at the National Archives. Doug Bojack and Joanna Gregson did yeoman's work photographing the original schedules. Dan Thomas was absolutely indispensable. I also thank the Robert Eisner Memorial Fellowship as well as the Sokoloff Fellowship for providing support.

factors such as capacity utilization, factor input quality, labor composition, labor hoarding, and increasing returns to scale. The decline in productivity is even more striking when put in the context of the major innovations being made at this time. To the point, Field (2011) has argued that the Depression was actually a "great leap forward" for the U.S. economy. Bernstein (1987) also documented a number of process innovations in a variety industries made around the same time. These inventions and innovations included Teflon in petrochemicals industries and household items as the radio and refrigerator. These innovations made during the depths of the Depression along with the expansion of the transportation network laid the groundwork for the economic miracle of WWII and the post-war boom. These breakthroughs should have had a positive impact on productivity all else equal. This makes the decline that much more striking and puzzling.[1]

This feature of the Depression is not unique to the U.S. experience. Calvo et al. (2006) find in a broad set of emerging market crises that output collapses and recoveries are associated with collapses and recoveries in TFP much like the U.S. Great Depression. In an even broader set of depressions not just those associated with sudden stops, a similar pattern of sharp productivity declines emerges (Kehoe and Prescott, 2002). In addition to these declines in TFP and output, usually there is an associated deterioration in credit market conditions. What these papers all highlight is that in an accounting sense, understanding depressions is closely tied to understanding the dynamics of aggregate productivity.

This paper makes two contributions to understanding the evolution of productivity during the Great Depression. First in an accounting sense, an increase in the misallocation of resources across production units explains a large fraction of the overall decline. Second, there is theoretical and empirical evidence to believe that this increase in misallocation is driven by the banking crisis and, in particular, the collapse in interbank lending between 1929 and 1933.

To measure misallocation, I build on the methodology used in both the growth (Hsieh and Klenow, 2009) (HK) and business cycle (Chari et al., 2007) literatures that measures deviations from a neoclassical benchmark.[2] The crucial distinction necessary for measuring misallocation is

[1] The seeming disconnect between Field (2011) and Ohanian (2001) is more apparent than real since the time periods they study are slightly asynchronous. Field studies the whole decade of the 1930s while Ohanian focuses on the first half of the 1930s and in fact, notes the remarkably strong productivity growth after 1933.

[2] At the same time, these two strands of the literature have used this framework to different ends. For example, in the business cycle literature, Chari et al. (2002) argue that a "wedge" between the marginal rate of substitution and the real wage during the Great Depression can explain the collapse in employment. In the growth literature, Hsieh and Klenow (2009) have suggested that 30-50% of the differences in TFP between the U.S. and China and India can

the difference between physical productivity $TFPQ$ and revenue productivity $TFPR$, which by definition is equal to $TFPQ * p$, where p is the price a plant charges. The difference is in the units productivity is measured in. The first is in terms of raw output, the second in terms of dollars. An efficient allocation of resources along the intensive margin, taking as given the distribution of $TFPQ$ will equalize $TFPR$ across heterogeneous plants. Therefore, differences in $TFPR$ across plants can be interpreted as a misallocation of resources.[3] In addition to the dispersion in $TFPR$, there are other dimensions of misallocation. For one, I consider the correlation between $TFPR$ and $TFPQ$. Restuccia and Rogerson (2008) emphasize this correlation as particularly deleterious for productivity since when the correlation is positive, the most physically productive firms also face the highest implicit taxes. In a calibrated model similar in spirit to HK, they show that *i.i.d.* dispersion in $TFPR$ across plants does not lead to large losses in productive efficiency, but a strong positive correlation does.

To estimate the empirical relevance of misallocation, I build a novel plant-level dataset from the Census of Manufactures taken in 1929, 1931, 1933 and 1935 of two industries: manufactured ice and cement.[4] These industries have a number of convenient features. First, their products are homogeneous making price and productivity comparisons valid. Second, because I observe a good measure of a plant's capital stock and physical output, I can estimate plant productivity directly. This is important because HK, who do not have output measures, have to lean heavily on a particular demand structure to infer physical output from revenue. Depending on the assumed elasticity of substitution between varieties for cement, an increase in misallocation can explain anywhere between 50% and 100% of the overall decline in productivity between 1929 and 1931. Between 1929 and 1933, increases in misallocation still play a crucial role explaining around 30%. Misallocation continues to be important for changes in productivity in the cement industry explaining between 10 and 20% for 1935. In addition, I find that changes in misallocation can explain between approximately 40 and 60% of the overall decline in industry productivity for the manufactured ice industry between 1929 and 1935. Both measures of misallocation, the dispersion of $TFPR$ and the correlation between $TFPR$ and $TFPQ$, show sharp increases over this time period.[5]

be explained by greater misallocation in the developing countries.

[3] I do not specify whether these differences are related to so-called output, labor, or materials wedges.

[4] I am currently collecting data on a number of other industries including timber and agricultural implements to extend the analysis.

[5] These patterns regarding dispersion and correlation are also present in another industry that I have collected,

My estimates are almost surely a lower bound on the overall effect of misallocation on productivity during the Great Depression since I ignore two potentially large sources of misallocation. First, I do not consider misallocation on the extensive margin of plant entry and exit. Though the empirical results will take into account changes in the distribution of physical productivities across plants, all of those changes will be thought of as efficient.[6] Second, the result will ignore a potentially large source of misallocation *between* industries. If the average productivity between industries changes, resources should flow from unproductive to productive industries. This is a dimension stressed by Bernstein (1987) for the Depression period. Unfortunately, I am unable to address it with my currently limited set of industries.

I stress the role of financial frictions in rationalizing these changes in misallocation and their effects on productivity. Not surprisingly, the literature on the role of financial frictions on business cycles has been strongly influenced by the experience of the Depression. The classic work of Friedman and Schwartz (1971) argued the banking crisis played a major causal role in the collapse of the real economy. However, they assigned a purely monetary role to the wave of bank failures between 1929 and 1933. The work of Bernanke (1983b) was the first to argue that the effect of bank failures was not solely felt through a decline in the money supply but also in more direct ways. In particular, he stressed declines in supply stemming from a loss of informational capital embodied in banks.

Three empirical observations motivate my theoretical focus on financial frictions. First, as predicted by the accounting framework, I find that there is a positive correlation between $TFPR$ and a key factor price, the cost of working capital. I proxy for the cost of working capital with state-level borrowing rates collected by Bodenhorn (1995). This shows that dispersion in lending rates can drive dispersion in $TFPR$. In turn, I document that the dispersion of state-level lending rates showed a sharp increase between 1929 and 1933 followed by a decline between 1933 to 1935. This timing exactly matched the changes in productivity and misallocation. At a time of more or less unit banking, the interbank market was crucial for moderating regional differences in lending rates. So the third observation reemphasizes the well-known fact that the interbank market for funds collapsed between 1929 and 1933. Taken together, these facts show the causal chain from

the macaroni industry. Results here are only for labor productivity since the data lack a capital measure.

[6] An extension of the model I develop endogenizes the dispersion in physical productivity in plants.

banking to real outcomes I attempt to capture in my formal model.

In my model, banks face a convex cost of taking on more leverage. I motivate this sort of friction through an adverse selection problem in the interbank market (Kurlat, 2011). The interbank market treats banks with large funding needs skeptically because of worries that the bank is trying to sell lemons. Because of this, banks with the highest funding requirements face a higher cost of funds, or equivalently, banks *ex ante* face a strictly convex cost of taking on leverage. Banks fund working capital loans to plants who have to borrow upfront to purchase inputs. In an efficient allocation of resources, the distribution of bank leverage ratios "matches" the distribution of plant productivities. Banks with good opportunities should be highly leveraged and those without opportunities should fund the good banks. The friction that limits bank leverage leads to differences in working capital interest rates and, hence, limits the amount of reallocation from unproductive to productive plants. This in turn generates dispersion in $TFPR$, a positive correlation between $TFPR$ and $TFPQ$, and an inefficiently low level of productivity.

The shock that I emphasize is one to the marginal cost of leverage stemming from an increase in the adverse selection problem.[7] When adverse selection problems worsen, the convexity in the leverage cost function increases. This leads resources to become stuck in areas where demand is relatively low or with plants that are relatively physically unproductive. The shock leads to a flattening of the distribution of leverage ratios across banks. In addition, dispersion in working capital interest rates rises thereby increasing dispersion in $TFPR$. Moreover, the correlation between $TFPR$ and $TFPQ$ increases as the higher cost of leverage falls most severely on the most productive plants. This generates an endogenous decline in productivity. Note that this mechanism does not emphasize changes in the *overall* leverage ratio of the financial sector nor the amount of bank capital *per se*. These actually have no effect on dispersion and productivity. Instead the relevant summary statistic for the health of the banking sector as it affects productivity is the dispersion of leverage ratios across financial firms and the dispersion of plant borrowing rates echoing Gilchrist and Zakrajsek (2011).[8]

I present a variety of empirical evidence to support the particular shock I focus on. One piece of

[7] Leverage can be thought of as total assets divided by equity. More precisely for the commercial banks I focus on, leverage is assets divided by equity plus deposits. This is more in line with my theory.

[8] Though this latter measure does not summarize the correlation between the rates and the productivity of the plants that pay them.

evidence comes from aggregate banking data. Figure 2 displays the dynamics of leverage, capital, and the standard deviation of leverage ratios across states.[9] In line with my theory, the changes in the standard deviation of leverage ratios across states very closely match those for aggregate productivity. It declines sharply starting in 1929 and then recovers quickly starting around 1933. Other measures such as total bank capital or the overall leverage ratio of the banking sector do not correlate with the changes in productivity. Instead they struggle to match the decline and recovery in productivity.

Besides this testable implication based on banking data, my theory also predicts that during the time when the interbank markets are shut down, real outcomes should be more closely related to local banking variables. I offer evidence that state-level banking leverage is positively correlated with $TFPR$ during the crisis years but is uncorrelated in the others. As a second piece of cross-sectional support, I find that regional dummies explain more of the variation in $TFPR$ in 1931 relative to 1929 and 1935. A final piece of evidence comes from a comparison to the Canadian experience during the Depression. The declines in output were very similar in both countries, but the fall in productivity is much less severe in Canada. A crucial difference between the depressions in these countries is that there is no banking crisis in Canada. Furthermore, the Canadian banking system had extensive branching, insulating resource flows from the vagaries of interbank markets.

The focus of my model is quite distinct from the classic work by Bernanke (1983b) and almost all subsequent work on financial frictions and the real economy. The papers in this literature have tended to focus on the role played by banks in funding long-term investments (and potentially consumer durable purchases). A central insight of these models was that small changes in the level of bank capital could have large effects on investment through constraints on leverage due to limited commitment and moral hazard problems. This view of how financial frictions matter has led people to solely focus on anomalous moves in investment as evidence for financial frictions. For example, Carlstrom and Fuerst (1997) show that the classic financial frictions model of Bernanke and Gertler (1989) can be written as the standard neoclassical growth model with a time-varying "tax" on investment. In that model, there is no impact of financial frictions on productivity.

This irrelevance of financial frictions for anything but investment has been taken to the extreme

[9] The data is taken from Comptroller of the Currency (1937). This is the finest level of disaggregation for comprehensive bank data that exists.

by Chari et al. (2007). They argue that since the neoclassical growth model can rationalize the fall in investment during the Depression, financial frictions and the banking collapse did not matter for the Depression. My paper shows that this conclusion is too hastily drawn. In conjunction with the theoretical work of Kurlat (2011) and Buera and Moll (2011), my results highlight another role for the non-monetary effects of the banking crisis during the Depression: the decline in aggregate productivity.

The paper proceeds as follows. The next section lays out the accounting framework that I employ in measuring the contribution of misallocation to productivity changes. Section 3 discusses the data source and the industries that I study. I then discuss the empirical implementation in section 4. Section 5 reports the empirical impact of misallocation. Then I build a model and sketch out its implications in section 6 to explain these patterns. Section 7 offers some evidence for predictions of that model. I conclude in section 8. Appendices collect some robustness checks for the empirical results, various extensions of the model, and a calibration exercise.

2 An Accounting Framework

To estimate the role of misallocation on industry productivity, I build on the accounting framework of HK. Industry output is a Dixit-Stiglitz aggregator of differentiated output from a continuum of plants

$$Y = \left(\int_0^1 Y_i^{\frac{\psi-1}{\psi}} di \right)^{\frac{\psi}{\psi-1}}$$

Plant i operates a constant returns to scale production function.[10]

$$Y_i = A_i L_i^{\gamma_L} M_i^{\gamma_M} K_i^{1-\gamma_L-\gamma_M}$$

I include materials and energy M_i as a third factor of production for consistency with my empirical work. The plant solves

$$\max_{L_i, K_i, M_i} p_i Y_i - (1+\tau_i)(wL_i - rK_i - p_M M_i)$$

[10] It is also possible to posit a decreasing returns to scale production function as proposed in Lucas Jr. (1978) and used in Restuccia and Rogerson (2008) and Sandleris and Wright (2010). It is possible then to dispense with the differentiated products setup. The inverse of the returns to scale parameter would play a similar role to ψ in my setting.

subject to its demand curve. The term τ_i is a "wedge" that distorts the outcome from the efficient one. One can think of it as an abstract tax that increases the costs of a plant's inputs. For exposition, I consider the case with only one wedge. It is possible to consider separate wedges on the different factors of production. These different wedges would then distort the plant's relative choice between, say, capital and labor. The wedge I consider simply affects the scale of operations.

This wedge is taken as given from the point of the view of the plant. HK and others such as Restuccia and Rogerson (2008) think of these wedges as generated by government policies that restrict entry or favor certain enterprises, say. For now, I remain agnostic on where the wedges come from and prefer that they be thought of as purely an accounting device. Eventually I will offer evidence that the wedge is driven in part by working capital interest rates. My model will emphasize differences in these borrowing rates as a key source of misallocation during the Depression.

HK building on Foster et al. (2008) stress the difference between $TFPR$, which is productivity in terms of revenue and A, which is physical productivity (also known as $TFPQ$). The two are linked by the identity

$$TFPR_i = p_i A_i$$

With this demand structure, the only reason $TFPR$ should vary across plants is due to wedges.[11]

It is important to understand why a frictionless market should have no variation in $TFPR$. The answer comes from the fact that for a monopolistically competitive plant facing a constant elasticity (CES) demand curve, the elasticity of price with respect to productivity is -1. So plants with higher productivity perfectly offset that productivity advantage by charge lower prices thereby leaving fixed $TFPR$. In particular,

$$TFPR_i \propto 1 + \tau_i$$

To emphasize, I am solely interested in dispersion in $TFPR$ since it is the relevant statistic for productivity losses. This is why I study the single wedge case here. That being said, it is potentially

[11] Note that I could just as well interpret differences across plants in terms of relative demand shocks instead of physical productivity. Assume instead that final output is given by

$$Y = \left(\int_0^1 (Z_i Y_i)^{\frac{\psi-1}{\psi}} \right)^{\frac{\psi}{\psi-1}}$$

where Z_i can be interpreted as a demand shock for variety i. This setup will be isomorphic to my model with differences in productivity A_i across plants.

important to consider more wedges as way to to identify the fundamental source of misallocation. Dispersion in $TFPR$ driven by labor wedges points to possibly a very different source than dispersion driven by capital wedges. Note that a particularly simple interpretation of differences in revenue productivity is that plant's face different factor prices. In particular, the framework shows that plants facing higher factor prices will have higher $TFPR$.

Now let $L = \int_0^1 L_i di, M = \int_0^1 M_i di, K = \int_0^1 K_i di$. Then it is straightforward to show that measured industry TFP is given by

$$TFP = \frac{Y}{L^{\gamma_L} M^{\gamma_M} K^{1-\gamma_L-\gamma_M}} = \left[\int_0^1 \left(A_i \frac{\overline{TFPR}}{TFPR_i} \right)^{\psi-1} di \right]^{\frac{1}{\psi-1}} \tag{1}$$

where $\overline{TFPR}$ is the geometric mean of plant-level $TFPR$ given by

$$\overline{TFPR} = \frac{\psi}{\psi-1} \left[\frac{r}{(1-\gamma_L-\gamma_M) \int_0^1 \frac{1}{1+\tau_i} \frac{P_i Y_i}{PY} di} \right]^{1-\gamma_L-\gamma_M} \left[\frac{p_M}{\gamma_M \int_0^1 \frac{1}{1+\tau_i} \frac{P_i Y_i}{PY} di} \right]^{\gamma_M} \left[\frac{w}{\gamma_L \int_0^1 \frac{1}{1+\tau_i} \frac{P_i Y_i}{PY} di} \right]^{\gamma_L}$$

To understand how they impact overall productivity, it is useful to develop a particular version of equation 1.

Proposition 2.1 *Assume that $A_i, TFPR_i$ are jointly log normal with means $\log A, \mu_R$, variances σ_A^2, σ_R^2 and correlation ρ_{QR}, then*

$$\log TFP = \log TFP^* - \frac{\psi}{2}\sigma_R^2 - (\psi-1)\rho_{QR}\sigma_A\sigma_R \tag{2}$$

where $\log TFP^* = \left[E A_i^{\psi-1} \right]^{\frac{1}{\psi-1}}$.

Equation 2 provides a straightforward decomposition of changes in productivity into changes in measures of misallocation.[12] It identifies separately two key sources of efficiency losses: changes in the variance of $TFPR$ and the correlation between $TFPR$ and $TFPQ$.

The first term $\log TFP^*$ can be thought of as the efficient level of industry TFP taking as given the distribution of plant physical productivities. To build intuition, the first term can further be

[12] It is useful to step back and compare this to other decompositions in the literature, e.g. Foster et al. (2008); Petrin et al. (2011). Those works have all written down accounting identities that decompose changes in productivity into broadly speaking within-plant changes and between-plant changes. The main interest there was in quantifying which of these terms dominated. While worthy exercises, those papers were not able to address the question of in what sense these shifts can be thought of as efficient since they all lacked a benchmark model.

written as

$$\left[\mathrm{E}A_i^{\psi-1}\right]^{\frac{1}{\psi-1}} = \log A + \frac{\psi-1}{2}\sigma_A^2$$

Here $\log A$ captures a "pure" technology shock that affects the mean of the productivity distribution. In reality, $\log A$ can also capture changes in the average plant productivity due to say labor hoarding. It will also capture any "cleansing effects" on the extensive margin of the Depression whereby the least physically productive plants are driven out (Caballero and Hammour, 1994). This selection process will also presumably have effects on the distribution of physical productivity, σ_A. My measure of the efficient level of productivity will incorporate all of these changes along the extensive margin. In the context of the model though, I will only focus on misallocation along the intensive margin treating the distribution of physical productivities as exogenous.

The comparative static for σ_A is on the face of it counterintuitive. Why should a more dispersed distribution of productivities increase overall productivity? The key to understanding this is to remember that industry TFP is *not the arithmetic mean but a generalized geometric mean* of the plant-level physical productivities. The generalized geometric mean is not invariant to arithmetic mean preserving spreads. In fact, because $\psi > 1$, the generalized mean upweights high productivity plants relative to low productivity ones. So a geometric mean preserving spread in the distribution of plant productivities increases industry-level productivity. The term σ_R works in exactly the opposite way as any variation in $TFPR$ about the industry mean is a loss in efficiency as emphasized by HK.[13] Finally, the term $\rho_{QR}\sigma_A\sigma_R$ is the dimension of misallocation stressed by Restuccia and Rogerson (2008). A higher correlation leads to greater efficiency losses all else equal because more productive plants face higher wedges on average.

It may seem that this particular approach to measuring misallocation is very dependent on the CES demand structure with the implication that the markup is constant across time and plants. What if instead markups are in fact countercyclical (Floetotto and Jaimovich, 2008)? To the extent, that movements in the markups are common across plants over the Depression, then this complication should not materially affect my results. Recall that misallocation is a concept closely tied to the cross-sectional properties of plant productivities. Common shocks be they to markups, technology, or demand should not affect the dispersion in the cross-section. Hence, countercyclical

[13] Though do note that a 1% increase in $TFPR$ does not necessarily have the same magnitude of an effect as 1% decrease in $TFPQ$ since they are multiplied by different coefficients.

markups will show up in the mean $TFPR$ over all the plants in the industry but will not affect inference on what role misallocation plays in productivity.

Common shocks affecting pricing decisions of the plant will not affect my inferences. But what if, for example, the true pricing model was more "exotic" such as a limit pricing model where the most productive plant charges a price just below what the second most productive plant charges? In this setting, there is no real sense in which shocks will be common. So under this assumption, to what extent are my results still valid? To begin addressing this worry, note that the pricing structure plays a two roles for HK. First, they use the demand structure to infer physical productivity of each individual plant. In their data, they do not observe physical output. Instead with an assumed value of ψ, they invert revenue to back out physical output and then measure $TFPQ$. It is clear that in the limiting pricing example, the method HK use could go astray. If the most productive plant is charging a price that only depends the productivity on the next most productive plant, then the inferred level of $TFPQ$ from $TFPR$ should has almost nothing to do with its own productivity and everything to do with its nearest competitor. As I discuss below, I have direct measures of physical output so I do not need to rely on the demand structure. Therefore, misspecification in the pricing structure does not affect my physical productivity estimates.

The second use of this pricing structure is in aggregating across individual plant productivities into industry productivity. In particular, it delivers an aggregation result that depends solely on a structural parameter. In addressing this use of the pricing structure, it is important to emphasize that even under the limit pricing case, there are gains in productivity to be had if resources were reallocated from low to high $TFPR$ plants. If a social planner operated both the final technology and all of the intermediate plants, the planner would choose optimally to equalize $TFPR$ taking as given the distribution of $TFPQ$. This is the sense in which dispersion in $TFPR$ is generically a sign of misallocation. The question is how those efficiency losses are translated into aggregate industry productivity. Returning again to the limit pricing case, clearly it will not be possible to aggregate along similar lines since the parameter ψ has no meaning in terms of pricing in this case. Still the social planner logic suggests that it is always define industry productivity relative to the efficient level where $TFPR$ is equalized across all plants. In this sense, equation 1 can be thought of more generally than the CES case I consider. It is simply necessary in this more general setting to no longer treat ψ as a structural parameter, but rather as a reduced form parameter that is an

amalgam of not only demand factors but some potentially non-constant function of the true pricing structure. This is the sense in which the formulation is more general than the CES case.

