# Financial Constraints, Sectoral Heterogeneity, and the Cyclicality of Investment

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**Abstract**

While investment in most sectors declines in response to a contractionary monetary policy shock, investment in the manufacturing sector *increases*. Using manually digitized aggregate income and balance sheet data for the universe of US manufacturing firms, I show this increase is driven by the types of firms which are least likely to be financially constrained. A two-sector New Keynesian model with financial frictions can match these facts; unconstrained firms are able to take advantage of the decline in the user cost of capital caused by the monetary contraction while constrained firms are forced to cut back.

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# 1 Introduction

Productive capital goods are among the most volatile and interest-sensitive components of GDP and receive significant attention from monetary policymakers. While past work such as Bernanke et al. (1999) and Christiano et al. (2005) has confirmed the conventional wisdom that aggregate investment is strongly procyclical in response to monetary shocks, these findings belie meaningful heterogeneity across sectors; in particular, investment in the manufacturing sector is strongly *countercyclical* conditional on monetary policy shocks. A model with financial constraints that vary across sectors can explain this behavior and suggests that the easing of financial constraints should lead to more strongly countercyclical aggregate investment dynamics in response to monetary policy.

I start by establishing several new stylized facts regarding manufacturing investment in Section 2. The main analysis utilizes manually digitized aggregate data from the Quarterly Financial Report for Manufacturing Corporations (QFR), which contain detailed income and balance sheet information for the entire manufacturing sector dating back to 1966. The aggregate capital stock in the manufacturing sector *increases* by almost 2% in the years following a 100 basis point contractionary monetary shock. This increase is driven entirely by nondurable producers as durable producers reduce their investment in response to the shock. The QFR data also show that durable manufacturers display a greater degree of financial constraint across several metrics commonly cited in the finance literature: They rely more on short-term debt, their cash flow is more volatile, and they have consistently lower dividend payout ratios.

Data from the National Income and Product Accounts (NIPA) can be used to further analyze these results. They suggest that structures, which have longer lives and more procyclical costs than other types of capital goods, are particularly important for explaining the investment behavior observed in the QFR. Data on building permits for new manufacturing structures from Dodge Analytics support these findings. While the number of new permits falls in response to contractionary monetary shocks, the total *value* of new permits rises. This suggests, at least for structures, that the increase in the value of the capital stock in manufacturing is driven by fewer, larger projects. The capital stock dynamics observed in the QFR can also be found in quarterly firm-level data from Compustat. Section 3 shows that Compustat aggregates for firms with predominantly US sales behave in a very similar manner to the QFR aggregates, which only include US firms' domestic operations.

The key feature underlying these countercyclical responses to monetary shocks is the long lifespan of investment goods, which means investment decisions should be very forward looking. One implication of this fact is that most of the value of investment goods comes from future service flows in the form of reduced marginal costs; transitory shocks that change the value of capital services in any one period will have a very small effect on the total demand for investment. Another implication is that firms should be very sensitive to changes in the prices of investment goods, as getting a discount on investment today is equivalent to locking in a long series of lower marginal costs.

In an economy with only one good, contractionary monetary policy will raise interest rates and lower demand, but there will be no relative price effects, so demand for investment goods will fall. In a multi-sector economy with separately priced investment and non-investment goods, however, monetary policy can also have an effect on the relative prices. If this decline in the relative price of investment is sufficiently large it can offset the higher interest rates and make investment *more* appealing. I test this in the data by calculating measures of manufacturing-specific user costs that incorporate relative prices, interest rates, and depreciation. These user cost measures suggest that the decline in relative prices of investment more than offsets the higher interest rates caused by the monetary contraction. The heterogeneity in responses across sectors can be explained by differing degrees of financial constraint.

To analyze the quantitative importance of financial factors in explaining this investment heterogeneity across sectors and explore counterfactual exercises with different degrees of financial constraint, I incorporate them into a model. Section 4 develops an otherwise-standard New Keynesian model with financial constraints that differ across sectors. The model is able to generate firm investment responses that are consistent with the data because it limits the ability of financially constrained agents to respond to changes in monetary policy. In the model, the relative price of investment goods falls in response to a monetary contraction. This reduces the value of collateral held by the constrained durable producers, who are forced to reduce their durable purchases. Unconstrained nondurable producers are able to take advantage of the lower prices and increase their durable expenditure. Households, a fraction of which are also constrained, are affected by a similar mechanism that leads to declines in aggregate consumption in both the nondurable and durable sectors. By generating on-impact investment and consumption responses consistent with the data, I am also able to resolve the "comovement puzzle" first reported in Barsky et al. (2007), who pointed out that simple New Keynesian models predict large increases in durable purchases in response to contractionary monetary shocks due to their extreme forward-looking nature.

These results complement recent work analyzing how firm characteristics can influence the effects of monetary shocks on investment including Cloyne et al. (2019), Jeenas (2019), Ottonello and Winberry (2020), and Crouzet and Mehrotra (2020) and have two important implications. First, they suggest policymakers should pay particularly close attention to the balance sheets of financially constrained firms when trying to use monetary policy as a tool to stabilize business cycles, as binding financial constraints can actually prevent them from adjusting and instead lead to increased investment in other, less-constrained sectors. Second, to the extent that financial modernization can reduce these financial constraints in other sectors, more firms should be able to take advantage of temporary demand-driven drops in prices when choosing the timing of their capital goods purchases.

# 2 Evidence of Manufacturing Investment Cyclicality

This section shows evidence from aggregate data that manufacturing investment is countercyclical conditional on monetary shocks and provides suggestive evidence that this behavior can be explained by financial constraints. First, I use manually digitized historical data from the Quarterly Financial Report for Manufacturing Corporations to show that the aggregate manufacturing sector capital stock increases in response to a contractionary monetary shock. Building permit data suggest that the responses of the stock of structures, which have longer lives and more cyclically sensitive prices relative to other types of investment, are driven by the intensive margin. Many different empirical estimates of the user cost of capital fall in response to contractionary monetary shocks, suggesting that firms have an opportunity to benefit from short-term fluctuations in the prices of these long-lived investment goods. Firms in the nondurables sector drive the increase in the aggregate manufacturing sector capital stock and these are the types of manufacturers that exhibit fewer signs of financial constraint.

## 2.1 Data

The main source of data is the Quarterly Financial Report for Manufacturing Corporations (QFR), a comprehensive survey of income and balance sheet information for the US manufacturing sector. A detailed description of the data, which were digitized manually going back to 1966Q1 from physical publications, can be found in the appendix. Relatively few papers have used these data; the most famous example is Gertler and Gilchrist (1994), who used the data to suggest that small firms are more sensitive to monetary policy changes than large firms. Some more recent examples include Crouzet (2017), Kudlyak and Sánchez (2017), and Crouzet and Mehrotra (2020).

The QFR data are well suited for answering this question. First and foremost, they are representative of the entire manufacturing sector, including small and non-public firms. This is important because a large body of empirical evidence, including recent work such as Hadlock and Pierce (2010), finds small and non-public firms are more likely to be financially constrained. The data offer detailed balance sheet information at the quarterly frequency, which makes them better suited to analyze the responses of short-term fluctuations in monetary policy than annual BEA or Census data. And unlike the US Financial Accounts data, which aggregate balance sheet information across nonfinancial corporate businesses of all sectors and sizes, the QFR data provide sector-specific measures of financial ratios as well as capital stocks. While the QFR data do not have any firm-level detail, I show in Section 3 that the results from the QFR align well with estimates obtained using aggregated firm-level data from Compustat and complement the findings from other work that uses the QFR microdata.

## 2.2 Empirical Responses to Monetary Shocks

To analyze the empirical responses of consumption and investment to monetary policy shocks, I use a local projection specification based on Jordà (2005). The estimating equation, which is similar to the one used in Ramey (2016), is shown in Equation 1. In this setup $y^i_{t+h}$ represents the $h$-period ahead realization of the log of the outcome variable $y$ for sector/size classification $i$ at time $t$, $\epsilon_t$ represents the monetary policy shock at time $t$, and $\nu^i_{t,h}$ is an error term.

$$y^i_{t+h} = c^i_h + q^i_h + Trend + \sum_j \beta^i_{j,h} X^i_{t-j} + \sum_k \Omega^i_{k,h} Z_{t-k} + \gamma^i_h \epsilon_t + \nu^i_{t,h} \tag{1}$$

Sales and capital stocks are the primary outcomes of interest.[1] I use the series developed by Romer and Romer (2004) (R&R) and extended by Coibion (2012) as my measure of monetary policy shocks $\epsilon_t$. $X^i$ includes size-and-sector-specific controls (6 lags of the dependent variable $y^i_t$) and $Z$ includes aggregate controls (1 lag each of real GDP growth and $\epsilon_t$). The regression also includes a linear time trend and calendar quarter fixed effects $q^i_h$ to deal with seasonality. In line with R&R, the sample starts in 1970 and includes shocks through 2004. Outcomes beyond 2008 are not considered to avoid concerns surrounding the zero lower bound on nominal interest rates and the financial crisis. Section 2 of the appendix shows that similar results are generated from a standard recursive VAR and that they are robust to alternative start dates, investment price indices, choices of controls, and alternative monetary shocks identified by Gertler and Karadi (2015).

The coefficient $\gamma^i_h$ represents the percent change in the $h$-period ahead forecast in variable $y$ for sector $i$. Newey-West standard errors are used to account for the serial correlation in residuals that arises from successively lagging the dependent variable. The top panels of

[1] Unlike measures of investment or capital expenditure, capital stocks are directly recorded in the QFR.

Figure 1 show the responses of sales and the capital stock.

Following a 100 basis point contractionary monetary shock, sales of manufacturing firms decline significantly, remaining 3-4% below their pre-shock levels between three and four years after the shock. As in Erceg and Levin (2006), the drop is even larger for durable producers, who experience sales declines of up to 5%. Despite the drop in sales the capital stock of all manufacturers rises by about 1.8%. This is driven by a large and statistically significant increase of 2.3% on the part of nondurable producers. The capital stock of durable producers, on the other hand, declines by up to 1.2%.

The persistence of these responses is consistent with Ramey (2016), who does not directly estimate the responses of investment to monetary policy shocks but finds the largest effects on industrial production at the 2-4 year horizon across a variety of specifications. These findings are also in line with Jeenas (2019), who analyzes the response of investment to monetary policy shocks in Compustat and finds the largest investment effects occur between 1-3 years after the shock, and can be accounted for by mechanisms such as those in Zorn (2018) and Arredondo (2020).

These estimates are obtained from separate regressions for each sector. An alternative approach is to directly estimate the differential responses between the durable and nondurable sectors in the same equation. The bottom panels of Figure 1 show the coefficient estimates from Equation 1 with the dependent variable replaced with "gaps" measuring the differential effect between sectors instead of estimating the effects on each sector separately. The gaps are defined as the log difference between the durable and nondurable sectors: $y_t \equiv \log(X_t^D) - \log(X_t^N)$, where $X$ is the variable of interest. The capital stock gap falls slowly to around 2% before stabilizing around two and a half years after the shock. This provides further evidence for the different behavior of the capital stocks in each sector.

This countercyclical response of investment to a monetary shock in the manufacturing sector stands in contrast to most other sectors. Establishing this fact requires moving beyond the QFR, which has historically focused on manufacturing.[2] The BEA fixed asset accounts provide an alternative measure of sector-specific capital stocks suitable for this purpose. These measures are calculated at the annual level, so to analyze the effects of monetary policy I create a quarterly series of fixed asset stocks for each industry by linearly interpolating the annual data.[3]

[2]The QFR began coverage of mining, wholesale trade, and retail trade in 1974 and was expanded to include a selection of service industries in 2010.

