Zombie Lending Due to the Fear of Fire Sales

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Abstract

This paper provides evidence of a new cost of fire sales: zombie lending by banks. Banks with high market share are more likely to internalize the negative spillovers of falling collateral prices during a fire sale. To prevent prices from falling further during a fire sale, these banks do not liquidate defaulted firms and instead give zombie loans to keep them alive. Using structural breaks in real estate prices to identify periods of fire sales in different MSAs, we provide evidence that banks with high market share give zombie loans to firms with relatively higher real estate assets during a fire sale. Further, congestion due to zombie firms in an industry reduces the investment and profitability of healthier firms. Overall, we highlight a new mechanism for zombie lending resulting from reduced collateral liquidation in markets prone to fire sales.

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1 Introduction

Fire sale of real assets occurs when the assets of financially distressed firms are sold at prices that are below their fair value because other specialist buyers may not have enough liquidity to buy these assets (Shleifer and Vishny, 1992). These fire sales generate negative spillover effects and reduce the value of firms holding similar assets (Kiyotaki and Moore, 1997; Brunnermeier and Pedersen, 2009). Since fire sales are both privately costly and socially inefficient because the assets are bought by nonspecialists at low prices,[1] market participants take actions to avoid it (Shleifer and Vishny, 2011).[2] Lenders may also internalize the negative externalities generated by fire-sale; for instance, Giannetti and Saidi (2019) find that lenders with large market share in an industry continue to provide liquidity to distressed firms in that industry and internalize negative spillover of industry downturns. We conjecture that if such support goes to otherwise insolvent or "zombie" firms, it may create another externality by diverting resources away from healthier firms (Caballero et al., 2008), possibly hindering creative destruction.

We use the real estate market in the US as our setting. Firms use real estate as collateral when they raise capital (Chaney et al., 2012; Gan, 2007; Cvijanović, 2014). However, real estate markets are illiquid and prone to fire-sale externalities during economic downturns (Harding et al., 2009; Campbell et al., 2011; Anenberg and Kung, 2014; Hartley, 2014). This paper examines whether lenders keep credit flowing to otherwise insolvent borrowers (zombie firms) during real estate downturns to avoid fire-sale externalities in real estate markets. We show that banks that have a high market share in a metropolitan statistical area (MSA) and are therefore more likely to internalize the cost of fire sale in that MSA give zombie loans to firms with relatively high real estate assets when the local real estate

[1] For evidence on the cost of fire sale, see Pulvino (1998), Campbell et al. (2011), Almeida et al. (2011), Benmelch and Bergman (2011), Carvalho (2015), among others.

[2] For example, Benmelech and Bergman (2009) show that airlines renegotiate their lease obligations downwards when they are financially stressed and the liquidation value of their airplanes is low. Also, see Asquith et al. (1994), Almeida et al. (2011), Schlingemann et al. (2002), Ortiz-Molina and Phillips (2010) for evidence of actions taken by agents to avoid fire sale.

market is under stress and subject to fire sale.

We begin our analysis by building a theoretical model to illustrate this new externality of zombie lending due to fear of fire sales. Firms borrow from banks using their real estate assets as collateral. Some of these firms default when faced with a negative shock and turn into low-productivity firms, which we call zombie firms. Banks can either liquidate these firms and sell their real estate collateral or keep them alive by giving negative NPV zombie loans. Very few firms default during the *normal* state, whereas several firms default during the *adverse* state. Since very few firms default in the normal state, banks can liquidate these firms and sell their collateral at a fair price as there are enough buyers and the market is liquid. However, in the adverse state, when many firms default, buyers do not have enough liquidity to buy the assets of the defaulted firms. Hence, there will be cash-in-the-market pricing (Allen and Gale, 1994), and assets will be sold at fire-sale price resulting in a decline in real estate price. The price decline further deteriorates the health of the local economy and affects the value of the loan portfolio of banks.

Atomistic banks take prices as given and do not internalize the effects of fire sale when they are making the decision of liquidating a loan; hence they liquidate all their loans. However, larger banks internalize the effect of their decision to liquidate on the price at which they will sell the collateral and also on the value of their loan portfolio. Hence they extend zombie loans to insolvent firms instead of liquidating them. In our model, banks with higher market share give more zombie loans, particularly to firms with higher real estate collateral. This is because liquidating firms with higher real estate collateral will have a larger impact on price when there is already a fire sale going on in the market.

We conduct our empirical analysis and test the model's implications in several steps. Our model suggests that when there is a fire sale in an MSA, then the banks with higher market share in that MSA would give zombie loans to firms with relatively high real estate in that MSA. Since fire sale in an MSA is not directly observable, we create two proxies for when an MSA is undergoing a fire sale. First, we assume that there is a fire sale in an MSA when the local real estate price is declining. This proxy for identifying fire sales may not be exogenous because while prices will decline when there is a fire sale in an MSA, they may also decline due to fundamental shocks such as productivity shocks to the firms in the MSA. If these shocks are for some reason correlated with zombie lending in the MSA, then there will be an endogeneity problem.

To overcome this challenge, we create another exogenous proxy for fire sale in an MSA. This method of identifying fire sale and our arguments herein are based very closely on Charles et al. (2018). We say that an MSA is undergoing a fire sale if there is a negative structural break in the real estate price trend of that MSA, that is there is a *sharp* decline in the real estate price in that MSA. The structural breaks in price trend of an MSA is estimated using standard methods in time-series econometrics ((Bai, 1997; Bai and Perron, 1998)). The underlying assumption is that these sharp declines in prices are not driven by changes in local fundamental factors because these factors move gradually; instead, these price declines are driven by speculative factors. The justification for our assumption comes from the emerging consensus in the existing literature which has argued that the variation in real estate prices during the boom and bust of the global financial crisis was caused by speculative "bubble" and not driven by fundamental factors like productivity or income. Since the sharp decline in prices are not driven by fundamentals, the real estate is effectively being sold at below their fundamental price, that is they are undergoing a fire sale.

We examine whether banks extended credit to distressed firms at subsidized rates, known as zombie lending, when an MSA is undergoing a fire sale. Following Caballero, Hoshi and Kashyap (2008), we identify zombie firms as those financially stressed firms that receive credit at interest rates lower than the most creditworthy firms in the economy. Firm level analysis suggests that indeed banks extend credit to zombie firms, particularly firms with relatively high real estate assets. Firms with above-median ratio of real estate assets to total assets have a 1.7% higher probability of receiving a zombie loan than firms with below-median real estate holdings when there is a price decline in an MSA. This result is in line with the predictions of our model, wherein banks are more likely to extend zombie credit to firms with higher collateral, as liquidating them would result in larger price declines. When fire sale is identified by negative structural breaks, we find that above median real estate firms are 2.1% more likely to be zombies than below median real estate firms during the fire sale.

To further test the model and pin down the channel, we use data at the loan level and estimate how banks' market share in an MSA affects the probability of them giving loans to zombie firms. According to our model, a bank with a high market share will internalize the effect of price decline more than a bank with a low market share. We show that a one percent increase in a bank's market share in an MSA increases the probability of extending zombie credit to high real estate firms by 0.16% (0.15%) when there is a fire sale in that MSA as identified by a negative structural break (price decline). Building on this channel, we conduct an alternate test and examine how bank market concentration affects zombie lending in an MSA. MSAs with higher bank concentration, as measured by the Herfindahl-Hirschman Index (HHI), are also associated with higher zombie lending to firms with high real estate assets during fire sales. In an MSA with one standard deviation (0.223 points) higher bank HHI, high real estate firms have a 12% (7%) higher likelihood of receiving a zombie loan compared to low real estate firms during a fire sale in that MSA as identified by a negative structural break (price decline).

Finally, we show that the presence of zombie firms harms the healthier non-zombie firms in an industry. Caballero et al. (2008) contend that zombie firms in an industry can divert resources, such as capital and labor, that would otherwise have been available to more efficient firms. Thus they congest the market and affect the performance of healthier firms. Indeed, we find that a 1% increase in the share of zombie firms in an industry is associated with a 1.2% lower investment by healthy firms. The return on assets of non-zombie firms is also lower by 1%.

The key contribution of this paper is to show that as lenders internalize the negative externality of declining collateral prices by extending zombie credit, they create another externality by keeping unproductive firms alive. Thus the actions that banks take may be privately or even locally optimal, but may be inefficient for the economy as a whole.

Our paper contributes to several strands of literature. Prior literature has documented that fire sales exist and are costly; hence lenders and borrowers take action to avoid fire sale of assets (Shleifer and Vishny, 2011). For example, Asquith et al. (1994) show that distressed firms are more likely to restructure debt than liquidate their assets when the industry is facing a downturn. Schlingemann et al. (2002) find that firms divest business units from industries with more liquid markets rather than liquidating the worst-performing units. Banks with a high market share in an industry are also more likely to provide liquidity to firms during distress due to the fear of fire-sale externalities (Giannetti and Saidi, 2019).