One final note is that this model only features *within* industry misallocation nor *between* industry misallocation. This will parallel my empirical work which will just focus on within industry misallocation. With data for a broader set of industries, it is trivial to extend this model to study aggregate productivity. Note that while the overall mean level of $TFPR$, μ_R, does not affect a given industry's TFP, it does in fact impact the industry's output. Industries that face higher than average mean $TFPR$ receive lower levels of resources in the form of a smaller total workforce and less capital. So in an aggregate model with many different industries, variation in *industry* level $TFPR$ would lead to losses in *aggregate* TFP as well. Bernstein (1987) has argued that for the Depression, much of the misallocation is between industries rather than within. He goes on to suggest that the sluggish movement of resources from slowly growing ones to rapidly growing ones explains the overall slow recovery from the Depression.

3 Data

The data used for this paper come from the Census of Manufactures (CoM) collected by the Census Bureau in one form or another since 1810. Yet after the 1880 Census, there has been little work done with plant-level returns from the CoM. The reason for this is that it had been assumed that the underlying schedules for the intervening years were destroyed. The 1890 population schedules along with the manufacturing schedules were lost to a fire.[14] The other years of the Census of Manufactures through 1950 were destroyed by an act of Congress in order to conserve space at the National Archives. While there are no regular procedures in place to preserve the underlying schedules once tabulations have been made, the Bureau of Economic Analysis has an ongoing large scale project to link the schedules from 1950 onwards (Nucci, 1998). This modern data has been used in a number of studies on a variety of different topics, e.g. Davis and Haltiwanger (1990) on labor markets and Kehrig (2011) on plant productivity among many others.

For reasons unknown, the schedules for 1929, 1931, 1933, and 1935,[15] the first half of the Great

[14]The story is a bit more complicated with only about 25% of the schedules totally destroyed. The other 75% were lost due to bureaucratic neglect.

[15]There can be a bit of confusion with the dating of the censuses. The year convention I will use refers to the year the data are meant to cover. The Archives usually employs a convention where the year refers to the year in

Depression, were kept and are housed at the National Archives.[16] Over these 4 censuses, there are close to 750,000 schedules with a wide variety of questions. These include revenue broken down by price (unit value) and quantity, total wage bill, cost of intermediate goods, and number of wage earners employed at a monthly frequency. There is other information about whether the plant is incorporated (if unincorporated, who the owner is) and whether the plant has moved or changed names in the last year. A major limitation of the data is that there are no specific questions about assets or liabilities. The modern census and even its 19th century counterpart have a question about the value of capital invested. However, for the Depression censuses, there are only questions related to the specific type of capital employed in a given industry. For example, bakery firms are asked the number of bread slicing machines and ovens. An example of the front page of a schedule is in Figure 3.

An important question when working with this data is coverage and quality. Raff (1998) argues the coverage is quite good. In my experience, I have discovered some missing schedules most likely related to misplacement by the Archives. For example, returns for the ice industry in 1931 in Texas seem to be missing. The bigger question is how the Census was conducted. The 1931 Census had to be organized on a tight schedule with a limited budget. The 1933 Census was a work relief project. It is not improbable that plants were missed. In other work (Chicu and Ziebarth, 2011), I have compared the Census records to other sources for the cement industry. In that work, we cross-checked not only the numbers from the schedules to other independent sources but to the published Census tables themselves. The tabulations from the schedules lined up remarkably well. First, it appears that at least for the cement industry, all of the schedules that the Census tabulated in creating the published tables are at the Archives. Second, in comparison to independent trade publication sources on revenue and physical output, the Census values differ by only plus or minus a few percent in any given year. Of course, cement is an industry that should be measured well by the Census. Cement is not a large industry in terms of the number of plants (around 160 plants per year) and all of the plants are quite massive and immobile making them hard to miss. Still I take some encouragement from these considerations.

which the data are collected, which is one year subsequent. For example, the data in the 1929 census cover things that occurred in calendar year 1929, while the data was collected during the calendar year 1930. The Archives is not altogether consistent in how they record the years.

[16] For years 1929 and 1935, the schedules are on microfilm while 1931 and 1933 are on paper. These are in Record Group 29, Entries 307, 307-A, 309, 309-A.

The plant-level data have been used previously in limited contexts. Bresnahan and Raff (1991) and Bertin et al. (1996) study two separate industries: automobiles and blast furnaces. They are particularly interested in how plant heterogeneity evolves over the Depression, a related topic. Foss (1981) created a representative sample of 9000 firms from 1929 to examine the length of the workweek.[17] Some recent work using the data includes my own work: Ziebarth (2011) and Vickers and Ziebarth (2011). The first studies the effects of the banking crisis that enveloped Mississippi while the latter examines the question of collusion under the National Recovery Administration's "Codes of Fair Conduct." To be sure, the published tables–sometimes disaggregated to the county-level–have been used in a number of works. Rosenbloom and Sundstrom (1999) were the first to transcribe the tables at the state-industry level before and after the Depression.

3.1 Industry backgrounds

3.1.1 Manufactured ice

The manufactured ice industry consisting of over 5000 plants spread across the country produced an important consumer staple.[18] While refrigerators were growing ever more popular with penetration rates rapidly rising throughout the Depression, the main way people still cooled their perishable goods was through ice boxes stocked with manufactured ice. How ice was manufactured at the time is almost no different than how a modern refrigerator makes ice. There are a few useful features of the industry. First, the Census in each year asked a question about the capacity of the plant's compressors, which do the serious work of compressing the coolant. This gives a very good capital stock measure though it does exclude capital in the form of structures and other equipment. Second, the production process is very simple with a minimal number of homogeneous inputs consisting of water, ammonia, and salt. This makes it unlikely that differences in technologies across plants are driving the misallocation results. Third, there is very little product differentiation between the types of ice produced. What is surely the most important source of product differentiation is spatial differentiation. [19]

[17] I have been unable to track down any extant copies of this data.

[18] Currently, my sample only includes the following states: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Massachusetts, Michigan, Mississippi, New Mexico, Oklahoma. The images for the remaining states have been collected just not digitized yet.

[19] There are two other minor sources of differentiation. A first source is in the size of the finished product. Can ice was sold to households in smaller portions while plate ice made of large chunks of ice was mainly used in cold storage

3.1.2 Cement

Portland cement, often known by its shorthand as "cement," was an important industry at the time supplying a crucial input for building structures and roads. The cement industry is a convenient industry to study for several reasons similar to ice.[20] Most important for this work is that the product is essentially homogeneous, so that for a buyer the identity of the plant offering the product is of limited relevance. Another useful feature like ice is that spatial differentiation is the key source of product differentiation. Portland cement is both relatively cheap to produce and particularly heavy. For this reason, shipping costs are a nontrivial component of cement prices, and it is uneconomical to ship cement long distances. Thus, for any given plant, its practical market lies within a relatively short distance – commonly cited to be within 200 miles, and often less.

For this industry's capital measure, production capacities were transcribed from exhibits that formed a major part of an anti-trust case against the industry in 1941 (*Cement Institute v. U.S.*).[21] These capacities have been cross-checked against the Pit and Quarry Handbook, which among other things contains a directory of all cement plants in any given year and has capacities for a subset of the plants. For the cases where capacities were reported in both, the correspondence between the directory and the FTC sources is quite good.

4 Empirical Setup

I calculate $\log TFPR, \log TFPQ$ for the ice and cement industries as

$$\log TFPQ_i = \log y_i - \gamma_L \log L_i - \gamma_M \log M_i - (1 - \gamma_L - \gamma_M) \log K_i$$

$$\log TFPR_i = \log p_i y_i - \gamma_L \log L_i - \gamma_M \log M_i - (1 - \gamma_L - \gamma_M) \log K_i$$

facilities. This dimension is observed in the data as the Census asks for production totals of each type. In actuality, very few of the firms in my dataset report producing plate ice.

One other dimension of product differentiation is between raw and distilled ice. The original process for making ice required distilled water. By the 1930s, this had been replaced by processes that could produce ice using "raw" or tap water. Very few firms in my sample are actually producing distilled ice for the obvious reason that distilling water is an expensive process. Moreover, when the vast majority of this ice is being used for cooling food or people, it does not really matter what kind of water the ice is made from. An ice box does not know whether or not the ice is made from raw or distilled water. Even if the ice was used to cool drinks, the quality advantage for distilled ice is trivial.

[20] Dumez and Jeunematre (2000) provide a comprehensive overview of the economic characteristics of the Portland cement industry.

[21] Stephen Karlson transcribed these capacities from the originals and graciously shared the data.

where y_i is physical output, $y_i p_i$ is revenue, L_i is wage earners, M_i is cost of total materials and energy used, and K_i is the capital measures discussed above. The term M_i is meant to at least partially control for differences in capacity utilization through variation in electricity use. The census has an hours worked variable that is unfortunately missing for 1933, which is why I focus on a specification with only number of wage earners as the labor measure.

I follow Basu and Fernald (1997) in specifying the production function in terms of gross output.[22] The question then is how to estimate the production elasticities. There is of course a large literature on estimating production functions e.g., Marschak and Andrews (1944), Griliches (1957), Olley and Pakes (1996), and Levinsohn and Petrin (2003). I employ a cost shares type method. Though a number of caveats apply, variants of this approach have been standard since Solow (1957). The complication relative to the standard case is that I do not observe total costs. So I rely on the fact that costs should be a constant multiple of revenue along with an assumption similar to HK that profits are distributed pro-rata to each of the factors. The assumption about distribution of profits is important. If instead all profits accrued to capital, then my estimates would be biased. With this assumption, the labor elasticity γ_L can be calculated as the fraction of total wage bill to revenue, similarly for materials, and $\gamma_K = 1 - \gamma_L - \gamma_M$ as the residual. To estimate the industry-specific production elasticities, I average across all plants and years. This estimation method will be consistent with my theoretical specification to the extent that the working capital constraint I will impose affects each factor of production equally.

One point to note is that M_i is in nominal terms. There does not appear to exist a suitable price deflator for this variable. A similar issue faces Sandleris and Wright (2010) and they choose to simply not deflate the variable. I make the same assumption so any changes in the price of these inputs will show up as shifts in aggregate productivity. It again is important to emphasize that this will not affect differences in productivity between plants. It will be useful to keep the possible scale of this bias in the overall productivity trends in mind. For reference, the overall price level falls by around 15% from 1929 to 1931 and then by another 7% from 1931 to 1935. Given an estimated materials share of around 1/2 and assuming that the prices of inputs track the general price index, then the growth of both $TFPQ$ and $TFPR$ will be overestimated by 7.5% from 1929 to 1931 and

[22] I have also experimented with a production function that only includes capital and labor as factors of production and specifies output as real value added where revenue is deflated by a plant's own price.

by an additional 3.5% from 1931 to 1935.

Besides lacking a deflator for materials inputs, an additional limitation is that I lack information on non-production workers. In 1929, 1933, and 1935, there is information about salaries paid for non-production workers. In principle, this piece of information would allow me to impute a labor input variable that included both types of workers along the lines of Baily et al. (1992) or Davis and Haltiwanger (1990). The problem is that I would have to drop 1931 since I have no information on salaries in that year. However, comparing the ratio of total salaries to total wages over the three years with data, I find little change in the mean ratio. Therefore, I simply assume that total workers (wage earners and salaried), which is equal to my labor input measure, are a constant multiple of total wage earners. I also inflate the total wage bill by the same multiple when I calculate production elasticities.

Finally, to reduce measurement error, I trim the 2% tails of the distribution for $TFPR, TFPQ$ then recalculate production elasticities and plant productivities. This is a slightly broader cut than the 1% trim than HK. Also, I eliminate any plants that report less than 50% of their revenue from the industry's primary product. An appendix collects a number of robustness checks with regards to the empirical results. These checks include varying the percentage of the tails trimmed, different specifications for output, and using hours worked for the limited years that I have.

Define

$$\log \widetilde{TFPQ}_t = \frac{1}{N} \sum_i \log TFPQ_{it}$$

$$\log \widetilde{TFPR}_t = \frac{1}{N} \sum_i \log TFPR_{it}$$

Then $\log \widetilde{TFPQ}_t$ will be my estimate of the $\log A_t$ term. Let $\widehat{TFPR}_{it}, \widehat{TFPQ}_{st}$ denote the deviations of the log plant value from the industry-year log average. The standard deviation of these deviations are my estimates of σ_{At}, σ_{Rt}. I also calculate the correlation between the deviations for a given year and industry, ρ_{QRt}. In an appendix, I show that these deviations from industry averages are correlated with exit decisions suggesting that these differences are economically meaningful and not simply measurement error.[23]

[23] They also display similar levels of autocorrelation to modern estimates also suggesting at least no greater degree of measurement error relative to modern data.

My estimate of the efficient level of productivity is given by

$$\log TFP^* = \frac{1}{\psi - 1} \log \left(\frac{1}{N} \sum_i TFPQ_{it}^{\psi-1} \right)$$

where I replace the integral by an average. Note I do not impose log normality in calculating the role of misallocation. To calculate the efficient level of productivity, I need to set a value for the elasticity of demand ψ. For "illustrative" purposes, I will choose a value of $\psi = 4$ in line with HK. I will also show how the fraction of the productivity declines explained by misallocation vary as ψ changes over a reasonable range of values from the literature (Hendel and Nevo, 2006). As emphasized above, one does not have to think about ψ structurally but instead as representing different *ad hoc* assumptions about how to aggregate plant productivities without having to specify the pricing structure.

5 Results

Before turning to the results, it is important to emphasize that in reporting the role of misallocation in productivity changes, I am deliberately not accounting for labor hoarding and changes in the composition of the labor force that can bias productivity measurements. I am solely interested in the difference between changes in the overall industry productivity and the efficient level. Changes in the efficient level, at least due to shifts in the mean, may be due to the usual explanations given for procyclical productivity. I take no particular stand on the quantitative role of those factors except to assume that they do not explain the total decline in productivity leaving a fraction to be explained. Of course, to fully resolve the productivity puzzle during the Depression will involve both of these channels.

Besides not accounting for these unobservable shifts, I will intentionally exaggerate the decline in productivity because of data limitations. Specifically, a major part of explaining the sharp mean productivity decline in my data is that my productivity estimates do not include hours worked, which fall sharply over the course of the Depression. However, the extent to which the declines in hours worked are similar across plants, *this omission should not bias the results focusing on cross-sectional differences and, if anything, bias downwards the contribution of misallocation.*

Previewing the results, I find that increases in misallocation in the cement industry can explain between 50% and the total fall in productivity between 1929 and 1931. The fraction explained between 1929 and 1933 is slightly lower though a still sizable fraction around 25%. For 1935, depending on the value ψ, the fraction explained is between 10 and 20%. For manufactured ice, an increase in misallocation can potentially explain 50% of the decline in productivity between 1929 and 1935.

I find that both sources of misallocation σ_R, ρ_{RQ} play important roles in the overall dynamics. For both industries, ρ_{RQ} shows a steady increase over the whole period. On the other hand, σ_R displays a countercyclical pattern. I also offer some evidence from the macaroni industry. I do not attempt to measure industry productivity because I lack a capital measure. Instead I show that the patterns in revenue and physical *labor* productivity[24] closely match those for the other industries with countercyclical patterns in σ_R and an increase in ρ_{RQ}.

5.1 Industry productivity and shifts in plant-level productivity averages

Figure 4 displays for the cement industry three productivity measures: industry, efficient, and mean plant-productivity. Almost the complete fall in productivity between 1929 and 1931 is explained by misallocation with very little movement in the efficient level though the mean plant-level productivity does fall. This suggests that there are important shifts in the dispersion of physical productivity offsetting the decline in plant-level productivity.

Figure 6 shows how the fraction of the observed productivity decline can be explained by increases in misallocation varies with ψ. Note that whether or not this fraction is increasing or not depends on the relative sizes of $\sigma_A, \sigma_R, \rho_{QR}$. The reason is that ψ not only changes the losses from misallocation but also the efficient level of productivity. Higher values of ψ make misallocation more costly all else equal, but they also make dispersion in σ_A more valuable for industry productivity. Changes in misallocation play a substantial role for all the years over a wide range of values for ψ. As noted above, depending on the value of ψ for 1931, misallocation can potentially explain the total decline in industry productivity. At a minimum, misallocation explains 50% of the decline. The fraction of decline between 1929 and 1933 averages around 20 to 30%, an economically meaningful. The smallest fraction is consistently in 1935 where this fraction hovers around 15% over the range

[24] This is not simply log output minus log labor input. Instead I weight the labor input by its cost share.

of ψ considered.

This disconnect between industry-level aggregates and plant-level means does not appear to be unique to the cement industry. Figure 5 displays the changes in industry productivity, the efficient level of productivity, and the mean productivity across plants for ice.[25] I find that industry productivity rises slightly from 1929 to 1931 and then plummets sharply from 1931 to 1935. The initial increase might seem puzzling given all of the discussion about how productivity drops during the Depression. Part of the explanation for this is that materials inputs are not deflated almost surely overestimating productivity growth in both years. However, after 1931, productivity collapses. Note that there is no data point for 1933 because the Census did not ask firms to report their capital stocks in that year. I would hazard to guess that it would show an even sharper decline in productivity before the slight recovery in 1935.

What is clear from Figure 5 is the the large decline in industry productivity between 1929 and 1935 cannot be explained by changes in the mean plant-level productivity nor changes in the efficient level of productivity. To be sure, for 1929 and 1931, the fact that industry productivity increases more than the efficient level implies less misallocation of resources. It is important to emphasize that this is a very small change in productivity and I prefer to interpret the first two years as showing no change. Figure 7 shows the fraction of productivity changes explained by misallocation changes as a function ofψ. First, declines in misallocation can play a major role in the slight increase in productivity between 1929 and 1931. However, over the whole period from 1929 to 1935, for a wide range of values for ψ, changes in misallocation explain nearly as much as changes in the efficient level of productivity. For some perspective, it is useful to compare there results to those in Sandleris and Wright (2010). They study the 2001 crisis in Argentina and attempt a similar accounting exercise. They quantify the loss on TFP from greater misallocation across and between sectors at 10% of the total decline. My results for these industries suggest much higher losses from misallocation during the Great Depression.

5.2 Shifts in misallocation measures

I now turn to the different sources of misallocation: dispersion in $TPFR$ and the correlation between $TFPR$ and $TFPQ$.. Note that these results do not depend on a particular choice of ψ.

[25] Recall that this is an example where $\psi = 4$.

In Figure 8, I display the statistics for cement. From 1929 to 1931, both the correlation and the standard deviation of $TFPR$ increase sharply[26] and then fall back slightly from 1931 to 1935. The standard deviation of physical productivity increases only slightly to begin with and then increases substantially from 1931 to 1935. These results closely match the dynamics in the interbank market, which will play a central role in the theory that I develop. Even at the end of the sample, both of these measures of misallocation are substantially elevated from the pre-Depression level while the dispersion in physical productivity is back to its to original value suggesting some persistence in the initial shock.

Figure 9 displays the dynamics of the standard deviation of $TFPR$, $TFPQ$, and the correlation between the two for the ice industry. There is a decline from 1929 to 1931 in the standard deviation of $TFPR$ while the same measure for $TFPQ$ rises. This contributes to the better allocation of resources in this industry over the first two years of the Depression. Subsequently, the dispersion in both variables increases with the dispersion in $TFPR$ well above its 1929 value. During the whole period, the correlation shows a steady rise increasing by 10 percentage points by 1935 signaling an increase in misallocation on this dimension. These results show that both of these dimensions of misallocation play a role in explaining productivity dynamics and misallocation for this industry.

I have also collected some evidence on the macaroni industry. Because the data do not contain good capital stock measures, I restrict attention to labor productivity and do not attempt to decompose TFP shifts into efficient shifts and those due to misallocation.[27] Instead I use the data to document the general patterns in the dispersion of revenue and physical productivity as well as the correlation between the two. Figure 10 shows that dispersion in labor productivity revenue increases in 1931 and then falls back in 1935.[28] Finally, there is a sharp increase and then a meager decline in the correlation between these two types of productivity over the remaining years. These

[26] In the appendix, I consider a potential worry about the effect of measurement error on ρ_{RQ} over time.

[27] The macaroni industry includes all kinds of dried pasta from spaghetti to egg noodles though the vast majority of the firms only produce macaroni. The industry was mainly concentrated in a few states in particular New York and California. While there is some degree of differentiation between the firms, the quality differences are not large enough to make quantity comparisons across firms meaningless. Alexander (1997). argues, at this time, the industry contained three main types of producers: small mom-and-pop operations that sold locally and large, industrial concerns that shipped nationally, and a middle tier of regional producers. The large firms used large scale production processes that made them much more efficient than the small producers. Hence, as Alexander points out, this created a major disparity in the costs of production. Both the regional producers and the mom and pop stores were at a major cost disadvantage to the large producers though at least the smallest stores could attempt to differentiate their product.

[28] Due to data limitations, I exclude 1933 from the analysis.

results serve to reinforce the patterns regarding changes in misallocation measures documented for the other two industries.

As an aside, it is interesting to note that the pattern in $TFPR$ dispersion is *not* the same for dispersion in $TFPQ$. Modern work by Kehrig (2011) and Bloom et al. (2011) has found strongly countercyclical revenue productivity dispersion, but these authors have had to remain silent about what that meant for physical productivity. As emphasized by Foster et al. (2008), selection in markets is on $TFPR$ not $TFPQ$. What actually matters is not whether a plant is physically productive but productive in terms of revenue. So there is no necessary reason why the two should move together and in fact for my limited set of industries, they do not. These differences matter for how changes in dispersion measures potentially drive productivity over the business cycle.