[3]Unlike the "Stock of Property, Plant, and Equipment" item in the QFR data, which is constructed based on reported book value estimates, the BEA capital stock measures are computed by using data on purchases of capital equipment combined with rates of economic depreciation. These measures will not necessarily always match, but Figure 1 of the appendix shows that both measures have consistently reflected the same underlying trends.

The left panel of Figure 2 shows the responses of the total fixed asset stock for a wide variety of sectors and shows several striking features. The first is that, as in the QFR data, the capital stock of the manufacturing sector increases in response to a contractionary monetary shock. The second is that the capital stocks of most other industries (including the aggregate) decline. The middle panel shows the response of equipment, which represents about 15% of the total capital stock for all industries. While the dispersion of responses is a bit higher than total fixed assets the pattern is quite similar. As in the total fixed asset case, manufacturing is clearly an outlier in terms of its countercyclical response. The stock of structures in manufacturing has a more modest increase and the stocks of several other industries (including construction and retail trade) climb in response to the shock as well. The rightmost panel shows that these increases in manufacturing investment occur despite a drop in sales that is larger than in most other industries.[4] These results are also consistent with estimates using BEA investment flows rather than capital stocks, which are shown in Figure 3. While noisier, the estimated responses are consistent with those of the corresponding capital stocks.[5]

Given the low-frequency nature of these series, the standard errors (which are shown in the Appendix) are large and the point estimates are statistically indistinguishable from zero throughout the response horizon for both durable and nondurable manufacturers. The *ratios* of these series, however, which are calculated as the log ratio of investment or the capital stock for durable producers relative to nondurable producers, decline in response to contractionary monetary shocks, particularly for the capital stock measures. These responses are shown in Figure 4 and are consistent with the main results using the QFR data.

One possible reason for why the investment of manufacturing firms behaves differently from nonmanufacturing firms is outlined in Buera et al. (2011). The authors point out that manufacturing establishments generally operate at a larger scale than nonmanufacturing establishments and argue that these differences can be explained by higher fixed costs of operation, which must be financed. Thus while the manufacturing sector is more constrained *ex ante*, firms in this sector should on average be less financially constrained than their nonmanufacturing counterparts *conditional on operating*.

[4] The appendix shows that a more detailed breakdown of the BEA data into manufacturing subsectors, while noisy, is still consistent with my main results. While the point estimates for each subsector are noisy and not significantly different from zero when estimated separately, the *ratio* of durable to nondurable capital stocks falls significantly in a pattern that closely matches a similar exercise using the QFR data.

[5] The fact that structures can have both the smallest *stock* response among different types of fixed assets but the largest *flow* response is due to the fact that structures have much lower investment rates (and much longer useful lives) than other types of investment.

## 2.3 Structures Investment Detail

Structures, which represent about 80% of the capital stock across the entire economy and 35% of the capital stock for the manufacturing sector based on BEA estimates, provide detailed evidence that the cost of new investment falls in response to contractionary monetary shocks and that financially unconstrained firms take advantage of these lower prices. Buildings have much longer lifespans than most other types of capital goods, meaning that they should be particularly sensitive to price changes. The cost of new construction (including materials and wages) is strongly correlated with the residential housing market, which is known to deteriorate sharply following a monetary contraction (see for example Leamer (2015)). This reduced demand lowers building costs and leads to large estimated increases in manufacturing construction. Detailed commercial building permit data show that this investment response is driven by the intensive margin: The *number* of new manufacturing structures falls while the total *value* of new structures rises.

The inverse relationship between manufacturing and residential construction activity growth can be seen in the responses to monetary shocks in the top row of Figure 5. While residential investment falls by almost 8% before returning to its baseline level, there is a much more muted effect in nonresidential structures investment. This is driven in part by manufacturing structures investment, which increases by up to 7.3%. Residential investment averaged about 58% of total structures investment from 1970-2008, meaning construction costs such as wages and building materials are driven to a large degree by activity in the housing market. This can be seen in the bottom row of Figure 5, which shows the responses of construction employment, real building costs[6], and the NIPA real manufacturing structures price deflated by the GDP price index. These measures show that the relative cost of construction falls significantly in the wake of contractionary monetary shocks and can help explain why manufacturing firms increase their investment expenditure in response.

Building permit data allow for analysis of structures investment at the "project" level. Dodge Analytics is a consulting firm that collects commercial building permits based on county-level filings. They generously shared aggregate data on commercial building permits dating back to 1967 for the total number and value of new (defined as those with a planned start date within 60 days) building permits split by type of structure. Details and definitions of the data can be found in the appendix. These data are useful because they can distinguish between the extensive (more/fewer projects) and intensive (more/less costly projects) margins when analyzing changes in construction activity.

The results for manufacturing structures are shown in Figure 6. The leftmost panel

[6]This measure is the Engineering News-Record's Building Cost Index, which is calculated based on a variety of wages and materials in the construction industry and deflated using the GDP price index.

shows that the number of new permits is strongly procyclical, declining by about 4% before returning to its pre-shock level over four years. The total value of the projects, shown in the middle panel, closely matches the shape of the response of the NIPA measure of manufacturing construction value by increasing for about two years. The right panel confirms that the average project size is strongly countercyclical. While these results are consistent with the idea that it is the subset of financially unconstrained firms which are able to respond to the decline in construction costs and increase the total value of manufacturing structures put in place, the next section shows that the procyclical movement in the cost of investment is not limited to structures.

## 2.4 User Costs and Monetary Policy

Investment decisions take into consideration not just relative prices but also other factors such as depreciation, adjustment costs, financial frictions, and expected price dynamics. Deriving an empirical estimate of the comprehensive cost of investment (known as the user cost of capital) is the driving question behind a large literature which dates back to Hall and Jorgenson (1967) and includes more recent examples such as Chirinko et al. (1999). This section shows that while contractionary monetary shocks increase interest rates, they also reduce the relative price of investment, and that the net effect of these shocks is a decline in the user cost of capital for manufacturing firms.

In a neoclassical setting the user cost $UC_t$ can be written as follows:

$$UC_t = \frac{P_t^I}{P_t^Y}\left[i_t + \delta_t - E_t \Delta P_{t+1}^I\right] \tag{2}$$

In this equation $P_t^I$ and $P_t^Y$ are the prices of investment and output, $i_t$ is the gross interest rate, $\delta_t$ is the depreciation rate, and $E_t \Delta P_{t+1}^I$ is the expected change in the price of investment. In this setting firms will increase their investment if: 1) the relative price of investment falls, 2) the expected price of future investment rises, or 3) interest rates decline. To estimate the response of the user cost of capital for each sector and its components to a monetary shock I use the following empirical specification:

$$y_{t+h}^i = c_h^i + q_h^i + Trend + y_{t-1}^i + \sum_{j=1}^{4} \Omega_{j,h}^i Z_{t-j} + \gamma_h^i \epsilon_t + \nu_{t,h}^i \tag{3}$$

The baseline specification is tailored for estimating responses of the capital stock, which is a slow-moving variable and thus needs more lags to accurately control for its past dynamics;

for more rapidly-adjusting variables like user costs, fewer autoregressive lags are needed, so only one is included. The control vector $Z$ includes one lag of real GDP growth to match my baseline regression and four lags of the Federal Funds Rate. While the results are robust to the choice of interest rate and lag length, including lags of an interest rate measure separately from the lagged user cost is important because the latter responds to changes in non-interest variables, and thus lagged user costs alone are not adequate to control for recent interest rate dynamics.

Data on price indices for investment and rates of economic depreciation are taken from the BEA fixed asset data for the durable, nondurable, and total manufacturing sectors. Effective interest rate measures are not directly observable in the QFR prior to 1998, so to obtain interest rates for the durable and nondurable manufacturing sectors I instead turn to Compustat. These interest rates are derived by first calculating the rate of interest expenses to total debt using the WRDS financial ratio suite, winsorizing the top and bottom 1% of observations, and calculating a mean for each sector in each quarter weighted by total debt. Because these observations are only available starting in 1975, change in yields on AAA bonds between 1970 and 1975 are retroactively applied to the 1975 Compustat series for each sector to get a measure running back to 1970. This assumes that the spread between each sector's average borrowing rate and the AAA yield was constant over this five-year window, though the results are extremely similar to those using a sample that begins after the Compustat interest rates are available.[7]

The empirical user cost estimates are shown in Figure 7. Given that direct estimates of expected changes in the price of investment goods are not observable, and that proxying for such expectations with either lagged or actual future price changes does not make a meaningful impact on the empirical results, I have dropped them from the user cost estimates (which imposes $E_t\left[\Delta P^I_{t+1} = 0\right]$).

The top row shows the baseline estimates, which use the effective Compustat interest rate for each sector described previously. The decline in the total user cost is driven by the nondurable sector, while the changes for the durable sector are both smaller and statistically insignificant. These results look virtually identical to those using the NIPA nonresidential fixed investment price index as the measure of investment prices (shown in the second row) or using BAA bond yields as the relevant interest rate (shown in the third row). The bottom row, which ignores interest and depreciation rates, shows that the decline in the user cost is driven by a decline in the relative prices of investment goods.

[7]Compustat calculations only give the *average* interest rate, whereas the *marginal* rate is in principle more relevant for the user cost calculation. In practice this does not appear to make a large difference, however, as the appendix shows user costs estimated using AAA or BAA bond yields as well as the Federal Funds Rate all yield similar results.

Crucially, these empirical user cost estimates do not include financial constraints, as these measures cannot easily be seen in the data. In the model, the firms face the same investment good prices and constant depreciation rates, so current and expected financial constraints are a primary driver of the differential responses of user costs across sectors. In the data the user cost does show a smaller and less significant decline for durable producers than nondurable producers; to the extent that monetary shocks also exacerbate the financial constraints on durable producers through falling capital goods prices and hence a tighter investment constraint, a more comprehensive user cost measure should show an even smaller decline for durable producers (or even an increase).

The baseline specification suggests a reduction in aggregate manufacturing user costs of up to 0.6% in the 8 quarters following the shock. The aggregate estimates in the previous section implied an increase in the capital stock of up to 1.7%, implying a back-of-the-envelope aggregate user cost elasticity of around -3 at its peak.[8] The estimated elasticities for the nondurable sector, which are responsible for the aggregate capital stock increase and which experience a larger drop in user costs, are about -2. To the extent that my user cost estimates do not fully account for changing financial constraints, the estimated user cost elasticity for the nondurable sector is likely to be more reliable than that of the aggregate manufacturing capital stock.[9] The next section shows that financial frictions can help explain why large and nondurable producers take advantage of this decline in user costs while small and durable firms do not.

## 2.5 Financial Constraints

In this section I show that durable producers are more financially constrained than nondurable producers using QFR income and balance sheet data and argue that these differences can explain the difference in investment behavior across sectors. Durable producers rely more on short-term liabilities, experience more volatile cash flow, and disburse fewer dividends.

While there is an extensive empirical literature that takes as given that some firms are

[8]These calculations are based solely on changes in the capital stock over an eight-quarter horizon. Alternative elasticities, such as those calculated by taking the integral of the IRFs, are very similar.