We show that banks with a higher market share in the local market are more likely to internalize the effect of real estate price declines and extend zombie credit. Our result is analogous to Favara and Giannetti (2017), who show that banks with a higher market share are less likely to trigger foreclosures. Similarly, Gupta (2022) shows that lenders with larger market shares in mortgage markets increase the supply of credit to low-quality high-risk borrowers to prop up the house prices at the end of a boom. However, our paper highlights the *harmful* effects of keeping zombie firms alive. Our findings add to the extensive literature on the effects of bank concentration on different aspects of lending activity, such as the quantity of credit provision (Garmaise and Moskowitz, 2006) and bank-firm relationships (Petersen and Rajan, 1995). We highlight that bank concentration can affect a bank's ex-post decision to either liquidate a firm or extend zombie credit.

This paper also contributes to the literature on zombie loans. In their seminal paper, Caballero et al. (2008) show that zombie firms can make industries unproductive as they prevent creative destruction. The literature on the causes of zombie lending has shown that, in the presence of limited liability, under-capitalized banks have the incentive to engage in zombie lending (Giannetti and Simonov, 2013; Acharya et al., 2019; Blattner et al., 2018) as they are reluctant to liquidate firms and recognize losses. Our paper provides a novel channel through which zombie lending arises: to prevent the liquidation of assets in illiquid markets prone to fire sales.

Our paper also adds to the literature on the role of collateral in credit provision. Theoretical models starting with Besanko and Thakor (1987) and Hart and Moore (1994) have revealed the importance of collateral in alleviating agency frictions and increasing firms' access to credit. Companies with access to more deployable collateral receive larger loans with longer maturity and lower interest rates (Benmelech et al., 2005). Chaney et al. (2012) show that real estate is a significant source of collateral for firms and that increasing collateral value increases investments. Cvijanović (2014), on the other hand, shows that increasing real estate prices lead to an increase in firm leverage. Our paper shows that high real estate assets can help firms secure loans but for a different reason. Liquidating firms with more real estate will result in larger price externalities, and as a result, banks are prepared to extend zombie loans to such firms.

The rest of the paper is organized as follows. Section 1 presents a model of bank lending where banks choose between liquidating firms or giving zombie loans. Section 2 discusses the data. Section 3 contains our empirical strategy. Section 4 presents the results, and section 5 concludes.

2 Model

In our model economy, there are four kinds of agents: firms, banks, depositors and outside investors; and two dates, $t = 0$ and 1. At $t = 0$, there is a continuum of atomistic identical firms, each owns C units of real estate assets (or land) that can be used as collateral and has a positive NPV project which requires one unit of investment. There is a continuum of atomistic banks of mass one, which raise funds from insured depositors. Using these deposits, each bank finances a portfolio of 1 unit of a continuum of firms taking the real estate assets of the firm as collateral. The face value of each loan is denoted by F, which needs to be paid by the firms at $t = 1$.

The project owned by firms can either succeed or fail. There are two aggregate states of nature: normal and adverse. The probability of success is denoted by $q \in \{\alpha, \beta\}$, where α (β) is the probability of success in the normal (adverse) state. We assume $\alpha > \beta$. The project fails with the complementary probability. If the project fails, then the firm defaults and pays nothing. Now the bank has two options. First, it can liquidate the firm and sell the collateral C at prevailing market prices (to be determined later). The second option is to roll over the loan and provide the required financing to keep the firm alive. This rolled-over loan is essentially a zombie loan with a negative NPV and has a very low probability of success in the future. The total cost to the bank of giving this negative NPV zombie loan to a firm and keeping it alive is L.

If a firm's project succeeds, then it pays F to its bank. The *successful* firm is then endowed with another project that is financed by the same bank, and the process can repeat in the future. The continuation value of loans given by the bank to each successful firm is denoted by V. So we are assuming that the banks are not competitive and earn positive profits. Banks may be earning this profit because of some market power or information rent from relationship lending (Rajan, 1992).

As discussed above, if a firm fails at $t = 1$, then the bank can liquidate it and sell the collateral at the market price denoted by p. We assume that the intrinsic or fair value of one unit of land is given by Z which is independent of the aggregate state.[3] This value can be interpreted as the net present value that can be generated by the investors who buy the land. This means that an investor will never pay a price larger than Z. The economy

[3] At the cost of some notational complexity, we can relax this assumption, and instead assume that the fair value of the land at $t = 1$ depends on the state (normal or adverse), without changing the results.

also has outside investors who are ready to buy the land at $t = 1$. These outside investors have a total wealth of W.[4] The investors can be interpreted as experts who understand the local economy and the real estate markets. Their wealth characterizes the demand for real estate assets. One factor that could affect the size of the set of possible buyers, and thus determine W, is zoning regulation which determines the set of uses of the real estate property (Benmelech et al., 2005).

The equilibrium price is determined as follows. If a bank decides to give a zombie loan to a failed firm with probability λ and liquidate it with probability $1 - \lambda$, then the supply in the real estate market in the normal state is given by $(1 - \alpha)(1 - \lambda)C$. We assume that in the normal state very few firms fail, that is α is high enough (hence the supply is low enough) such that even if banks liquidate all their defaulted loans ($\lambda = 0$), the land is sold at the fair price Z.

Assumption 1. $W > Z(1 - \alpha)C$.

The assumption says that the total wealth of outside investors is high enough to buy all liquidated collateral at price Z, which is the fair price. As the readers might have guessed, we will assume that in the adverse state many firms fail, that is β is high enough such that if all banks liquidate with probability one, then land will not be sold at the fair price.

Assumption 2. $W < Z(1 - \beta)C$.

If assumption 2 holds, then there may be a fire sale in which case the price will be determined by cash available with the buyers, that is there will be cash-in-the-market pricing as in Allen and Gale (1994).[5] Under symmetric equilibrium, if all banks liquidate

[4] Again, the wealth of the investors can be taken to be state-dependent without changing the results.

[5] While in our model the supply of liquidity, W, is fixed which creates fire sale through cash-in-the-

with probability $1-\lambda$ in the adverse state, then the price is given by

$$p(\lambda) = \begin{cases} Z, & \text{if } W \geq (1-\beta)(1-\lambda)CZ. \\ \frac{W}{(1-\beta)(1-\lambda)C}, & \text{if } W < (1-\beta)(1-\lambda)CZ. \end{cases} \quad (1)$$

Thus the price is given by fair price if very few failed firms are liquidated (λ is high), else there is a fire sale and the price is determined by cash-in-the-market pricing. This price is weakly decreasing in $1-\lambda$, i.e. weakly increasing in the number of zombie loans.

We assume that the continuation value of the loans given by a bank to successful firms, V, will be an increasing function of price which in our model depends on the number of firms operating in the economy. If more firms are operating because banks choose to roll over more loans, i.e. λ is higher, then the price is higher. There are many justifications for assuming that V increases with price. First, as the price of real estate falls, it may also reduce the home equity value of the residents in the area, who may in turn reduce their consumption (Mian et al., 2015). This reduced consumption will negatively affect the profitability of the local firms and reduce the value of loans given to them. Second, the profitability of a firm or the probability of its success depends on the number and scale of other firms functioning in the economy (Cooper and John, 1988). This is because firms use goods produced by other firms as inputs or the workers in one firm use their wage to consume goods produced by other firms. Thus, as the number of firms operating in the economy and their scale increases, the positive feedback loops on each other also increase which further increases the profitability and the probability of success. We assume that this will be true even if the firms are low-productive zombie firms as even they employ people and use inputs (see Bebchuk and Goldstein (2011)). Thus the banks have an incentive to keep zombie firms alive which also keeps the prices higher. Further, as pointed out by Benmelch and Bergman (2011), a higher price of collateral due to the

market pricing; we could alternatively have assumed the supply to be a decreasing function of price as in Diamond and Rajan (2011), and still generate fire sale and attain our results.

prevention of bankruptcy can reduce the cost of capital and increase investment by neighboring firms. More investment would imply a larger scale of operation which will have a higher positive spillover effect on firms in the locality. We capture these ideas in a reduced form by assuming that V depends on p and is denoted by $V(p)$. Also, $V(.)$ is increasing ($V'(.) > 0$), concave ($V''(.) < 0$) and reaches its maximum at $p = Z$ ($V(Z) = \bar{V}$).

The state contingent utility function of a bank is given by

$$q(F + V(p(\lambda))) + (1 - q)(1 - \lambda)Cp(\lambda) - (1 - q)\lambda L; \tag{2}$$

where q equals α (β) in the normal (adverse) state. The first term is the current revenue plus the continuation value of the successful firms. The second term is the revenue from the liquidation of collateral and the final term is the loss from zombie loans. There are two reasons a bank may want to give a zombie loan. The first reason is to increase the liquidation price of collateral and the second reason is to increase the continuation value which depends on the liquidation price. Next, we determine the equilibrium when all the banks are atomistic as has been assumed so far.

2.1 Equilibrium with atomistic banks

If all the banks are atomistic, then they all take the price as given and will choose their λ to maximize their utility. Since they cannot influence the price by their decision to either liquidate or give a zombie loan, they all choose not to give a negative NPV zombie loan and instead liquidate the firm in both states. So by assumptions 1 and 2, in the normal state, the price will be equal to the fair value and in the adverse state, there will be cash-in-the-market pricing. The equilibrium is characterized by the following lemma.

