The Effect of Financial Crises and Dependence on External Financing on US Manufacturing Productivity

by

Shagun Varma

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Professor Marti G. Subrahmanyam	Professor Simone Lenzu
Faculty Advisor	Thesis Advisor

Abstract

Prior research has shown a clear relationship between firm size and leverage in determining firm productivity during a crisis. More specifically, this research has shown that size is a good indicator of financial constraints, and that there is a relationship between firm size and leverage, especially in the case of smaller and/or private firms. This paper aims to conduct a similar analysis, specifically studying how US manufacturing firms with higher dependence on external financing perform during a crisis on the basis of size and type of leverage (short-term/long-term). The study conducted in this paper provides a fresh perspective on the topic because of the use of the US Census Bureau's *Quarterly Financial Report*, a relatively new and publicly available dataset that spans both small and larger firms alike, making it a better reflection of the broader US economy.

The results in this paper reveal that size and leverage, for firms with high dependence on external financing, do have an impact on firm productivity during crises. Specifically, small firms with high short-term leverage are most impacted. This study shows evidence for an impact on firm productivity in the case of short-term leverage in itself but did not reveal any conclusive evidence for firm size alone. However, the interaction between size and leverage together revealed that the combination of being a small firm with high short-term leverage made firms most susceptible to economic shocks when they had a high dependence on external financing.

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Introduction

Studying firm productivity during crises on the basis of industry, asset size, leverage, and dependence on external financing, among other factors, is key in understanding the characteristics of firms that recover from these crises. Prior empirical research, as summarized by Dinlersoz, Kalemli-Ozcan, Hyatt and Penciakova (2018), has established that borrowing restraints, as measured through short-term borrowing behavior, play a major role in conducting macroeconomic analyses for crisis periods. Until recently, what was known of firm financing was based on studies of large, publicly traded companies that are not representative of the broader US economy. Recent literature has introduced the study of smaller, private firms, whose financing behavior drastically differs from that of larger firms. Zetlin-Jones and Shourideh (2017) found that 80% of private firm investment was funded by external funds, versus only 20% for public firms. As private firms make up over 55% of aggregate US gross output, and because they are more susceptible to financial shocks, conducting an analysis of these firms is essential to our understanding of firm productivity during crises.[1]

An exercise that would then be worthwhile is to analyze borrowing behavior using the *Quarterly Financial Report* database of the US Census Bureau, which is composed of sub-sector and asset size-level data on private and public companies, predominantly in the manufacturing industry. While the date range of this data is narrower than that of Standard & Poor's *Compustat North America*, it is a more accurate reflection of the US economy as it spans a wider range of firm sizes, both public and private, while *Compustat North America* is limited to publicly listed firms only. Focusing on this *QFR* data, this study quantifies the relationship between firm

[1] Dinlersoz, Kalemli-Ozcan, Hyatt and Penciakova (2018)

productivity (as a measure of firm performance), size, leverage, and dependence on external financing during a crisis. I aim to answer the following question in my empirical analysis: How is the capital productivity of firms across different manufacturing sub-sectors and asset sizes affected by the firm's dependence on external financing and type of financing (short-term/long-term) during a crisis? More specifically, this paper explores the link between capital productivity and firm dependence on external financing during a crisis with the hypothesis that capital productivity during these crises for firms with high dependence on external financing is lowest for smaller firms that are most dependent on short-term debt.

This study reveals that size and type of leverage do in fact have an impact on the reduction in productivity during a crisis for high external financing-dependent firms. We find that firms with high short-term leverage are more affected during crises than those with low short-term leverage. No conclusions could be made for high or low long-term leverage. When looking at size, although there was no concrete evidence that size in itself had an impact on productivity, the results revealed that the interaction between size and type of leverage did have an effect. More specifically, given a high dependence on external financing, small firms with high short-term leverage appeared to be most impacted during a crisis.

Past Research and Literature Review

Literature on financial dependence in industrial sectors in the US finds its inception in work by Rajan and Zingales (1998), who studied economic growth as it relates to an industry's external dependence on financing. They pioneered the simple yet highly effective index of external dependence, henceforth referred to as the "RZ Index," to measure each industrial sub-sector's dependence on external financing. The index is calculated as a fraction of firm investments financed externally, using data on publicly listed firms from Standard & Poor's *Compustat North America* (1994). The calculated index values support the "common wisdom" that younger firms are more dependent on external financing, while mature companies that have been public for at least 10 years effectively have an external financial dependence of zero.