6 A Model of Financial Frictions and Productivity

> *"As the crisis of 1929-33 ha[s] proved, the [interbank] system has contributed to intensify cyclical maladjustments."* Palyi (1939)

6.1 Empirical Motivation

The obvious next question is what drives these changes in misallocation. I offer three related facts that motivate the model I build, which prominently features financial frictions. First, the accounting framework showed that variation in factor prices induces variation in $TFPR$. In particular, higher factor prices should be associated with higher $TFPR$. One potential source of variation in $TFPR$ is variation in the costs of working capital used to fund wage and materials bills. Ideally, I would have plant-level information about whether the interest rates faced by the plants. Unfortunately, the most disaggregated data on lending rates is at the state-level from Bodenhorn (1995). Table 1 shows the results of regressing the deviation of $TFPR$ from its industry-year average on state lending rates. I control for the deviation of a plant's wage from the industry-year average, which is potentially another large source of variation in $TFPR$.[29] The results show a clear positive relationship between state-level interest rates and $TFPR$. A one percentage point increase in the lending rate in the preferred specification increases $TFPR$ by .026 percentage points. Relative to

[29] I construct the average wage by dividing total wage bill by a constructed total hours measure for 1929, 1931, and 1935.

the effect of wages, the effect of interest rates is a bit more than one fifth. This is a non-trivial amount when one considers how imperfect of a proxy these state-level rates are for the "true" rates faced by the plant.

Second, this regression implies that the dynamics of the dispersion of borrowing rates induce similar dynamics in the dispersion of $TFPR$. In fact, there is some evidence that the dynamics of the dispersion of interest rates track those of misallocation. Figure 15 shows a sharp increase in the dispersion of lending rates measured both by the standard deviation, interquartile range, and 90-10 range. These changes are not driven by outliers in 1933 as I have trimmed the high and low observations for each year. This pattern is also present with the higher frequency though less geographically representative data in Smiley (1981). Furthermore, spreads between Baa bond yields and the Treasuries increased by more than 400 basis points between 1929 and the peak in 1933 (Calomiris, 1993). By way of comparison, the spread between Baa and Aaa industrial bonds during the most recent criss only increased by 200 basis points (Gilchrist and Zakrajsek, 2011).[30] To be clear, regional variation in lending rates is only one source of variation in lending rates. I focus on it because it is the easiest to observe though it seems possible that variation across plant sizes and industries also played an important role as well.

What drives these changes in the dispersion of lending rates is the behavior of the interbank markets. This is period of U.S. economic history when branching was severely restricted. There was no interstate branching and in the majority of states, banks could not open up other branches even within the state. The lack of branching made banks very dependent on functioning interbank markets to fund liquidity shortfalls. With branching, resources can move at least relatively freely between branches of the same bank. Without branching, banks have to rely on anonymous interbank markets for liquidity. Plants in the real economy, of course, are able to mitigate these breakdowns in bank funding to the extent that they form a part of a multi-plant plant with plants spread across the country. Still as late as the Depression, some authors such as Bodenhorn (1995) have argued that the U.S. did not have a fully integrated capital market. Even on the eve of the Depression, geographically-concentrated agricultural shocks had a tendency to lead to a weakening

[30]Note that this is comparison is not altogether clear. There is reason to believe that the measure for the most recent crisis is an underestimate of the increase in the spread over Treasuries. Moreover, these spreads are not exactly the same as spreads in working capital interest rates across different regions. At a minimum though, if there was little movement in these spreads, it would be difficult to argue that spreads on working capital interest rates increased sharply over the same period of time.

of financial conditions in that region as the drought set off a spiral of declining income and bank capital (Landon-Lane et al., 2011). Of course, each region was not completely on its own especially after the creation of the Federal Reserve system, which allowed for flows between the reserve banks. Below the level of the reserve banks, an integral part of interbank markets were so-called correspondent networks. Crucial to these networks were eponymous correspondent banks located in certain reserve cities that discounted paper provided by small, local banks who were not members of the Federal Reserve system. The correspondent banks then turned around and rediscounted this paper at the relevant regional Fed. Writing at the time, Palyi (1939) aptly summarized the tight link between unit banking and the correspondent networks.

> Unit banking as it exists in this country cannot be maintained unless an institutional setup is provided to keep the units in close contact with the money market...Unless we develop a similar system, which has never existed in this country, we have to rely on correspondent relationships as the only other alternative to permit the survival of unit banking, which would soon deteriorate without contact with the "fresh air" of the open money market.

This system of correspondents allowed small local banks the opportunity to tap a broader set of funds. The ability to tap this broader pool was crucial in mitigating differences in borrowing rates across regions.

The final observation motivating my model is the collapse of part of the interbank market driven by cascading failures through these correspondent networks. Richardson (2007) highlighted the fragility of the correspondent system at this time. Correspondent banks would credit checks upon receipt, and respondent banks would do so as soon as the check was dropped in the mail before the funds were ever drawn from the check-writing bank. Because checks usually passed through at least two banks before finally being cleared, this process led to a build up of fictitious reserves throughout the chain of correspondences. These reserves made the system very fragile and subject to contagion. Using archival evidence, Richardson (2007) showed that a large fraction of bank suspensions during 1931 were due to failures of correspondent banks. These failures in the correspondent networks translate into declines in gross flows in the interbank market. This is despite the fact that demand for these short-term funds was very high as the country was swept by panicked depositors looking for their cash. In 1933, the total amount of interbank deposits for all Federal Reserve member banks reached a low point of $3.4 billion in June of 1933, a decline of 23%

from its peak. After the nadir, interbank deposits rapidly regained their pre-Depression highs by the end of 1934. These three observations regarding the link between $TFPR$ and lending rates, the dispersion of lending rates, and the collapse of interbank markets highlight the chain of reasoning that I will attempt to capture in my theoretical model.

6.2 Plants

I now present a simple static model to explain the losses in productivity due to misallocation stemming from financial frictions exacerbated by the banking collapse. The model focuses on the role that banks play in reallocating resources from unproductive to productive firms. It points to a particular shock to banks, an increase in the marginal cost of leverage, as the culprit for the decline and part of the recovery in productivity. When it becomes more costly for banks to obtain funds through the interbank market, resources become "stuck" in unproductive locations and productivity suffers.

There is a continuum of geographically separated regions ("islands") and on each island, there is a continuum of plants.[31] On island i, all plants are the same and produce variety i. Final output is a Dixit-Stiglitz aggregator of all the types

$$Y = \left[\int_0^1 y_i^{\frac{\psi-1}{\psi}} di \right]^{\frac{\psi}{\psi-1}}$$

For now, I will take final demand Y as exogenous. Plants operate a linear production technology in labor alone

$$y_i = A_i L_i$$

It would not be difficult to extend the analysis to a constant returns to scale production function that included other factors of production. However, since my empirical analysis focuses solely on $TFPR$, my theoretical focus will similarly abstract from possibly different wedges on the different factors of production. At the beginning of the period, each island receives a productivity draw A_i

[31] There is a slight complication here. Because I will require a plant to obtain credit from a bank on its own island, to insure that price taking of interest rates is a reasonable assumption, I need many plants on a given island. The issue with this assumption is that it then makes the assumption of monopolistic competition suspect. To justify this assumption rigorously, I would have to add another layer of product differentiation within a given island. To ease exposition, I assume this issue away.

from a log normal distribution with mean 0 and variance σ_A^2. Shocks are *i.i.d.* across islands and independent over time as well.

Plants have a working capital constraint that requires them to borrow up front to pay their wage bill, e.g., Christiano et al. (2005); Barth and Ramey (2001); Christiano et al. (2010). Working capital constraints have also been emphasized by the literature examining sudden stops in emerging markets as a potential key source of amplification (Neumeyer and Perri, 2005). Plants can fund that wage bill by borrowing from *only* banks on their own island at gross rate r_{fi}.[32] Hence, they maximize

$$p_i y_i - r_{fi} w L_i$$

where they face demand curve derived from the profit maximization problem of the final goods producer,

$$\frac{p_i}{P} = \left(\frac{y_i}{Y}\right)^{\frac{-1}{\psi}}$$

and the production function $y_i = A_i L_i$.

This assumption about the local nature of plant finance is very natural and in part motivated Bernanke (1983b) to argue for the presence of non-monetary effects of bank failures. Banks in his view embodied information about the quality of various local projects. When a bank fails, its unique information is destroyed and only slowly over time is it built back up again. In the meantime, plants with profitable projects have to make due with limited access to credit. Since Bernanke's pioneering work, the local connection between plants and banks in the Depression has been stressed by a number of papers. Calomiris and Mason (2003) document a positive relation between changes in building permits and deposit growth over the period of 1930 and 1932. Some of my own work (Ziebarth, 2011) has found a connection between local bank failures and economic outcomes using an "exogenous" banking crisis.

The optimal choice of labor solves

$$r_{fi} w = Y^{\frac{1}{\psi}} \left(\frac{\psi - 1}{\psi}\right) A_i^{\frac{\psi-1}{\psi}} L_i^{-\frac{1}{\psi}} \tag{3}$$

[32] An interesting extension would be to allow multiple factors of production with differences in the pledgability of the different inputs. In particular, one might think that it is easier to use materials purchased with a loan as collateral than labor inputs. In this case, there might be a wedge between the rates a plant can borrow for materials versus labor. Shocks to the financial shock may then have asymmetric effects on the different interest rates and generate different dynamics for labor versus materials wedges.

where I have normalized the final price index P to 1 without loss of generality. Dividing the optimal choices for firms on island i, j yields an expression useful for later

$$\frac{r_{fi}}{r_{fj}} = \left(\frac{A_i}{A_j}\right)^{\frac{\psi-1}{\psi}} \left(\frac{L_i}{L_j}\right)^{-\frac{1}{\psi}} \tag{4}$$

which shows that the ratio of labor use across islands is related to the ratio of both productivities and interest rates across islands. Now I calculate $TFPR_i$ as

$$TFPR_i \equiv p_i A_i = A_i \left(\frac{y_i}{Y}\right)^{-\frac{1}{\psi}} = \frac{w r_{fi}}{Y^{\frac{1}{\psi}} \left(\frac{\psi-1}{\psi}\right)}$$

This implies that ratio of $TFPR$ for any pair of islands i, j is given by

$$\frac{TFPR_i}{TFPR_j} = \frac{r_{fi}}{r_{fj}}$$

Plants on islands with higher interest rates have higher levels of $TFPR$ reflecting the fact that they are constrained from fully expanding output to the efficient scale.[33] In fact,

$$\sigma_R = \frac{w}{Y^{\frac{1}{\sigma}} \left(\frac{\sigma-1}{\sigma}\right)} \sigma_{r_f}$$

where σ_{r_f} denotes the standard deviation of (log) working capital interest rates. Therefore, any shock that increases the interest rate spread on working capital loans will increase the dispersion of $TFPR$. This is not a surprising finding as r_{fi} is a direct analog of $1 + \tau_i$ in the accounting framework. The idea that measures of dispersion in $TFPR$ are closely related to dispersion in borrowing costs is similar in spirit to Gilchrist and Zakrajsek (2011). I now turn to the banking sector to close the model and determine the working capital interest rates.

6.3 Banks

There is a continuum of banks on each island. Abstracting from differences across the island, each bank starts out with net worth N. To finance working capital loans H_i, banks use their net worth

[33] Note that this model abstracts from credit rationing in the sense that certain firms are not simply excluded from the credit market. An extension I consider allows for some firms to be shut out of the market.

and interbank loans b_i ($b_i \geq 0$ implies a bank is borrowing funds). The assumption that commercial banks are mainly in the business of short term loans is in line with much of the evidence from the time. White (2000) notes that commercial banks by "law and tradition" specialized in short term loans to fund materials and labor outlays. This was distinct from the role played by investment banks in facilitating long-term investment. Of course, the collapse of investment banks play a potentially major role in explaining the precipitous decline in investment and consumer durable purchases. However, I will abstract from that separate question for now to focus on this particular type of intermediation.[34]

So the flow of funds constraint is given by

$$H_i = b_i + N$$

As noted above, banks can only fund projects on their own island and can only obtain additional funds from other banks through the interbank market at r_b. This assumption is motivated by an important feature of the banking system, which is its highly localized nature due to regulatory constraints on branching.

I will focus on a particular financial friction stemming from adverse selection in the interbank market due to a lemons problem. In particular, banks will have private information about the return of the projects they can invest in. Stiglitz and Weiss (1981) were the first to study this friction in the context of private information about the riskiness of a project. In that model, all projects had the same expected return. They showed that in this setting, credit might be rationed as higher interest rates would not increase the expected profitability of a loan. Instead it would draw a riskier pool of firms applying for funding. The broader idea of adverse selection and moral hazard motivated the analysis of the historical record on financial crises by Mishkin (1991). Kurlat (2011) has studied a model of adverse selection with private information about the return of a project rather than its riskiness. He shows that with sufficiently severe shocks, financial markets shutdown and the most productive entrepreneurs are unable to invest.

There is a whole laundry list of possible financial frictions that have been considered. For

[34] Another main source of funding for commercial banks is deposits. In an extension, I consider a deposits choice by the households. However, in the context of that extension, they play a role no different than capital. So for the time being, one could just as easily think about N as combining both of these sources of funding. To be sure, deposits are callable and they may be an important source of funding needs through the interbank market.

example, banks could face an incentive problem where the market limits their leverage because of fears that the bank will abscond with assets (Gertler and Kiyotaki, 2010). Limitations on leverage can also be motivated by problems due to costly state verification (Bernanke et al., 1999) or margin value-at-risk requirements (Brunnermeier and Pedersen, 2009). Brunnermeier et al. (2011) provide an extensive survey of the rich literature on what makes banks special.

To solve the model in closed form, I will assume that the adverse selection problem translates into a particular reduced form expression for interbank borrowing. In an appendix, I more carefully lay out the logic of this friction and how it affects intebank borrowing. In particular, I assume that

$$\frac{b_i}{N} = \frac{r_{fi} - r_b}{\omega}$$

where ω is the marginal cost of leverage. This expression implies that a particular bank's leverage is a smooth increasing function of the differential between the rate it can charge firms on its island and its borrowing costs from the interbank market. One can think about this as a first order approximation to the bank's profit maximization problem given some general function Ω for the cost of leverage about $b_i = 0$. There is an interesting limiting case where the credit market imperfections disappear. If $\omega \to 0$, then $r_{fi} \to r_b$ for all i and there is no dispersion in $TFPR$ across islands. In this limiting case, banks can take advantage of any arbitrage opportunity by leveraging up with no cost. Hence, there cannot be any interest rate differentials across islands.[35]

I will approximate the solution around a particular level of productivity $\bar{A}$ such that if $A_i \leq \bar{A}$, banks on those island will be net interbank lenders and vice versa. For $A_i = \bar{A}$, then it must be the case that

$$r_{fi} = r_b$$

Setting $b_i = N - wL_i$ to 0 pins down the productivity cutoff $\bar{A}$

$$N = w\bar{L} = w^{1-\psi} L \bar{A}^{\psi-1} r_b^{-\psi}$$

[35]Note that there is another constraint on the choice set which is that $b_i \geq -N$, i.e. banks cannot lend out more in the interbank market than they have in capital. This is a potentially binding constraint for banks on very unproductive islands. However, because the marginal product of labor goes to ∞ as the use of labor goes to 0, in equilibrium, it will never be optimal for banks to exceed this interbank lending constraint.

where $\bar{L}$ is labor demand for this type of plant.

6.4 Market clearing

Loan market clearing implies that the total amount of working capital loans on a given island has to be equal to the amount of bank net worth on the island plus interbank borrowing.

$$wL_i = N + b_i \Rightarrow wL_i = N\left(1 + \frac{r_{fi} - r_b}{\omega}\right) \tag{5}$$

This relationship delivers a positive relationship between plant borrowing rates and total wage bill taking everything else as given. *Ceteris paribus* more productive firms pay higher interest rates, a slightly counterintuitive result. If the quality of plants were with regards to the risks of bankruptcy, then intuition would suggest that the lower quality plants with a higher probability of failure would face higher working capital interest rates to compensate banks for the risk. However, in this model as in Gertler and Kiyotaki (2010) with a quasi-fixed supply of loans and no internal supply of funds, more productive plants have a higher demand for loans, and, hence they must pay higher interest rates.

Interbank clearing requires that

$$\int_0^\infty b_i dF(\log A_i) = 0$$

Subbing for the expression for optimal interbank lending,

$$\int_0^\infty N\left(\frac{r_{fi} - r_b}{\omega}\right) dF(\log A_i) = 0 \tag{6}$$

where F is the cdf of the normal distribution function with mean 0 and standard deviation σ. Then I have

Proposition 6.1 *$\tilde{r}_f = r_b$ where $\tilde{r}_f = \int_0^\infty r_{fi} dF(\log A_i)$ is the average working capital interest rate.*

It is useful to note here that this model will generate a distribution of leverage ratios across banks though the overall banking sector will not be leveraged. The lack of overall leverage follows from the aggregate loan market clearing constraint. Again this assumption can be relaxed in a richer

model where banks can also raise funds through the retail deposit market before the productivity shocks are realized.

Equation 5 will be the key equation since it pins down the relationship between r_{fi} and A_i. Using the labor demand expression to solve for wL_i,

$$w^{1-\psi} L A_i^{\psi-1} r_{fi}^{-\psi} = N\left(1 + \frac{r_{fi} - r_b}{\omega}\right)$$

Denote the implicit relationship between r_{fi} and A_i by $r_{fi} = g(A_i)$. It is useful to note that g is a strictly increasing function as demand for loans is strictly increased in A_i. Differentiating with respect to A_i, I have

$$\frac{\partial \log r_{fi}}{\partial \log A_i} = \frac{\psi - 1}{\psi + \frac{w^{\psi-1}N}{L\omega} A_i^{1-\psi} r_{fi}^{\psi+1}} \tag{7}$$

Therefore,

Proposition 6.2 *To a first order approximation about* $\log A_i = \log \bar{A}$, $\log R_{fi}$ *will also be normally distributed with mean* $\log R_b$ *and variance*

$$\sigma_R = \sigma_A \cdot \rho_{QR}$$

This first-order approximation also implies that

$$\rho_{QR} = \left.\frac{\partial \log r_{fi}}{\partial \log A_i}\right|_{\log A_i = \log \bar{A}} = \frac{\psi - 1}{\frac{N r_b}{\omega} + \psi}$$

The expression shows that as frictions in the interbank market go to 0 i.e. $\omega \to 0$, then the standard deviation of $TFPR$ goes to 0 along with the correlation between the $TFPR$ and $TFPQ$. To reiterate in the case where banks are not punished for being highly leveraged, any differences in plant borrowing costs must be arbitraged away. Therefore, there is no variation in plant borrowing costs and the correlation between working capital interest rates and productivity must be 0.

The model here is slightly counterfactual as it draws a very tight one-to-one link between σ_R and ρ_{QR} though it is clear from the data that the relationship is not nearly so simple. This tight link depends on the fact that σ_A is taken as exogenous. Any log-linear approximation will have this problem as both ρ_{QR} and σ_R are linear functions of the derivative of relationship between R_{fi} and

A_i. A richer model is discussed in the appendix with entry and exit driving variation in σ_A, which opens up the possibility for different dynamics of ρ_{QR} and σ_R. Also, my approximation ignores non-linear behavior in the tails of the productivity distribution brought on by the fact that leverage scales with the *difference* between r_{fi} and r_b rather than the *ratio* of r_{fi} to r_b.

To solve the model, note that aggregating loan market clearing across all islands along with interbank clearing implies $w = \frac{N}{L}$ and labor clearing will be trivially satisfied. Then I simply need to solve for $r_b, \bar{A}$ to fully characterize the equilibrium. Under my approximation, I have that

$$\log r_{fi} = \log r_b + \rho_{QR}(\log A_i - \log \bar{A})$$

Recall that

$$\tilde{r}_f = \int_0^\infty r_{fi} d\Phi(\log A_i) = r_b \tag{8}$$

Substituting my expression for $\log r_{fi}$ into equation 8, I find that

Proposition 6.3 *The values of $\bar{A}, r_b$ are determined by the intersection of the following two curves*

$$\log \bar{A} = \frac{1}{2} \frac{\sigma_A^2(\psi - 1)}{\frac{N r_b}{\omega} + \psi} \tag{9}$$

$$\log \bar{A} = \frac{\psi}{\psi - 1} \log r_b N - \frac{\psi}{\psi - 1} \log L \tag{10}$$

where the second equation is a rewritten expression for the cutoff $\bar{A}$.[36]

These equations characterize equilibrium in the interbank market. Equation 9 determines a negative relationship between r_b and $\bar{A}$. An increase in r_b implies a higher supply of interbank loans from banks with marginal products. This leads to a lower productivity threshold as marginal firms are able to take advantage of the increased supply. Equation 10 on the other hand determines a positive relationship between the two. When r_b increases, this increases the threshold productivity since only relatively more productive firms are able to compensate banks for foregoing higher returns in the interbank market. Note that both equations only depend on the product of the interbank rate and bank capital, $r_b N$. Therefore,

Proposition 6.4 *Shocks to N do not affect the distribution of $TFPR$ nor TFP.*

[36] Note that the cutoff $\bar{A}$ is a direct function of ρ_{QR}, $\log \bar{A} = \frac{1}{2}\sigma_A^2 \rho_{QR}$.

Decreases in N are completely compensated by increases in r_b and vice versa. It is also clear from this that a shift in the overall leverage ratio of the financial sector does not play a role. In fact for my setup, this ratio is fixed to a value of 1.

Under the linear approximation, calculating the effects on productivity is trivial since as beforeI have

$$\log TFP = \log TFP^* - \frac{\psi}{2}\sigma_R^2 - \rho_{QR}(\psi - 1)\sigma_Q\sigma_R$$

It is clear that a shock to ω only affects equation 9 shifting it rightwards. This leads to an increase in ρ_{RQ} and, thereby, an increase in σ_R and a loss in productivity. Hence,

Proposition 6.5 *Increases in the marginal cost of leverage ω increase both the variation in $TFPR$, σ_R, and the correlation ρ_{QR} thereby reducing* $\log TFP$.