Lemma 1. When banks are atomistic, then in both states they choose $\lambda = 0$. In the normal state the price is given by Z and in the adverse state the price is given by $W/(1 - \beta)C$.

The more interesting scenario is one where all banks are not atomistic, which we analyze next.

2.2 Equilibrium when banks are not atomistic

Now let us assume that one of the banks, which we call the "large bank" has a higher fraction of market share denoted by $f < 1$ and the others are still atomistic. As before in the normal state, all banks will continue to liquidate all defaulted loans (no zombie lending), and the market price is given by Z because of assumption 1. But in the adverse state, the large bank will internalize the effect of its liquidation strategy on the selling price of collateral as well as on the continuation value of the successful loans. The atomistic banks will continue to liquidate all loans in the adverse state since they will take the price as given. The following assumption ensures that in the adverse state, the price is below fair value.

Assumption 2′. $W < Z(1-f)(1-\beta)C$.

Assumption 2′ is analogous to but stronger than assumption 2. It implies that if all atomistic banks liquidate in the adverse state, then the supply in the adverse state is high enough that collateral will not be sold at fair price. Now if the large bank chooses the probability of zombie loan as λ, then the price is given by

$$p(\lambda) = \frac{W}{(1-\beta)C[1-\lambda f]}. \tag{3}$$

The utility function of the large bank in the adverse state is given by

$$\beta(F + V(p(\lambda))) + (1-\beta)(1-\lambda)Cp(\lambda) - (1-\beta)\lambda L.$$

This expression is the same as (2), where q takes value β; but now the price is given by (3) rather than (1). The large bank chooses λ to maximize its utility. We denote the equilibrium value of λ by λ^*. The first order condition w.r.t. λ can be written as:

$$(1-\beta)(1-\lambda)Cp'(\lambda) + \beta V'(p(\lambda))p'(\lambda) - (1-\beta)Cp(\lambda) - (1-\beta)L = 0. \tag{4}$$

As discussed above, there are two benefits of giving a zombie loan. First, it increases the price of collateral that is liquidated, as captured by the first term. Second, the increased price increases the value of V (expressed by the second term). The third term captures the cost of forgoing the cash received by liquidation and selling the collateral. The final term captures the cost of the negative NPV zombie loan. The large bank will internalize these costs and benefits and choose the optimal λ accordingly.

Clearly, if L is very large, then the banks will never do zombie lending as it will be very costly. So to simplify our analysis, we assume that L is a small number close to zero.[6] The next proposition says that large banks will give zombie loans with positive probability ($\lambda^* > 0$) under suitable conditions. Further, as the market share of the large bank increases, it gives zombie loans to a higher fraction of failed firms.

Proposition 1. If assumptions 1 and 2′ hold true, L is close to zero and

$$\frac{dV(p(0))}{dp} > \frac{(1-\beta)(1-f)C}{\beta f} > \frac{dV(p(1))}{dp}, \tag{5}$$

then there exists a unique $\lambda^* \in (0,1)$ which maximizes the large bank's utility. Also, λ^* increases as f increases.

Proof: See appendix.

The intuition for the result is simple. More liquidation results in a lower selling price

[6] This assumption is not necessary but considerably simplifies the analysis. The results will still hold as long as L is small enough.

which further results in lower continuation value of the second round of loans given to firms. As the market share of the large bank increases, it internalizes these costs more and gives zombie loans with a higher probability. Condition (5) simply gives the boundary conditions required for an interior solution. It says that $V'(.)$ should be large enough at $p(0)$ and small enough at $p(1)$ for an interior solution to exist.

We have so far assumed that all firms have the same collateral. However, in an economy, firms have different levels of collateral. So the next question is how does the level of collateral affect the likelihood of receiving a zombie loan? We turn to this issue next.

2.3 Collateral level and the probability of zombie lending

We now assume that there are two types of firms. Half of the firms have high collateral denoted by C_H and the remaining half of the firms have low collateral denoted by $C_L < C_H$. The average size of the collateral is still C.[7] The other characteristics of the firm—V and L—remain the same.[8] As before there is a large bank with market share f and atomistic banks with a combined market share of $(1 - f)$. Each bank's portfolio is equally distributed between the two types of firms and the face value of loans remains the same.[9]

In the normal state, by assumption 1, all banks will continue to liquidate all firms. In the adverse state, when a firm goes bankrupt, the large bank chooses to give a zombie loan to the high (low) collateral firm with probability λ_H (λ_L). The total collateral liquidated

[7]This assumption is not necessary and merely reduces the effort of refining assumptions 1 and 2′

[8]It may seem unreasonable to assume the other characteristics of a firm do not change with the size of the collateral. However, in the empirical part of the paper, we will be comparing firms with different ratios of real estate collateral as a fraction of their total assets. Hence we can assume that the total assets of all firms are the same, but some firms have more real estate assets than others. The other characteristics of the firms, i.e. V and L, depend on total assets and not the real estate collateral. We are basically abstracting from modeling the market for non-real estate assets of the firm when it is liquidated.

[9]We can assume that the face value changes with collateral level without changing any result. Here the face value can be interpreted as the average face value of the loans. Since liquidation probability does not affect the current payoff, the face value is irrelevant to our calculations.

by the large bank is denoted by τ and is given by

$$\tau = f(1-\beta)((1-\lambda_H)C_H + (1-\lambda_L)C_L)/2. \tag{6}$$

The equilibrium values are denoted by λ_H^*, λ_L^* and τ^*. The atomistic banks will continue to liquidate all firms in the adverse state because they take prices as given. The price in the adverse state is given by

$$p(\lambda_H, \lambda_L) = \frac{W}{\tau + C(1-f)}; \tag{7}$$

and the utility function of the large bank in the adverse state is given by

$$\beta(F + V(p(\lambda_H, \lambda_L))) + \tau p(\lambda_H, \lambda_L) - \frac{1-\beta}{2}(\lambda_H + \lambda_L)L.$$

Given this setup, it can be shown that the high collateral firms are more likely to get a zombie loan than the low collateral firms, that is $\lambda_H^* > \lambda_L^*$.

Proposition 2. Given assumption 1 and $2'$,

i. If $\tau^* \leq f(1-\beta)C_L/2$, then $\lambda_H^* = 1$ and $\lambda_L^* = \frac{\tau^*}{C_L f(1-\beta)/2}$.

ii. If $\tau^* > f(1-\beta)C_L/2$, then $\lambda_H^* = \frac{\tau^* - C_L f(1-\beta)/2}{C_H f(1-\beta)/2}$ and $\lambda_L^* = 0$.

Proof: See appendix.

The proposition says that the large bank prefers to first liquidate the low-collateral firms and then the high-collateral firms. Part i. of the proposition says that if the total collateral sold by the large bank in equilibrium is less than the total collateral of the low collateral firms (this is the inequality in the if condition of part i.), then it will only liquidate the low collateral firms and all the high collateral firms get a zombie loan ($\lambda_H^* = 1$).

But if the total collateral sold by the large bank in equilibrium is more than the total collateral of the low-collateral firms (this is the inequality in the if condition of part ii.), then the bank will first liquidate all the low-collateral firms ($\lambda_L^* = 0$), and the remaining collateral will come from the high-collateral firms.

The intuition is as follows. For a given number of firms that the large bank is giving zombie loans to and incurring the cost L per zombie loan, it wants to keep the price as high as possible. Liquidating the firms with a higher level of collateral will have a higher impact on price; hence it prefers to first liquidate all firms with low collateral and only then liquidate the firms with high collateral. The alternative equivalent interpretation is that, for a given amount of collateral that the large bank sells (which determines the effect on price and $V(.)$), it wants to liquidate as many firms as possible to minimize the loss from zombie lending. So it prefers to first liquidate the firms with low collateral.

3 Data

For our paper, we use accounting data for listed US firms from Standard & Poor's Compustat database. Data on loans to firms is accessed from the Thompson Reuters DealScan database. We get the House Price Index for MSAs from the Office of the Federal Housing Enterprise Oversight and the Consumer Price Index from the Bureau of Labour Statistics.

From Compustat database, we select firms with non-missing real estate assets headquartered in the United States, and as in Chaney et al. (2012), exclude finance, insurance, real estate, construction, and mining firms. We restrict our sample period from 1993 to 2014 and to firms that have data for at least three years in this period. This leaves us with 3,280 firms and 35,243 firm-year observations. The summary statistics of these firms are shown in Table 1. The average (log) asset is 4.964, and the average leverage ratio is 0.275.

To test our hypothesis, we require information on loans given by banks to firms in different MSAs. While DealScan provides data of loans to mostly larger firms, it is reasonable to use this in our setting as these large firms are the ones which are going to create a negative price externality in local real estate market when they are liquidated. Approximately 30% of the loans in our sample have a single lender. For the remaining loans, we ascribe a loan to a lender only if it is the Lead Arranger, Agent, Bookrunner, Manager, Underwriter or Sole Lender. This is because participants in a syndicated loan are more likely to sell their loans in the secondary market (Irani, Iyer, Meisenzahl and Peydro, 2021). Also, although both the arranger and participants commit capital to a syndicated loan, the average arranger share is four times as large as the average participant share. Further, there is poor coverage in DealScan database on the amount of loans given by participants in the syndicated loans. For these reasons, we follow the common convention in the literature and consider the lead arranger as the "lender" (Ivashina and Scharfstein, 2010; Giannetti and Saidi, 2019).