Researchers have since found many economic growth-related applications for the RZ index. A study that very closely resembles this one is by Dinlersoz, Kalemli-Ozcan, Hyatt and Panciakova (2018), which studies firm growth and response to economic shocks through the lens of firm leverage. Unlike Rajan and Zingales, their study uses the U.S. Census Bureau's Longitudinal Business Database (LBD) from 2005 to 2012 to compare and contrast the behavior of public and private firms. Their study concluded that for public firms, there was a weak, negative relationship between leverage and firm size, while contrastingly for private firms, the relationship was strong and positive. Results showed that for private firms, financial constraints could be predicted using firm size, and that growth for private firms was positively correlated to leverage as during non-recession periods, growth was financed using short-term borrowing.

Data and Methodology

I. Compustat North America

Early research on the subject, most importantly including the Rajan and Zingales (1998) paper, has been conducted using Standard & Poor's *Compustat North America* data, which consists of comprehensive financial data on publicly listed companies in the United States. Given mandated reporting standards and disclosure requirements for publicly listed companies, *Compustat North America* maintains detailed line item-level and firm-level data that can be used to calculate productivity, financial dependence, leverage and asset size measures, among other relevant metrics. While this data is extremely comprehensive, a major shortcoming of the dataset is that it is not representative of all US firms in a particular sub-sector, as it only maintains publicly available data from large, publicly listed companies. Smaller and younger firms are not accounted for in the database, thereby producing analyses that are biased towards more "stable" firms that are anticipated to be less dependent on external financing overall. During financial crises, these are the firms whose productivity is expected to be least impacted, especially since these are also the firms that face fewer frictions in accessing credit.

II. Historical QFR

This study provides a fresh angle on prior research by using a nascent database: The US Census Bureau's *Quarterly Financial Report (QFR)* data, henceforth referred to as *QFR*. Although the dataset covers a few industries beyond manufacturing, this study focuses on the US Manufacturing industry alone. The dataset consists of income statements and balance sheets for each manufacturing sub-sector per quarter, and is organized across multiple dimensions:

1. Aggregate sub-sector level data, based on NAICS codes (30 sub-sector/industry groups)

2. Aggregate asset size-level data for each sub-sector (under $25 million, over $25 million)
3. Time (quarterly, from Q1 1996 to Q4 2018).

Note that the aggregate data covers both publicly listed and private firms. Given the inclusion of private firms, the *QFR* data does not include firm-level data, and instead aggregates the data across both the sub-sector and asset size-levels.

The panel *QFR* data allows for similar analysis as conducted with *Compustat North America* data, but provides an additional asset size layer. While prior research distinguished firms by their age (young/mature), and the "young" category could potentially serve as a proxy for "small," the "Under $25 million" asset size category in the *QFR* dataset includes a list of even smaller firms that are entirely missing from *Compustat*.

The relevant data was pulled from the *QFR* dataset to formalize the variables analyzed in this paper:

(1) Capital Productivity = Net Sales / Property, Plant and Equipment

(2) Short-Term Debt = Short-Term Loans from Banks + Short-Term Commercial Paper + Other Short-Term Loans

(3) Short-Term Leverage = Short-Term Debt / Total Assets

(4) Long-Term Debt = Long-Term Loans from Banks + Long-Term Loans (Bonds) + Other Long-Term Loans

(5) Long-Term Leverage = Long-Term Debt / Total Assets

(6) Leverage = Short-Term Leverage + Long-Term Leverage

(7) Asset Size (Dummy) = 1 if Greater than or equal to $25 million ("Large"), 0 if Under $25 million ("Small")

(8) Crisis (Dummy) = 1 for Crisis period (01/01/2008 to 12/31/2010), 0 otherwise

For the empirical analysis conducted in the Results and Discussion section, note that we take the natural logarithm of any non-dummy variables above and standardize them prior to running the regressions.

Summary statistics for the variables used in this model can be found in *Table 1* below.