What these results have shown is that an increase in the severity of the adverse selection problem in interbank markets that translates into a higher marginal cost of leverage can drive declines in productivity. This demonstrates another non-monetary effect of the banking collapse.[37]

My model focuses on a particular aggregate shock that affects banks symmetrically. However, a different explanation could emphasize the geographic variation in bank failures. As emphasized by Wicker (1996), while the breadth of the banking crises during the Depression were unprecedented, the incidence was not uniform across different regions. For example, in the first banking crisis of 1930, bank failures were basically restricted to the St. Louis Federal Reserve region and in New York City due to the collapse of the Bank of the United States. In the beginning of 1931, the epicenter of the banking crisis moved to Chicago before spreading to the entire country in lieu of Britain's exit from the gold standard. This broad scope of the crisis continued in 1933. It is possible to argue that this geographic variation in banking outcomes in turn generated the variation in revenue productivity across regions.

[37] One thing interesting to note about the model is that it naturally generates procyclical productivity independent of shifts in the marginal costs of leverage. Recall that I took final demand Y to be exogenous and that I normalized total labor supply to

$$L = Y\left(\frac{\psi}{\psi - 1}\right)^{\psi}$$

Note that $\log \bar{A}$ depends negatively on L. Therefore, a demand shock that increases Y drives down $\log \bar{A}$ and with it, ρ_{QR} and σ_R. This will increase overall productivity. Similarly if I had included an aggregate productivity shock, this would enter positively into L and hence, supply shocks would be multiplied endogenously in this framework. So even abstracting from business cycles driven by financial factors such as changed in ω, my model delivers procylical labor productivity.

The problem with this view is that it has a hard time explaining the increase in the correlation between $TFPR$ and $TFPQ$. Under the geographic variation hypothesis, exogenous shocks cause runs to occur in some places and not in others. Then by construction, there should be no correlation between $TFPR$ and $TFPQ$. In contrast, my empirical work showed a strong increase in this correlation over time. My explanation focusing on adverse selection can explain this increase through the fact that an increase in the cost of leverage falls most heavily on the most productive plants. I would argue that this is a compelling argument for my aggregate shock view rather than one that focuses on cross-sectional heterogeneity.

7 Empirical evidence for the role of the collapse of the interbank market in the productivity decline

In this section, I first show that evidence on the banking sector at this time is consistent with the predictions of my model and then link those bank variables to my micro-level data to document some predictions of my theory.

7.1 Evidence from Banking Data

One testable prediction of my model and the shock that it emphasizes is that while the dispersion in $TFPR$ is countercyclical, the dispersion in bank leverage ratios is procylical. Previously highly leveraged banks reduce their leverage and banks with low levels of leverage increase their asset holdings. Using data disaggregated to the state-level, Figure 2 plots this crucial variable. It in fact moves quite closely with the dynamics of productivity showing a sharp fall between 1929 and 1933 and then a rapid recovery from then onwards. This fact confirms the prediction of the model along this dimension.

There is some fragmentary evidence from modern data on the question of the cyclicality of the dispersion of leverage ratios. He et al. (2011) document that during the most recent crisis, hedge funds and the broker/dealer sector shed assets while the commercial banking sector increased asset holdings over this time. This is consistent with the idea that the variance in leverage across financial intermediaries declined over this time assuming hedge funds started with higher leverage ratios. Papers by Gatev and Strahan (2006) and Pennacchi (2006) also discuss the reintermediation process

that goes on during crises whereby certain financial institutions have to take on the assets shed by other financial institutions.

But what about other measures of the health of the banking sector? My model, while making a strong prediction about the procyclicality of the dispersion of leverage, also makes equally strong predictions that these productivity changes need not be correlated with other banking measures such as leverage ratios or the level of bank capital. The declines in the banking sector over the first four years of the Depression are all too clear. At an aggregate level between 1929 and 1933, the number of banks drops from around 24,000 to 14,000, a 54% decline.[38] Capital for all banks in the Federal Reserve system falls by 33% over a similar time frame[39] and only recovers around 5% from 1933 to 1935. Banks in 1929 were leveraged 9.5 to 1 and over the course of the first half of the Depression, they deleverage with the leverage ratio falling to around 8 in 1933. Hence, when asset prices collapse, the deleveraging process has multiplier effects on total loans, which fall by 66%, two and half times the decline in capital.

These declines in banking variables can surely match the downturn in productivity. Figure 2 confirms that fact with data from Comptroller of the Currency (1937). This is a source proving data at the state-level, which is more disaggregated than Federal Reserve districts. Recall that state borders at this timer were relevant economically since there was absolutely no interstate banking. The drops in capital, leverage, number of banks, and so on all line up well with the decline in productivity. However, each of these variables struggles to match other dynamics of aggregate productivity. For example, overall leverage is declining well in advance of the drop in productivity so that by 1929, it is already quite close to its nadir 1933. On the other hand for bank capital, while there is a precipitous drop between 1929 and 1933, there is no real recovery afterwards. In fact, bank capital was still 13% below its pre-Depression peak in 1941. These facts provide additional evidence for the particular shock that I emphasize.

7.2 Cross-sectional evidence

I now turn to regression evidence using my plant-level dataset and banking data from Comptroller of the Currency (1937). The first implication of the model I test is the following. When interbank

[38] All the statistics reported in this paragraph come from Board of Governors of the Federal Reserve System (1941).
[39] This decline is even smaller in real terms when the deflation occurring at this time is taken into consideration.

markets are closed, there should be a positive relationship between bank leverage and $TFPR$. To under this, consider the limiting case where interbank markets are perfect, then there should be no correlation between the two variables as there is no variation in $TFPR$. However, during the crisis period, the banks with the best projects are restricted from leveraging up further thereby generating a positive correlation. Table 3 regresses $TFPR$ on the overall leverage ratio of commercial banks in a given state. What is striking is that there is basically no relationship between the variables in 1929 and strongly positive one in 1931 and then a smaller effect in 1935 that is imprecisely estimated. To interpret the results, the standard deviation of log leverages ratios is around .3. So a one standard deviation increase in leverage ratios increases $TFPR$ by around .03 log points, which is around 10% of the standard deviation. I do not intend for these regressions to show causality merely correlations. At the same time, a correlation is sufficient to support an important equilibrium prediction of my theory.

A related implication of the model is the following. When interbank markets are functioning well, economic outcomes are not that dependent on local banking measures. Conversely, when interbank markets have shut down, economic outcomes, in particular $TFPR$, is highly dependent on local bank outcomes. This suggests that regional dummies should explain more of the variation in $TFPR$ during the crisis years of 1931 and 1933. The test then is not an F-test for whether interaction terms of region dummies and years are zero. Instead the test is whether the R^2 of the regression is substantially higher in the crisis years relative to the non-crisis years. In other words, I am not testing whether the regional dummies are the same across years but how their explanatory power changes over time.

I implement this test by separately regressing the plant-level data on interactions between industry and state fixed effects for each year separately. The results in Table 2 in fact show a sharp decline in 1931 and a rebound in 1935.[40] The R^2 of the regression with interactions between state and industry fixed effects in 1929 is around 7% and this jumps to 12% in 1931 before falling back to its previous level in 1935. This is a statistically significant difference.[41] In terms of economic significance, at least in terms of the ratio of the R^2, the increase is a substantial 54%. Summing

[40] I drop the data for 1933 because of the fact that I do not have capital measures for the ice data. This makes the comparison of variation explained across years invalid. For this reason, I simply exclude this year.

[41] I bootstrap the standard errors since the test statistic, a comparison of the R^2 across regressions, is rather non-standard.

up, both of these tests provide some cross-sectional evidence for my model.

7.3 A comparison: Canada during the Great Depression

More evidence on the effects of the banking crisis on productivity comes from comparing the U.S. experience during the Great Depression to Canada's. Over a similar period of time to the U.S., Canadian GNP falls by around 40% relative to a 2% trend between 1929 and 1933.[42] The U.S. experiences a decline of around 38% over the same time. Comparing TFP changes, Canada's aggregate productivity falls by around 15% while U.S. productivity falls by 20% relative to trend. If not in the context of the Depression, this difference of 5 percentage points would seem quite large. But the differences between the two are much starker if one considers productivity excluding the government and agricultural sectors.[43] With this measure, the decline in U.S. TFP is nearly double that of Canada's between 1929 and 1933. What is striking is the divergence in productivity after 1933. While U.S. aggregate and private non-agricultural productivity begins to recover in 1935, Canadian TFP stubbornly remains well below trend.

What explains this difference in the behavior or productivity? One of the biggest differences is the fact that Canada did not suffer a banking crisis like the U.S. No Canadian banks failed during the Great Depression though the economy did suffer a debt crisis brought on by an unexpected deflation (Amaral and MacGee, 2002). The fact that a crisis was averted may have been partly due to the fact that Canada did not have branching restrictions (Bordo et al., 1994, 2011).[44] Instead of the fragmented U.S. banking system, the banking market in Canada was heavily concentrated with a few large banks owning branches in nearly every small town. Much like today, these wide branch networks allowed for the movement of resources within a bank itself. By insulating a sizable fraction of resource flows from the vagaries of interbank markets, this limited the potential damage on productivity from a collapse in interbank funding. My model suggests then that it is no coincidence that the decline in TFP is much larger for the U.S. Furthermore, it is not a surprise that the paths of the two diverge after 1933 as the U.S. interbank markets slowly begin to heal and confidence in the banking sector is restored.

[42] All numbers are from Amaral and MacGee (2002).

[43] There are good reasons to ignore the government sector since my model does not strictly apply to outcomes there. Similarly for agriculture.

[44] Interestingly, while Canada had a much more integrated banking sector, it did not have a central bank like the U.S. at this time.

8 Conclusion

I have proposed a new hypothesis to explain part of the sharp decline in aggregate TFP during the Great Depression. It identifies an increase in the misallocation of resources across plants as playing a crucial role. To develop this hypothesis, I collected a plant-level dataset of the two industries with supporting evidence from a third industry. Across these industries, changes in misallocation explain large fractions of the decline. The fraction is about 15% of between 1929 and 1935 for cement and 50% for ice. I find that two sources of misallocation, dispersion in $TFPR$ and correlation between $TFPR$ and $TFPQ$, both show sharp increases and contribute to the overall productivity decline.

Shocks to the financial sector can provide a plausible explanation for this productivity decline. I develop a model with heterogeneity in productivity across plants that rely on banks for working capital. Banks face a convex cost of taking on more leverage stemming from adverse selection. Hence, banks are unwilling to take on an arbitrarily large amount of leverage and interest rate differentials across regions exist. Moreover, since the most productive firms require the most resources, the convex cost of leverage falls disproportionately on this group. This leads to a positive correlation between revenue and physical productivity. In response to a shock to the marginal cost of leverage, spreads in interest rates rise, the correlation between productivity and working capital costs increases, and productivity declines. Interestingly, changes in the actual level of bank capital or leverage do not impact measures of dispersion and productivity.

There is still much work remaining to be done. First in terms of interpretation, recently another explanation has come to view differences in revenue productivity in modern data as related to plant-level uncertainty and not as misallocation *per se* (Bloom, 2009). When there are fixed costs to adjusting factors of production, following an increase in uncertainty, reallocation freezes as firms exercise the option of waiting. This can lead to a decline in productivity. Others such as Romer (1990) have argued that uncertainty increased sharply with the stock market crash of 1929. This suggests that this uncertainty interpretation could also explain the decline in productivity. It is important to emphasize that the uncertainty view does not invalidate my empirical findings on the cross-sectional changes in $TFPR$. It is instead a different way to interpret those results in terms of uncertainty rather than misallocation. While I would argue that the uncertainty explanation has difficulty explaining the cross-sectional results presented, work to more carefully formulate a test

to discriminate between the two is an important avenue for future work.[45]

More work is needed to extend the analysis to other industries and ask whether similar results hold there. A broader set of industries would also for an examination of between industry misallocation. In particular, a set of industries along the lines of Foster et al. (2008) that have very homogeneous products would be particularly insightful. This work has also not attempted to address what type of wedges be they labor, capital, or output drives the dispersion in $TFPR$. Understanding the particular source of misallocation may provide crucial evidence for or against my particular explanation. In the future, it would also be useful to link the Census plant-level data with data from Dun and Bradstreet, which was a credit rating plant at the time. These records at the plant-level provide information about a plant's net worth and a credit rating. This would allow me to use variation in the exposure of the plants to financing requirements. But most importantly, subsequent work should ask whether the "classical" explanations of procyclical productivity in conjunction with my approach can finally solve one of the more vexing problems of the Depression – the decline in aggregate productivity. This paper has attempted to take one small step towards that ambitious goal.

[45] A potentially useful source of variation here would be to consider the differences in banking markets across countries and how those relate to declines in productivity. The current Great Recession might also provide useful insights on this account.

9 Appendix: Two Data Quality Checks

In this appendix, I consider two checks on to what extent the data are severely contaminated with measurement error. First, I ask whether $TFPQ$ or $TFPR$ predict exit decisions. The outcome of this exercise provides some evidence on the economic significance of the differences in these productivity variables. To do this, I estimate a simple probit for exit on revenue and physical productivity using the data from cement, ice, and macaroni. This will be labor productivity for macaroni and total factor productivity for the other two industries. Results are reported in Table 4. Suggesting that these differences in productivity are meaningful, $TFPQ$ or $TFPR$ both have strong negative effects on the probability of exit. The marginal effect for $TFPQ$ calculated from the mean is around 8 percentage points off an average exit rate of 32% per census. The effect is not quite as strong for $TFPR$ with an marginal effect of closer to 7 percentage points. This contradicts slightly the finding in Foster et al. (2008) who find that revenue productivity is a stronger predictor of survival than physical productivity.[46]

A further check on the validity of these productivity differences involves calculating the persistence of these productivity measures. Measurement error usually by assumption is not correlated or, at least, only weakly correlated over time. On the other hand, a variety of studies such Foster et al. (2008) have found that productivity measures at the plant-level is highly persistent. If my data were severely corrupted with measurement error, I would expect a much lower persistence. Results are reported in Table 5. The implied annual autocorrelation for $LFPQ$ is very similar to Foster et al. (2008). I find a value of .76 only slightly lower than their reported value of .79. The results are similar for $TFPR$ where I find an annual persistence of .68 whereas they find .78.[47] Finally, the autocorrelation in prices is .73 within a reasonable range of reported values from modern data. These tests do not rule out persistent measurement error driving the dispersion, but they do cast doubt on the idea that year to year variation is simply noise.

[46] One interesting thing to note not reported here is that there does not seem to significant differences in terms of $TFPR$ and $TFPQ$ between continuing and entering firms. Foster et al. (2008) report that entering firms have on average lower revenue productivity and higher physical productivity.

[47] A possible reason for the difference is that they annualize an autocorrelation over five years while I annualize a biennial autocorrelation.

10 Appendix: Robustness checks for empirical results

10.1 Different degrees of tail trimming

The results reported in Oberfield (2011) are very sensitive to how the tails are handled. This makes it very tenuous to draw any implications about the magnitude of misallocation. To check on this worry, I repeat my analysis varying how I trim the tails. In Figures 11 and 12, I conduct the same exercise for the cement industry. In Figures 13 and 14, I repeat the calculations for ice trimming 1% and also trimming 3%. In both of these cases, the broad implication that misallocation plays a major role in productivity dynamics is confirmed for the both more and less stringent cuts of the data.

10.2 Hours worked for labor input variable

Here I consider another robustness check using the hours per wage earner variable along with the wage earners variable to construct a total hours at the plant-level. I did not use this specification in the baseline results because the hours variable does not exist for 1933. Therefore, that observation would have to have been dropped. For these results, I also eliminate any observations that report a workweek less than 20 hours or greater than 84. The results for cement are nearly identical with a rise in the standard deviation of $TFPR$ of .25 log points instead of .3 and basically no differences for the results on the correlation. Similarly for ice, there is very little difference between this specification and the baseline in terms of misallocation measures.

10.3 Real value added specification vs. gross output specification

Another check on the results is to use real value added as the output measure rather than the direct physical output measure that I use. It is important to emphasize that this is still substantially different than the usual "real" output measures used in most studies employing plant-level data. In those studies such as Kehrig (2011), revenue or value added is deflated by an industry-level price deflator. I instead employ the real output data I have to construct a plant-level price to deflate value added. So in effect, the only difference is that in the real value added specification, I impose that the elasticity of output with respect to materials and energy is one. When I make this assumption, results are basically unchanged. There is a slightly larger increase in the dispersion of

revenue productivity for cement over the first few years and a larger increase for ice in the last 2 years. The overall implications drawn from the results are the same.

11 Appendix: Adverse selection and interbank borrowing

Consider the following situation. As before, there are island-specific productivity shocks that will be common knowledge to plants and banks on the given island. However, that piece of information will *not* be observed by banks on other islands. After this shock has been realized and banks *commit* to a certain amount of working capital loans, a lemons shock λ_i occurs meaning a fraction λ_i of the projects already committed to be funded will be produce nothing. Like the productivity shock, this will be an *i.i.d.* shock across islands and will be private information as well. An equivalent way to conceptualize the shock is that there is a bank run shock where some banks are hit with particularly heavy redemption requests by depositors. This too leads to particularly high demand for funds to satisfy creditors.

Following the lemons shock, banks can attempt to raise funds in the interbank market by effectively selling both the lemon and non-lemon projects (Kurlat, 2011). While at the same time, they must respect the constraint that they fund all projects with funds committed. The problem is that the interbank market cannot distinguish between two types of banks with high borrowing "demands": those with high productivity projects versus those with lots of lemons. Banks will face a schedule of interest rates and amounts of funding $\{r_b, b\}$ from which to choose. What the contract aims to separate out is the "true" amount of funding required by a particular bank i.e. $H_i - N$.

It is possible to separate the different types of banks by setting an upward sloping interest rate schedule or equivalently a downward sloping price schedule. The reason is the following. Consider two banks with "similar" funding needs i.e. $H_i - N = \lambda_j N$. Then with a sufficiently upward sloping interest rate schedule only bank i with true funding needs will borrow. The issue is that this upward sloping interest rate schedule will affect most severely the banks with the most productive projects. One can think about this *ex post* adverse selection problem as generating an *ex ante* convex cost of leverage. This latter formulation will be a useful modeling tool.

The degree of the adverse selection problem will depend on the relative variances of the pro-

ductivity shock versus the lemons shock. When the variance of the lemons shock increases holding fixed the mean size of the lemons shock, then the adverse selection problem becomes more severe and the limits on leverage more stringent. The reason for this is that as the variance of lemons shock increases, it becomes more difficult to infer from a bank's lending needs the quality of the projects it has in its portfolio. This shock to the variance of the lemons problem gives a particular microfoundation to the reduced form shock that I consider in the model.

12 Appendix: Closing the Model

To close the model, I allow banks to collect deposits in the retail market at rate r_d taking this rate as given. Besides the deposits raises, they still have their own net worth with which to fund loans. After deposits have been collected, the island-specific productivity shocks are realized and banks can attempt to obtain funds from the wholesale interbank market at rate r_b for lending to firms on their island. The bank's problem can be solved by backward induction. I assume that banks have perfect foresight over what rates will prevail in the interbank market though they do not know what the realization will be on their particular island. Here, I assume a general cost of leverage function Ω, $\Omega' > 0, \Omega'' \leq 0$. Note that I do not assume that this cost must be strictly positive. This will ensure that banks on islands with projects that return less than r_b will still receive some funding.

Profits of a bank are given by

$$r_{fi}H_i - r_b b_i - \Omega\left(\frac{H_i}{N} - 1\right)$$

Then the optimal choice for interbank borrowing is given by

$$r_{fi} - r_b = \Omega'\left(\frac{b_i}{N}\right)$$

Then banks maximize

$$\mathrm{E}\left[r_{fi}(D + b_i + N) - r_b b_i - r_d D - \Omega\left(\frac{b_i + D + N}{N} - 1\right)\right]$$

where N, r_b, r_d are all taken as given from the point of view of the bank and I have substituted out for the flow of funds constraint. The expectation is over the distribution of r_{fi} that depends on the realization of the productivity shock A_i. Continuing to assume the same approximation for Ω, the problem is homogeneous of degree 1 in N. Denoting variables scaled by N with a tilde, I can rewrite the problem as

$$\mathrm{E}\left[r_{fi}(\tilde{D}+\tilde{b}_i+1)-r_b\tilde{b}_i-r_d\tilde{D}-\frac{\omega}{2}\left(\tilde{b}_i+\tilde{D}\right)^2\right]$$

Similar to before, the optimal choice of b_i after A_i is realized (under the assumption of a linear approximation to the optimal choice) is given by

$$\frac{b_i+D}{N}=\frac{r_{fi}-r_b}{\omega}$$

This equation implies that greater deposits reduces the need for subsequent interbank borrowing. Note that with this expression, the optimized value for bank profits as a function of $\tilde{D}$ is linear in $\tilde{D}$ where the slope is $r_b - r_d$. For there to be an equilibrium, it is necessary that $r_b = r_d$. So the level of deposits will be pinned down by the supply from households. The fact that $r_b = r_d$ is an implication of the fact that deposits and interbank funds are treated symmetrically in the leverage cost function. Given this, there is no reason to raise deposits unless the cost of deposits is cheaper than the cost of borrowing subsequently in the interbank market.[48] I can write down the optimized level of profits scaled by N as

$$r_b-\frac{N^2}{3\omega}\sigma_R^2$$

Note how optimized profits are a function of the difference between the mean return r_b and the spread in interest rates σ_R^2.

I assume households maximize

$$\sum_{t=0}^{\infty}\beta^t\left(\log C_t-\frac{\nu}{1+\pi}L_t^{1+\pi}\right)$$

where π is the Frisch elasticity of labor supply and ν is a utility scaling parameter. For tractability

[48] Gertler and Karadi (2011) allow for these two sources of funds to be treated differently and motivate the difference by assuming that it is more difficult to misappropriate funds garnered in the interbank market.

following Gertler and Kiyotaki (2010), within the household, there is a $1-f$ fraction of workers and the remaining fraction f are bankers. Workers supply labor and return their wages to the household. Bankers manage "banks" and return non-negative dividends to the household. I assume that there is perfect consumption insurance in the family. Households can deposit funds in their local bank and own equal shares in all of the firms across the various islands. They then face a budget constraint given by

$$C_t + D_t = \int_0^1 \pi_{it}^f di + \Pi_t^B + R_t D_{t-1} + T_t + w_t L_t$$

where D_t denotes deposits, $\int_0^1 \pi_{it}^f di$ profits from firms, and Π_t^B a net transfer from exiting banks. Each period a fraction $1-\gamma$ of bankers exit and transfers retained earnings to the household. Finally, T_t represents net transfers the households receive from the government from the rebate of taxes paid by banks on their leveraged position.