We merge the DealScan database with Compustat using the link table provided by Chava and Roberts (2008). We could match 16,273 facilities (syndicated loans) to firms in our data set for 26,138 bank-firm-year observations. Using this merged data set, we calculate a bank's outstanding loans to a firm each year. Next, assuming that all of a firm's real estate is in the same MSA as its headquarters (Chaney et al., 2012), we calculate the outstanding loans of each lender in each MSA. We conduct our analysis at both the firm level and the loan level.

3.1 Identifying zombie lending

3.1.1 Identifying zombie firms using accounting data

Zombie firms are unproductive firms incapable of servicing their debt (at market rates) but continue to operate because they receive subsidized credit. To identify zombie lending, we follow the approach of Caballero et al. (2008) and Acharya et al. (2019). We identify a firm as a zombie if it is financially stressed (as measured by interest coverage ratio) but is getting credit at a cost lower than the most creditworthy firms in the economy. We calculate the interest rate paid by the most creditworthy firms in two ways. First, we calculate the median of the "average interest rate" (*total interest expense/total debt*) paid by all firms with an AAA rating in any given year. Second, we calculate the median of the "average interest rate" paid by the top decile of firms by interest coverage ratio (ICR).

To be conservative, we take the lower of the two interest rates as the rate paid by the most creditworthy firms in the economy. Given this interest rate benchmark (r^{top}) and the total debt of a firm (D_{it}), we calculate the minimum required interest payment of a firm (R^{min}) as

$$R_{it}^{min} = r_t^{top} * D_{it}.$$

Next, we calculate the excess interest paid by the firm. Excess interest is the difference between the actual interest expense of a firm (R_{it}), and the minimum required interest payment, that is

$$x_{it} = R_{it} - R_{it}^{min}.$$

Given x_{it}, a firm is classified as a zombie if it meets the following two criteria: (i) x_{it} is negative, that is the excess interest paid by the firm is negative, which implies that its interest cost is less than that of the most creditworthy firms, and (ii) it is in the bottom tercile of firms when classified by the 3-year average of the interest coverage ratio. According to Damodaran (2024), ICR is a good proxy for the credit rating of a firm: an ICR of less than 2 corresponds to a rating of Ba2/BB or lower for large firms and a rating of B2/B for smaller firms. In the sample of firms which fall in the bottom tercile of ICR, no firm has a 3-year average ICR above 2. Thus these firms are firms with poor rating and should not be getting subsidized credit. We find that as per our definition, 4.2% of firm-year observations can be classified as zombie firms. The summary statistics of these firms is shown in table 2. These zombie firms have higher leverage (median leverage is 0.279) and lower 3-year average ICR (median ICR is -9.995) compared to non-zombie firms.

3.1.2 Identifying zombie loans using Dealscan data

We use the Thompson Reuters LPC Dealscan data set to identify individual loans as zombie loans. This data set has the variable "AllInDrawn" which is a composite way of reporting the pricing of facilities and is quoted as a spread over the LIBOR. This variable allows us to identify the specific loans that are "subsidized." It is comparable across facilities regardless of the underlying fee structure. Since the spread is not calculated for fixed-rate loans, letters of credit, or subordinated debt, these are not included in our calculations. As before, we classify loans as zombie loans if the interest rate spread on the loan is lower than the spread for the highest-rated firms and the firm is in the bottom tercile when classified by 3-year average ICR. The calculation of benchmark interest rate r_t^{top}, and the comparison with interest rate on loans to firms in bottom tercile, is done separately for secured and unsecured loans. In our sample, there are 16,272 facilities of which, 8,167 are secured facilities and out of the 26,138 bank-firm loans, we find that 3.8% are zombie loans.

3.2 Real estate assets of firms

To calculate the market value of a firm's real estate, we follow precisely the method used by Chaney et al. (2012). We classify real estate as total Buildings, Land, and Improvement and Construction in Progress. Real estate assets are not marked-to-market but are held on the balance sheet at historical cost. To impute the market value of the real estate, we calculate the average age of those assets and use historical prices to compute their current market value. To calculate the average age of assets, we calculate the ratio of accumulated depreciation in 1993 to the gross book value of the real estate. This measures the proportion of the cost claimed as depreciation in 1993. Assuming a depreciable life of 40 years and straight-line depreciation, we estimate the average age of a firm's real estate. We then inflate real estate assets using the MSA-level real estate inflation. For real estate purchased before 1975, we use the CPI to inflate its value till 1975 and the real estate price index after 1975. Our sample is restricted to firms active in 1993 as accumulated depreciation is unavailable in Compustat after 1993.

We use the firm's headquarter location as a proxy for the location of the real estate. As pointed out by Chaney et al. (2012), there are two assumptions underlying this choice. First, headquarters and production facilities are generally clustered in the same MSA and state. Second, the headquarters account for a large fraction of corporate real estate assets.[10]

3.3 Bank market shares

To calculate bank market shares in an MSA, we follow the procedure in Giannetti and Saidi (2019) and use the DealScan data.[11] As mentioned earlier, approximately 30% of the loans in our sample have a single lender. For the remaining loans, we ascribe a loan to a lender only if it is the Lead Arranger, Agent, Bookrunner, Manager, Underwriter or Sole Lender. If the arranger share data is missing, we resort to the common practise in the literature and set the loan share provided by the lead arranger as the median of our sample. In the case of more than one lead arranger, we assign each arranger an equal fraction of the lead arrangers' total loan share. We also assume that a bank that arranges a loan retains it on its balance sheet. To calculate the loans retained by a bank, we add all loans that have not matured.

In our setting, lenders with higher market share in an MSA have stronger incentives to avoid price-default spirals. A bank's market share is calculated as the dollar amount of loans arranged by a bank to firms headquartered in an MSA that has not matured, divided by the dollar amount of all outstanding loans in an MSA. The average market share is 4.8% (see panel C of Table 1). We then take the three year average of the bank's market share in the MSA and use this as our market share variable (Giannetti and Saidi,

[10] Chaney et al. (2012) also provide some evidence to support these assumptions.

[11] Even though syndicated loans provided by the DealScan database constitute a fraction of banks' total lending, they consist of the largest loans to the largest firms and thus account for a sizeable portion of total lending and have been used in previous studies (Giannetti and Saidi, 2019; Chodorow-Reich, 2014) to evaluate bank lending policies.

2019; Saidi and Streitz, 2021). We use the above market share to compute a Herfindahl-Hirshman Index (HHI), which captures the credit concentration at the MSA-year level (Bank HHI). The average Bank HHI is 0.191.

4 Empirical analysis and results

We first conduct firm-level analysis to establish an increased incidence of zombie lending to firms with higher real estate when the local real estate market is under stress and undergoing a fire sale. Then we move to a more granular loan-level analysis to pin down the channels that might be driving our results.

4.1 Firm-level analysis: zombie lending and real estate collateral

At the firm level, our theory suggests (see proposition 2) that firms with higher real estate assets relative to total assets are more likely to receive zombie credit if the local real estate market is stressed and real estate assets are being sold at fire sale prices. While we cannot directly identify if there is a fire sale in the local real estate market, we create two different proxies for a fire sale in an MSA. First, we assume that there is a fire sale in the real estate market in an MSA if the local real estate price is declining that year. This is obviously not the perfect indicator of a fire sale because while price will fall if there is a fire sale in the real estate market, they may also fall if the MSA has suffered a negative productivity shock leading to a decline in the real value of real estate assets. Hence we use a second way to identify a fire sale in an MSA by identifying structural breaks in real estate prices in that MSA (see section 4.1.1). This second method will also allow us to address the endogeneity issues in our identification which will be discussed shortly.

We test our hypothesis that firms with relatively higher real estate assets are more likely to be zombies when the real estate market is undergoing a fire sale by estimating the following OLS regression:

$$\begin{aligned}\text{Zombie}_{i,t} =&\beta_1 \cdot \text{High Real Estate}_{i,t} + \beta_2 \cdot \text{Negative Shock}_{MSA,t} \\ &+ \beta_3 \cdot \text{High Real Estate}_{i,t} \cdot \text{Negative Shock}_{MSA,t} + \text{Controls}_{i,t-1} \\ &+ \alpha_i + \delta_t + \epsilon_{i,t}\end{aligned} \tag{8}$$

$\text{Zombie}_{i,t}$ is an indicator variable that takes the value 1 if firm i is a zombie in the year t. As detailed in section 3.1.1, we have followed the methodology used by Caballero, Hoshi and Kashyap (2008) and Acharya et al. (2019) to identify zombie firms. The variable $\text{High Real Estate}_{i,t}$ is an indicator for firms with above-median real estate value, measured as the ratio of the market value of real estate held by a firm and the value of lagged property, plant and equipment. $\text{Negative Shock}_{MSA,t}$ is an indicator for an MSA-year with negative real estate price change where the price in an MSA is measured by the local house price index. As discussed above, this variable acts as a proxy for the local real estate market being under stress, where the liquidation of real estate assets may be undergoing a fire sale. Control variables included are sales and leverage. α_i and δ_t are the firm and year fixed effects and respectively control for the time-invariant firm-level unobservable factors and the annual shocks affecting all firms uniformly. The time fixed effects thus control for the interest rate environment which may be affecting zombie lending (Banerjee and Hofmann, 2018). Our main coefficient of interest is β_3, which estimates the probability of a firm with above-median real estate being a zombie firm compared to those with below-median real estate during a negative shock. β_1 estimates the probability of being a zombie firm for high real estate firms relative to low real estate firms during normal times when real estate prices are not declining.