[9]These numbers are larger in magnitude than most past estimates, which range between -0.5 and -1.0 according to Hassett and Hubbard (2002), but they are more in line with the larger estimates found in Zwick and Mahon (2017). It is also aligned with Caballero et al. (1995), who look at plant-level investment data in manufacturing. They find industry-specific elasticities from 0 to -2 with an average around -1 and larger elasticities concentrated in nondurable industries. Thus while the elasticities implied by my results are large they are not implausible relative to existing estimates, which are usually derived from changes in taxes rather than monetary shocks.

more constrained than others[10], this paper builds on a research agenda that links the durability of a firm's output to the degree of financial constraint that it faces. Rajan and Zingales (1998), for example, find that six of the eight manufacturing industries with the highest reliance on external finance are durable producers. Almeida and Campello (2007) argue that the assets of durable producers are less liquid than their nondurable counterparts, which reduces their value as collateral. Banerjee et al. (2008) show evidence that durable producers in bilateral relationships maintain lower levels of leverage than nondurable producers as a way of maintaining bargaining power to prevent holdup problems. Finally, Gomes et al. (2009) find that durable goods manufacturers have a large equity risk premium and argue this is a fundamental consequence of the higher volatility of demand for their products. To my knowledge, this paper is the first to directly consider these effects in the context of monetary policy.

Analyzing these features requires a clear definition of what it means for a firm to be financially constrained. I define a firm as being financially constrained if it faces a convex cost of obtaining external capital. This implies that a firm's marginal cost of raising one more dollar of external funding is increasing in the amount raised.[11] In the limiting case in which a firm faces an explicit cap on the quantity of funds it can raise, this curve will be vertical, but in the absence of information about such limits, this will be indistinguishable from the case in which a firm is able to raise additional funds but is deterred by the costs of doing so.

While measuring financial constraints in the data is notoriously difficult, there are several commonly cited indicators discussed in the literature. These include higher reliance on short-term debt, more volatile cash flows, and lower dividend disbursements. Figure 8 shows that these measures all point to more binding financial constraints for durable producers relative to nondurable producers.

The first panel shows that durable producers have a higher share of their total liabilities with a maturity of less than one year. Past studies of the determinants of debt maturity such as Barclay and Smith (1995) and Guedes and Opler (1996) find that smaller, riskier, and more credit-constrained firms are more likely to rely on short-term liabilities.

The second panel, which shows net income normalized by the capital stock, offers further evidence that durable producers face a higher risk premium on their debt. Not only is cash flow more volatile for durable producers, but the fluctuations are asymmetric in magnitude; while there is a short stretch in the mid-90s in which the ratio was higher for durable

[10] See for example Fazzari et al. (1988), Kaplan and Zingales (1997), Almeida and Campello (2001), Whited and Wu (2006), Giroud and Mueller (2017), and Farre-Mensa and Ljungqvist (2016).

[11] This is the definition used in Almeida and Campello (2001) and Farre-Mensa and Ljungqvist (2016).

producers, it is far lower during the most recent three recessions.

Another commonly cited indicator of financial constraint in the finance literature (including Whited and Wu (2006)) is the ability of a firm to pay dividends. If firms face a premium to obtain outside financing, it will raise the real value of internal funds relative to dividend disbursements. The third panel shows that the dividend payout ratio is consistently lower for durable producers, particularly since the mid-1980s. The appendix shows that these results hold even when looking at just the largest firms in each sector, suggesting that the results are not driven solely by different firm size distributions across durable and nondurable industries, and that they are also present in Compustat data.

Models that generate a need for finance through agency problems or incomplete contracts usually do not allow first-best levels of investment.[12] To the extent that volatility of cash flow can exacerbate these frictions, durable producers should be more financially constrained in these settings. The appendix provides a more rigorous theoretical treatment based on Tirole (2010) showing that volatile demand can endogenously reduce the borrowing capacity of a firm compared to one which is otherwise identical. The next section extends my analysis to manufacturing firms in Compustat.

# 3 Evidence from Microdata

The previous section showed the effects of monetary shocks on the aggregate capital stock of the manufacturing sector. I found that contractionary shocks led to increases in investment driven by firms in the nondurable sector. To explain these features I showed that the aggregate user cost of capital fell and provided suggestive evidence that financially unconstrained firms were able to take advantage of the cyclical drop in prices. This section shows that my results can also be seen in Compustat. Throughout this section, I construct capital stocks using the procedure outlined in Ottonello and Winberry (2020). This methodology takes as an initial value the the earliest observation of the value of each firm's gross stock of property, plant, and equipment and then adds to this series the change in the *net* stock of property, plant, and equipment in each quarter. The process is described in detail in the appendix.

## 3.1 Compustat Aggregate Results

While firms in Compustat report capital stock measures that include international operations, firms in the QFR are specifically asked to restrict their responses to include only US

[12] Holmstrom and Tirole (1997) and Kiyotaki and Moore (1997) are two examples.

operations. Thus to facilitate further comparison, I use the geographical segment data to restrict analysis to firms which are more likely to align with the QFR sample.

I create a set of "nonforeign" firms by dropping those that explicitly report a significant share of sales outside the US. Of US firms which report both total and foreign sales, a firm is classified as having foreign operations if the average share of foreign sales to total sales is greater than 20% over the quarters in which the company reports both. After dropping these firms with substantial foreign operations, the remaining group of domestic firms represents approximately 95% of the capital stock of the manufacturing sector in Compustat in the 1980s, though this share drops to just above 50% by 2012. The results of this approach are shown in Figure 9. Nondurable manufacturers are estimated to increase their capital stock while durable producers show a decline, particularly toward the end of the response horizon. Overall, these results suggest that the primarily domestic firms in Compustat show very similar capital stock behavior to the patterns observed in the QFR.

## 3.2 Comparison to Existing Literature

In this section I compare my results to several recent papers which analyze the cyclical properties of investment. The first is Crouzet and Mehrotra (2020). While my results rely on the publicly available aggregate QFR data and Compustat, they use the QFR microdata. Their paper argues that the industry scope of a firm—that is, the number of industries in which a firm operates—can explain the difference in cyclical sensitivity between small and large firms. They use panel regressions to estimate the response of average firms in the top 1% and bottom 99% of the QFR firm size distribution to monetary policy shocks identified in a similar manner to those used in my paper. In their paper both types of firms decrease their investment in response to contractionary monetary shocks, but they use interactions between durable/nondurable industry dummies and monetary shocks in their specification. To the extent that my results are driven by the distinction between durable and nondurable producers, these interaction terms can reconcile these seemingly contradictory results. Even with this specification, they note that firm-level investment in the QFR microdata increases in response to monetary contractions starting in the 1990s, which is consistent with the main results in my paper as well as a series of comparable robustness checks shown in the appendix.

The key mechanism in my paper is that investment increases for unconstrained firms in response to falling relative prices, even in the presence of reduced demand. To the extent that the relative price of investment goods also moves in response to other drivers of business cycles, several other findings in their paper provide further support the mechanism at the heart of my paper. Crouzet and Mehrotra (2020) show that while the average marginal effect of GDP growth on fixed investment is positive, the conditional average marginal effect for the largest 0.5% of QFR firms is negative and statistically significant. Furthermore, they find that dividend-paying firms increase their investment during the three years following the onset of a recession; in contrast, investment falls for firms which don't pay dividends. While these empirical results are based on business cycles caused by both monetary and non-monetary shocks, they are consistent with the idea that periods of reduced demand can be attractive times to invest for unconstrained firms.

The second group of papers analyze firm-level investment patterns using panel regressions based on Compustat data. These include Jeenas (2019) and Ottonello and Winberry (2020). While these papers do not focus explicitly on the heterogeneity of firm responses across sectors, they are both consistent with my findings that it is the *least* financially constrained firms which drive the investment responses to monetary policy. In the Appendix I extend my main results using a Compustat panel specification based on these approaches and estimate results that support my findings based on aggregate data.

# 4 Model

In this section I develop a model that can match the empirical findings in Sections 2 and 3. In light of the results outlined previously, the key feature is that durable goods producers are financially constrained. In response to a contractionary monetary policy shock, the flexibility of pricing for durable producers causes the relative price of durables to fall. Durable producers and borrower households are constrained and are unable to take advantage of these lower prices, while nondurable producers and saver households increase their durable purchases. The result is a model which can qualitatively match the responses of durable goods for both consumers and producers to monetary shocks. This intuition is idential to that of the model in Barsky et al. (2007). I include additional frictions such as sticky wages, capital adjustment costs, and habit formation in consumption to allow the model to match the slow and persistent adjustments to the capital stock, but none of these features are necessary to generate the core result that investment increases for the unconstrained sector in response to a contractionary monetary shock. A detailed treatment of the model is provided in Section 3 of the appendix.

## 4.1 Households

The household side of the model is based on Chen and Liao (2014). Measure $\omega$ are savers with discount factor $\beta_S$, while measure $(1-\omega)$ are borrowers with discount factor $\beta_B$. Savers are more patient ($\beta_S > \beta_B$), which allows for borrowing in the steady state, and are endowed with ownership of the firms. Households of type $i \in \{S, B\}$ maximize utility over nondurable consumption $C_{i,t}^N$ with habit formation in the manner of Fuhrer (2000), stocks $D_{i,t}$ and flows $C_{i,t}^D$ of durable consumption, labor $H_{i,t}$, and nominal bond holdings $B_{i,t}$:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left[ \eta \log(C_{i,t}^N - hC_{i,t-1}^N) + (1-\eta)\log(D_{i,t}) - \nu \frac{H_{i,t}^{1+\chi}}{1+\chi} \right]. \tag{4}$$

Durable goods accumulate according to a standard law of motion with depreciation rate $\delta_D$:

$$D_{i,t} = C_{i,t}^D + (1-\delta_D)D_{i,t-1}. \tag{5}$$

Labor is perfectly substitutable between sectors, meaning that households only derive disutility from total labor $H_{i,t}$ and that equilibrium wages will be equal across sectors. The budget constraints are identical for savers and borrowers except for the inclusion of profits in the budget of savers. Relative prices $p_t^j$ are defined as the ratio of the nominal price in sector $j$ to the aggregate price level, with $\Pi_t$ representing the aggregate inflation rate.

$$p_t^N C_{B,t}^N + p_t^D C_{B,t}^D + B_{B,t} = \frac{(1+i_{t-1})B_{B,t-1}}{\Pi_t} + w_t H_{B,t}^D + w_t H_{B,t}^N, \tag{6}$$

$$p_t^N C_{S,t}^N + p_t^D C_{S,t}^D + B_{S,t} = \frac{(1+i_{t-1})B_{S,t-1}}{\Pi_t} + w_t H_{S,t}^D + w_t H_{S,t}^N + \frac{1}{\omega}\left(Profits_t\right). \tag{7}$$

The Lagrange multiplier on the budget constraint for each household is $\lambda_{i,t}$. Households supply labor through a common labor market so that the same wage $w_t$ applies to both savers and borrowers in both sectors. Real wages are subject to rigidity as in Blanchard and Galí (2007) and will be weighted averages of past real wages and consumers' current marginal disutility of labor times a markup $\mu^w$, which helps prevent the real wage from dropping below the marginal disutility of labor:[13]

$$w_t = \left( \frac{\nu H_{i,t}^{\chi}}{\lambda_{i,t}} (1 + \mu^w) \right)^{1-\rho_w} \left( \frac{w_{t-1}}{\Pi_t} \right)^{\rho_w}. \tag{8}$$

Households are constrained in that they can only borrow up to some exogenous share $m$ of the value of their stock of durable goods. This constraint will bind in the steady state for borrowers but not savers due to the difference in discount factors.

$$(1 + i_t) B_{B,t} = p_t^D D_{B,t} m \tag{9}$$

Let $\psi_t$ be the Lagrange multiplier on the borrowing constraint. If the constraint doesn't bind, $\psi_t = 0$ and the intertemporal efficiency conditions look the same for both borrowers and savers. If $\psi_t > 0$, then the decisions of borrowers are distorted in two ways. First, the marginal value of one dollar today will be greater than the discounted expected marginal value of a dollar tomorrow. Second, borrowers will receive an additional benefit to buying durable goods because they will ease the borrowing constraint.