The model delivers a standard consumption Euler equation

$$\mathrm{E}_t \Lambda_{t+1} R_{t+1} = 1$$

where

$$\Lambda_{t+1} = \beta \frac{u'(C_{t+1})}{u'(C_t)}$$

As well as a standard condition for the optimal choice of labor

$$\nu L_t^{\pi} C_t = w_t$$

I assume that each period before the island-specific productivity shocks are realized, banks can move between islands to eliminate any differentials in expected returns. This eliminates the need to keep track of the distribution of bank net worths across the islands stemming from different histories of island-specific productivity shocks.

Unlike Gertler and Kiyotaki (2010), there is no particular incentive for banks to build up retained earnings since the exogenous friction imposed is never really overcome. This is due to the fact that I assume an exogenous cost of leverage rather than allowing this constraint to be relaxed as the bank builds up net worth. Aggregating across banks to calculate total net worth of the

banking sector delivers the following law of motion

$$\frac{N_{t+1}}{N_t} = \gamma + \frac{\gamma}{2} r_{bt} - \frac{N_t^2}{3\omega} \sigma_{Rt}^2$$

Because the banks per period maximization problem is completely static, they only need to maximize period by period with no regard for intertemporal considerations.

Finally, the resource constraint states that

$$Y_t = C_t$$

As a modeling device, I will consider the leverage costs as stemming from a government imposed tax on leverage. The government balances its budget period by period rebating the revenues from the tax on leverage to the households.

$$T_t = \int_0^1 \omega \left(\frac{b_{it} + N_t}{N_t} \right) di = \frac{N_t^3 \sigma_{Rt}^2}{3\omega}$$

where the right hand side represents the revenue raised by the leverage tax on banks. The second equality follows from substituting in the expression for b_i.

With deposits, there are only minor modifications that need to be made to the equilibrium equations. Now interbank clearing implies that

$$w_t = \frac{D_t + N_t}{L_t}$$

The cutoff equation can be written as

$$\left(\frac{N_t + D_t}{L_t} \right)^{-\psi} = \bar{A}_t^{\psi - 1} r_{bt}^{-\psi}$$

Then the modified expression for ρ_{QRt} is

$$\rho_{QRt} = \frac{\psi - 1}{\frac{(N_t + D_t) r_{bt}}{\omega} + \psi}$$

Proposition 12.1 *Shocks to $N + D$ have no effect on $TFPR$ dispersion nor productivity.*

Changes in the overall availability of resources for lending $N + D$ will translate one for one into changes in r_b. Though $N + D$ does not affect productivity, shifts in this variable still has effects on labor demand and through that, effects on output.

To summarize the variables determined in equilibrium $\{r_{dt}, r_{bt}, N_t, D_t, C_t, Y_t, TFP_t, \sigma_{Rt}, L_t, \rho_{QRt}, w_t, \bar{A}_t\}$ are defined by

$$
\begin{aligned}
Y_t &= TFP_t L_t && (11)\\
r_{dt}\mathrm{E}\left[\beta\frac{C_t}{C_{t+1}}\right] &= 1 && (12)\\
\nu L_t^{-\pi} C_t &= w_t && (13)\\
\sigma_{Rt} &= \rho_{QRt}\sigma_A && (14)\\
\frac{N_{t+1}}{N_t} &= \gamma + \frac{\gamma}{2}R_{bt} - \frac{N_t^2}{3\omega}\sigma_{Rt}^2 && (15)\\
\log \bar{A}_t &= \frac{\psi}{\psi-1}\log(R_{bt}N_t) - \frac{\psi}{\psi-1}\log L_t && (16)\\
\log \bar{A}_t &= \frac{1}{2}\frac{\sigma_A^2(\psi-1)}{\frac{N_t R_{bt}}{\omega}+\psi} && (17)\\
w_t &= \frac{N_t + D_t}{L_t} && (18)\\
\rho_{QRt} &= \frac{\psi-1}{\frac{N_t R_{bt}}{\omega}+\psi} && (19)\\
\log TFP_t &= \log A + \frac{\psi}{2}\sigma_A^2 - \frac{\psi-1}{2}\sigma_{Rt}^2 - \rho_{QRt}\sigma_{Rt}\sigma_A(\psi-1) && (20)\\
Y_t &= C_t && (21)\\
r_{bt} &= r_{dt} && (22)
\end{aligned}
$$

12.1 A calibration exercise

In this section, I calibrate the model and consider the comparative statics for ω. For most of the parameters of the model, I take the values reported in Gertler and Kiyotaki (2010). These include $\beta, \pi, \nu, \gamma, \xi$. I choose the elasticity of substitution to be the same value as that used in the empirical work. What remains to calibrate are σ_A, ω. First, I choose a value of $\sigma_A = .25$ similar to modern estimates that examine within industry productivity dispersion (Foster et al., 2008).[49] Finally and most importantly, I need to choose an initial value for ω. I will choose to match the ratio of bank

[49] From the steady state equations, it is clear that the value for A only effects the scale of output. So it can just be normalized.

equity to total assets, which in my model is $\frac{N}{wL}$. From modern data, this fraction has averaged around 9%, which is the target that I will use. The values for all the parameters are reported in Table 6.

The results of the simulation are reported in Figure 16. A 50% increase in ω leads to an approximately 2.5% decline in productivity. This fall in productivity is roughly in line with my empirical estimates. This shift also drives an endogenous decline in bank capital, labor, and output. These declines are much larger than the fall in productivity and imply that even this relatively small fraction of productivity explained by the shock to the marginal cost of leverage could potentially explain a much larger fraction of the overall fall in output and labor employed. The intuition for the multiplier effect is that the shock to ω, in turn, drags down labor demand through loan market clearing. So overall output falls because of the decline in productivity and the resultant fall in labor employed, much like how declines in productivity has multiplier effects in the neoclassical growth model.

13 Model Extension: Changes on the extensive margin

In this appendix, I show how to endogenize movements in $\sigma_Q, \log A$ as well as changes in σ_R, ρ_{QR}. I now assume that if firms are sufficiently unproductive, they are excluded from production by banks who prefer to lend into the interbank market. Previously, my assumption on the bank's lending policy implied that even if $r_{fi} < r_b$, banks would still lend some fraction of their resources to firms on their island. Now I instead assume that if $r_{fi} < r_b$, then $b_i = -N$. Hence, firms with productivity $A_i < \bar{A}$ do not produce because they have no resources to hire labor. There is an implicit relationship between $r_b, \bar{A}$ given by

$$N r_b = \bar{A}^{\frac{\psi-1}{\psi}} L \tag{23}$$

where I have used the fact that $w = \frac{N}{L}$ assuming banks do not collect deposits. Now interbank clearing implies that

$$\frac{\tilde{r}_f - r_b}{\omega - r_b} = \Phi\left(\frac{\psi - 1}{\psi} \log \bar{A}\right) \tag{24}$$

where $\tilde{r}_f = \int_{\bar{A}}^{\infty} r_{fi} d\Phi(\log A_i)$ as before. The difference now is that there is a wedge between $\tilde{r}_f$ and r_b related to the fact that there is a supply of capital from banks on bad islands. For firms with productivity $A_i \geq \bar{A}$, loan market clearing implies that

$$w^{1-\psi} L A_i^{\frac{\psi}{\psi-1}} r_{fi}^{-\psi} = N \left(1 + \frac{r_{fi} - r_b}{\omega}\right)$$

I will approximate the solution to this expression like before with a log linear relationship between A_i, r_{fi}. I will approximate around $\hat{A}$ implicitly defined as

$$w^{1-\psi} L \hat{A}^{\frac{\psi-1}{\psi}} \tilde{r}_f^{-\psi} = N \left(1 + \frac{\tilde{r}_f - r_b}{\omega}\right) \tag{25}$$

This is the level of productivity for which the interest rate charged on the island is equal to the average interest rate across islands. As before, I can now write under this approximation,

$$r_{fi} = \tilde{r}_f \left(\frac{A_i}{\hat{A}}\right)^{\rho_{QR}}$$

where ρ_{QR} is the derivative of the loan market clearing expression evaluated at $\hat{A}$

$$\rho_{QR} = \frac{\psi - 1}{\psi + \frac{\hat{A}^{1-\psi}(N\tilde{r}_f)^{\psi+1}}{L^{\psi+1}\omega}}$$

Substituting this expression into the definition of $\tilde{r}_f$, I have

$$\hat{A} = \left[\int_{\bar{A}}^{\infty} A_i^{\rho_{QR}} d\Phi(\log A_i)\right]^{\frac{1}{\rho_{QR}}} \tag{26}$$

I now have unknowns $\tilde{R}_f, \hat{A}, \bar{A}, r_b$ and equations 26, 25, 24, and 23 as well as the definition of ρ_{QR}. For illustrative purposes, I will consider the case where $\sigma_A = 1$ and $N = L$. Then the system of

equations defining the solution is given by

$$
\begin{aligned}
\frac{\tilde{r}_f - r_b}{\omega - r_b} &= \Phi\left(\frac{\psi-1}{\psi}\log\bar{A}\right) \\
1 + \frac{\tilde{r}_f - r_b}{\omega} &= \hat{A}^{\frac{\psi-1}{\psi}}\tilde{r}_f^{-\psi} \\
\log\hat{A} &= \frac{1}{2}\rho_{QR} + \frac{1}{\rho_{QR}}\log\Phi\left(\rho_{QR} - \frac{\psi-1}{\psi}\frac{\log r_b}{\rho_{QR}}\right) \\
\rho_{QR} &= \frac{\psi-1}{\psi + \frac{\hat{A}^{1-\psi}\tilde{r}_f^{\psi+1}}{\phi}} \\
r_b &= \bar{A}^{\frac{\psi-1}{\psi}}
\end{aligned}
$$

In contrast to the basic case, these equations cannot be written solely in terms of Nr_b and $N\tilde{r}_f$. This implies that shocks to N do have effects on productivity. The key difference here is that capital levels affect the extensive margin and changes to that margin are not neutral with regards to misallocation.

What is interesting under this specification is that there are endogenous movements not only in ρ_{QR}, σ_R but also σ_Q and $\log A$. In particular, it will now be the case that with a slight abuse of notation,

$$\log A = \mathrm{E}[\log A_i | A_i > \bar{A}] = \frac{\sigma_A \phi\left(\log\bar{A}\right)}{1 - \Phi\left(\log\bar{A}\right)}$$

$$\sigma_A^2 = Var(\log A_i | A_i > \bar{A}) = \left[1 - \left(\frac{\phi\left(\log\bar{A}\right)}{1 - \Phi\left(\log\bar{A}\right)}\right)^2\right]$$

These are simply the formulas for the first and second moments of truncated normals. It will still be that $\sigma_R \propto \sigma_{rf}$ and approximately

$$\log TFP = \log A + \frac{\psi-1}{2}\sigma_A^2 - \frac{\psi}{2}\sigma_R^2 - \rho_{QR}(\psi-1)\sigma_A\sigma_R$$

Therefore, shocks to the marginal cost of leverage ω will generate endogenous movements in all of these moments and productivity. It is difficult to get analytical results for the effect of shocks to ω. I simulate the model in Figure 17 varying ω over a range fixing $\psi = 4$. As in the basic setup, increases in ω lead to increases in ρ_{QR} and σ_R. Note that the overall effect on productivity from these shifts are somewhat mitigated by the fact that σ_A also increases. On the other hand, the

mean plant-level productivity also falls dragging down the overall industry average.

The logic for the changes in σ_R, ρ_{QR} are the same as the model with no extensive margin *conditional* on a fixed $\bar{A}$. The question then is why this cutoff falls with ω with knockon effects for σ_A and $\log A$. The key is that r_b falls with ω. This reflects decreased demand for funds through the interbank market with the borrowing banks unwilling to take on the marginal dollar of leverage. Because demand for funds is lower, this leads banks with marginal projects to lend to the firms on their island instead of lending to the interbank market. Business cycles driven by this type of shock would not experience "cleansing" during recessions (Caballero and Hammour, 1994) though the reason is distinct from those sketched out in either Kehrig (2011) or Barlevy (2002).

At least for the calibration I consider, shocks to ω have similar effects as the baseline model. Figure 17 displays the comparative statics results varying ω. Not only do the measures of misallocation increase but also the average productivity declines. At the same time, these shifts are partially compensated for by an increase in the dispersion of physical productivity. The fact that both productivity dispersion measures increase fits the data well. What is interesting to note is that shocks to bank capital can have both positive and negative effects on the productivity threshold $\bar{A}$. For very low levels of capital, the cutoff is increasing and then decreasing for sufficiently high levels of capital.

References

Alexander, B. (1997). Failed cooperation in heterogeneous industries under the National Recovery Administration. *Journal of Economic History 57*, 322–344.

Amaral, P. and J. MacGee (2002). The Great Depression in Canada and the United States: A Neoclassical Perspective. *Review of Economic Dynamics 5*, 45–72.

Baily, M., C. Hulten, and D. Campbell (1992). Productivity dynamics in manufacturing establishments. *Brookings Papers on Economic Activity*, 187–249.

Barlevy, G. (2002). The sullying effect of recessions. *Review of Economic Studies 69*, 65–96.

Barth, M. and V. A. Ramey (2001). The cost channel of monetary transmission. In *NBER Macroeconomics Annual*, Volume 16, pp. 199–256. NBER.

Basu, S. and J. Fernald (1997). Returns to scale in U.S. manufacturing: Estimates and implications. *Journal of Political Economy 105*, 249–283.

Bernanke, B. (1983a). Irreversibility, uncertainty, and cyclical investment. *Quarterly Journal of Economics 98*, 85–106.

Bernanke, B. (1983b). Nonmonetary effects of the financial crisis in the propagation of the Great Depression. *American Economic Review 73*, 257–276.

Bernanke, B. and M. Gertler (1989). Agency costs, net worth, and business fluctuations. *American Economic Review 79*, 14–31.

Bernanke, B., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle model. In *Handbook of Macroeconomics*. Elsevier.

Bernstein, M. (1987). *The Great Depression: Delayed recovery and economic change in America, 1929-1939*. Cambridge University Press.

Bertin, A., T. Bresnahan, and D. Raff (1996). Localized competition and the aggregation of plant-level increasing returns: Blast furances, 1929-1935. *Journal of Political Economy 104*, 241–266.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica 77*, 623–685.

Bloom, N., N. Jaimovich, and M. Floetotto (2011). Really uncertain business cycles. Unpublished, Stanford University.

Board of Governors of the Federal Reserve System (1941). *Banking and Monetary Statistics 1914-1941*.

Bodenhorn, H. (1995). A More Perfect Union: Regional Interest Rates in the United States, 1880-1960. In M. D. Bordo and R. Sylla (Eds.), *Anglo-American Financial Systems: Institutions and Markets in the Twentieth Century*. Irwin Professional Publishing.

Bordo, M., A. Redish, and H. Rockoff (2011). Why didnt Canada have a banking crisis in 2008 (or in 1930, or 1907, or ...)? NBER WP 17312.

Bordo, M., H. Rockoff, and A. Redish (1994). The U.S. banking system from a northern exposure: Stability versus efficiency. *Journal of Economic History 54*, 325–341.

Bresnahan, T. and D. Raff (1991). Intra-industry heterogeneity and the Great Depression: The America motor vehicles industry, 1929-1935. *Journal of Economic History 51*, 317–331.

Brunnermeier, M., T. Eisenbach, and Y. Sannikov (2011). Macroeconomics with financial frictions: A survey. Unpublished, Princeton University.

Brunnermeier, M. and L. H. Pedersen (2009). Market liquidity and funding liquidity. *Review of Financial Studies 22*, 2201–2238.

Buera, F. and B. Moll (2011). Aggregate implications of a credit crunch. Unpublished, UCLA.

Caballero, R. and M. Hammour (1994). The cleansing effect of recessions. *American Economic Review 84*, 1350–1368.

Calomiris, C. (1993). Financial factors in the Great Depression. *Journal of Economic Perspectives 7*, 61–85.

Calomiris, C. and J. Mason (2003). Consequences of bank distress during the Great Depression. *American Economic Review 93*, 937–947.

Calvo, G., A. Izquierdo, and E. Talvi (2006). Phoenix miracles in emerging markets: Recovering without credit from systemic financial crises. Inter-American Development Bank Working paper 570.

Carlstrom, C. and T. Fuerst (1997). Agency costs, net worth and business fluctuations: A computable general equilibrium analysis. *American Economic Review 87*, 893–910.

Chari, V., P. Kehoe, and E. McGrattan (2002). Accounting for the Great Depression. *American Economic Review 92*, 22–27.

Chari, V., P. Kehoe, and E. McGratten (2007). Business cycle accounting. *Econometrica 75*, 781–836.

Chicu, M. and N. Ziebarth (2011). Multimarket contact and collusive behavior: Evidence from the Depression-era cement industry. Unpublished, Northwestern University.

Christiano, L., M. Eichenbaum, and C. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy 115*, 1–45.

Christiano, L., M. Eichenbaum, and S. Rebelo (2010). When is the government spending multiplier large? NBER Working Paper 15493.

Cole, H. and L. Ohanian (2000). Reexamining the contributions of monetary and banking shocks to the U.S. Great Depression. *NBER Macroeconomics Annual 2001 15*, 183–227.

Comptroller of the Currency (1937). *Annual Report of the Comptroller of the Currency.*

Davis, S. and J. Haltiwanger (1990). Gross job creation and destruction: Microeconomic evidence and macroeconomic implications. *NBER Macroeconomics Annual 1990 5*, 123–168.

Dumez, H. and A. Jeunematre (2000). *Understanding and regulating the market at a time of globalization: The case of the cement industry.* St. Martin's Press.

Field, A. (2011). *A Great Leap Forward: 1930s Depression and U.S. Economic Growth.* Yale University Press.

Floetotto, M. and N. Jaimovich (2008). Firm dynamics, markup variation and the business cycle. *Journal of Monetary Economics 55*, 1238–1252.

Foss, M. (1981). Long-run changes in the workweek of fixed capital. *American Economic Review 71*, 58–63.

Foster, L., J. Haltiwanger, and C. Syverson (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *American Economic Review 98*, 394–425.

Friedman, M. and A. Schwartz (1971). *A Monetary History of the United States: 1867-1960.* Princeton University Press.

Gatev, E. and P. Strahan (2006). Banks' advantage in supplying liquidity: Theory and evidence from the commercial paper market. *Journal of Finance 61*, 867–892.

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics 58*, 17–34.

Gertler, M. and N. Kiyotaki (2010). Financial intermediation and credit policy in business cycle analysis. Unpublished, NYU.

Gilchrist, S. and E. Zakrajsek (2011). Credit spreads and business cycle fluctuations. NBER WP 17021.

Griliches, Z. (1957). Specification bias in estimates of production functions. *Journal of Farm Economics 39*, 8–20.

He, Z., I. Khang, and A. Krishnamurthy (2011). Balance sheet adjustments during the 2008 crisis. *IMF Economic Review Forthcoming*.

Hendel, I. and A. Nevo (2006). Measuring the implications of consumer inventory behavior. *Econometrica 74*, 1637–1673.

Hsieh, C.-T. and P. Klenow (2009). Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics 124*, 1403–1448.

Kehoe, T. and E. Prescott (2002). Great Depressions of the 20th Century. *Review of Economic Dynamics 5*, 1–18.

Kehrig, M. (2011). The cyclicality of productivity dispersion. Unpublished, Northwestern University.

Kurlat, P. (2011). Lemons, market shutdowns, and learning. Unpublished, Stanford University.

Landon-Lane, J., H. Rockoff, and R. Steckel (2011). Droughts, floods and financial distress in the United States. In G. Libecap (Ed.), *The Economics of Climate Change: Adaptations Past and Present*. University of Chicago Press.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for observables. *Review of Economic Studies 70*, 317–341.

Lucas Jr., R. (1978). On the size distribution of business firms. *Bell Journal of Economics 9*, 508–523.

Marschak, J. and W. Andrews (1944). Random simultaneous equations and the theory of production. *Econometrica 12*, 143–205.

Mishkin, F. (1991). Asymmetric information and financial crises: A historial perspective. In R. G. Hubbard (Ed.), *Financial markets and financial crises*. NBER. NBER WP 3934.

Munday, H. W. (Ed.) (Various years). *Pit and Quarry Handbook*. Chicago: Complete Service Publishing Company.

Neumeyer, P. and F. Perri (2005). Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics 52*, 345–380.

Nucci, A. (1998). The Center for Economic Studies Program to assemble economic census establishment information. *Business and Economic History 27*, 248–256.

Oberfield, E. (2011). Productivity and misallocation during a crisis. Unpublished, Federal Reserve Bank of Chicago.

Ohanian, L. (2001). Why did productivity fall so much during the Great Depression? *American Economic Review: Papers and Proeedings 91*, 34–38.

Olley, G. and A. Pakes (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica 64*, 1263–1297.

Palyi, M. (1939). Should interbank balances be abolished? *Journal of Political Economy 47*, 678–691.

Pennacchi, G. (2006). Deposit insurance, bank regulation, and financial system risk. *Journal of Monetary Economics 53*, 1–30.

Petrin, A., T. White, and J. Reiter (2011). The impact of plant-level resource reallocation and technical progress on U.S. macroeconomic growth. *Review of Economic Dynamics 14*, 3–26.

Raff, D. (1998). Representative firm-analysis and the character of competition: Glimpses from the Great Depression. *American Economic Review 88*, 57–61.

Restuccia, D. and R. Rogerson (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic Dynamics 11*, 707–720.

Richardson, G. (2007). The check is in the mail: Correspondent clearing and the collapse of the banking system, 1930 to 1933. *Journal of Economic History 67*, 643–671.

Romer, C. (1990). The Great Crash and the onset of the Great Depression. *Quarterly Journal of Economics 105*, 597–624.