Table 1. Summary Statistics (2006 to 2010)

	Mean	Std. Dev	Minimum	25%	Median	75%	Maximum
Productivity	1.1965	0.9398	0.3238	0.7920	1.1550	1.4610	3.0216
Net Sales ($ million)	66,652	63,859	8,270	21,210	36,445	83,092	401,593
Property, Plant and Equipment ($ million)	59,825	55,579	6,120	24,865	40,891	73,509	346,965
Total Assets ($ million)	269,756	235,397	28,536	73,635	166,813	351,188	987,339
Leverage	0.2666	0.0720	0.1397	0.2117	0.2656	0.3143	0.4681
Long-Term Leverage	0.2392	0.0727	0.1253	0.1867	0.2303	0.2867	0.4344
Short-Term Leverage	0.0273	0.0345	0.0062	0.0192	0.0262	0.0335	0.0662
RZ Index	0.2461	0.2626	-0.1850	0.0900	0.2400	0.3300	1.1400

III. The RZ Index

The RZ Index provides an innovative yet simple approach to measuring sub-sector dependence on external financing. The index is calculated as a fraction of firm investments financed externally, using the formula below:

RZ Index = (Capital Expenditure - Cash Flow from Operations) / Capital Expenditure[2]

[2] Federal Reserve Bank of St. Louis (2017)

The intuition behind this formula is fairly straightforward. The difference found in the numerator gives us the dollar amount of capital expenditure that was not, and could not, be funded using firm liquidity. This difference therefore represents the dollar amount of capital expenditure funded by external sources, and adding the denominator standardizes the dollar amount into an index of externally financed expenditure as a ratio of total expenditure.

The index values were used to create a dummy variable that split up the sub-sectors into two groups: High RZ (= 1), representing sub-sectors with above median RZ that are more dependent on external financing, and Low RZ (= 0), representing sub-sectors with below median RZ that are less depending on external financing. Therefore, in the scope of this study, we do not need to be concerned with negative RZ values (i.e. when capital expenditure is lower than cash flow from operations), as RZ is treated as a high-low categorical variable.

Note that the RZ indices used in this study have been pulled from the Rajan and Zingales (1998) paper and have been used as a time-independent measure. The paper used *Compustat North America* (1994) data to calculate the index using the RZ equation above.

IV. The Productivity Measure

The primary dependent variable used to analyze sub-sector performance in this study is Productivity. It is important to note, however, that given limitations in the data (explicitly stated in Data and Methodology IV below), the productivity measure is restricted to Capital Productivity alone. This productivity measure is calculated as the natural log of the ratio of Net Sales and Property, Plant and Equipment, as seen in Data and Methodology II (1) above, and is standardized. Although the scope of this study is limited by this productivity measure, this does not dilute the fresh perspective that this dataset provides. Given the lack of other publicly available datasets that

cover a wider variety of firm sizes and ages than Standard & Poor's *Compustat North America* or any other dataset solely covering publicly listed firms, any analysis conducted using this dataset is a more accurate reflection of the broader US economy.

V. Categorizing Leverage

The analysis in this paper distinguishes between high leverage and low leverage sub-sectors for a given asset size. In order to capture leverage-based effects on productivity during the crisis period and to avoid reverse causality, a sub-sector is defined as high or low leverage depending on its leverage in Q1 2006. Using this time-independent leverage distinction allows us to determine the level of debt falling due during the crisis period, and therefore evaluate its impact on sub-sectors that have a high dependence on external financing. Had we instead used simultaneous leverage to sort firms, the analysis would be conducted using an endogenous regressor. This distinction between high and low leverage firms is made per asset size category to more effectively consider impacts on productivity jointly across both size and leverage.

VI. QFR Limitations

While the *QFR* dataset can provide a refreshing perspective on the study of productivity and financial dependence, it is important to note certain shortcomings with the *QFR* data. Firstly, although *Compustat North America* data is limited in that it only spans larger, publicly traded companies, its advantage over the *QFR* data is that it is significantly more comprehensive, given reporting standards for publicly listed firms. As the *QFR* dataset includes private companies that are not mandated to report financials to the same granularity as public ones, there are a significant number of line items missing from the financial statements. The most important of these is the lack

of labor measures, i.e. direct/indirect labor costs. The lack of labor data limits the study to measures of capital productivity only, as stated in Data and Methodology III above. Furthermore, the lack of Cash Flow statements for each quarter results in the inability to calculate the RZ index from the *QFR* data itself. Therefore, the RZ index values are from *Compustat North America* (1994), as seen in Rajan and Zingales (1998). This unfortunately biases the RZ indices towards behavior of large, public firms rather than the entirety of the firms covered in the *QFR* dataset. As *Compustat North America* covers a different range of sub-sectors, the number of sub-sectors covered in this study was cut down from 30 to 19.