The results of this regression are presented in Table 3. Column (1) reports the results for the specification with the fixed effects and column (2) shows the results with fixed effects and controls. The coefficient of the interaction term, β_3, is positive and statistically significant in both specifications indicating that firms with proportionally higher real estate assets are more likely to be zombie firms when the real estate prices are declining in that MSA. Results in column (2) imply that during a negative shock, firms with above-median real estate assets are 1.7% more likely to be zombie firms compared to firms with below-median real estate assets. Further, β_1 is close to zero and statistically insignificant in column (2) suggesting that the likelihood of being a zombie firm is the same for both above and below-median real estate firms when real estate prices are not declining.

4.1.1 Identifying fire sale using structural breaks in real estate prices

The key endogeneity concern in our estimation is that zombie lending in an MSA could be, for some reason, correlated with local fundamental unobserved factors such as productivity shocks, and these factors could also lead to a subsequent decline in real estate prices. For example, zombie lending in an MSA could be correlated with local productivity shocks to firms which in turn could default and reduce the level of capital of banks operating in that MSA, and these undercapitalized banks in turn could resort to zombie lending (Caballero et al., 2008; Bruche and Llobet, 2014). These negative productivity shocks could also affect the value of local real estate leading to a decline in prices, thus resulting in an endogeneity problem.

We address these concerns in two ways. First, we include bank-time fixed effects in our loan level regressions (see section 4.2), which control for the health of the banks. Second, we create an indicator for a fire sale by identifying a sharp decline in real estate prices and use exogenous variation in the timing of these sharp declines in prices across different MSAs for the purpose of our identification. This identification strategy and our arguments herein are similar to those of Charles et al. (2018). The underlying assumption is that these sharp declines in prices are not driven by changes in local fundamental factors because these factors move gradually, and even if these factors move abruptly, their effects are incorporated slowly into the prices; instead, these price declines are driven by speculative factors. The justification for our assumption comes from the existing literature, which has argued that the variation in real estate prices during the boom and bust of the great recession in the United States was not driven by fundamental factors like productivity or income. It was rather caused by factors specific to local real estate markets, such as irrational exuberance and "bubbles" or "fads" (Shiller, 2009; Mayer, 2011; Chinco and Mayer, 2016; Burnside et al., 2016), introducing products like interest-only mortgages (Barlevy and Fisher, 2010), and changes in mortgage lending standards (Favilukis et al., 2017). So sharp changes in real estate prices would have resulted from exogenous factors uncorrelated with local fundamental economic factors. Since the sharp decline in prices is not driven by fundamentals, the real estate is effectively being sold at below their fundamental price, that is they are undergoing a fire sale.

Figure 1 Panel (A) shows the quarterly average log of real estate price (normalized by the CPI) (the dotted line) of MSAs from Q1:2001 to Q4:2014. Visual inspection suggests that the price changes can be divided into three periods. The first period is from 2001 to 2006 in which the real estate price increased. This was followed by the second period from 2007 to 2012 when the prices were declining which was then followed by the third period from 2013 to 2014 when the prices started increasing again. The second period from 2007 to 2012 was when on average the real estate market was under stress with the likelihood of fire sale. However, there is significant variation across MSAs in terms of when they have a price decline. We exploit this variation for our identification as described below.

To find sharp negative changes in real estate prices in an MSA, we use the standard method of estimating structural breaks when the dates of the breaks are unknown (Bai, 1997; Bai and Perron, 1998). Using quarterly prices, we estimate equation 9 using OLS regression with two structural breaks for each MSA. We use two breaks as the average price trend shown in Figure 1 Panel (A) has two breaks, first showing a decline and then a price increase.

$$HPI_{MSA,t} = \alpha_{msa} + \tau_{msa} \cdot t + \lambda^*_{msa}(t - t^*_{msa})\mathbb{1}(t > t^*) + \lambda^{'}_{msa}(t - t^{'}_{msa})\mathbb{1}(t > t^{'}) + \epsilon_{MSA,t} \quad (9)$$

Using this equation and quarterly house price index data from 2001:Q1 to 2014:Q4 we find the location of the two breaks which maximizes the R^2 of the regression for each MSA, thus dividing the time series into three periods. Here, $HPI_{MSA,t}$ is the log of house price index in an MSA in quarter-year t; and $t^{'}$ and t^* are the timing of the first and the second structural breaks respectively. τ_{MSA} is the trend in the MSA's real estate price before the first break, and λ^* and $\lambda^{'}$ are the size of the first and second structural breaks respectively. Real estate prices had an increasing trend before the global financial crisis which would be identified by positive τ_{msa}. To identify a fire sale in an MSA, we look for a sharp decline in real estate prices. The argument, as mentioned above, is that since these sharp declines are not driven by fundamental factors, it is reasonable to say that these MSAs are seeing a decline in prices because of fire sales. We identify three kinds of MSAs:

i. The first category is MSAs where there is a sharp decline after the first break, i.e. in the second period, as shown in panels (B) and (C) of Figure 1. These are identified by instances where $\tau_{msa} + \lambda^*_{msa}$ is negative and statistically significant. The prices in these MSAs resemble the average price trend as shown in panel (A). For these MSAs, the second period is identified as having a fire sale. Panels (D) and (E) show MSAs with negative and significant structural breaks in the second period, but the HPI in these MSAs continue to decline even in the third period although the rate of decline is lower ($\lambda' > 0$). For these MSAs too, we consider the second period as the period of fire sale. Out of a total of 206 MSAs, 183 fall in this category.

ii. If a fire sale is not identified in the second period, we check for cases where $\tau_{msa} + \lambda^* + \lambda^{'}$ is negative and statistically significant, i.e. there is a sharp decline in the third period. These are the second kind of MSAs as shown in panels (F) and (G). For these MSAs, the third period is identified as having a fire sale. Out of a total of 206 MSAs, 22 fall in this category.

iii. Finally, the third kind of MSAs are those that do not have a statistically significant decline in prices. Panel (H) shows such an MSA. This MSA did not have a fire sale.

Figure 2 shows the fraction of MSAs undergoing a fire sale each year as identified by this method. Having identified fire sale through structural breaks, we estimate the following OLS regression:

$$
\begin{aligned}
Zombie_{i,t} =& \beta_1 \cdot \text{Structural Break}_{MSA,t} + \beta_2 \cdot \text{High Real Estate}_{i,t} \\
&+ \beta_3 \cdot \text{Structural Break}_{MSA,t} \cdot \text{High Real Estate}_{i,t} + \text{Controls}_{i,t-1} + \alpha_i + \delta_t + \epsilon_{i,t}.
\end{aligned} \tag{10}
$$

Here Structural Break$_{MSA,t}$ is an indicator for the period of fire sale in that MSA, i.e. it takes a value of one in the second period for the first kind of MSAs, in the third period for the second kind of MSAs and never take a value of one for the MSA which did not have fire sale (third type). $Zombie_{i,t}$ is an indicator for a zombie firm. High Real Estate$_{i,t}$, as before, is the indicator for firms with above median real estate. Control variables included are sales and leverage. The coefficient of interest, β_3, allows us to estimate the impact of a fire sale as identified by the structural break in prices on the likelihood of being a zombie firm for high real estate firms.

The results for estimating equation (10) are presented in Table 4. As in table 3, the coefficient of the interaction term is positive and statistically significant in both specifications, without (column(1)) and with (column (2)) controls. We find that the likelihood of being a zombie firm is 2.1% higher (column (2)) for high real estate firms during a fire sale compared to low real estate firms. The magnitude of the estimate is very similar to the magnitude estimated in Table 3. These results confirm our initial results that during a fire sale in the local real estate market, firms with a higher ratio of real estate assets to total assets are more likely to receive subsidized credit and be zombie firms.