Rosenbloom, J. and W. Sundstrom (1999). The sources of regional variation in the severity of the Great Depression: Evidence from manufacturing, 1919-1937. *Journal of Economic History 59*, 714–747.

Sandleris, G. and M. Wright (2010). The costs of financial crises: Resource misallocation, productivity and welfare in the 2001 Argentine Crisis. Unpublished, UCLA.

Smiley, G. (1981). Regional variation in bank loan rates in the interwar years. *Journal of Economic History 41*, 889–901.

Solow, R. (1957). Technical change and the aggregate production function. *Review of Economics and Statistics 39*, 312–320.

Stiglitz, J. and A. Weiss (1981). Credit rationing in markets with imperfect information. *American Economic Review 71*, 393–410.

Vickers, C. Z. and N. Ziebarth (2011). Did the NRA foster collusion? Evidence from the macaroni industry. Unpublished, Northwestern University.

White, E. (2000). Banking and finance in the Twentieth Century. In S. Engerman and R. Gallman (Eds.), *Cambridge Economic History of the United States*, Volume 3, pp. 301–328. Cambridge University Press.

Wicker, E. (1996). *The Banking panics of the Great Depression.* Princeton University Press.

Ziebarth, N. (2011). The local effects of bank failures on real outcomes: Evidence from Mississippi during the Great Depression. Unpublished, Northwestern University.

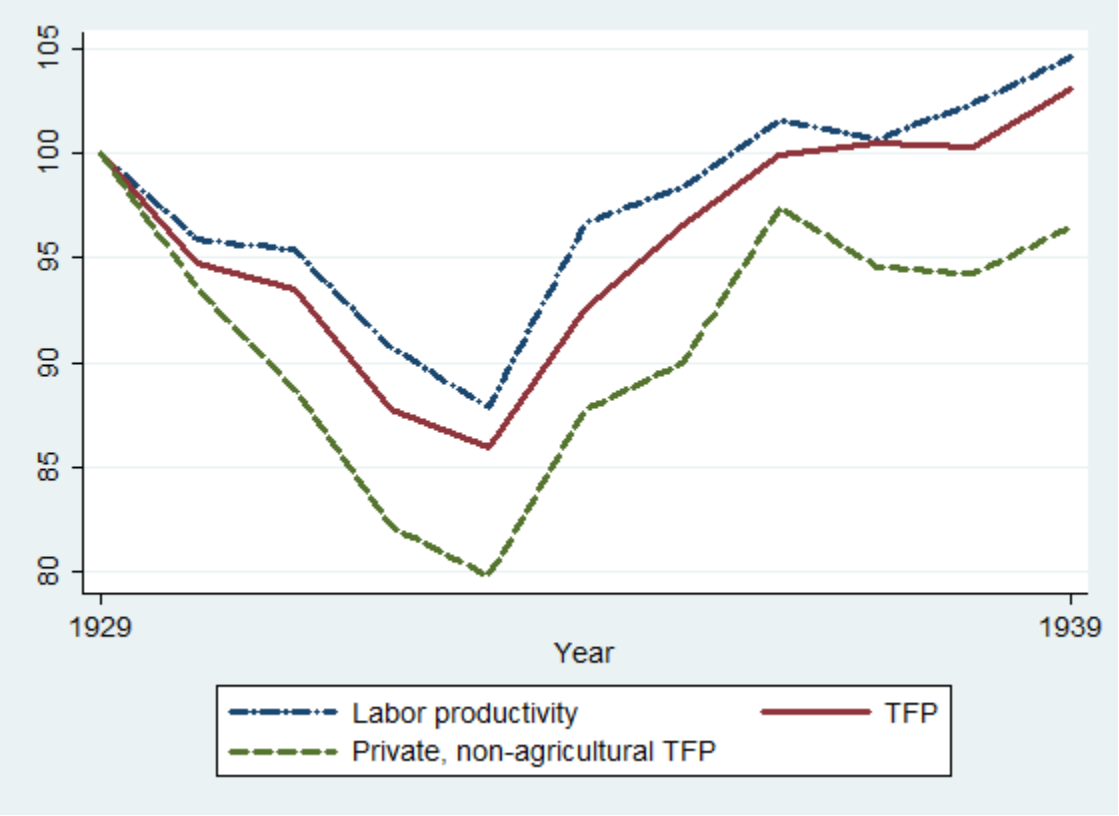

Figure 1: From Cole and Ohanian (2000) and Amaral and MacGee (2002). Deviation from a linear trend.

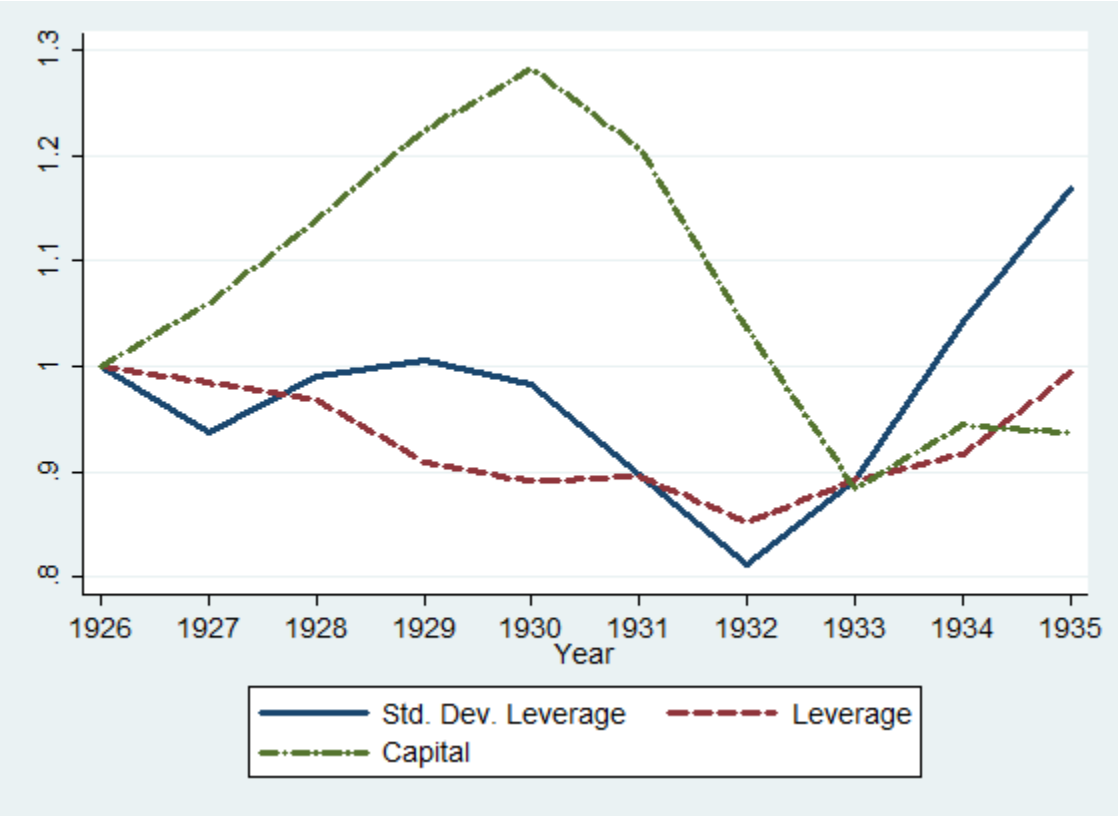

Figure 2: Data for all banks disaggregated to the state-level from various volumes of the Report of the Comptroller of the Currency. All variables have been normalized to their 1926 value. Leverage is measured as the ratio of total assets to bank capital. The denominator includes capital, surplus, and undivided profits.

CONFIDENTIAL GOVERNMENT REPORT

File No. 1-2

119.

FOR OFFICE USE ONLY
01-10
(State and County)
(City) 119
(Industry Number)

Form 119

DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
WASHINGTON

The law makes it obligatory upon every manufacturer to furnish census data. All answers will be held in strict confidence.

CENSUS OF MANUFACTURES, 1931

REQUIRED BY ACT OF CONGRESS APPROVED JUNE 18, 1929

ICE, MANUFACTURED

Under the law, no one not a sworn employee of the Bureau of the Census will be permitted to examine your report, and no information can or will be given out by the Bureau of the Census to any person outside that Bureau, whether in Government or in private life, which would disclose, exactly or approximately, any of the facts or figures in your report.

GENERAL INSTRUCTIONS.—Reports are required for all plants. Separate reports are required for plants in different counties and for those in different cities having 10,000 inhabitants or more. A combined report may be made for two or more plants engaged in the same line of manufacture and located in the same city, town, borough, or village, or for two or more such plants located in the same county but in different cities, towns, boroughs, or villages having fewer than 10,000 inhabitants. The name and location of each plant must be given. DATA FOR MERCHANDISING AND OTHER NONMANUFACTURING ACTIVITIES SHOULD BE OMITTED.

Answer all the inquiries in detail, supplying estimates if records are not available. The explanations should be read carefully before the inquiries are answered.

1. DESCRIPTION OF PLANT.—*If this report covers more than one plant, give name and location of each, under "Remarks." (See "General Instructions," above.)*

a. NAME OF PLANT: Nelson Ice Company

b. NAME OF ~~OWNER~~ OR OPERATOR: G. H. Nelson

Is this an incorporated concern? (Yes or No): No

c. POST-OFFICE ADDRESS OF GENERAL OFFICE: Stockton, Ala.

LOCATION OF PLANT

d. STATE: Alabama *e.* CITY, TOWN, OR VILLAGE: Lathem

f. COUNTY: Baldwin *g.* STREET AND NUMBER:

h. POST-OFFICE ADDRESS IF DIFFERENT FROM LOCATION (*e*): Stockton, Ala.

i. IS PLANT LOCATED WITHIN PRESENT CORPORATE BOUNDARIES OF CITY, TOWN, OR VILLAGE? (Yes or No): No

If not, name township, borough, or other civil division in which plant is located:

j. IS THIS PLANT A BRANCH OR SUBSIDIARY OF SOME OTHER CONCERN? (Yes or No): No If so, give name and address of such concern:

k. PLACE A CHECK MARK (√) IN PROPER SPACE IF, SINCE JANUARY 1, 1930, THIS PLANT HAS CHANGED ITS NAME ____; LOCATION ____; OWNERSHIP ____; GENERAL NATURE OF BUSINESS ____ If so, give former name, location, ownership, or nature of business:

2. CHARACTER OF INDUSTRY.—These answers should be as definite as possible in brief space, indicating specific products and materials. Return with the schedule a card, a catalogue, or other printed matter ordinarily used by the concern to show the nature of its business.

a. PRODUCTS: Ice

(Specify chief kinds of goods manufactured or kinds of work done)

b. MATERIALS USED: Water, Ammonia, Salt.

(Specify principal kinds of materials or stock, in order of importance)

3. PERIOD COVERED.—This report should relate *preferably* to the calendar year 1931, but it may be made to cover the business or fiscal year ending within the period from April 1, 1931, to March 31, 1932. It should, in either case, cover a full year's operation, unless the plant was newly organized or went out of business within the year.

The fiscal year or period covered by the information given below— Began Jan 1, 1931; Ended Jan 1, 1932

4. TIME IN OPERATION AND HOURS OF LABOR:

a. NUMBER OF DAYS PLANT WAS OPERATED DURING PERIOD COVERED: 210.

(Give the number of days the plant, or any important part of it, was actually in operation. Do not include Sundays and holidays unless the plant was actually in operation, and do not include days when only the office was open.)

b. NORMAL NUMBER OF HOURS PER WEEK FOR THE INDIVIDUAL WAGE EARNER: 48 hrs.

c. DOES NUMBER OF HOURS (*b*) REFER TO A 6-DAY, A 5½-DAY, OR A 5-DAY WEEK, OR TO SOME OTHER BASIS (specify)? 6 day.

TABULATED

8-6120 (OVER) 11—10/87

Figure 3: Example of first page of census schedule.

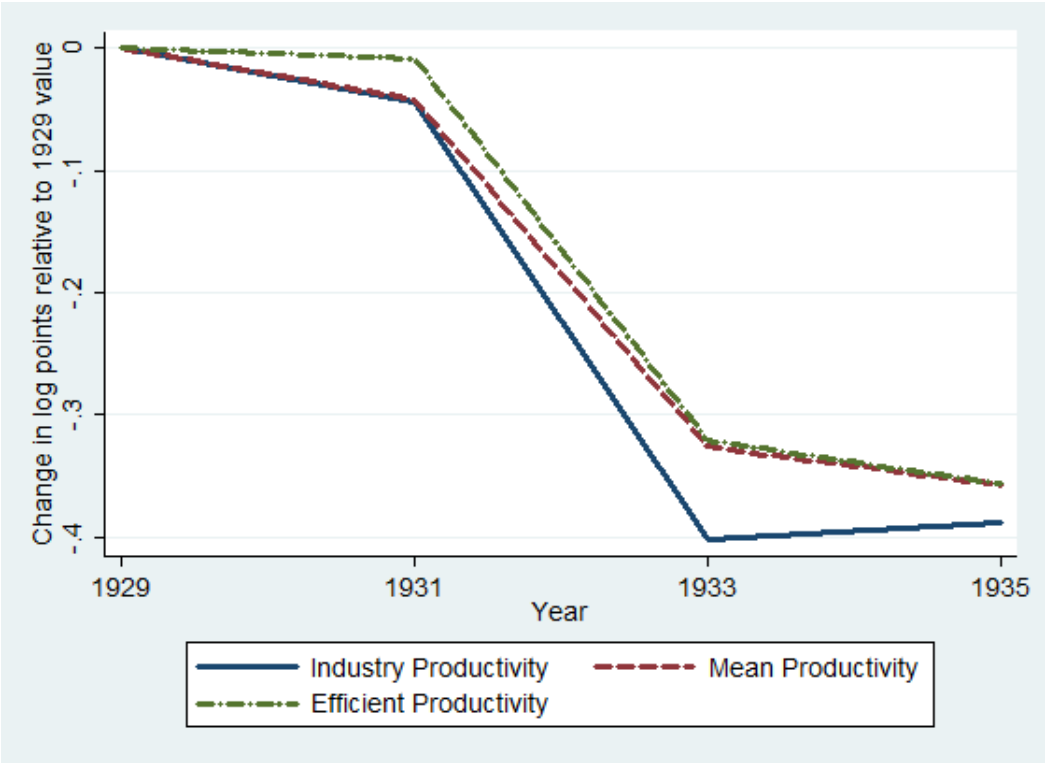

Figure 4: Dynamics of industry, efficient, and plant-level productivity for cement.

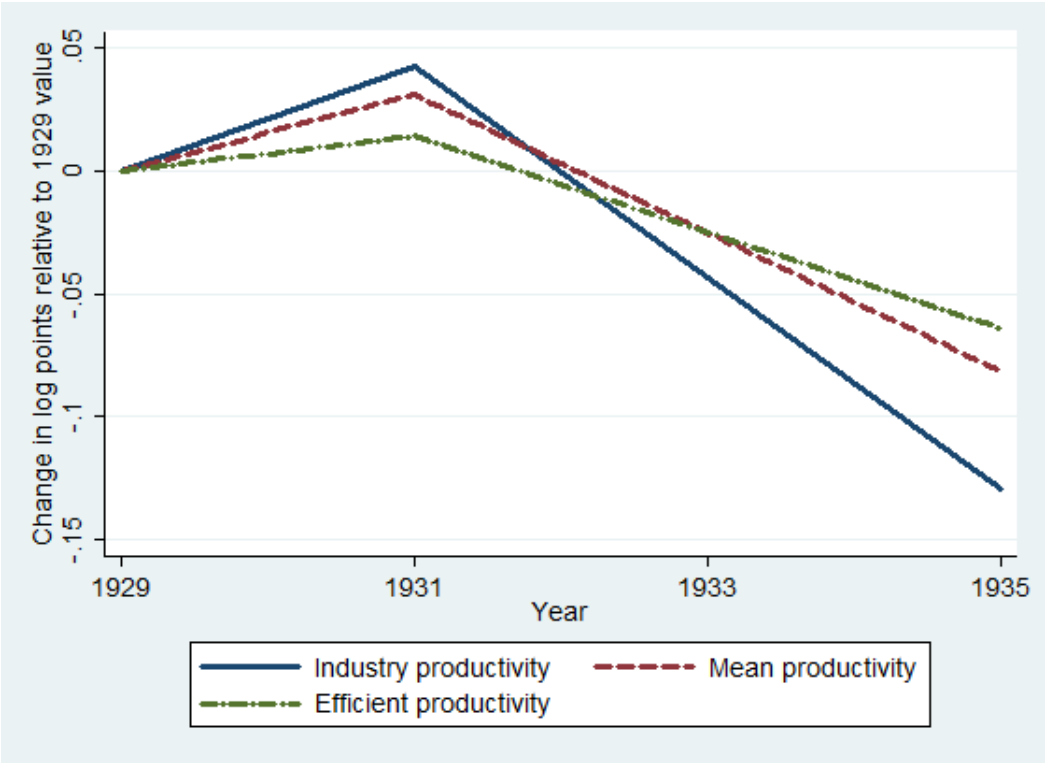

Figure 5: Dynamics of industry, efficient, and plant-level productivity for manufactured ice.

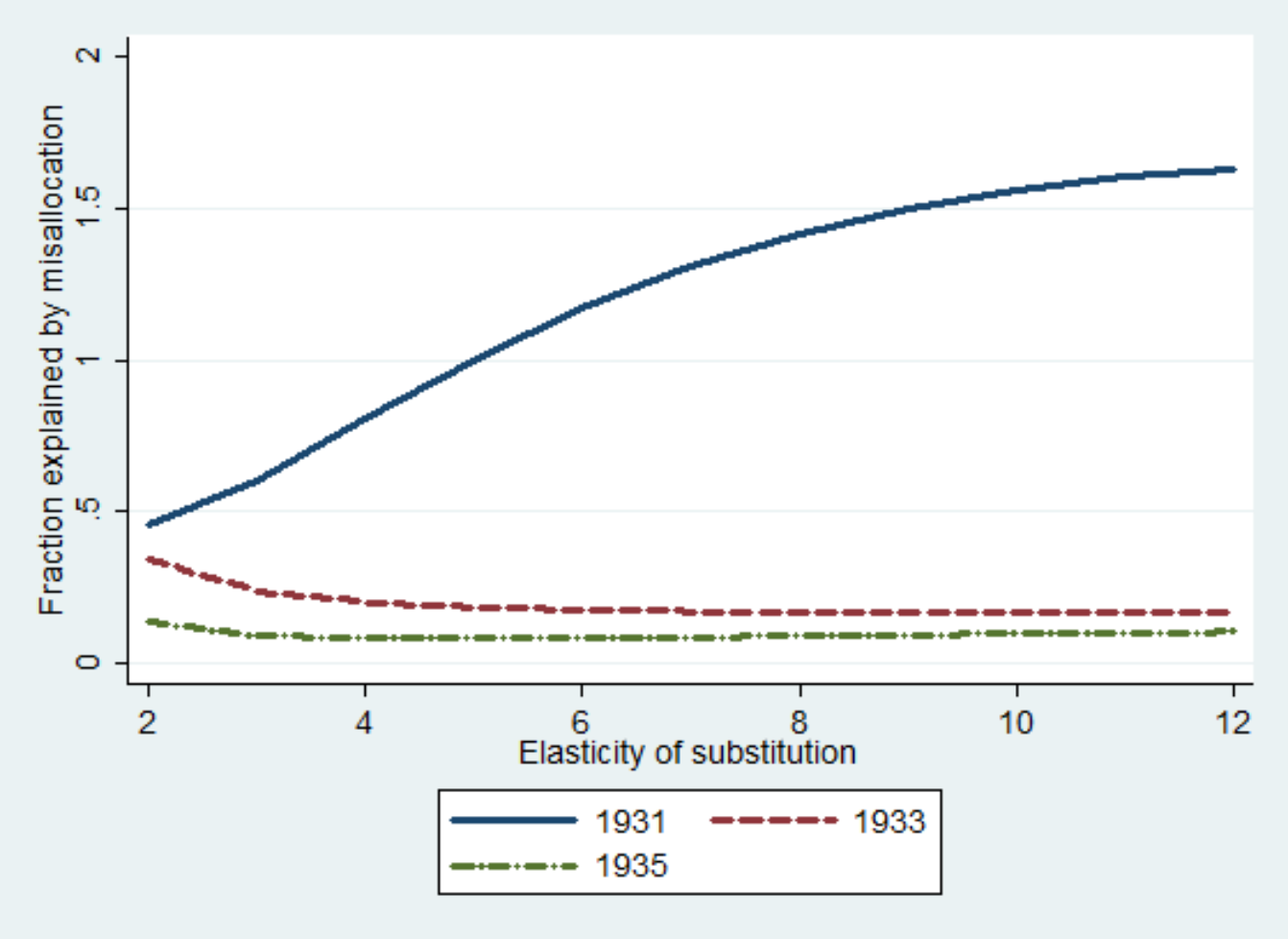

Figure 6: Fraction of productivity decline from 1929 explained by changes in misallocation for cement varying ψ.