A second shortcoming is that because the data is relatively new, the timeframe over which empirical analysis can be conducted only includes one crisis, i.e. the 2008 financial crisis. The inability to conduct the analysis over multiple crisis periods results in the amplification of any idiosyncratic effects of the 2008 financial crisis. Furthermore, although the dataset spans from 1996 to 2018 as of the date of this paper, the 1996 to 2005 data is in PDF form, and could not be included in this analysis given time restrictions. Therefore, the pre-crisis period in this study only covers 2006 and 2007 data.

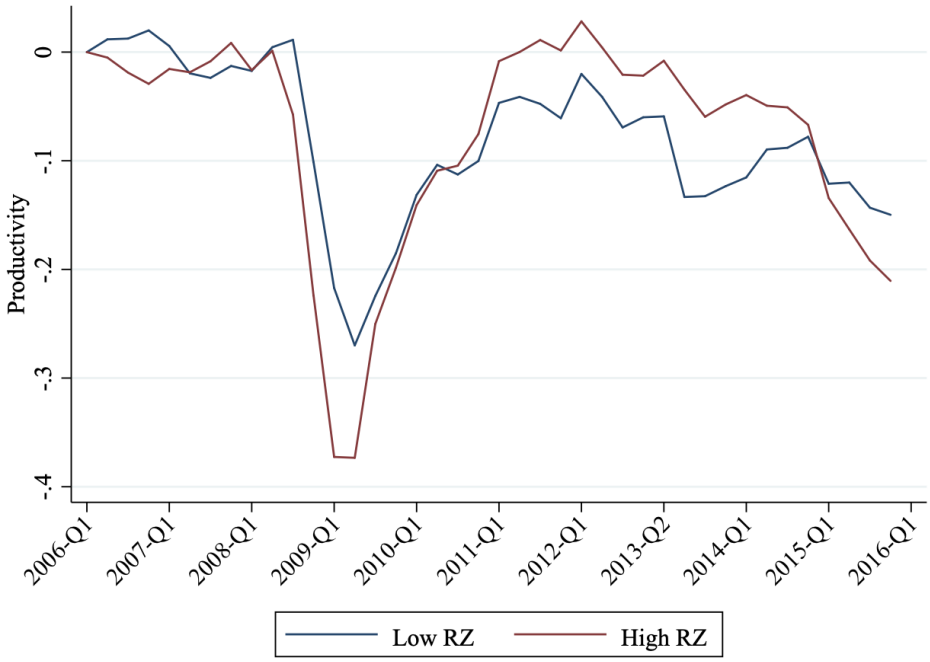
Results and Discussion

Before discussing the results below, it is important to note that any regressions run in this paper only cover data from 2006 to 2010, despite the underlying dataset covering data from 2006 to 2018. This was done to limit the periods covered in this study to a pre-crisis period (2006 and 2007) and a crisis period (2008 to 2010), and to avoid the inclusion of the recovery period (2011 to 2018).

I. Productivity for High RZ Sub-Sectors

The difference-in-difference graph in *Figure 1* below shows the impact of the 2008 financial crisis on high and low external financing-dependent sub-sectors. The graph shows similar behavior for both high and low RZ sub-sectors, however, it is important to compare and note the difference in productivity levels between the high and low RZ sub-sectors in the pre-crisis, crisis, and recovery periods separately. In the pre-crisis period, we see similar productivity levels for high and low RZ firms. However, in the crisis period, we clearly see a greater drop in productivity for high RZ firms relative to low RZ firms, which is consistent with the hypothesis that sub-sectors that are most dependent on external financing see the greatest drop in productivity. Then, during the recovery period, we see a reversal of this effect, where high RZ sub-sectors now see higher productivity than low RZ sub-sectors. Although the recovery period is not covered in the scope of this study, it is helpful in creating a comparison to understand how the greater decrease in productivity for high RZ firms is unique to crisis periods. Such an outcome for the recovery period is consistent with the findings by Dinlersoz, Kalemli-Ozcan, Hyatt and Panciakova (2018), which states that during non-recession periods, high dependence firms use their leverage to fuel growth.