4.2 Bank market share and zombie lending

In this section, we conduct loan-level analysis and exploit the variation in bank market share in local markets to test our hypothesis. In our model, atomistic banks act as price takers, and liquidation of firms by them does not affect the price in real estate markets; hence they do not give negative NPV zombie loans and instead liquidate the failed firms. However, a large bank internalizes the price effect of liquidating a firm, and so it does some zombie lending in equilibrium. Proposition 2 predicts that banks with higher market share are more likely to give zombie loans to firms with relatively higher real estate assets when there is a fire sale in the local real estate market. To identify this effect in the data, we estimate the following regression:

$$\begin{aligned}\text{Zombie Loan}_{i,k,t} =& \beta_1 \cdot \text{High Real Estate}_{i,t} + \beta_2 \cdot \text{Fire Sale}_{MSA,t} + \beta_3 \cdot \text{Share}_{k,MSA,t} \\ &+ \beta_4 \cdot \text{High Real Estate}_{i,t} \cdot \text{Fire Sale}_{MSA,t} \cdot \text{Share}_{k,MSA,t} \\ &+ \text{Controls}_{i,t-1} + \alpha_{k,t} + \gamma_i + \epsilon_{i,k,t}.\end{aligned} \tag{11}$$

Here Zombie $\text{Loan}_{i,k,t}$ is an indicator variable for a zombie loan (see section 3.1.2) given by lender k to a firm i in the year t. High Real $\text{Estate}_{i,t}$, as before, indicates firms with above-median ratio of real estate assets and lagged plant, property and equipment. $\text{Share}_{k,MSA,t}$ is the market share of lender k in the MSA, where market share is defined as the three-year average share of outstanding loans held by the bank in an MSA (see Saidi and Streitz (2021) and Giannetti and Saidi (2019)). Fire $\text{Sale}_{MSA,t}$ is an indicator variable for fire sale in an MSA in year t. As in section 4.1, we estimate equation 11 separately using the two different indicators for fire sale that we have created: negative shock and structural break. γ_i is the firm fixed effect, and $\alpha_{k,t}$ is the lender-year fixed effect that, as discussed earlier, would control for the health of the banks and take care of the endogeneity problem which could have been created by local productivity shocks affecting the health of local banks whilst also causing distress in the real estate market in the

MSA. Firm-level control variables include sales and leverage. The second-order interaction terms are included in the regression but not displayed in equation 11 above for conciseness. If positive, the coefficient of interest, β_4, would indicate that banks with higher market share are more likely to provide zombie loans to firms with relatively higher real estate assets when there is a fire sale going on in the MSA.

Table 5 shows the results of estimating equation 11. Columns (1) and (2) show the results when we use the structural breaks to identify fire sales in the MSA, while columns (3) and (4) show the results when we use price decline in an MSA as an indicator for fire sale. Column (1) shows that banks with higher market share are not more likely to give zombie loans during fire sales. However, when we examine heterogeneity by real estate assets in column (2), we see that high real estate firms are more likely to get zombie loans from high market share firms during a fire sale. The coefficient of the triple interaction term is 0.156. A 1% increase in a bank's market share increases its probability of giving a zombie loan to high real estate firms relative to low real estate firms by 0.16% during a fire sale. The results are similar when we use price decline in an MSA as a proxy for fire sales as can be seen in columns (3) and (4).

4.2.1 Bank concentration and zombie lending in an MSA

Another obvious implication of our model is that higher bank concentration in an MSA should increase the probability of zombie lending in that MSA. We test this by estimating equation 12 below:

$$\begin{aligned}\text{Zombie}_{i,t} =& \beta_1 \cdot \text{High Real Estate}_{i,t} + \beta_2 \cdot \text{Fire Sale}_{MSA,t} + \beta_3 \cdot \text{Bank HHI}_{MSA,t} \\ &+ \beta_4 \cdot \text{High Real Estate}_{i,t} \cdot \text{Fire Sale}_{MSA,t} \cdot \text{Bank HHI}_{MSA,t} \\ &+ \text{Controls}_{i,t-1} + \alpha_{k,t} + \gamma_i + \epsilon_{i,k,t}.\end{aligned} \tag{12}$$

Here Bank $\text{HHI}_{MSA,t}$ is the Herfindahl–Hirschman index of bank market concentration in an MSA in year t, defined as the sum of the squares of banks' market shares in an

MSA. High Real Estate$_{i,t}$ is an indicator for firms with above median ratio of real estate assets and lagged plant, property and equipment. Fire Sale$_{MSA,t}$ is an indicator for an MSA undergoing a fire sale in year t, which is identified by the two different indicators that we have created: negative shock and structural break. We include firm fixed effects, lender-year fixed effects, and sales and leverage as firm-level controls. The second-order interaction terms are included in the regression but not displayed above in equation 12 for brevity. The coefficient of interest is β_4, which estimates the sensitivity of the credit concentration to the probability of zombie lending to high real estate firms relative to low real estate firms during a fire sale.

The results are presented in Table 6. Columns (1) and (2) show the results when we use the negative structural breaks to identify a fire sale in the MSA, while columns (3) and (4) show the results when we use price decline in an MSA as an indicator for fire sale. The coefficient of the interaction term in column (1) is noisy. We next examine heterogeneity by real estate assets and find the coefficient of the triple-interaction term to be 0.376 (see column (2)). This implies that in an MSA with one standard deviation (0.318 points) higher HHI, high real estate firms have a 12% higher likelihood of receiving a zombie loan compared to low real estate firms during a fire sale. Our estimates in column (4), where we use negative shocks to identify fire sales, suggest a qualitatively similar result.

Overall, our evidence suggests that firms with higher real estate are more likely to receive zombie loans from banks with higher market share and in markets with higher bank concentration. This is in line with our theory that banks with higher market share may be giving zombie loans to mitigate fire sales in the MSAs they are operating in.

5 Spillover effects of zombie firms

Most studies of zombie lending have focused on Southern Europe post the sovereign debt crisis or Japan during the lost decades of 1990-2010. Since we are studying a different country, we similarly explore the spillover effects of zombie lending on healthy firms

(Caballero et al., 2008). Healthy firms in an industry can be affected by zombie firms through two channels. First, the evergreening of loans shifts the supply of credit to these zombie firms. This may lead to a reduction in credit available to healthier firms and may also increase their cost of credit. So, healthy firms will make lower investments in the industry where there are more zombie firms.

Second, the prevalence of zombies also distorts the competitive process in an industry. In a market without distortions, impaired firms would reduce employment and lose market share. This gives more productive (non-zombie) firms access to a larger talent pool, allowing them to increase market share and profitability. But, subsidized credit keeps zombie firms artificially alive, which congests the market. This reduces product market prices and corresponding markups, and also increases wages in the industry. Our regression specification follows Caballero et al. (2008) and Acharya et al. (2019):

$$\begin{aligned} y_{i,t} =& \beta_1 \times \text{Healthy Firms}_{i,t} + \beta_2 \times \%\text{Zombies}_{j,t} + \beta_3 \times \text{Healthy Firms}_{i,t} \times \%\text{Zombies}_{j,t} \\ &+ \alpha_i + \delta_{j,t} + \epsilon_{i,t}. \end{aligned} \tag{13}$$

Healthy $\text{Firms}_{i,t}$ is an indicator for firms not classified as zombies in the year t. $\%\text{Zombies}_{j,t}$ is the percentage of zombie firms in the year t in the industry j that the firm belongs to. α_i is the firm fixed effect, and $\delta_{j,t}$ is the industry-year fixed effect. The dependent variables are investment, return on assets (ROA), and change in employment. We expect zombie firms in an industry to depress these variables for healthy firms, that is we expect the coefficient of interest β_3 to be negative.

Table 7 reports the results of this regression analysis. We have alternatively used year and industry-year fixed effects, while firm fixed effects are included in all specifications. The results suggest that the presence of zombie firms in an industry leads to healthier firms making lesser investments and also having lower return on assets ($\beta_3 < 0$). A 1% increase in zombie firms in an industry leads healthy firms to decrease their investment by 1.2% (column 2). Also, the ROA of healthy firms is lower by 1% if the zombie firms in an industry are higher by 1% (column 4). We do not observe any impact on employment by firms. Overall our evidence suggests that zombie firms in an industry have a negative effect on the healthy firms in the industry.

6 Conclusion

This paper shows that banks with high market share in an MSA give zombie loans to firms with relatively high real estate collateral when there is a fire sale in the local real estate market. Any liquidation of assets happening during a fire sale will depress the price further. This will hurt the liquidation price of the collateral and also the health of the firms in the local economy thereby reducing the value of the portfolio of loans held by these banks. Hence banks with high market share who do not act as price takers internalize this cost. They trade off the cost of giving zombie loans to unproductive firms against the benefit of higher prices in the local real estate markets.

Thus, while high concentration in an area can help mitigate fire sales during a crisis, it can create another negative externality of keeping unproductive firms alive by giving zombie loans. Zombie lending has negative spillovers on healthy firms in an economy. Firms in an industry dominated by zombies face a crowded market, have lower markups, and have higher labor costs. We provide evidence that this credit misallocation reduces the investment and ROA of healthy firms in industries dominated by zombie firms. This negative externality of zombie lending can delay economic recovery after a systemic crisis. We thus highlight a new cost of market concentration apart from the traditional costs such as high prices and low quantities. Policymakers thus need to consider this additional cost of market concentration when designing policies for limiting the market power of banks. Additionally, while designing policies for economic recovery after a crisis, they need to take into account the cost of externality created by zombie lending which could delay recovery.