## 4.2 Firms

Each firm produces according to a standard Cobb-Douglas production technology and has a law of motion for capital subject to "second-order" adjustment costs in the manner of Christiano et al. (2005):

$$Y_t^j = A_t \left(K_t^j\right)^{\alpha_j} \left(H_t^j\right)^{1-\alpha_j}, \quad K_{t+1}^j = (1 - \delta_K) K_t^j + I_t^j \left[ 1 - \frac{\theta_j}{2} \left( \frac{I_t^j}{I_{t-1}^j} - 1 \right)^2 \right]. \tag{10}$$

Output in each sector $Y_t^j$ will be a function of aggregate productivity $A_t$, capital stock $K_t^j$, and labor $H_t^j$. Capital is owned by the firms and depreciates at rate $\delta_K$. The good produced by the durable sector can be used as either a consumer durable good or as productive capital; all durable goods have the same price and can be traded between firms and households. Adjustment costs for investment $I_t^j$, which are governed by $\theta_j$, help the model generate more realistic persistence in the dynamics of the capital stock but are not necessary for the paper's main results.

[13] This mechanism helps lead to smoother and more persistent model dynamics across all variables in response to shocks, but none of the main results in the paper depend on it (see Figure 12).

Durable goods producers face an intratemporal working capital constraint. Their purchases of labor and investment are constrained to be an exogenous share $\xi$ of the value of their stock of durable goods:[14]

$$w_t H_t^D + p_t^D I_t^D = \xi p_t^D K_t^D \tag{11}$$

The model takes as given the fact that durable producers are financially constrained while nondurable producers are not. This modeling choice is consistent with the empirical results shown in Section 2.5 and the literature regarding financial constraints of durable producers such as Gomes et al. (2009). I also show in Section 3 of the appendix that a simple model in which durable goods producers face more volatile demand for their product can endogenously lead to more restrictive financial constraints for durable producers relative to nondurable producers with less volatile demand.

Let $\mu_t$ be the Lagrange multiplier on the durable firm financial constraint. If the constraint binds, $\mu_t > 0$ and durable producers face an effective wedge on their input prices relative to nondurable producers. In addition to increasing production, expanding their capital stock also eases the working capital constraint faced by durable producers in both the current and future periods.

Firms maximize the expected sum of future dividend payments subject to their production function, the financial and investment frictions discussed previously, the household demand curve, and Rotemberg-style price adjustment costs. Because savers own the firms, their stochastic discount factors are used to value future dividend flows. Define $mc^j$ and $mk^j$ to be the marginal cost and marginal product of capital, respectively, for the firm in sector $j$. The firm maximization problem can be written:

[14] For simplicity I allow the producers to borrow at zero net interest. This is a conservative assumption, as increases in the cost of capital will exacerbate the constraints faced by durable producers. In the appendix I show contractionary monetary shocks have about the same effects on the interest rates of durable and nondurable producers, suggesting that the differential effects on user costs across sectors are driven by prices and not interest rates. Forcing durable producers to borrow at the risk-free interest rate leads to virtually identical model dynamics because variation in interest rates is tiny compared to variation in relative prices.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_S^t \frac{\lambda_{S,t}}{\lambda_{S,0}} \left\{ p_t^j(i) \left( \frac{p_t^j(i)}{P_t^j} \right)^{-\epsilon_j} Y_t^j - w_t N_t^j - p_t^D I_t^j - \frac{\phi_j}{2} \left( \Pi_t^j(i) - 1 \right)^2 Y_t^j(i) \right.$$
$$+ mk_t^j \left[ I_t^j \left( 1 - \frac{\theta_j}{2} \left( \frac{I_t^j}{I_{t-1}^j} - 1 \right)^2 \right) + (1-\delta_j) K_t^j - K_{t+1}^j \right] + \mu_t^j \left[ \xi p_t^D K_t^j - w_t N_t^j - p_t^D I_t^j \right]$$
$$\left. + mc_t^j \left[ A_t (K_t^j)^{\alpha_j} (N_t^j)^{1-\alpha_j} - Y_t^j(i) \right] \right\}. \tag{12}$$

In the baseline model, durable producers have flexible prices ($\phi_D = 0$) but face credit constraints ($\mu_t > 0$). Nondurable producers, on the other hand, face frictions in adjusting prices ($\phi_N > 0$) but are unconstrained in their expenditure on capital and labor ($\mu_t = 0$). This heterogeneity in financial constraints faced by each sector is crucial for the model's ability to generate empirically consistent investment dynamics.

## 4.3 Equilibrium and Solution

The market clearing conditions for labor in each sector ($H_t^N, H_t^D$) and household expenditure ($C_t^N, C_t^D$) require that the aggregates be equal to the sum across different types of households weighted by their measure. Market clearing for household borrowing implies that the total quantity of bonds demanded by borrowing households is supplied by lending households.

$$\omega H_{S,t}^D + (1-\omega) H_{B,t}^D = H_t^D, \quad \omega H_{S,t}^N + (1-\omega) H_{B,t}^N = H_t^N \tag{13}$$

$$\omega C_{S,t}^D + (1-\omega) C_{B,t}^D = C_t^D, \quad \omega C_{S,t}^N + (1-\omega) C_{B,t}^N = C_t^N, \quad \omega B_{S,t} + (1-\omega) B_{B,t} = 0 \tag{14}$$

Market clearing in the durable goods market requires that the total quantity of durable output $Y_t^D$ be equal to total household durable purchases $C_t^D$ plus total investment ($I_t^D + I_t^N$). Total output in the nondurable sector $Y_t^N$ must be equal to household consumption $C_t^N$ plus any output loss due to price adjustment.

$$C_t^D + I_t^D + I_t^N = Y_t^D, \quad C_t^N + \frac{\phi_N}{2} \left( \Pi^N - 1 \right)^2 Y_t^N = Y_t^N \tag{15}$$

To close the model, I specify a standard Taylor Rule for the nominal interest rate:

$$\beta_S(i+i_t) = (\beta_S(i_{t-1}))^{\rho} \left(\Pi_t^{\phi_\Pi}\right)^{1-\rho} \exp(e_t^M). \tag{16}$$

Following Monacelli (2009) and Chen and Liao (2014), I ensure that the calibration results in the constraint binding in the steady state and then linearize around that steady state, assuming that it will continue to bind for small perturbations. Section 3 of the appendix shows the full set of equilibrium conditions and lists all of the parameter values in Table 2. Most of the parameters related to household borrowing, including the share of borrowers ($\omega = 0.5$) and the discount rates ($\beta_S = 0.99, \beta_B = 0.98$) are taken from Chen and Liao (2014).[15] I also use their values for price stickiness ($\phi_D = 0, \phi_N = 58.25$) and the nondurable share of consumption ($\eta = 0.8$). The parameter governing habit formation ($h = 0.9$) is taken from Fuhrer (2000). The persistence of wage stickiness ($\rho_w = 0.5$) is based on Blanchard and Galí (2007) and the wage markup ($\mu^w = 0.1$) is chosen to generate a 10% steady state markup in the goods markets.

Other parameters including the capital shares of each industry ($\alpha_D = \alpha_N = 0.33$), the Taylor Rule parameters governing the central bank's response to inflation and persistence in the interest rate ($\phi_\Pi = 1.5, \rho = 0.9$), the parameters governing labor supply ($\nu = 4, \chi = 1$), the elasticity of substitution across intermediate goods ($\epsilon_D = \epsilon_N = 11$), depreciation rates ($\delta_D = 0.02, \delta_K = 0.03$), and capital adjustment costs ($\theta_D = \theta_N = 2$) are standard in the literature. The major addition relative to past work is the parameter governing the exogenous working capital constraint $\xi$, which is set to be 0.1. In addition to resulting in a positive value for the Lagrange multiplier $\mu$ in the steady state given the other parameter values, it is also close to the sample averages for the ratios of cash (14.4%) and short-term bank debt (8.2%) to the capital stock observed in the QFR.[16]

## 4.4 Results and Mechanism

The model impulse responses for the capital stocks of producers can be seen in the left panel of Figure 10. When a contractionary monetary policy shock hits, the price of durable goods falls. Nondurable producers, which are unconstrained, take advantage by increasing their capital purchases. Durable producers, whose constraint is exacerbated by the decline in the

[15] The household borrowing limit is set to $m = 0.7$, which is slightly smaller than their value of 0.75. This helps the model generate more persistent consumption dynamics but is not necessary to match the on-impact consumption responses in the data and has a negligible impact on the behavior of investment.

[16] My results are robust to parameter values throughout this range. For large enough changes, however, adjustments to other parameters are necessary to ensure the firm borrowing constraint will bind.

value of their capital stock used as collateral, are forced to reduce their investment. The increase in capital expenditure by the nondurable sector is larger than the decline from the durable sector, so the aggregate capital stock rises. For comparison, the right panel shows the estimated capital stock responses from the QFR from Figure 1. The model is able to match the empirical dynamics of the manufacturing capital stock quite well.

The long life of durable goods combined with the decline in their relative price leads investment in my model to increase following a monetary contraction. When a monetary shock hits, both types of producers want to cut prices. Because nondurable prices are sticky, durable producers are able to reduce their prices by a larger amount. Even small drops in the relative price are able to spur large increases in durable purchases in this model because durables are long-lived; buying the durable good at a low price today is equivalent to getting a discount on a long series of future service flows.

As a result, this drop in the relative price of durable goods is large enough to offset the decline in household consumption and causes nondurable producers to expand their investment. The presence of financial constraints prevents durable producers from increasing investment in two ways. Because they are financially constrained, the fall in the relative price of durables reduces the value of their capital stock and hence the amount of money that they can borrow to fund production. In addition, durable producers experience a drop in demand from the consumer side due to the tightening of the borrowing constraints on impatient consumers that leads to a decline in aggregate household durable expenditure.

The key driver of the empirical results is that the user cost of investment, driven by a decline in the prices of investment goods, falls in response to a contractionary shock. This is also true in the model, where user costs are more complicated and include both current and expected prices, demand, adjustment costs, and, for the durable firms, degrees of financial constraint. For durable producers, the financial constraints are powerful enough to push up the user cost of capital and lead to a reduction in their capital stock. Nondurable producers, undeterred by financial constraints, experience a decline in user costs that leads them to increase their capital stock.

This mechanism can be seen directly by looking at the model responses of the prices of durable goods and the user cost in Figure 11. The orange line shows that the relative price of durable goods falls sharply in response to a contractionary monetary shock before ultimately rising above its pre-shock level. The red and blue lines represent the respective user costs—that is, the implicit rental rate set equal to the marginal product of capital—for the durable and nondurable producers. These expressions are complicated and include both current and expected prices, demand, adjustment costs, and, for the durable firms, degrees of financial constraint. For durable producers, the financial constraints are powerful enough to push up the user cost of capital and lead to a reduction in their capital stock.

The drop in durable goods prices in response to a contractionary monetary shock is usually modeled as a consequence of the assumption that durable prices are more flexible. This assumption is backed by a large body of work in the pricing literature. The benchmark paper on the price flexibility of durables comes primarily from Bils and Klenow (2004), who look at BLS microdata for 350 categories of goods from 1995-1997 and find that durable goods show more frequent price changes than nondurable goods. More recent work by Klenow and Malin (2010) uses the same CPI microdata over a longer range (1988-2009) to show that the mean price duration for durable goods (3.0 months) is much shorter than for nondurables (5.8 months). Both of these papers abstract from housing and structures in their analysis; including them would likely make durable prices look even more flexible.