Figure 1. Productivity for High RZ versus Low RZ industries



In Table 2, regressions were run for the entirety of the data using productivity as the dependent variable, and without any distinctions based on size or leverage. The results revealed a weak, negative relationship between the coefficient of interest, *Crisis x HighRZ* and productivity. These results tell us that during a crisis, sub-sectors with high dependence on external financing saw a greater decrease in productivity, which is in line with the results in figure 1. This weak relationship encouraged study on the characteristics of firms that see a stronger negative relationship between high RZ and productivity during a crisis.

II. Leverage

A key piece of the hypothesis and literature review focused on the impact of leverage on firm performance during a crisis. Specifically, the hypothesis predicts that firms that have high short-term leverage are most impacted when they are more dependent on external financing. To test this hypothesis, regressions were run to compare the *Crisis x High RZ* interaction terms. The

dataset was split into two groups, high short-term (ST) leverage and low short-term (ST) leverage, based on the methodology described in Data and Methodology V. These results are shown in *Table 3* below.

Table 2. Fixed Effects Regression of the Interact of Crisis and High RZ on Productivity

	Productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
High RZ	0.205*					
	(0.082)					
Crisis		-0.199***	-0.413***			
		(0.037)	(0.128)			
Total Assets (t-4)		-0.462*	-0.062	-1.079***	-0.062	-1.228***
		(0.255)	(0.081)	(0.231)	(0.081)	(0.225)
Crisis * High RZ		-0.065	-0.055	-0.081*	-0.055	-0.085*
		(0.055)	(0.168)	(0.047)	(0.168)	(0.045)
Observations	380	380	380	380	380	380
Adjusted R2	0.161	0.911	0.158	0.935	0.158	0.940
Year FE	Y	N	Y	Y	Y	N
Quarter FE	Y	Y	Y	Y	Y	N
Year-Quarter FE	N	N	N	N	N	Y
Subsector FE	N	Y	N	Y	N	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01

Table 3. Fixed Effects Regression of the Interaction of Crisis and High RZ on Productivity, by Short-Term Leverage

	Productivity (High ST Leverage)		Productivity (Low ST Leverage)	
	(1)	(2)	(3)	(4)
Crisis	-0.192***		-0.248***	
	(0.037)		(0.068)	
Total Assets (t-4)	-0.063	-0.629**	-0.157	-1.181***
	(0.302)	(0.277)	(0.424)	(0.378)
Crisis * High RZ	-0.412***	-0.376***	0.089	0.023
	(0.079)	(0.064)	(0.089)	(0.075)
Observations	180	200	180	200
Adjusted R2	0.925	0.952	0.908	0.935
Year FE	N	N	N	N
Quarter FE	Y	N	Y	N
Year-Quarter FE	N	Y	N	Y
Subsector FE	Y	Y	Y	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01

The results in Table 3 support the hypothesis. This is evidenced in the significant and negative coefficient of the *Crisis x HighRZ* interaction term for the high short-term leverage category. It appears that during a crisis, the sub-sectors with high dependence on external financing that are most affected are those that have high levels of short-term leverage. This outcome is in line with lending practices during a crisis. Typically, when firms have debt coming due, they opt to rollover that debt when possible, instead preserving cash flows for productivity enhancements, among other capital expenditures. However, given the credit crunch that arises during crises, lenders are less inclined to rollover that debt. With short-term debt coming due, firms are forced

to give up liquidity that would ordinarily go towards productivity enhancements to instead repay loans, leading to a decrease in productivity.

The same analysis was run for long-term leverage, found in *Table 4* of the Appendix. The regression did not provide any conclusive results or significant coefficients for the *Crisis x HighRZ* interaction term. The lack of results may in itself be telling. Long-term leverage differs from short-term leverage in that the time period over which it is paid back often extends years beyond the duration of the crisis. Therefore, the impact of high long-term leverage on productivity is not anticipated to be as drastic as that for high short-term leverage.

III. Size

Similar to Results and Discussion II above, regressions were run to test the hypothesis that the firm size influences productivity for high RZ firms during a crisis. Specifically, that smaller firms see a greater impact on productivity. However, the results, as seen in *Table 5*, do not reveal any conclusive evidence to support this hypothesis, despite the coefficient of the *Crisis x High RZ* terms being greater for small firms than for large firms, as was anticipated. The intuition behind why firm size is expected to affect productivity is not only in the abundance of research that supports this claim, but also in the fact that smaller businesses generally operate on tight cash flows, and therefore are hit hardest when buyers do not pay what is owed during periods of crisis. Reduced access to credit during crises means that these small businesses cannot easily overcome this loss of income from buyers. The lack of clarity in these results calls for an analysis on the effect of both size and leverage simultaneously on sub-sector productivity, which could better account for the effect of reduced access to credit for these small businesses.