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Table 1: Summary Statistics

Panel A: Firm Level Data

	Mean	Median	SD	Min	Max
Zombie	0.042	0	0.201	0	1
Real Estate	1.096	0.231	2.837	0	22.686
Sales	13.260	5.460	26.233	0	190.646
Log Assets	4.964	4.831	2.333	0	13.081
Investment	0.379	0.203	0.619	0	5.605
Leverage	0.275	0.194	0.413	0	3.852
Tobin's Q	2.544	1.519	4.513	0.534	62.878
ICR (3-yr avg)	8.430	3.332	87.518	-701.667	598.400
Number of Firms	3280				
Observations	35243				

Panel B: MSA Level Data

	Mean	Median	SD	Min	Max
Negative Shock	0.205	0	0.402	0	1
Structural Break	0.135	0	0.342	0	1
Bank HHI	0.191	0.107	0.223	0	1
Number of MSAs	206				

Panel C: Bank Level Data

	Mean	Median	SD	Min	Max
Market Share	0.048	0.017	0.113	0	1
Number of Lenders	1507				
Observations	8,548				

Table 1 reports the summary statistics of our sample. Tobin's Q is calculated as the ratio of enterprise value of a firm to its book value. *Investment* is measured as capex normalized by lagged fixed assets. *Leverage* is the ratio of total debt to assets. *Sales* is measured as the ratio of sales to lagged PPE, while *Log Assets* is the log of assets plus one. *ICR* is the three-year average of firms' interest coverage ratio which is the ratio of firms' EBIT to interest expense. *Negative Shock* is an indicator for falling real estate prices, while *Structural Break* is an indicator for the period with significantly declining real estate prices. *Bank Market Share* is the average share of outstanding loans in the past 3 years attributed to a lender. *Bank HHI* is the Herfindahl–Hirschman Index for bank concentration in an MSA.

Table 2: Summary Statistics for Zombie Firms

	Mean	Median	SD	Min	Max
RealEstate	1.088	0	3.405	0	22.686
Sales	13.459	4.766	28.171	0	190.646
Log Assets	3.635	3.384	1.925	0	13.073
Investment	0.535	0.234	0.894	0	5.605
Leverage	0.457	0.279	0.642	0	3.846
Tobin's Q	3.207	1.690	6.065	0.534	62.878
ICR (3-yr avg)	-51.422	-9.995	141.521	-701.667	1.316
Number of Firms	805				
Observations	1491				

Table 2 reports the summary statistics of zombie firms in our sample. *High Real Estate* is an indicator for above median real estate holdings, normalized by lagged PPE. Tobin's Q is calculated as the ratio of the enterprise value of a firm to its book value. *Investment* is measured as capex normalized by lagged fixed assets. *ICR* is the three-year average of firms' interest coverage ratio which is the ratio of firms' EBIT to interest expense. *Leverage* is the ratio of total debt to assets. *Sales* is measured as the ratio of sales to lagged PPE, while *Log Assets* is the log of assets plus one.

Table 3: Price decline, real estate assets and likelihood of zombie firms

	(1)	(2)
Dependent Variable	Zombie	
High Real Estate	0.002	0.002
	(0.007)	(0.007)
Negative Shock	-0.008	-0.007
	(0.006)	(0.006)
High Real Estate × Negative Shock	0.018***	0.017***
	(0.006)	(0.007)
Observations	35106	34074
Controls	No	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 estimates the probability of firms being zombies when there is a decline in local real estate prices. *Zombie* is an indicator for a firm whose average interest cost is lower than the highest rated firms in the year and is in the bottom tercile of firms by ICR. *High Real Estate* is an indicator for firms with an above-median ratio of the market value of real estate assets and lagged value of property, plant and equipment. *Negative Shock* is an indicator for MSA-years in which there is a decline in the House Price Index in an MSA which proxies for fire sales in our setting. Column (1) shows the results with firm and time fixed effects. Column (2) shows the results with these fixed effects and *Sales* and *Leverage* as controls. All standard errors are clustered at the firm level.

Table 4: Structural breaks, real estate assets and likelihood of zombie firms

	(1)	(2)
Dependent Variable	Zombie	
High Real Estate	0.003	0.003
	(0.005)	(0.007)
Structural Break	-0.016**	-0.018*
	(0.006)	(0.009)
High Real Estate × Structural Break	0.019***	0.021***
	(0.006)	(0.010)
Observations	35106	34074
Controls	No	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 estimates the probability of firms being zombies during a fire sale as identified by a negative structural break in HPI in an MSA. We regress an indicator for zombie firms on the structural break and an indicator for firms with above median real estate to assets ratio. *Zombie* is an indicator for zombie firms and *High Real Estate* is an indicator for firms with above median ratio of market value of real estate and lagged value of property, plant and equipment. *Structural Break* is an indicator for a negative structural break in real estate prices in the MSA which proxies for fire sale in our setting. Column (1) shows the results with firm and time fixed effects. Column (2) shows the results with these fixed effects and *Sales* and *Leverage* as controls. All standard errors are clustered at the firm level.

Table 5: Bank market share and zombie lending

	(1)	(2)	(3)	(4)
Dependent variable:	Zombie Loan			
	Structural Break		Negative Shock	
Share	-0.000	0.010	0.004	0.023
	(0.018)	(0.061)	(0.018)	(0.060)
Fire Sale	-0.016**	-0.004	0.021***	0.024**
	(0.008)	(0.010)	(0.008)	(0.010)
Fire Sale × Share	-0.027	-0.138**	-0.030	-0.142**
	(0.054)	(0.067)	(0.043)	(0.065)
High Real Estate		-0.007		-0.008
		(0.006)		(0.006)
High Real Estate × Share		-0.012		-0.023
		(0.068)		(0.067)
High Real Estate × Fire Sale		-0.017		-0.004
		(0.012)		(0.009)
High Real Estate × Fire Sale × Share		0.156**		0.151**
		(0.067)		(0.067)
Observations	20768	20768	20768	20768
Controls	Yes	Yes	Yes	Yes
Lender × Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 estimates a linear probability model to estimate how the probability of zombie lending depends on bank market share. *Zombie Loan* is an indicator for a zombie loan to a firm by a lender in a year. The independent variables include *High Real Estate* which is an indicator for firms with above-median ratio of real estate to total assets, and *Share* which is the three-year average share of outstanding loans in an MSA arranged by a bank. *Fire Sale* is an indicator for fire sale in an MSA. Fire sale in an MSA is identified by structural breaks in columns (1) and (2) and by negative price shocks in columns (3) and (4). We use *Sales* and *Leverage* as controls. All standard errors are clustered at the lender level.

Table 6: Bank concentration in MSA and zombie lending

	(1)	(2)	(3)	(4)
Dependent Variable	Zombie Loan			
	Structural Break		Negative Shock	
Bank HHI	0.041**	0.043	0.053**	0.055
	(0.020)	(0.063)	(0.022)	(0.063)
Fire Sale	-0.027***	0.009	0.020**	0.032***
	(0.008)	(0.012)	(0.008)	(0.010)
Fire Sale × Bank HHI	0.080	-0.198**	-0.015	-0.178**
	(0.076)	(0.083)	(0.060)	(0.070)
High Real Estate		-0.007		-0.010
		(0.008)		(0.008)
High Real Estate × Bank HHI		-0.005		-0.005
		(0.073)		(0.074)
High Real Estate × Fire Sale		-0.049***		-0.015
		(0.016)		(0.010)
High Real Estate × Fire Sale × Bank HHI		0.376***		0.217**
		(0.124)		(0.086)
Observations	20768	20768	20768	20768
Controls	Yes	Yes	Yes	Yes
Lender × Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 estimates how the probability of zombie lending varies with bank concentration. *Zombie Loan* is an indicator for a zombie loan to a firm by a lender in a year. *High Real Estate* is an indicator for firms with an above-median ratio of real estate assets to total assets. The bank concentration (Bank HHI) is measured as the sum of the squared market shares of outstanding loans in an MSA. *Fire Sale* is an indicator for fire sale in an MSA as established by either a structural break in real estate prices (columns (1) and (2)) or a decline in real estate prices in an MSA in a year (columns (3) and (4)). We use *Sales* and *Leverage* as controls. All standard errors are clustered at the lender level.

