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Gianni La Cava

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Economic Research Department
Reserve Bank of Australia

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Author: lacavag at domain rba.gov.au

Media Office: rbainfo@rba.gov.au

Abstract

A sharp decline in inventory investment was an important contributor to the economic slowdown in Australia in 2008/09. I identify the extent to which this was due to a tightening in short-term credit constraints. In an experimental design setting, I identify the causal effect of short-term credit constraints on inventory investment by exploiting variation in the debt maturity structure of Australian companies just prior to the global financial crisis. I show that the companies that were forced to refinance or repay a relatively large share of debt in 2008/09 reduced inventory investment by significantly more than companies that were due to refinance or repay their debt at some other time. A case study on the Australian motor vehicle industry supports the hypothesis that a decline in the availability of short-term credit significantly hampered corporate investment in inventories in 2008/09.

JEL Classification Numbers: C31, C33, D92, E22, E32, E51, G32
Keywords: inventory investment, credit supply, financial crisis

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Inventory Investment in Australia and the Global Financial Crisis

Gianni La Cava

1. Introduction

A sharp drop in inventory investment was the main contributor to the decline in real GDP in Australia in the December quarter of 2008. Inventory investment consistently fell in each of the following seven quarters, directly contributing to the slowdown in the Australian economy at that time. The size of the fall in inventory investment following the onset of the global financial crisis has been only superseded over the past 40 years by the early 1980s recession (Figure 1).[1]

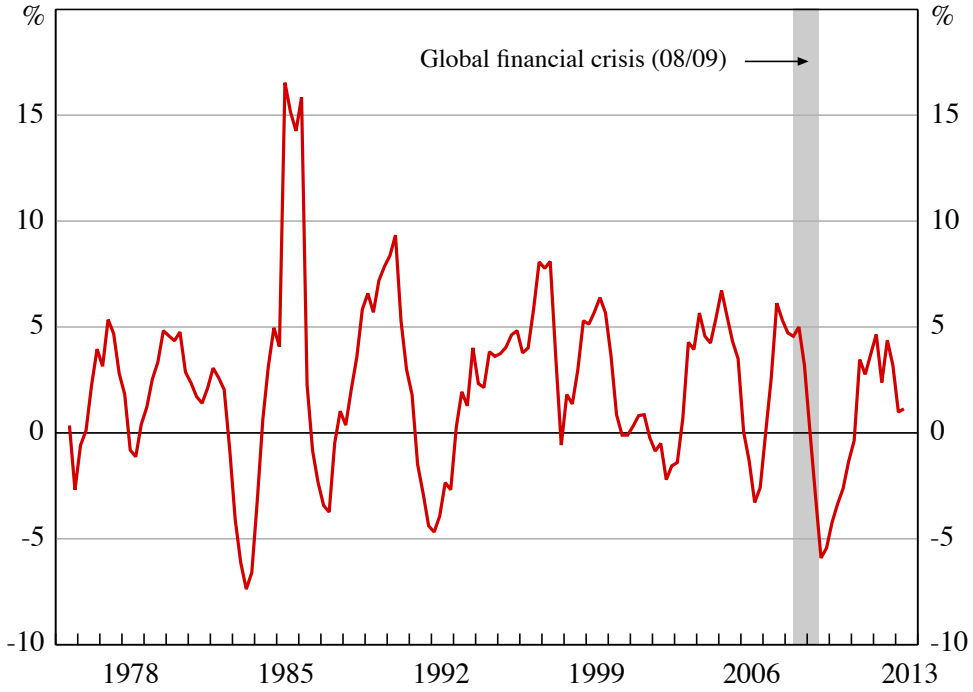
There are at least two plausible explanations for this particularly sharp decline in inventories. First, firms may have expected a large fall in sales. A notable feature of the financial crisis period was a significant fall in demand for consumer durables in Australia and other advanced economies (Black and Cusbert 2010). If firms expected demand for their goods and services to fall, this would have encouraged them to meet demand by running down existing stocks rather than investing in new stocks. Second, firms may have been less willing (or less able) to invest in inventories as the cost of obtaining credit increased and its availability decreased.

The aim of this paper is to identify the extent to which the large decline in inventory investment in 2008/09 can be traced to a tightening in credit conditions (the 'credit constraints hypothesis') as opposed to a fall in actual, or expected, demand (the 'demand hypothesis').

An important challenge in attributing the fall in inventories to tighter credit conditions is to separately identify a fall in credit supply from a fall in credit demand (Peek, Rosengren and Tootell 2003). I address this identification problem

1 The quality of the national accounts estimates of inventory investment is known to be relatively low. For instance, the Australian Bureau of Statistics (ABS) indicates in its *Concepts, Sources and Methods* (ABS 2012) that private non-farm inventory investment has a relatively 'poor' data quality rating. Related to this, inventory investment estimates are particularly prone to revision. The ABS' estimates of real inventory investment during the global financial crisis have generally been revised down over time.

Figure 1: Private Non-farm Inventories
Chain volumes, year-ended percentage change



Source: ABS

in an experimental design framework. In particular, I identify the relationship between inventory investment and credit conditions by exploiting variation in the maturity structure of the debt owed by listed Australian companies in the period before the global financial crisis.