This evidence is used as the basis for virtually all other papers in the literature analyzing the effects of monetary shocks on New Keynesian models with durable goods. Some examples of papers assuming perfectly flexible durable prices include Barsky et al. (2007), Monacelli (2009), Carlstrom and Fuerst (2010), Kim and Katayama (2013), and Chen and Liao (2014). In addition to a baseline calibration that assumes durable prices are more flexible, Kim and Katayama (2013) also use Bayesian techniques to estimate the degrees of price stickiness across sectors using their model and finds that the data support parameterizations in which durable producers are able to adjust their prices far more frequently.

Crucially, my model does not depend on a specific parameterization in order to generate its key results because there are multiple channels through which the user cost of investment can fall. The next section shows that the model is able to generate qualitatively similar impulse responses even with perfectly flexible prices ($\phi_D = \phi_N = 0$) in both sectors without changing any other parameter values. In addition, the appendix shows that the model is able to match the data even if the baseline level of price stickiness is applied to both sectors ($\phi_D = \phi_N = 58.25$) if the financial constraint parameter for durable producers is tightened. This suggests that my results do not depend critically on the assumption of flexible durable prices even if there is substantial empirical evidence to support it.

## 4.5 Alternative Models and Investment Comovement

The key mechanism in the model that allows it to generate responses to monetary shocks that are consistent with the data for both consumption and investment is the same as the one pointed out in Barsky et al. (2007): Periods of lower demand are a good time to buy durable goods because these goods are cheap and will provide service flows for a long time. This has been termed the "comovement puzzle" and resulted in a literature attempting to generate more empirically accurate responses. I show in Section 3 of the appendix that the combination of financial frictions on firms and durable producers allows my model to match the empirical dynamics of not only investment, but also consumption. Most alternative approaches to fixing the comovement puzzle do not include endogenous capital accumulation, and those that do include it are unable to generate the investment patterns observed in the QFR data.

Figure 12 provides insight into the model's ability to match the data by comparing impulse responses under a variety of alternative assumptions. The top row compares my baseline results to models which have perfectly flexible prices in both sectors (the middle panel) and which do not include any non-financial frictions such as sticky wages or habit formation (the right panel). While these changes alter the size and persistence of the investment responses relative to the baseline model, they do not change their direction. The bottom row compares different types of financial constraint and shows that constraints on only one of households (shown in the left panel) or firms (in the middle panel) are unable to match the data. The lower-right panel, which displays the results if neither households nor firms are financially constrained, shows large expansions in the capital stocks of both sectors. To the extent that more financially constrained firms are able to obtain access to funding through reductions in barriers to financing over time, this suggests that the responses of constrained sectors should look more like that of the manufacturing sector in the future.

# 5 Conclusion

Understanding which types of firms are financially constrained and how this affects aggregate dynamics is a crucial research question in macroeconomics and corporate finance. I use a manually digitized data set to show that the capital stock in the manufacturing sector responds countercyclically to monetary shocks. This behavior is driven by firms that display fewer signs of financial constraint, particularly nondurable producers. A model in which durable producers and impatient consumers face financial constraints can match the data well. In response to a contractionary monetary policy shock, the relative price of durables falls and the unconstrained firms respond by increasing their investment expenditure. This model suggests that the firms which respond *most* to monetary shocks are actually the *least* financially constrained. Removing financial constraints on all sectors in the model leads to investment dynamics that are even more strongly procyclical than the baseline.

These findings have two important implications for policymakers. The first is that monetary policy can have a larger impact on the investment of unconstrained producers than constrained producers even when the latter have much more volatile and interest-sensitive demand. The second is that the response of investment to monetary shocks should become more countercyclical over time as financial modernization reduces the number of firms which are financially constrained. Holding all else equal, this means more firms should be expected to purchase capital goods during periods of low prices even if these are also periods of lower demand.

# References


Almeida, H. and M. Campello (2001). Financial constraints and investment-cash flow sensitivities: New research directions.

Almeida, H. and M. Campello (2007). Financial constraints, asset tangibility, and corporate investment. *The Review of Financial Studies 20*(5), 1429–1460.

Arredondo, A. (2020). Time to deliver: Financing constraints of capital goods producers and investment dynamics. Mimeo.

Banerjee, S., S. Dasgupta, and Y. Kim (2008). Buyer–supplier relationships and the stakeholder theory of capital structure. *The Journal of Finance 63*(5), 2507–2552.

Barclay, M. J. and C. W. Smith (1995). The maturity structure of corporate debt. *the Journal of Finance 50*(2), 609–631.

Barsky, R. B., C. L. House, and M. S. Kimball (2007). Sticky-price models and durable goods. *American Economic Review 97*(3), 984–998.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics 1*, 1341–1393.

Bils, M. and P. J. Klenow (2004). Some evidence on the importance of sticky prices. *Journal of political economy 112*(5), 947–985.

Blanchard, O. and J. Galí (2007). Real wage rigidities and the new keynesian model. *Journal of Money, Credit and Banking 39*, 35–65.

Buera, F. J., J. P. Kaboski, and Y. Shin (2011). Finance and development: A tale of two sectors. *American Economic Review 101*(5), 1964–2002.

Caballero, R. J., E. M. Engel, J. C. Haltiwanger, M. Woodford, and R. E. Hall (1995). Plant-level adjustment and aggregate investment dynamics. *Brookings Papers on Economic Activity*, 1–54.

Carlstrom, C. T. and T. S. Fuerst (2010). Nominal rigidities, residential investment, and adjustment costs. *Macroeconomic Dynamics 14*(1), 136–148.

Chen, B.-L. and S.-Y. Liao (2014). Capital, credit constraints and the comovement between consumer durables and nondurables. *Journal of Economic Dynamics and Control 39*, 127–139.

Chirinko, R. S., S. M. Fazzari, and A. P. Meyer (1999). How responsive is business capital formation to its user cost?: An exploration with micro data. *Journal of Public Economics 74*(1), 53–80.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy 113*(1), 1–45.

Cloyne, J., C. Ferreira, M. Froemel, and P. Surico (2019, December). Monetary policy, corporate finance and investment. Mimeo.

Coibion, O. (2012, April). Are the effects of monetary policy shocks big or small? *American Economic Journal: Macroeconomics 4*(2), 1–32.

Crouzet, N. (2017). Aggregate implications of corporate debt choices. *The Review of Economic Studies 85*(3), 1635–1682.

Crouzet, N. and N. R. Mehrotra (2020, January). Small and large firms over the business cycle. Mimeo.

Erceg, C. and A. Levin (2006). Optimal monetary policy with durable consumption goods. *Journal of Monetary Economics 53*(7), 1341–1359.

Farre-Mensa, J. and A. Ljungqvist (2016). Do measures of financial constraints measure financial constraints? *The Review of Financial Studies 29*(2), 271–308.

Fazzari, S. M., R. G. Hubbard, B. C. Petersen, A. S. Blinder, and J. M. Poterba (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity 1988*(1), 141–206.

Fuhrer, J. C. (2000). Habit formation in consumption and its implications for monetary-policy models. *American Economic Review 90*(3), 367–390.

Gertler, M. and S. Gilchrist (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics 109*(2), 309–340.

Gertler, M. and P. Karadi (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics 7*(1), 44–76.

Giroud, X. and H. M. Mueller (2017). Firm leverage, consumer demand, and employment losses during the great recession. *The Quarterly Journal of Economics 132*(1), 271–316.

Gomes, J. F., L. Kogan, and M. Yogo (2009). Durability of output and expected stock returns. *Journal of Political Economy 117*(5), 941–986.

Guedes, J. and T. Opler (1996). The determinants of the maturity of corporate debt issues. *The Journal of Finance 51*(5), 1809–1833.

Hadlock, C. J. and J. R. Pierce (2010). New evidence on measuring financial constraints: Moving beyond the kz index. *The Review of Financial Studies 23*(5), 1909–1940.

Hall, R. E. and D. W. Jorgenson (1967). Tax policy and investment behavior. *The American Economic Review 57*(3), 391–414.

Hassett, K. A. and R. G. Hubbard (2002). Tax policy and business investment. In *Handbook of public economics*, Volume 3, pp. 1293–1343. Elsevier.

Holmstrom, B. and J. Tirole (1997, August). Financial intermediation, loanable funds, and the real sector. *Quarterly Journal of Economics 112*(3), 663–691.

Jeenas, P. (2019, July). Monetary policy shocks, financial structure, and firm activity: A panel approach. Mimeo.

Jordà, Ò. (2005, March). Estimation and inference of impulse responses by local projections. *American Economic Review 95*(1), 161–182.

Kaplan, S. N. and L. Zingales (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints? *The Quarterly Journal of Economics 112*(1), 169–215.

Kim, K. H. and M. Katayama (2013). Non-separability and sectoral comovement in a sticky price model. *Journal of Economic Dynamics and Control 37*(9), 1715–1735.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), 211–248.

Klenow, P. J. and B. A. Malin (2010). Microeconomic evidence on price-setting. In *Handbook of monetary economics*, Volume 3, pp. 231–284. Elsevier.

Kudlyak, M. and J. M. Sánchez (2017). Revisiting the behavior of small and large firms during the 2008 financial crisis. *Journal of Economic Dynamics and Control 77*, 48–69.

Leamer, E. E. (2015). Housing really is the business cycle: what survives the lessons of 2008–09? *Journal of Money, Credit and Banking 47*(S1), 43–50.

Monacelli, T. (2009). New keynesian models, durable goods, and collateral constraints. *Journal of Monetary Economics 56*(2), 242–254.

Ottonello, P. and T. Winberry (2020, June). Financial heterogeneity and the investment channel of monetary policy. Mimeo.

Rajan, R. and L. Zingales (1998). Financial dependence and growth. Technical Report 3.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. In *Handbook of macroeconomics*, Volume 2, pp. 71–162. Elsevier.

Romer, C. D. and D. H. Romer (2004, September). A new measure of monetary shocks: Derivation and implications. *American Economic Review 94*(4), 713–727.

Tirole, J. (2010). *The Theory of Corporate Finance*. Princeton University Press.

Whited, T. M. and G. Wu (2006). Financial constraints risk. *The Review of Financial Studies 19*(2), 531–559.

Zorn, P. (2018, February). Investment under rational inattention: Evidence from us sectoral data. Mimeo.

Zwick, E. and J. Mahon (2017). Tax policy and heterogeneous investment behavior. *American Economic Review 107*(1), 217–48.