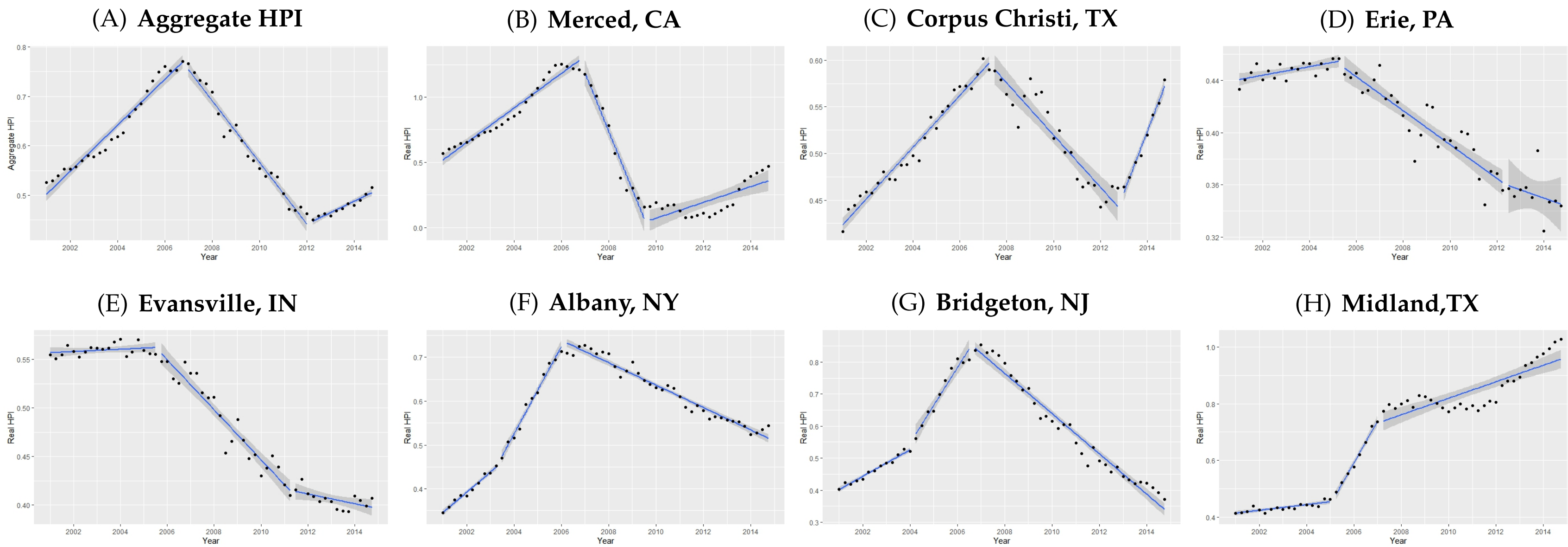
Table 7: Spillover on healthy firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Investment		ROA		ΔEmployment	
Healthy Firms	0.019	0.021	0.079***	0.082***	-0.017***	-0.019***
	(0.028)	(0.031)	(0.024)	(0.027)	(0.006)	(0.008)
% Zombies	1.045**		0.592*		0.039	
	(0.436)		(0.310)		(0.098)	
Healthy Firms × % Zombies	-1.165***	-1.218**	-0.953***	-1.028***	0.057	0.095
	(0.445)	(0.523)	(0.326)	(0.395)	(0.100)	(0.125)
Observations	106437	106394	116509	116466	94130	94094
R^2	0.31	0.33	0.65	0.65	0.17	0.19
Industry × Year FE	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	Yes	No	Yes	No

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

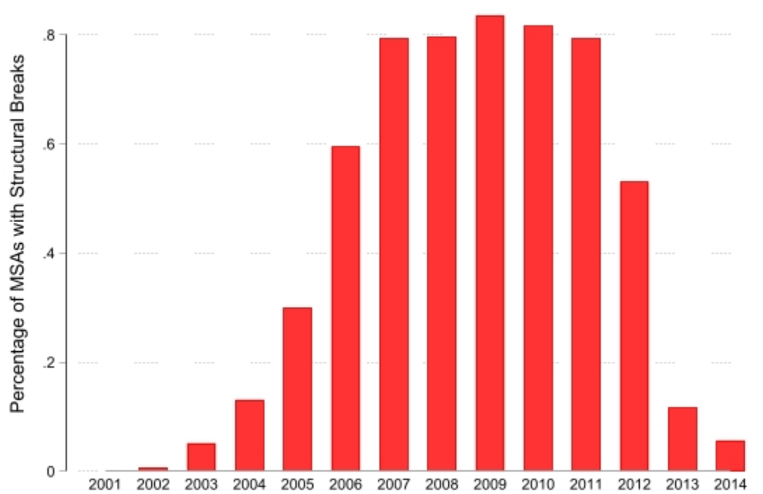
Table 7 explores the spillover effects of zombie lending. The specification follows Caballero, Hoshi and Kashyap (2008). The regressors are an indicator for non-zombie firms (*Healthy Firms*), the percentage of zombie firms (%Zombies) in the industry and the interaction term. Our dependent variables of interest are investment, return on assets (ROA) and change in employment. *Investment* is measured as capital expenditure normalized by the lagged PPE, and ROA as EBIT normalized by lagged assets. We control alternatively for year and industry-year fixed effects, while including firm fixed effects in all specifications.

Figure 1: Structural Breaks



Note: Figure 1 shows graphs of log of house price data for seven MSAs and the average house price index across the US. The house price index for each MSA is normalized by the CPI. The dotted lines report the house price series, while the solid lines report the estimated house price and the structural breaks. Panel A shows the average HPI. Panel B and C show index for Merced, CA and Corpus Christi, TX which have a negative structural break in the second period but a positive slope in the third period. Panels D and E (Erie, PA and Evansville, IN respectively) also show MSAs that have a negative structural break in the second period but the HPI continues to decline in the third period. Panels F and G (Albany, NY and Bridgeton, NJ respectively) show a positive structural break in the second segment but a negative structural break in the third segment. The third segment is thus chosen as the period of fire sales. Finally, Panel H (Midlands, TX) shows no negative structural break and therefore no fire sales in any period.

Figure 2: Number of MSAs having a fire sale



Note: Figure 2 shows the percentage of MSAs that are having a fire sale as identified by negative structural breaks.

Appendix A: Proofs

A.1 Proof of Proposition 1

Taking the first order condition given in equation 4 and substituting $L = 0$ (since it has been assumed to be very small), we get

$$\frac{dV(p(\lambda))}{d(p(\lambda))} - \frac{(1-\beta)(1-f)C}{\beta f} = 0. \tag{A.1}$$

λ^* is given by the solution to this equation. The first term is decreasing in λ and last term is independent of λ. Hence we get a unique solution λ^* if condition (5) holds.

Next we analyse how λ^* changes with f. The derivative of the first term in (A.1) w.r.t is f equals $V''(p(\lambda))p_f(\lambda)$, where p_f is partial derivative of p w.r.t. f. Both $V''(p(\lambda))$ and $p_f(\lambda)$ are negative, hence product is positive. Thus the first term is increasing in f. The second term in (A.1) is clearly decreasing in f. Hence as f increases λ^* must increase.

A.2 Proof of Proposition 2

We prove only the first part of the proposition. The second part can be proved analogously. The proof is by contradiction. Suppose $\tau^* \leq f(1-\beta)C_L/2$ and in the optimal solution all high collateral firms have not been given zombie loan ($\lambda_H^* < 1$). Now suppose if we increase λ_H^* by ϵ and reduce λ_L^* by $\eta = \epsilon\frac{C_H}{C_L} > \epsilon$, then the total collateral liquidated remains the same but the number of zombie firms reduces. Since total collateral liquidated is same, the price will remain same and the first two terms in (2.3) will be same. But the number of zombie loans will reduce increasing the utility. Thus $\lambda^* < 1$ cannot be true in equilibrium. Finally, we get λ_L^* by diving total collateral liquidated by all the collateral of the low collateral firms which failed.

Online Appendix: Variable Definitions

Table C1: Details of Variables used in the paper

Variable Name	Definition and source
Bank HHI	Bank HHI is the Herfindahl Index calculated using the market share of a bank in an MSA in a given year.
Fire Sale	is an indicator variable for a negative structural break in the real estate prices in an MSA between 2001 and 2014. It relies on the Bai and Perron (1998) test and maximizes the R^2 by varying the location of the breaks in the time series. The estimated equation is $$HPI_{MSA,t} = \alpha_{msa} + \tau_{msa} \cdot t + \lambda^{*}_{msa}(t - t^{*}_{msa})\mathbb{1}(t > t^{*}) + \lambda^{'}_{msa}(t - t^{'}_{msa})\mathbb{1}(t > t^{'}) + \epsilon_{MSA,t}$$
Healthy Firms	is an indicator variable for firms not classified as zombies
High Real Estate	is an indicator for firms with above median ratio of real estate to lagged PPE.
Investment	is the capital expenditure normalized by the lagged-PPE.
Market Share	is a bank's share of outstanding loans arranged by a bank in an MSA over the past three years.
Negative Shock	is an indicator for falling real estate prices in an MSA.
ROA	Return-on-assets is the operating income minus depreciation and amortization divided by assets.
Tobin's Q	The market-to-book ratio is calculated as the ratio of a firm's market value to its book value. The book value is measured as the book value of the property, plant, and equipment while the market value of a firm is calculated as below $$MarketValue = assets + price * sharesoutstanding - commonequity - deferredtaxes$$
Zombie	Indicator variable for firms classified as zombie firms. Firms are classified as zombie if they have an average interest expense lower than that of the most credit-worthy firm while being in the bottom tercile of firms by interest coverage ratio. This identifies them as receiving subsidized loans.

Variable Name	Definition and source
Zombie Loan	is an indicator for loans classified as zombie loans which is defined as loans with an interest rate lower than that of the most creditworthy firms (top-tercile by ICR), but, the firm is in the bottom tercile of firms by interest coverage ratio.
Δ Emp	is the log of percentage change in employment.
% Zombies	is the percentage of zombie firms in a sector defined as the 2-digit SIC code.