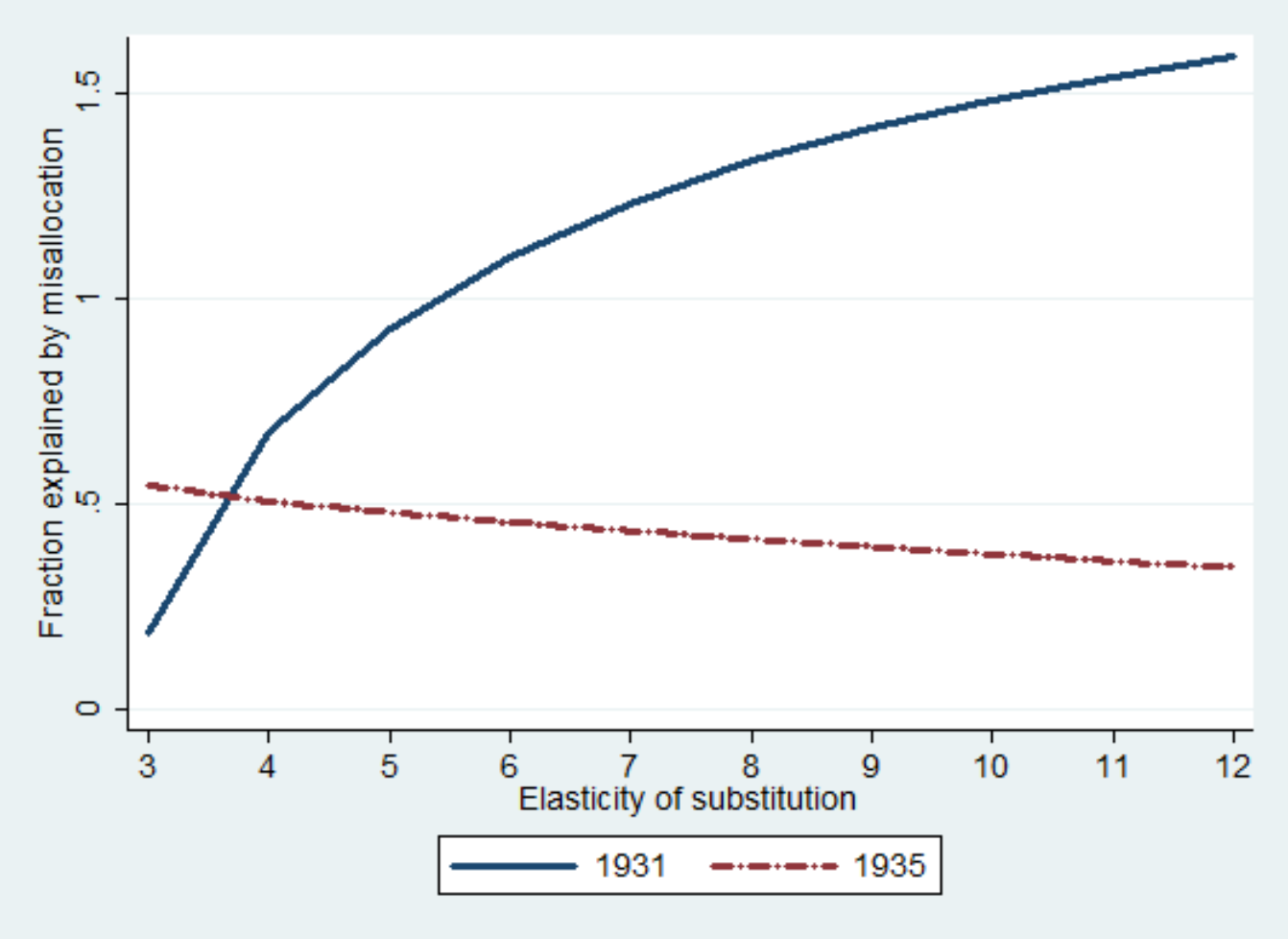

Figure 7: Fraction of productivity decline from 1929 explained by changes in misallocation for ice varying ψ.

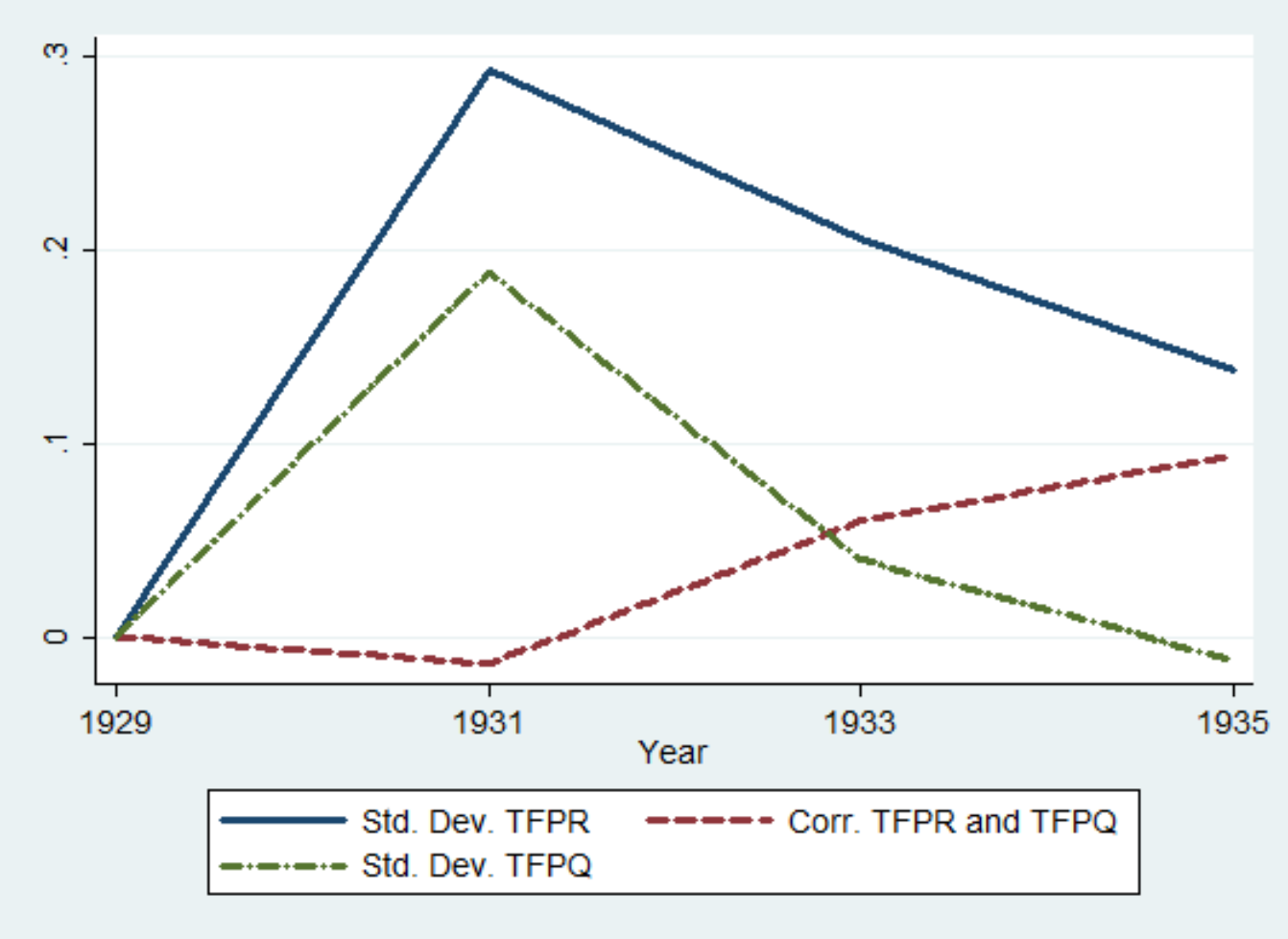

Figure 8: Dynamics of σ_R, σ_Q and ρ_{QR} for cement industry. Changes in correlation is in levels. For standard deviations in logs.

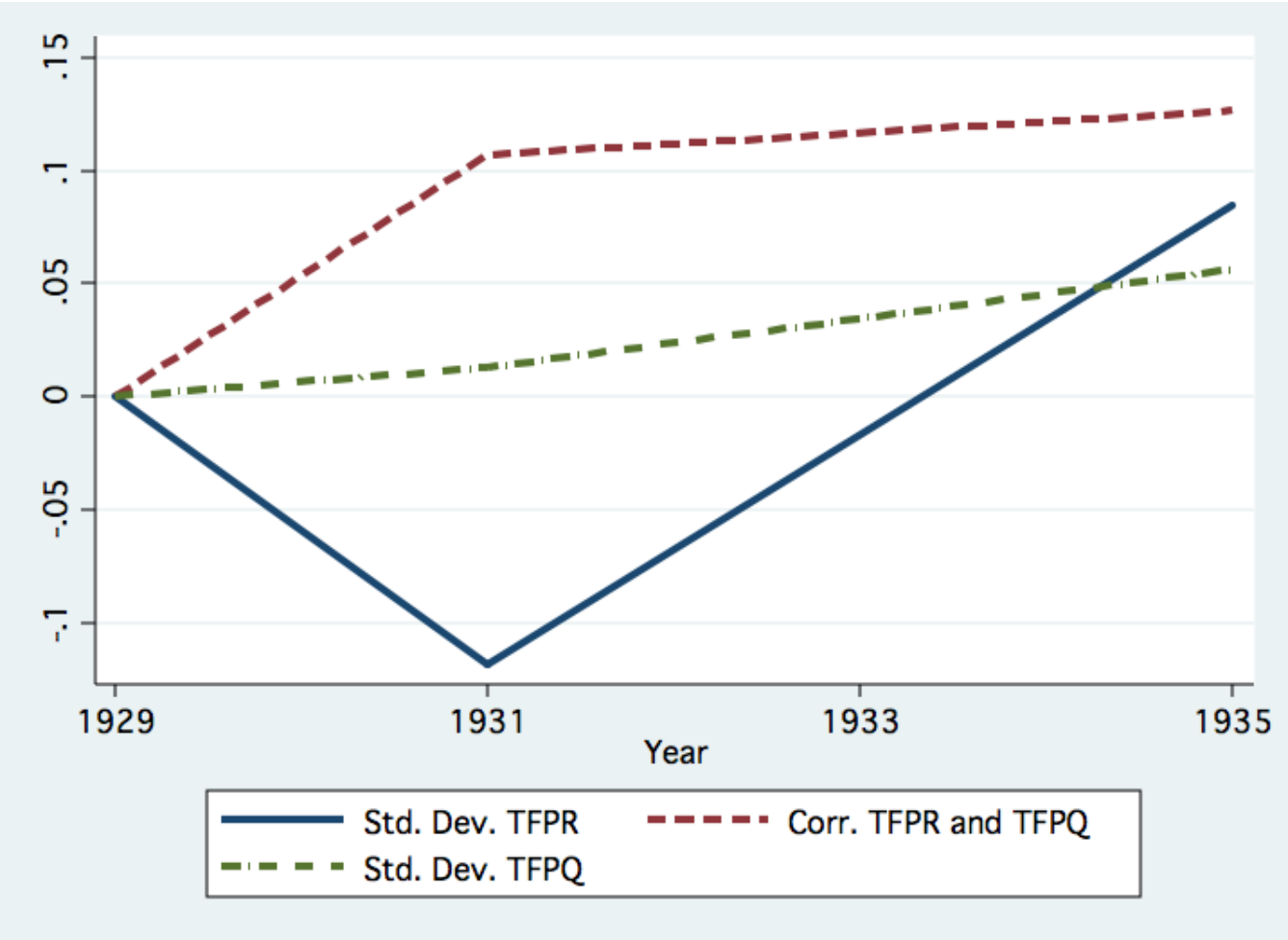

Figure 9: Dynamics of σ_R, σ_Q, and ρ_{QR} for ice industry. Changes in correlation is in levels. For standard deviations in logs.

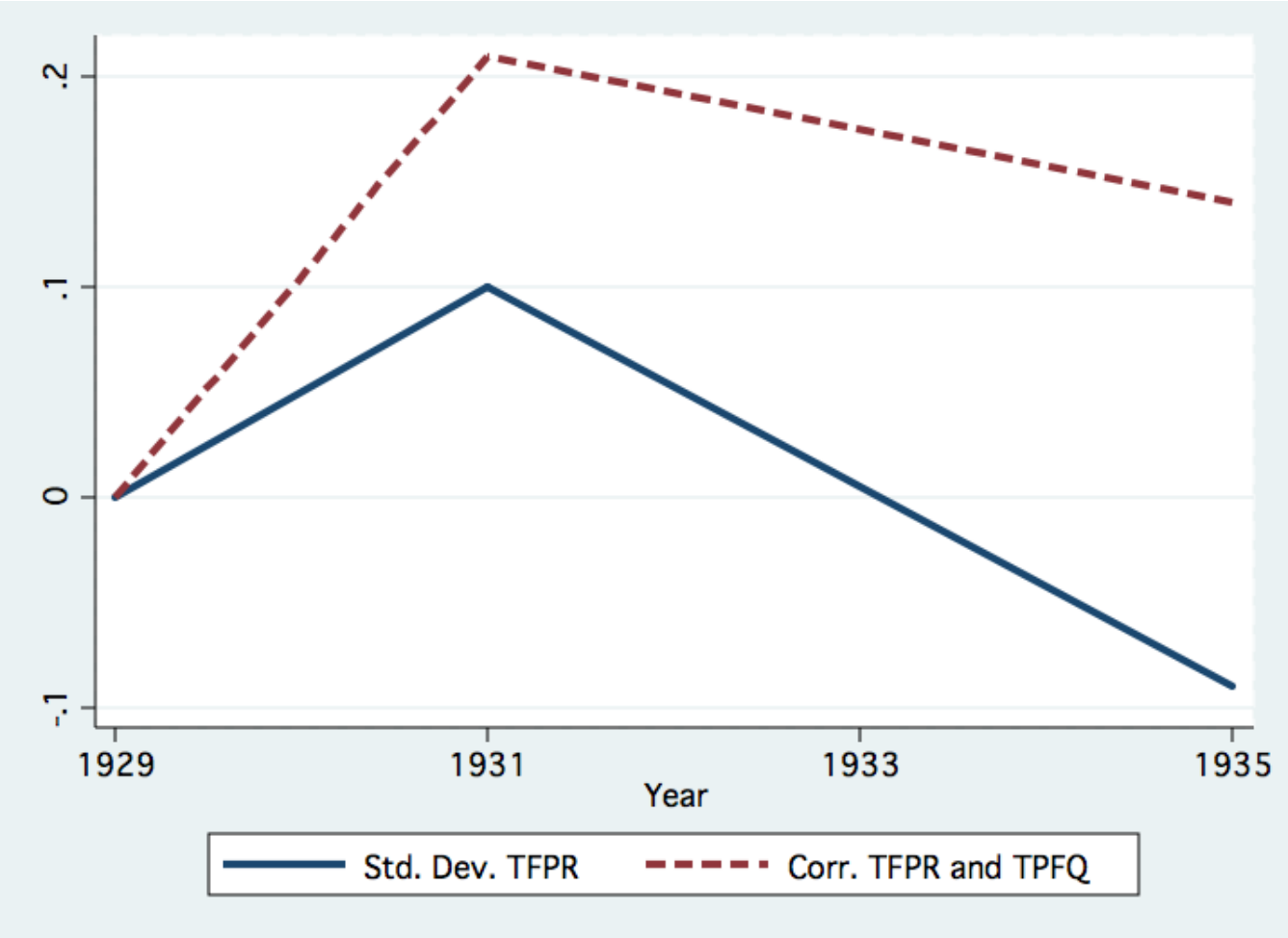

Figure 10: Dynamics of σ_R and ρ_{QR} for macaroni industry. Because of data limitations, this is only for labor productivity not TFP. Changes in correlation is in levels. For standard deviations in logs.

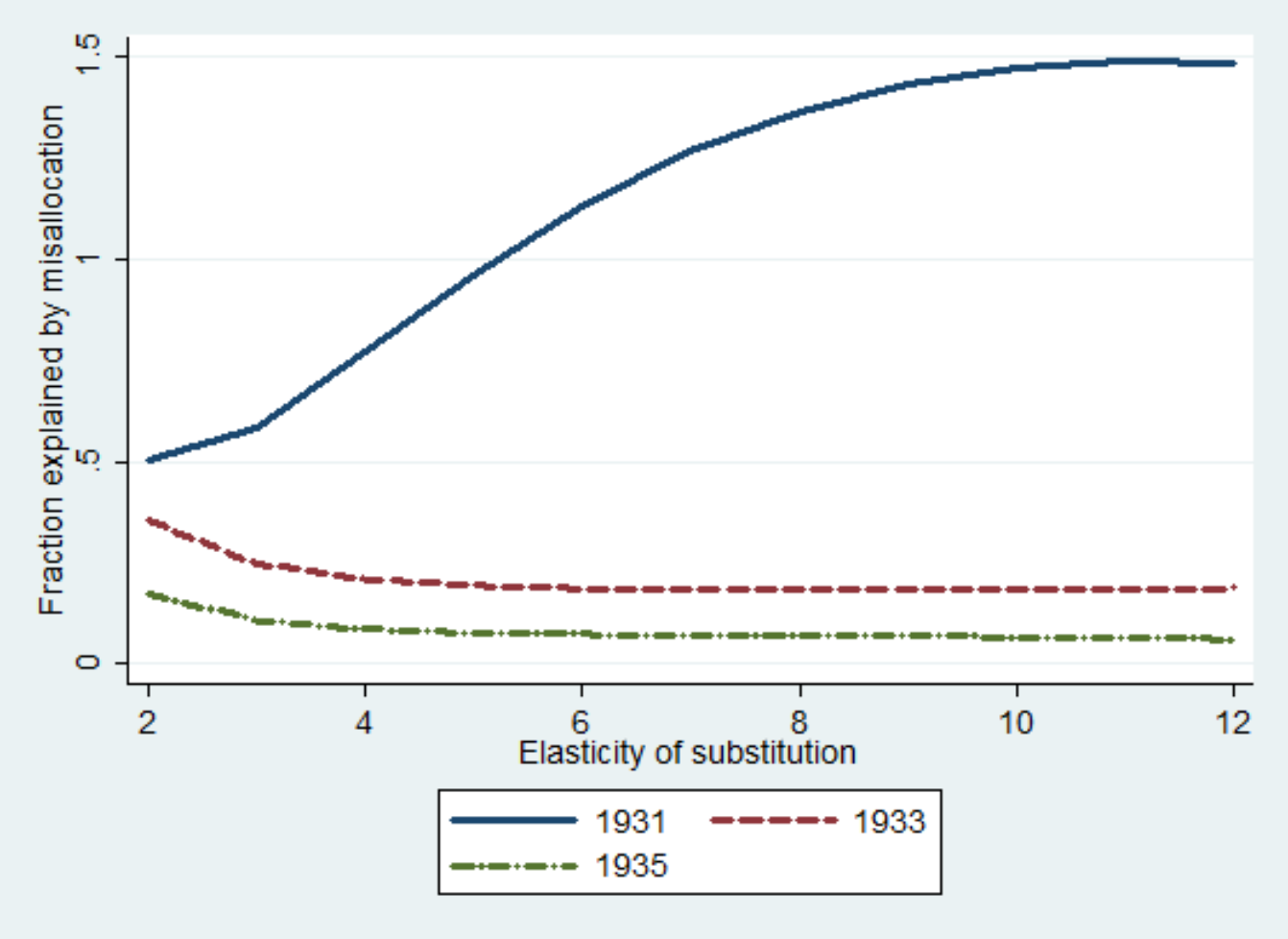

Figure 11: Results for cement varying ψ with 1% cut. This is fraction of decline in industry productivity explained by changes in misallocation explained from 1929 to given year.

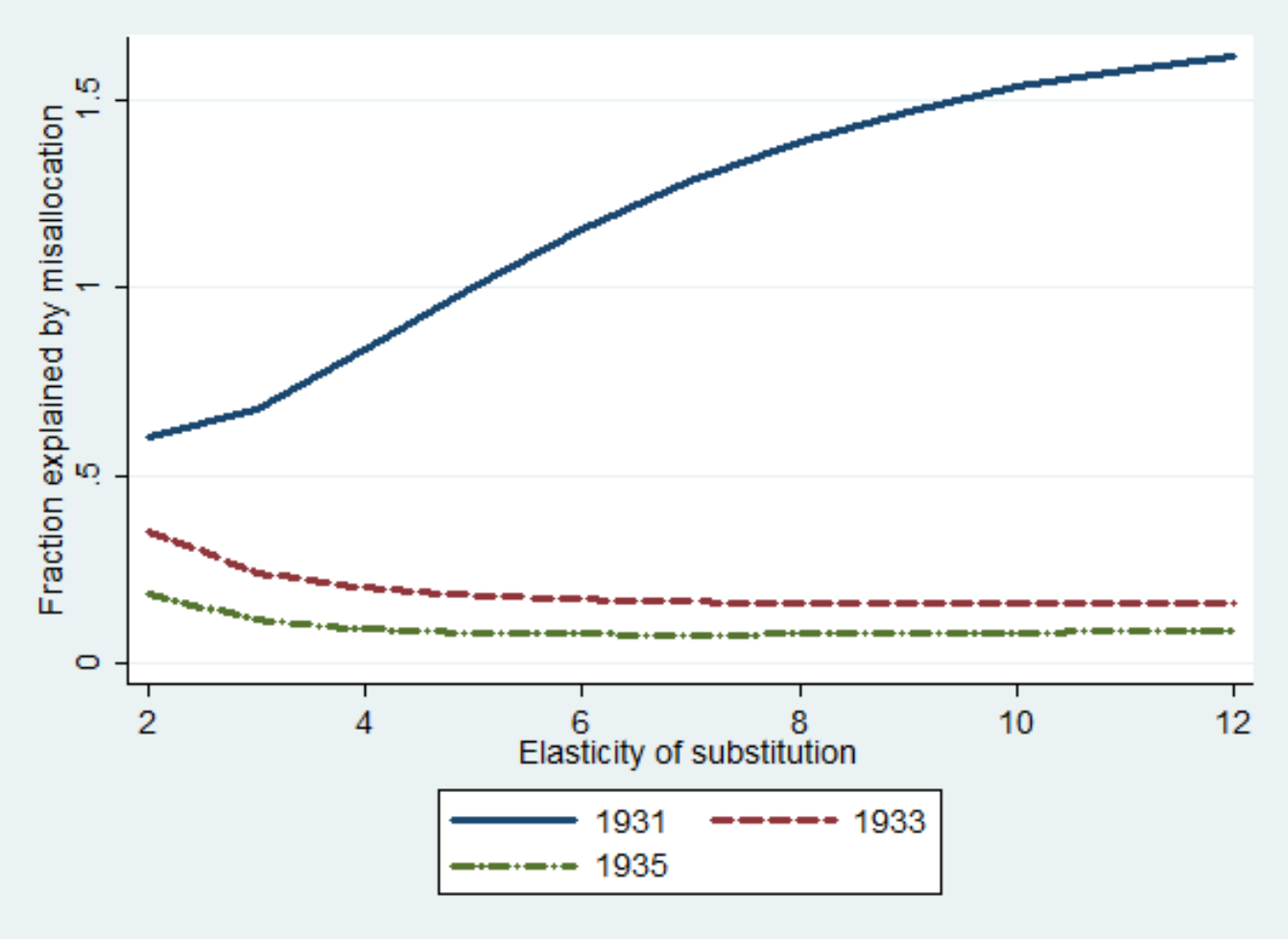

Figure 12: Results for cement varying ψ with 3% cut. This is fraction of decline in industry productivity explained by changes in misallocation from 1929 to given year.