Table 5. Fixed Effects Regression of the Interaction of Crisis and High RZ on Productivity, by Size

	Productivity (Small)		Productivity (Large)	
	(1)	(2)	(3)	(4)
Crisis	-0.190***		-0.100***	
	(0.046)		(0.032)	
Leverage (t-4)	-0.111***	-0.090***	-0.446***	-0.361***
	(0.025)	(0.025)	(0.033)	(0.031)
Crisis * High RZ	-0.056	-0.061	-0.035	-0.038
	(0.070)	(0.067)	(0.046)	(0.041)
Observations	380	380	380	380
Adjusted R2	0.919	0.927	0.947	0.958
Year FE	N	N	N	N
Quarter FE	Y	N	Y	N
Year-Quarter FE	N	Y	N	Y
Subsector FE	Y	Y	Y	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01

IV. Leverage and Size

Given the lack of significant results to conclude whether size in itself has an impact on productivity for high RZ sub-sectors, the analysis was run to study behavior across both size and leverage. The regressions were run as in Results and Discussion II, except this time additionally distinguishing high leverage and low leverage data groups by size. *Table 5* reports the results for short-term leverage and size.[3]

[3] As stated in Data and Methodology V, distinctions between high and low leverage firms are made within each asset size category. Therefore, it is possible for a sub-sector to be considered high leverage in the small category but low leverage in the large category, and vice versa.

Table 5. Fixed Effects Regression of the Interaction of Crisis and High RZ on Productivity, by Size and Short-Term Leverage

	Productivity (Small & High ST Leverage)	Productivity (Small & Low ST Leverage)	Productivity (Large & High ST Leverage)	Productivity (Large & Low ST Leverage)
	(1)	(2)	(3)	(4)
Crisis * High RZ	-0.240**	0.076	-0.141	0.105
	(0.120)	(0.083)	(0.092)	(0.101)
Observations	180	200	180	200
Adjusted R2	0.925	0.940	0.894	0.912
Year FE	N	N	N	N
Quarter FE	Y	N	Y	N
Year-Quarter FE	N	Y	N	Y
Subsector FE	Y	Y	Y	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01

The results in Table 5 once again support the hypothesis in that during a crisis, firms with high dependence on external financing are most affected if they are small firms with high short-term leverage. The coefficient of the *Crisis x HighRZ* interaction term is solely significant and largest for the small and high short-term leverage firms. This outcome is consistent with the inaccessibility of commercial loans for small businesses during the 2008 financial crisis. Prior to the crisis, commercial loans to small businesses were abundant and growing at about 15% per year. However, during the crisis, all loans to small businesses came to a drastic halt. Larger banks stopped lending to small businesses altogether, with commercial loans to small businesses growing at -2%, while loan growth for small businesses at smaller banks was at 2.5%.[4] With small firms being most affected by the credit crunch, those in high RZ industries with high levels of short-term debt were expected to be hit hardest, using the same intuition as in Results and Discussion II.

[4] Cole, R.A. (2018)

Running the same size-based regressions for long-term leverage, as seen in *Table 6* of the Appendix, did not yield any significant results. The reasoning behind why this may be resembles that of Results and Discussion II. As the period over which long-term debt is repaid extends beyond the course of the crisis, the impact on productivity, regardless of firm size, is expected to be less severe.

Conclusion

The results discussed in this paper suggest that size and leverage do have an impact on productivity for high RZ firms during a crisis. When studying leverage, we see that sub-sectors with high short-term leverage see a clear drop in productivity, whereas we do not see this impact for low short-term leverage sub-sectors, or for sub-sectors with either high or low long-term leverage. This outcome can be explained by the inability of firms to rollover debt during a crisis, leaving firms to use their liquidity to repay debt rather than making productivity enhancing investments.