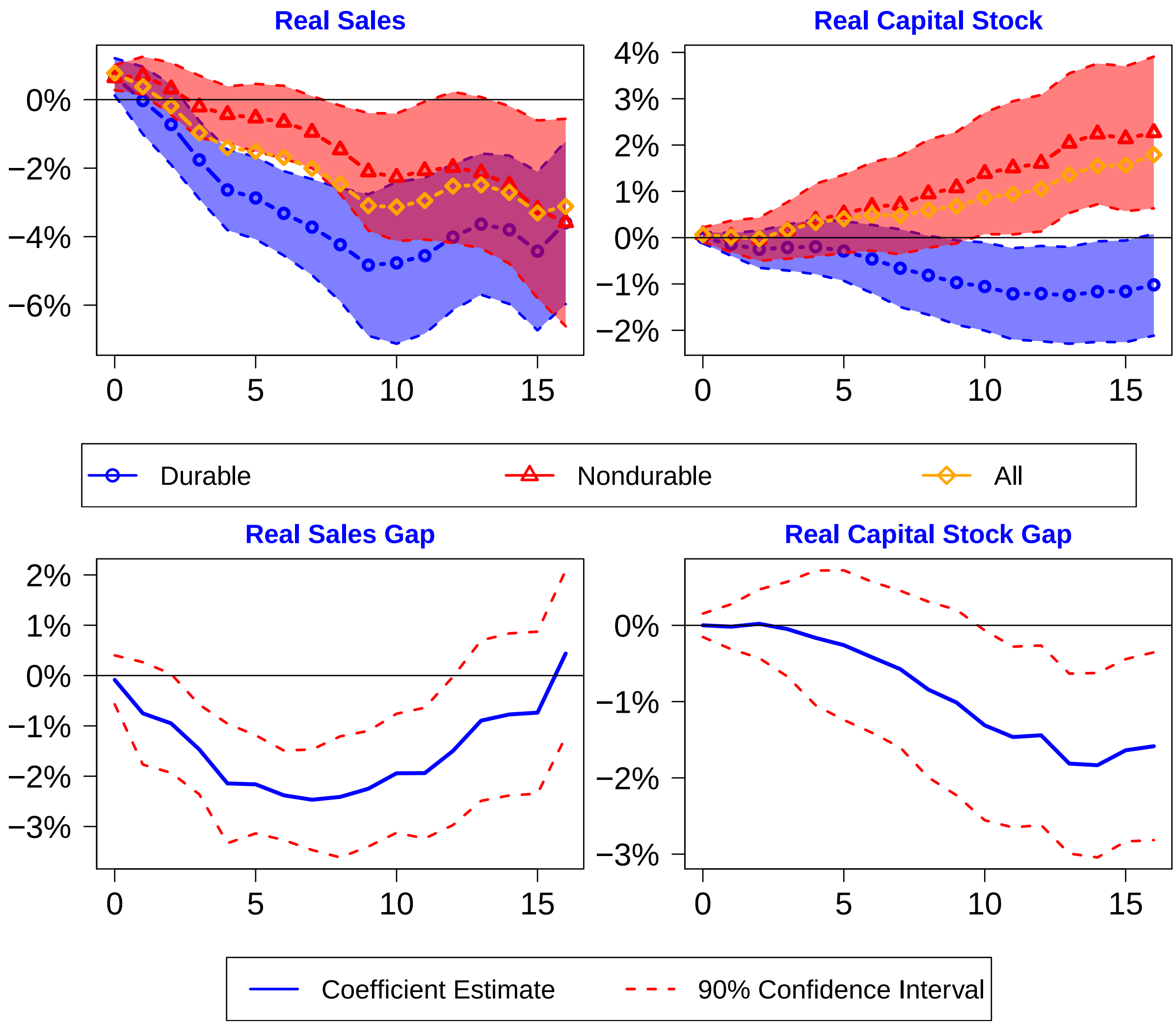


Figure 1: Empirical Responses to 100bp Contractionary MP Shock (90% CI)

Note: This figure shows the coefficient estimates $\gamma_h^i$ from Equation 1, which correspond to the effects of a 100bp contractionary monetary shock. The horizontal axes correspond to quarters after the shock. The top row shows the responses of NPPE, which is measured by the QFR item "Stock of Property, Plant, and Equipment Net of Depreciation" and deflated using the NIPA nonresidential fixed investment price index, and sales, which is the QFR sales measure deflated by the NIPA manufacturing output price index for each sector. The bottom row shows the estimated effects on the log difference between each measure: $y_t \equiv \log(X_t^D) - \log(X_t^N)$. 90% confidence intervals are calculated using Newey-West standard errors. Regressions include shocks from 1970-2004 and outcomes through 2008.

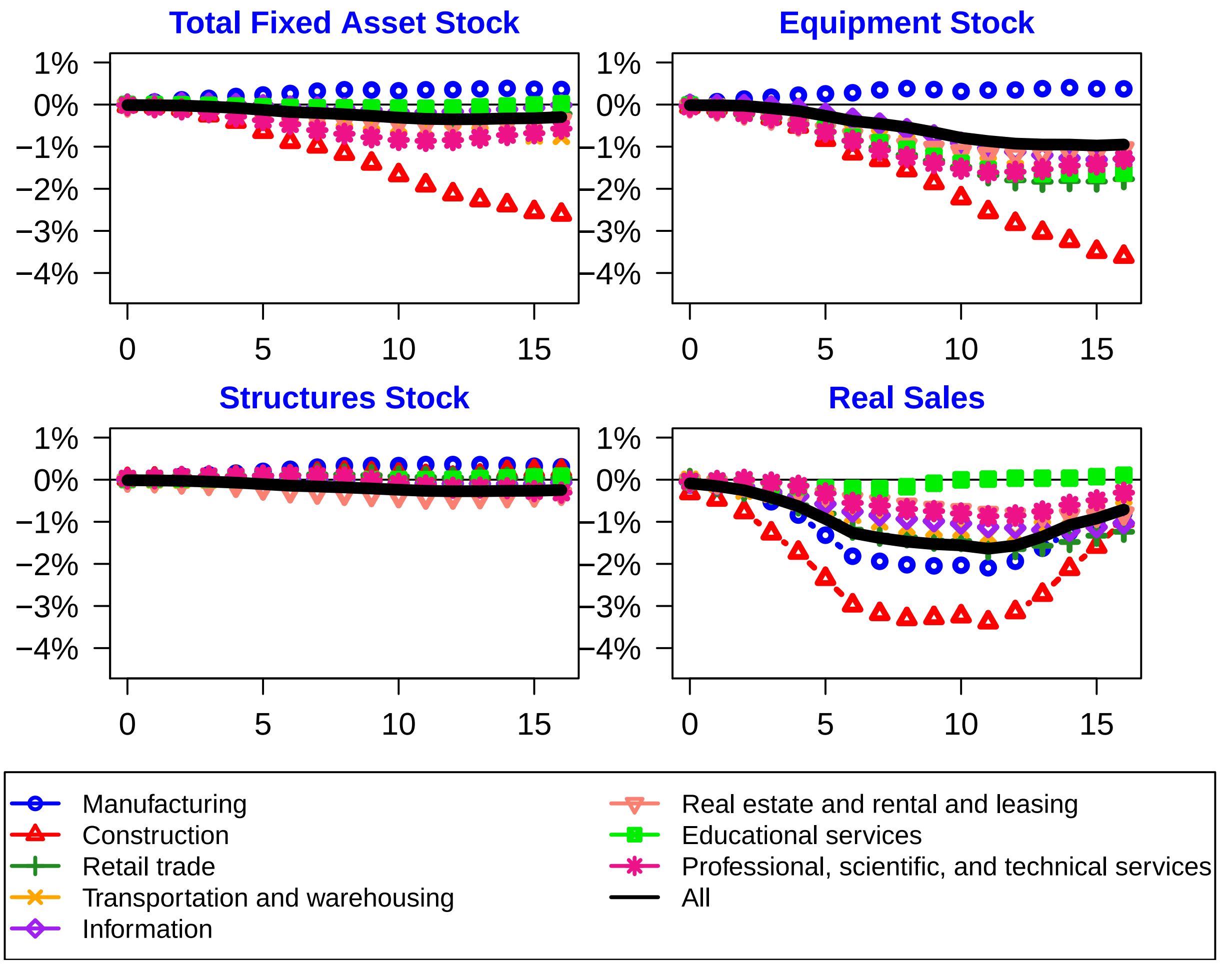


Figure 2: Empirical Responses to 100bp Contractionary MP Shock

Note: The first three panels use annual BEA on the real fixed asset stock for each sector. The horizontal axes correspond to quarters after the shock. The fourth panel uses annual BEA data on the real output of each sector. A quarterly series is obtained from these annual series through linear interpolation. The estimating equation has the same structure and number of lags as Equation 1 but does not include calendar quarter fixed effects because the data are already seasonally adjusted. Regressions include shocks from 1970-2004 and outcomes through 2008.

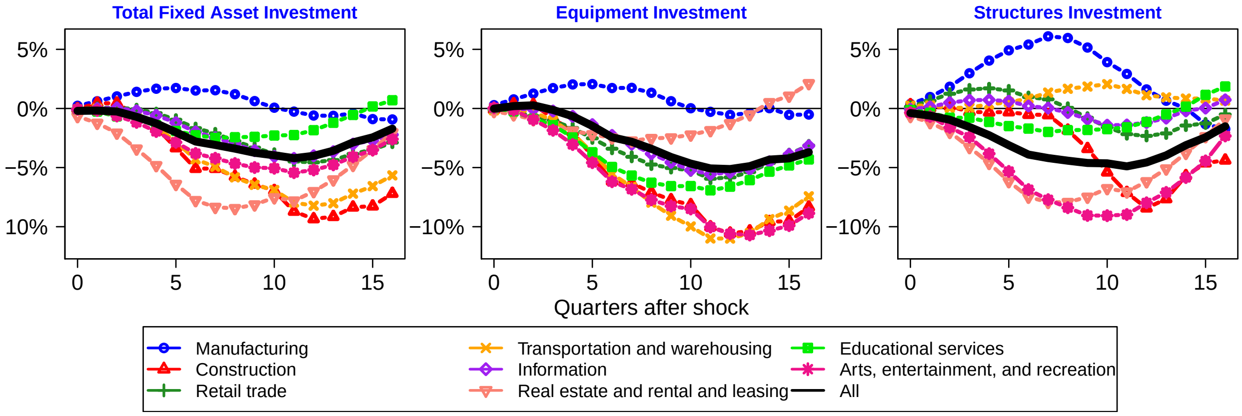


Figure 3: Empirical Responses to 100bp Contractionary MP Shock

Note: These figures use BEA on real investment for each sector. The horizontal axes correspond to quarters after the shock. A quarterly series is obtained from these annual series through linear interpolation. The estimating equation has the same structure and number of lags as Equation 1 but does not include calendar quarter fixed effects because the data are already seasonally adjusted. Regressions include shocks from 1970-2004 and outcomes through 2008.

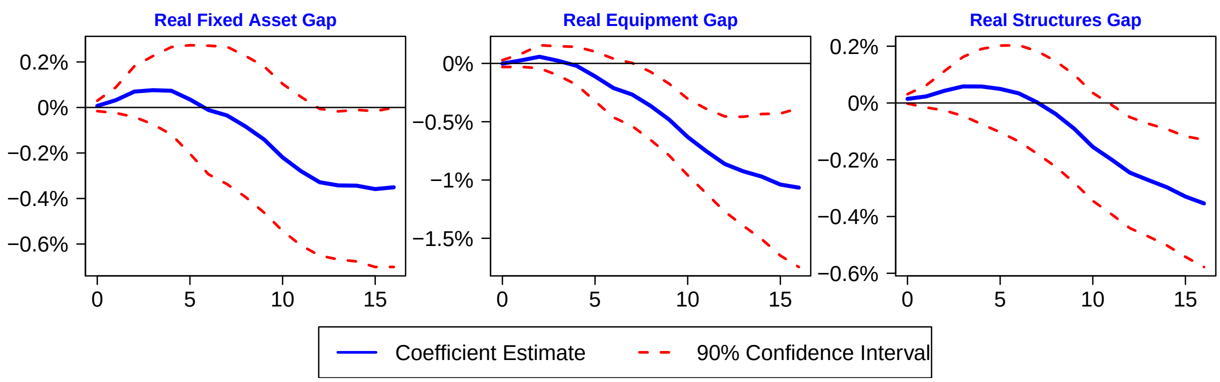


Figure 4: IRFs for BEA Capital Stock Measures (90% CI)

Note: This figure shows the responses of investment to a 100bp monetary shock based on a linear quarterly interpolation of the annual BEA real fixed asset stock data using the same estimating equation as in my baseline results. The dependent variable in each regression is the estimated log difference between the durable and nondurable sectors for each measure: $y_t \equiv \log(X_t^D) - \log(X_t^N)$ for $X \in \{Total, Equipment, Structures\}$. Regressions include shocks from 1970-2004 and outcomes through 2008. 90% confidence intervals are calculated using Newey-West standard errors.