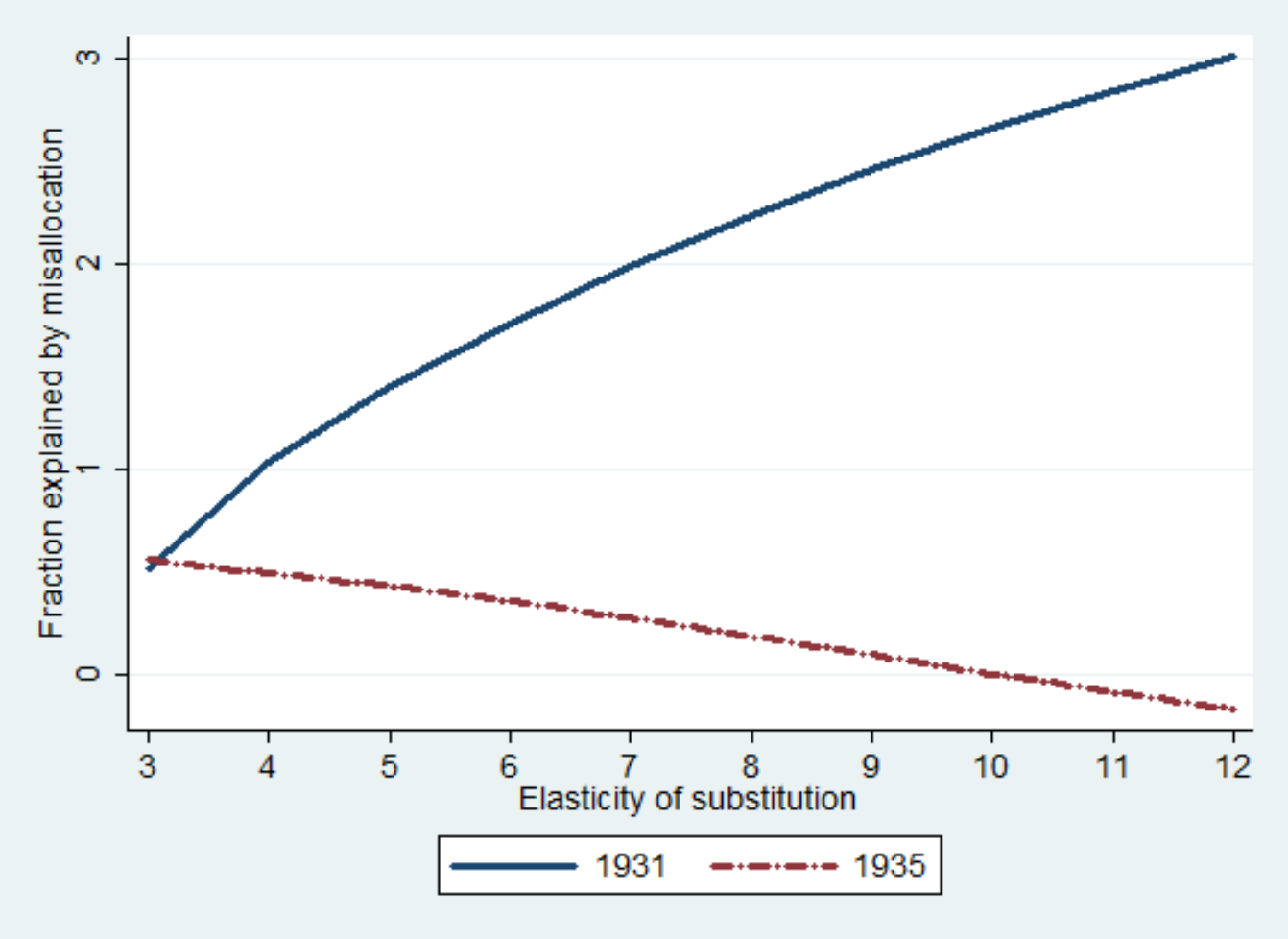

Figure 13: Results for ice varying ψ with 1% cut. This is fraction of decline in industry productivity explained by changes in misallocation from 1929 to given year.

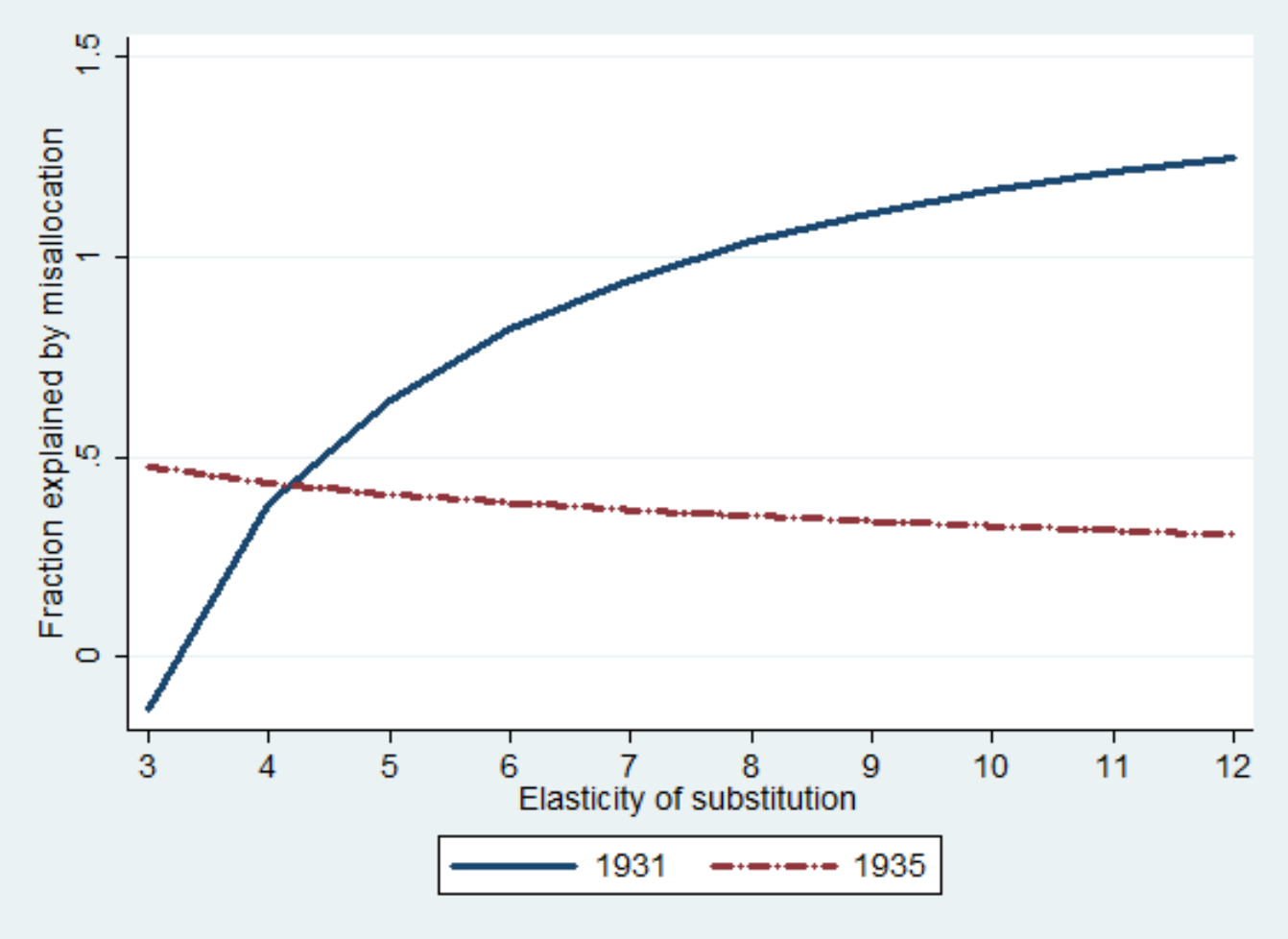

Figure 14: Results for ice varying ψ with 3% cut. This is fraction of decline in industry productivity explained by changes in misallocation from 1929 to given year.

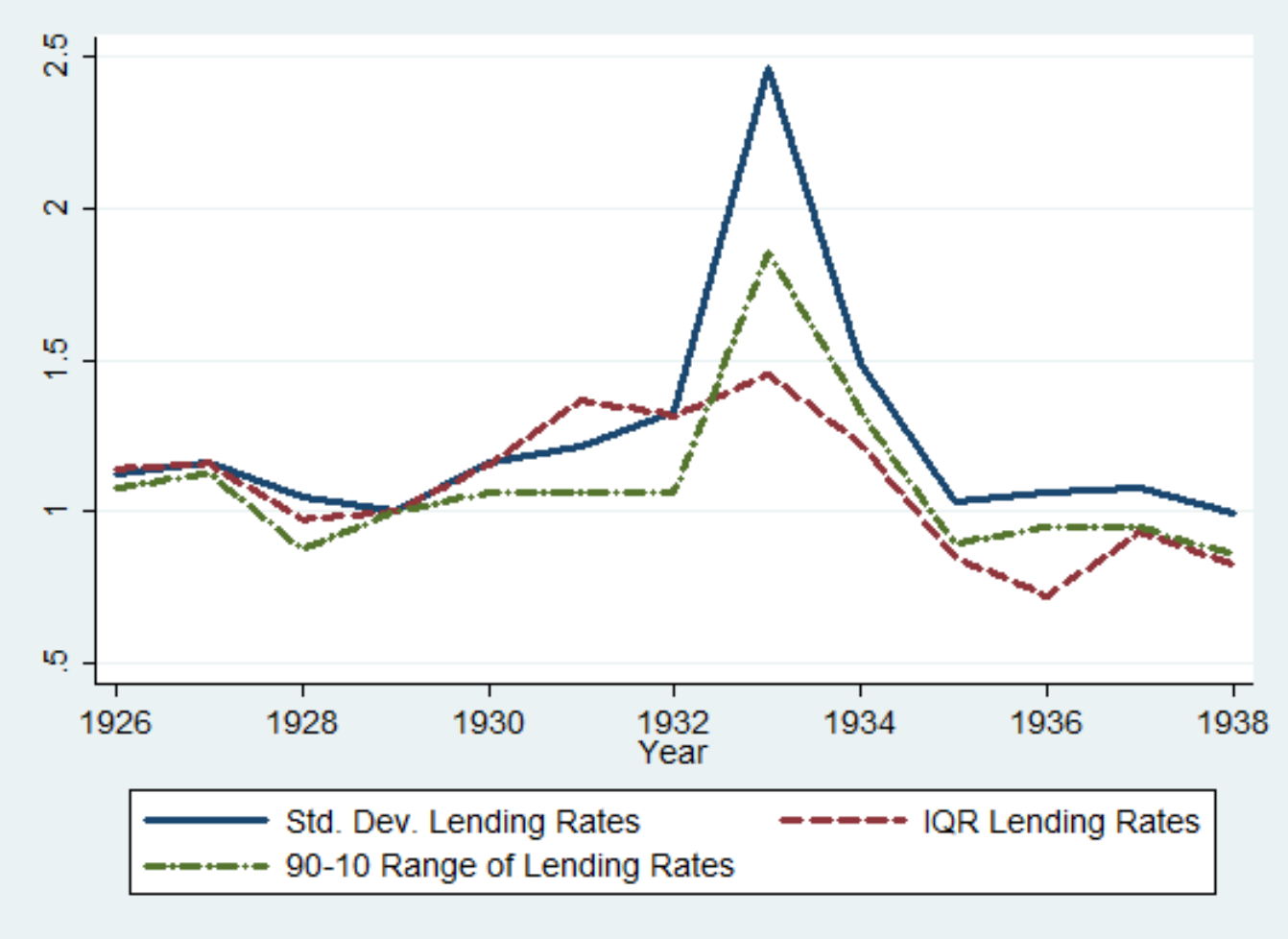

Figure 15: Standard deviation and IQR of state-level net lending rates from Bodenhorn (1995) normalized to 1929 value. The 1% tails have been trimmed from each year.

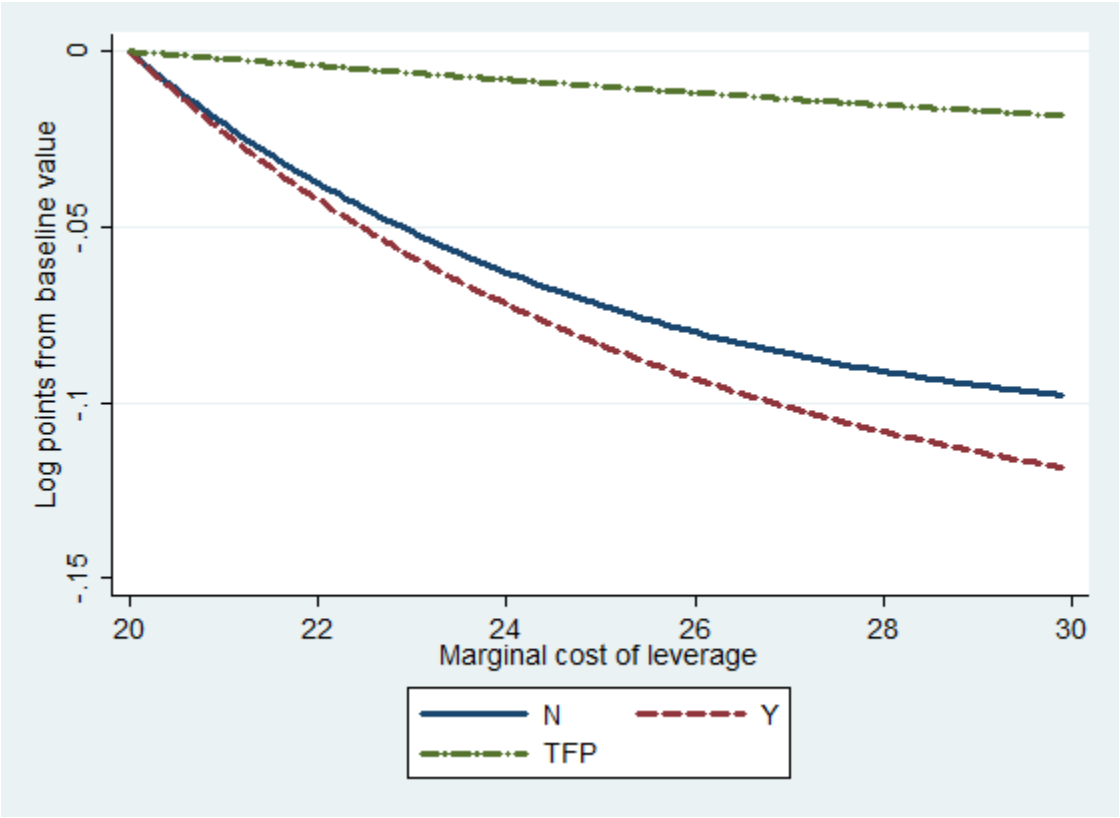

Figure 16: Effect of ω on steady state values with no extensive margin.

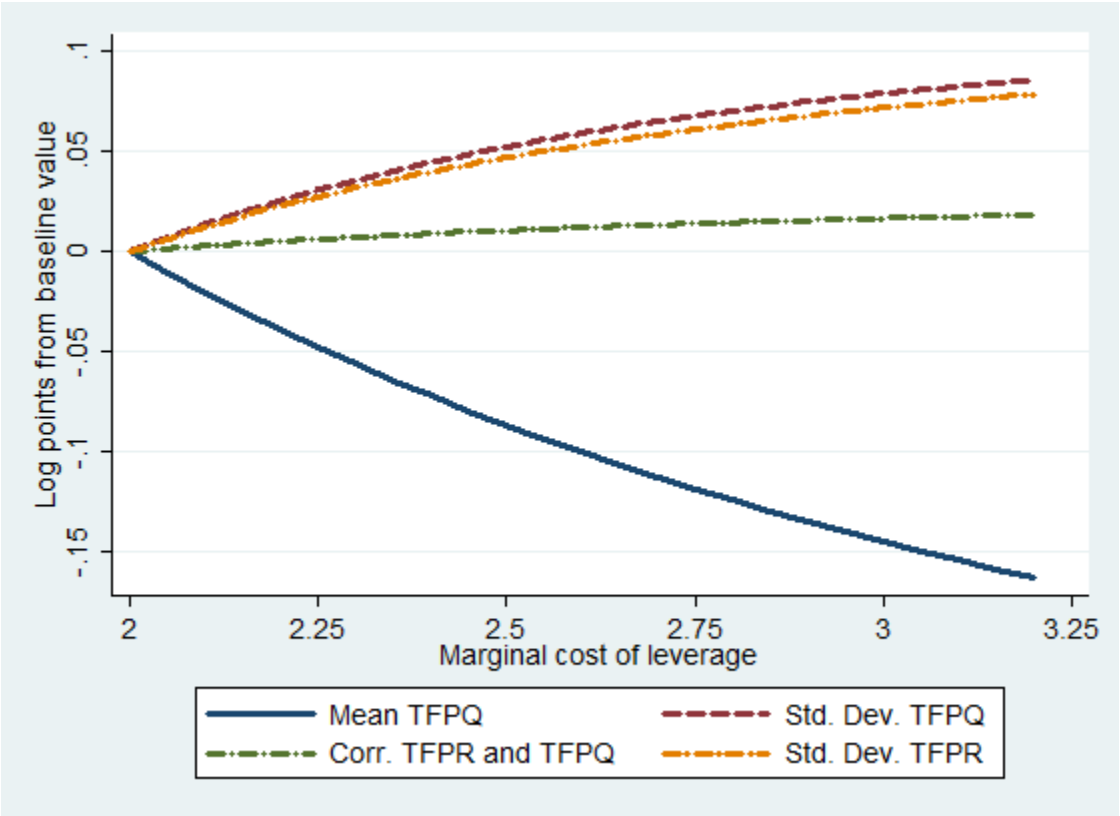

Figure 17: Effect of ω on steady state values with extensive margin.

	$TFPR$			
	(1)	(2)	(3)	(4)
Rate	.024***	.016***	.025*	.017*
	(.007)	(.005)	(.015)	(.009)
Log Wage	.088***	.085***	.088***	.086***
	(.01)	(.01)	(.016)	(.016)
Plant effects	Random	Random	Fixed	Fixed
Year effects?	YES	NO	YES	NO

Table 1: Regression of deviations in $TFPR$ on state-level lending rates from Bodenhorn (1995). Log wage is deviation from industry-year average. The regressions exclude observations from 1933. Standard errors are clustered at the plant-level. *** significant at 1% level. ** significant at 5% level. * significant at 10% level.

	R^2 State $*$ Industry
1929	.07
1931	.12*
1935	.07

Table 2: R^2 of regression of $TFPR$ on state by industry interactions. The year 1933 is dropped for comparability since I do not have $TFPR$ data for ice in that year. * denotes reject the hypothesis that R^2 in 1929 is equal to R^2 in other given year at 10% level. ** at 5% level. I use a bootstrap procedure to calculate these values with 500 repetitions.

	$TFPR$	
	(1)	(2)
Log Bank Leverage	.04	.04
	(.09)	(.07)
Log Bank Leverage 1931	.12**	.13 ***
	(.05)	(.04)
Log Bank Leverage 1935	.07	.11**
	(.07)	(.05)
Plant effects?	Fixed	Random

Table 3: Regression of deviations in $TFPR$ on state-level log leverage ratios. The regressions exclude observations in 1933. All regressions include year fixed effects. Standard errors are clustered at the plant-level. *** significant at 1% level. ** significant at 5% level. * significant at 10% level.

	Exit			
$TFPR$	-.18*	-.16	-	-
	(.10)	(.11)		
	-.07	*-.06*		
$TFPQ$	-	-	-.21**	-.18**
			(.09)	(.07)
			-.08	*-.07*
Industry effects?	YES	NO	YES	NO

Table 4: Probits for exit on $LFPR$ and $LFPQ$ for the two industries. I do not include both $TFPR$ and $TFPQ$ simultaneously. because of multi-colinearity issues. 2% tails of $TFPR$ and $TFPQ$ are trimmed. All regressions include year and state fixed effects. Robust standard errors are reported in parentheses and and marginal effects calculated at the means are reported in italics. * denotes significance at the 10% level. ** denotes significance at the 5% level. *** denotes significance at the 1% level.

	$TFPR$	$TFPQ$	Log Price
Lag	.68***	.76***	.73***
	(.03)	(.03)	(.03)
R^2	.31	.46	.95

Table 5: Biannual Autocorrelations for a variety of plant-level variables for the two industries. $TFPR, TFPQ$ are revenue and physical productivity demeaned by industry average. They are only labor productivity for the macaroni plants. Price is also demeaned by industry year average. As before the 2% tails of productivity distribution are trimmed before estimation. Each regression includes year, industry, and state fixed effects. Standard errors are clustered at the plant-level and calculated using the delta method. * denotes significance at the 10% level. ** denotes significance at the 5% level. *** denotes significance at the 1% level.

Parameter	Value	Comment
β	.99	Standard discount rate.
σ	4	Elasticity of substitution used in empirical work.
γ	.97	Survival of bankers from Gertler and Kiyotaki (2010).
π	.33	Frisch elasticity of labor supply from Gertler and Kiyotaki (2010).
ω	20	Chosen to target initial steady state of $\frac{N}{wL} = .09$.
ν	5.584	From Gertler and Kiyotaki (2010).
σ_A	.25	Match ratio of productivity dispersion from Foster et al. (2008).
ξ	.003	Transfer to entering bankers. Similar to Gertler and Kiyotaki (2010).
A	-6	Normalization.

Table 6: Parameter values for baseline model.