When looking at firm size, we do not see conclusive evidence that size in itself is a deciding factor in firm performance for high RZ firms during a crisis. However, we see that the interaction of both size and leverage plays a role in determining the level of reduction in productivity. We find that small firms with high short-term leverage are most impacted during crises when they are in high RZ sub-sectors. This conclusion is in alignment with data from the 2008 financial crisis, which showed that small businesses saw a sharp decline in access to credit, which would be expected to greatly impact the smaller firms that were highly dependent on short-term debt.

I. Policy Implications

When determining which businesses should receive government assistance and to what extent during a crisis, it is worthwhile for governments to consider both size and type of leverage in their decision. By identifying firms that are not only small, but also highly dependent on short-term debt, governments can better assist those firms that are most impacted. As over 55% of

aggregate gross output in the US is generated by small businesses[5], governments must prioritize efficient allocation of grants and loans to small businesses by identifying these vulnerable groups.

II. Limitations and Looking Ahead

Beyond the data limitations listed in Data and Methodology VI, there are additional shortcomings that could be worked on to improve the accuracy and universality of this study. Firstly, since the data used in this study is covered at an aggregate level, this study is subject to some degree of survivor bias. As we cannot access firm-level data, any analysis conducted does not account for the fact that some firms during this period may have filed for bankruptcy and closed, and therefore were excluded from the analysis. This exclusion gives rise to results that paint a more positive picture of firm performance relative to the actual outcome. While excluding the recovery period mitigates this issue to a certain extent, as it excludes the analysis of the period which would purely study survivors, the crisis period covered in this study may have seen bankruptcies as well.

Additionally, as mentioned in Data and Methodology VI, this study only covers a single crisis, and therefore is subject to results that may solely apply to the 2008 financial crisis and not to crises in general. However, given that the *QFR* data is updated quarterly and with a quick turnaround, this analysis can be conducted in the future to include the 2020 economic downturn. Not only would including this second period address the universality issue of the results, but it would also be a unique study in and of itself as it covers a period where manufacturing, an industry heavily-reliant on in-person labor, is forced to move to teleworking unless deemed "essential." The same study could be conducted, but this time including a third category that distinguishes

[5] Dinlersoz, Kalemli-Ozcan, Hyatt and Penciakova (2018)

between sub-sectors as essential or non-essential. The hypothesis for the third category would be that non-essential sub-sectors that had to work remotely or pause operations saw a greater decrease in productivity than essential sub-sectors. Should labor data later become available for the *QFR* dataset, conducting a study of labor productivity during the coronavirus pandemic would be especially interesting as many workers were laid off, and those that were retained had to work remotely. Moreover, sub-sectors that were more reliant on labor versus those that were automated would see a greater impact on productivity. If labor data becomes available in the *QFR* database, it would be worthwhile to reconduct this study to cover more crises and labor productivity.

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Appendix

Table 4. Fixed Effects Regression of the Interact of Crisis and High RZ on Productivity, by Long-Term Leverage

	Productivity (High LT Leverage)		Productivity (Low LT Leverage)	
	(1)	(2)	(3)	(4)
Crisis	-0.155***		-0.291***	
	(0.031)		(0.075)	
Total Assets (t-4)	-0.008	-0.280	-0.552	-2.236***
	(0.246)	(0.244)	(0.453)	(0.370)
Crisis * High RZ	0.096	0.076	-0.032	-0.078
	(0.066)	(0.063)	(0.092)	(0.065)
Observations	180	200	180	200
Adjusted R2	0.961	0.964	0.866	0.935
Year FE	N	N	N	N
Quarter FE	Y	N	Y	N
Year-Quarter FE	N	Y	N	Y
Subsector FE	Y	Y	Y	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01

Table 6. Fixed Effects Regression of the Interaction of Crisis and High RZ on Productivity, by Size and Long-Term Leverage

	Productivity (Small & High LT Leverage)	Productivity (Small & Low LT Leverage)	Productivity (Large & High LT Leverage)	Productivity (Large & Low LT Leverage)
	(1)	(2)	(3)	(4)
Crisis * High RZ	-0.002	-0.064	0.086	-0.014
	(0.085)	(0.112)	(0.066)	(0.095)
Observations	180	200	180	200
Adjusted R2	0.915	0.918	0.966	0.876
Year FE	N	N	N	N
Quarter FE	Y	N	Y	N
Year-Quarter FE	N	Y	N	Y
Subsector FE	Y	Y	Y	Y

Note: p* < 0.1, ** p < 0.05, *** p < 0.01