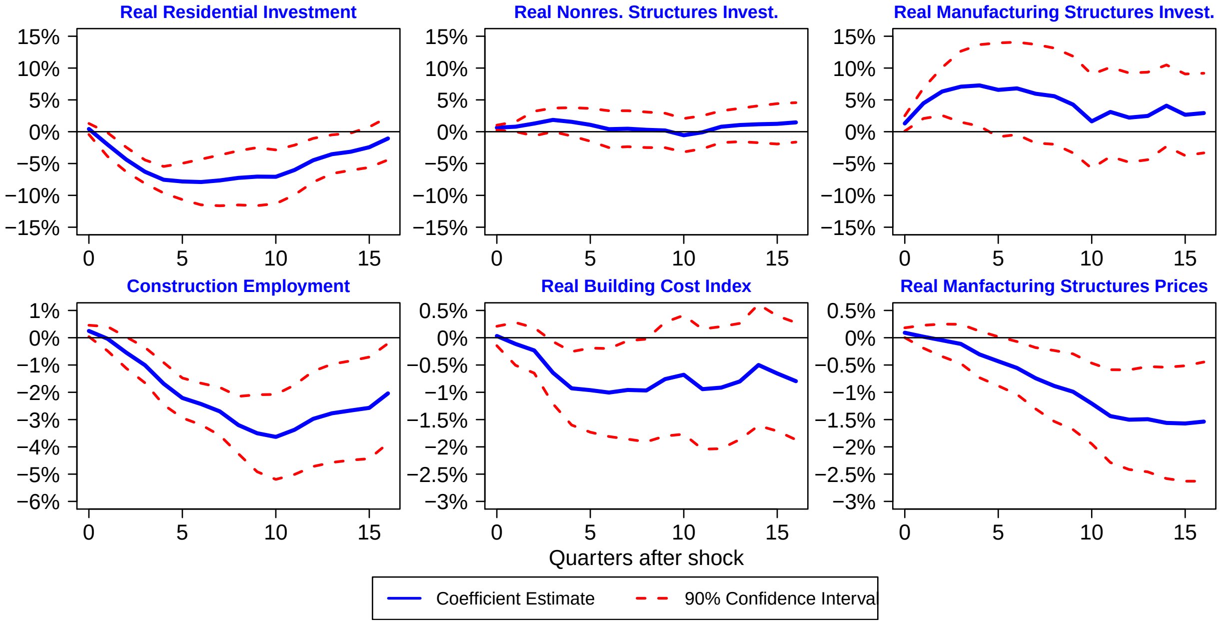


Figure 5: Empirical Responses to 100bp Contractionary MP Shock (90% CI)

Note: Real residential investment, real nonresidential structures investment, and real manufacturing structures investment data come from the NIPA. Construction employment data are from the BLS establishment survey (CES). The Real Building Cost Index is calculated by dividing the nominal building cost index calculated by the Engineering News-Record, which is based on measures of material and labor costs, by the GDP price index. Real manufacturing structures prices are calculated by dividing the NIPA price index for manufacturing structures investment by the GDP price index. The estimating equation is Equation 1 but does not include calendar quarter fixed effects as the data are already seasonally adjusted. Regressions include shocks from 1970-2004 and outcomes through 2008.

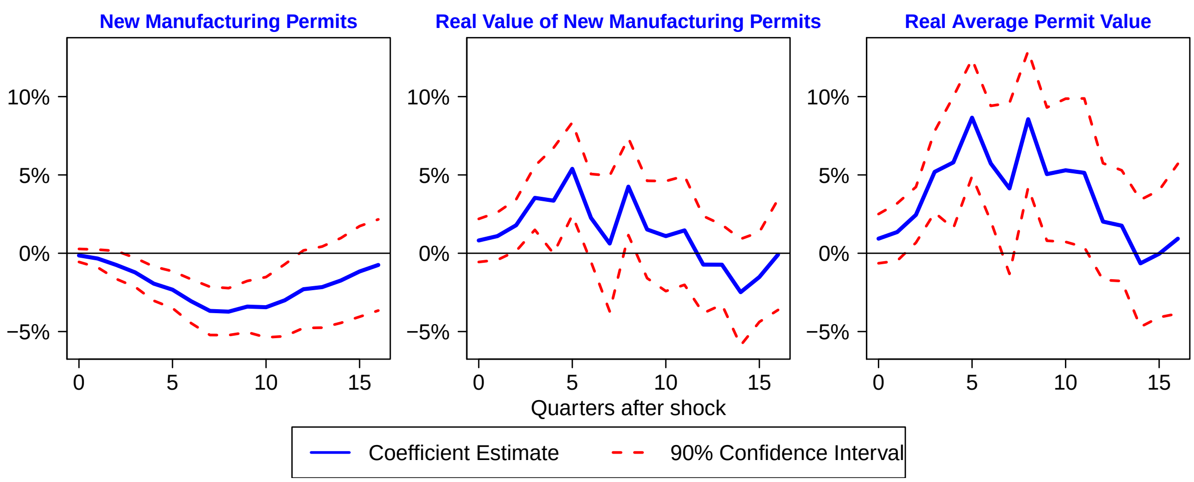


Figure 6: Empirical Responses to 100bp Contractionary MP Shock (90% CI)

Note: Building permit data were provided by Dodge Analytics and are smoothed using a four-quarter moving average. New permits are defined as those with a planned start date of within 60 days. Only permits for manufacturing structures are included. The real value of all permits is obtained by deflating the nominal value by the manufacturing structures investment price index. The real average permit value is obtained by dividing the real value of new permits by the number of new permits. The estimating equation is the same as Equation 1 but with the addition of a quadratic time trend. Regressions include shocks from 1970-2004 and outcomes through 2008.

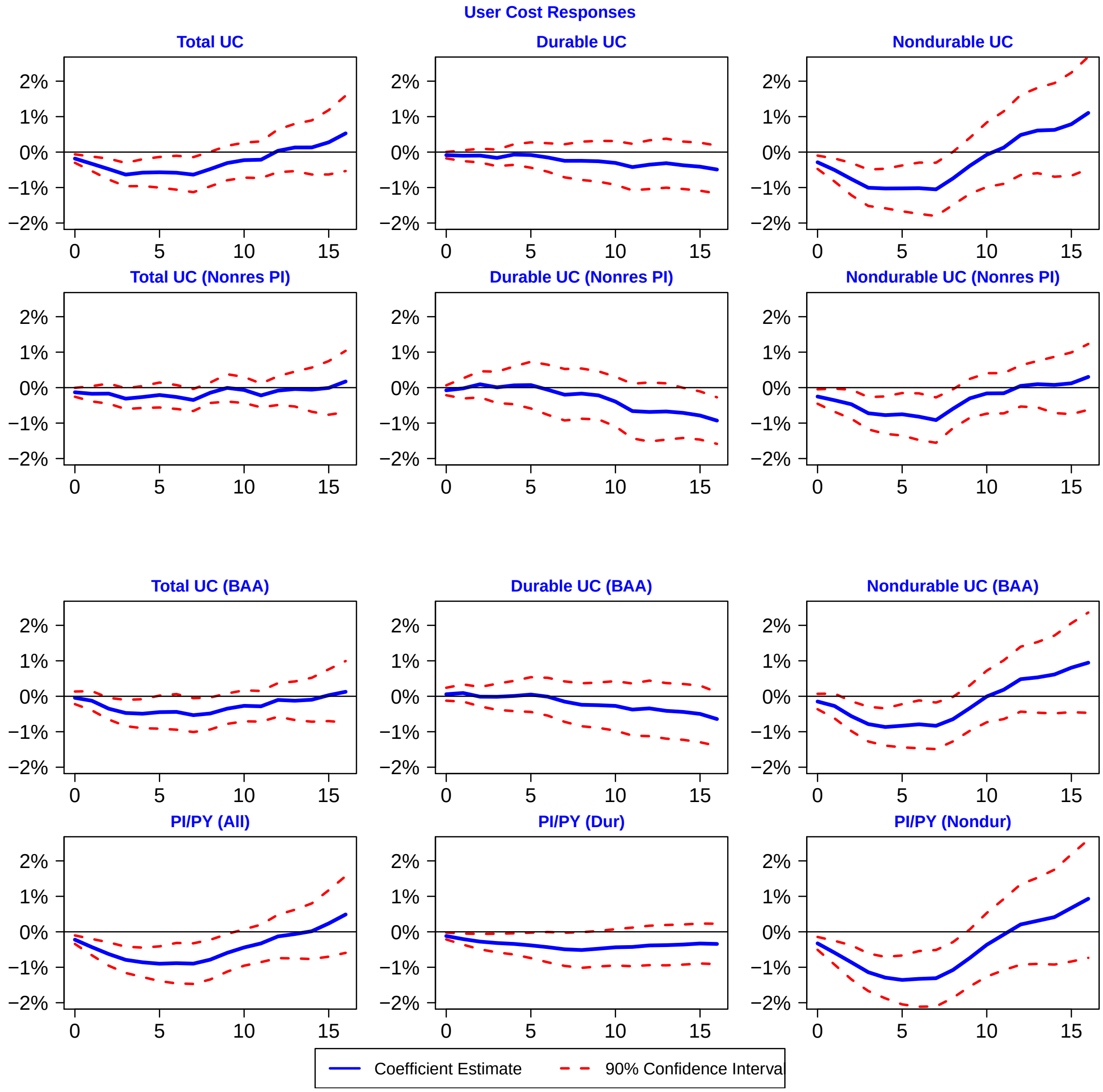


Figure 7: Empirical Responses to 100bp Contractionary MP Shock (90% CI)

Note: All user cost calculations are based on Equation 2 after imposing zero for expected price changes given the lack of data. The estimating equation is Equation 3. All specifications use the BEA manufacturing output deflator for each sector as the measure of $P_t^Y$ and the BEA depreciation rates $\delta_t$ as they capture economic depreciation as opposed to accounting depreciation measures used in the QFR. The investment price index $P_t^I$ is taken from the BEA sector-specific manufacturing price indices for the first and third row and the NIPA nonresidential fixed asset price index in the second row. Interest rates for the top two rows are four-quarter moving averages of sector-specific interest rates calculated from Compustat for 1976 and beyond. Interest rates prior to 1976 are calculated by retroactively applying changes in AAA bond yields to the 1976 Compustat level for each sector. Interest rates for the third row use BAA bond yields for the entire time period. The "PI/PY" specification includes only the sector-specific ratios of manufacturing investment prices to manufacturing output prices and ignores interest rates and depreciation. Regressions include shocks from 1970-2004 and outcomes through 2008.

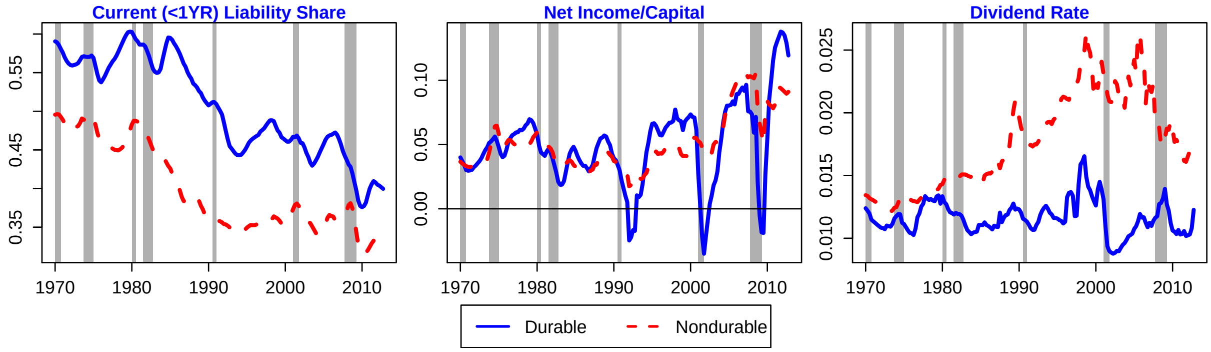


Figure 8: Financial Constraint Measures

Note: All figures show four-quarter moving averages calculated from the QFR. The first panel shows the ratio of each sector's aggregate liabilities with maturity of less than one year to its total liabilities. The second panel shows the ratio of net income after taxes to the stock of property, plant, and equipment net of depreciation. The rightmost panel shows the ratio of dividend payments to the book value of equity. Shaded areas indicate recessions.

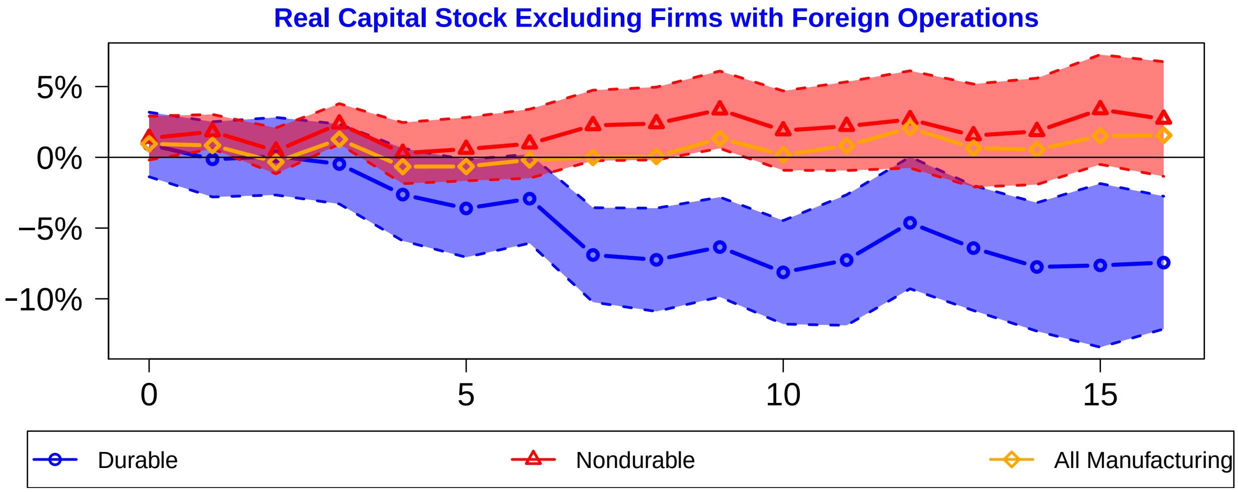


Figure 9: IRFs for Aggregated Compustat Data, Excluding Foreign Operations (90% CI)

Note: This figure shows the coefficient estimates $\gamma_h^i$ from Equation 1, which correspond to the effects of a 100bp contractionary monetary shock. The dependent variable is the four-quarter moving average of the aggregate capital stock across Compustat firms deflated by the NIPA nonresidential fixed investment price index. The "Nonforeign" set of firms excludes all firms with an average share of foreign sales to total sales greater than 20% over the quarters in which the company reports both. 90% confidence intervals are calculated using Newey-West standard errors. Because the Compustat data are less reliable prior to 1985 and my baseline specification includes six autoregressive lags, regressions include shocks from 1986Q3-2004Q4 and outcomes through 2008Q4.

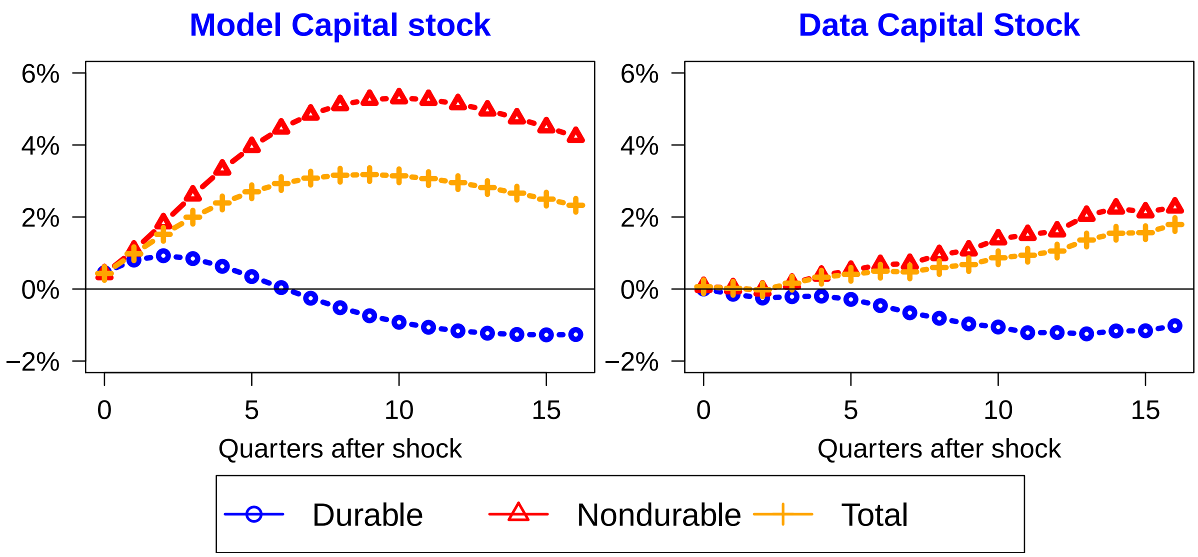


Figure 10: Model and Data Responses to Contractionary MP Shocks

Note: The left panel shows the model responses to a 100bp contractionary monetary shock to the capital stocks for the total manufacturing sector as well as each subsector. The right panel shows the empirical responses to a 100bp contractionary monetary shock shown previously in Figure 1.

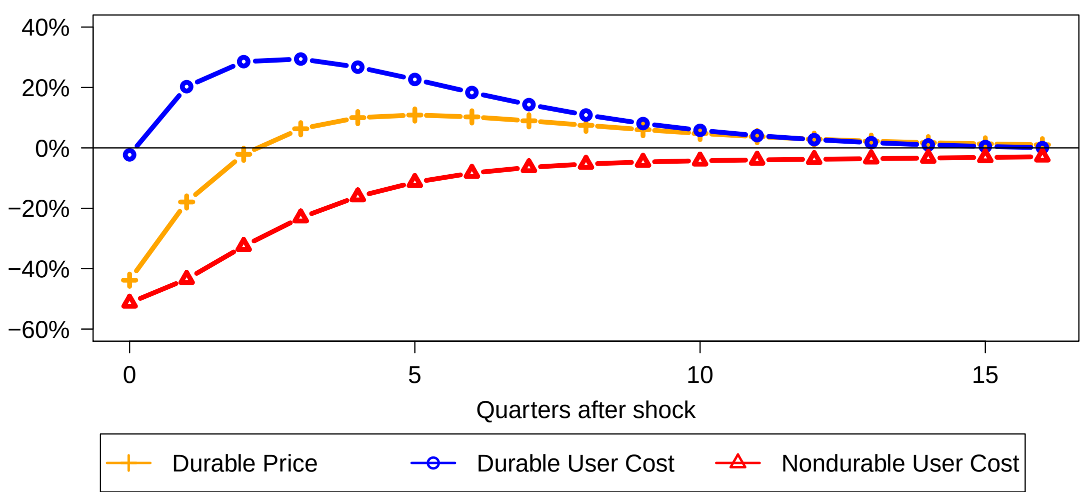


Figure 11: Model User Cost Responses to Contractionary MP Shocks

Note: This figure shows the model response to a 100bp contractionary monetary shock for the relative price of the durable good (which serves as the investment good in both sectors) as well as the user costs for each sector. The user cost in the model can be calculated by rearranging the firm's first order condition on investment to include everything but the marginal product of capital on one side and all remaining variables—including current and expected prices, demand, and financial conditions—on the other.

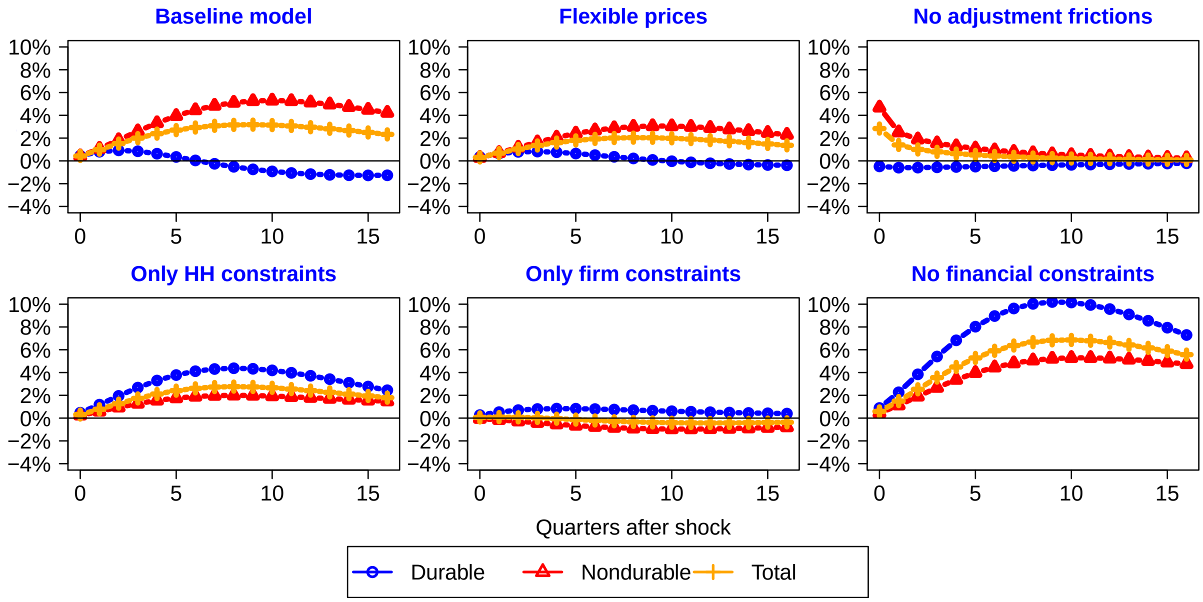


Figure 12: Capital Stock Responses under Alternative Model Assumptions

Note: All responses shown are for the capital stock to a 100bp contractionary monetary shock. The baseline model (top left) shows the same responses as in Figures 10. The flexible price responses (top middle) use the same structure as the baseline model but with no price stickiness in either sector ($\phi_D = \phi_N = 0$). The model without adjustment frictions (top right) is the same as the baseline model (including price frictions) but does not have adjustment costs on investment, wage stickiness, persistence in the Taylor Rule, or habit formation. All responses from the top row are based on models with financial frictions on both firms and households. The responses in the bottom left are from a modification of the baseline model that includes financial frictions on households but has no financial frictions for firms. The model in the bottom middle has financial frictions that apply to firms but none that apply to households. The model in the bottom right includes no financial constraints for either firms or households. All model responses shown on the bottom row include the baseline parameter values for price stickiness and adjustment costs.