More specifically, I separate listed companies into two groups – those companies that were 'unlucky' in that they had a large share of outstanding debt falling due at the peak of the crisis in late 2008 and those companies that were 'lucky' in that most of their debt fell due at some other (non-crisis) time. The assumption is that the unlucky firms would be forced either to repay or refinance much of their debt at a time when lenders were most concerned about credit and liquidity risk, and hence were looking to scale back the supply of credit. In other words, the unlucky firms would have been more constrained by the supply of credit. If the unlucky (constrained) firms reduced their inventory investment by more than the lucky (unconstrained) firms during the crisis, then, all other things being equal, this would provide evidence that credit conditions significantly affected inventory investment. A similar experimental design is constructed by Almeida *et al* (2009) to identify the effect of debt maturity on corporate investment in the United States.

The contribution of this paper is to link the sharp decline in inventory investment in Australia to the tightening of credit conditions in 2008/09. There is extensive evidence linking the cyclical behaviour of inventories to changes in credit conditions (e.g. Carpenter, Fazzari and Petersen 1994, 1998; Gertler and Gilchrist 1994; Kashyap, Lamont and Stein 1994; Tsoukalas 2006). But, to my knowledge, there has been no research linking the fall in inventory investment in 2008/09 to tighter credit conditions. This is despite evidence that an adverse credit supply shock and a sharp fall in inventories occurred simultaneously in many advanced economies during the crisis (Alessandria, Kaboski and Midrigan 2010). Jacobs and Rayner (2012) identify a key role for a negative credit supply shock in the 2008/09 downturn in Australia. This paper builds on their research by investigating whether the effect of such a credit supply shock can be traced to an inventory investment channel. To my knowledge, this is the first paper to examine the inventory cycle in Australia since Flood and Lowe (1993).

I find that the companies that were due to repay a relatively large share of debt in 2008/09 reduced their investment in inventories by significantly more than companies that were due to repay their debt at some other time. Furthermore, I show that the effect of debt maturity on inventories is only significant during the crisis period. However, I also find that the type of maturing debt matters; firms that had a relatively large share of short-term revolving credit due in 2008/09 were significantly more likely to reduce inventory investment. In contrast, firms that had a relatively large share of fixed-term debt maturing in 2008/09 did not necessarily reduce inventory investment. This raises the possibility that the link between debt maturity and inventory investment is not causal. Instead, less creditworthy firms may have drawn down more intensely on their existing credit facilities (leading to relatively high short-term debt) and reduced their inventories to free up liquidity. In this case, the maturity structure of the firms' debt would be a response to, rather than a cause of, tighter credit constraints.

A case study of the domestic motor vehicle industry also suggests that the withdrawal of two large international finance companies had an adverse effect on credit supply and, subsequently, inventory investment in the motor vehicle industry.

On balance, the results are consistent with the hypothesis that a tightening in credit conditions caused a fall in inventory investment during the crisis. But I cannot rule out the possibility that declining demand for credit also contributed.

2. Inventory Investment and Short-term Credit Conditions

Under perfect capital markets, credit conditions only affect inventory investment through unexpected changes in short-term interest rates to the extent that they represent changes in the opportunity cost of internal finance. But early empirical research, which typically relied on time-series evidence, generally found that real short-term interest rates had no influence on inventory investment (Maccini, Moore and Schaller 2004).[2]

Advances in corporate finance theory, as well as the development of microeconomic (firm-level) datasets, helped to reconcile this puzzle. Theoretical research showed that capital market imperfections, such as transaction costs and asymmetric information, could cause external finance to be more costly than internal finance for firms. Moreover, the cost of external finance typically varies (inversely) with the health of borrowers' balance sheets. If some firms are credit constrained in the sense that they cannot obtain external finance, or can obtain it only by paying a premium over the opportunity cost of internal funds, then their investment can be affected by financial factors, such as their holdings of liquid assets.

With imperfect capital markets, all types of investment should be affected by credit constraints, but inventories are likely to be particularly sensitive (Carpenter *et al* 1994). First, inventory investment involves low adjustment costs so businesses can respond quickly to adverse financing shocks by liquidating inventories. Second, inventory investment is largely reversible, as firms can dramatically cut their inventory stocks, unlike other investments, such as research and development and fixed capital (Carpenter *et al* 1998). Third, inventory investment is generally financed through short-term debt supplied by banks and trade creditors, rather than long-term debt or equity, so unexpected external finance shocks can have a relatively large impact on the accumulation of stocks. If credit supply shocks directly affect the real economy, this should be most

2 There is recent aggregate evidence that the risk premium component of interest rates is negatively related to inventory investment (Jones and Tuzel 2013).

readily observed in inventory investment (Lown and Morgan 2006). There is now extensive empirical research at the firm-level suggesting that credit constraints do affect inventory investment (e.g. Carpenter *et al* 1994, 1998; Gertler and Gilchrist 1994; Kashyap *et al* 1994; Guariglia 1999; Guariglia and Mateut 2006).

3. Short-term Business Finance in Australia

Firms typically need liquidity to finance their daily operations, such as purchasing supplies, paying workers, and producing output. Demand for inventories in the manufacturing, wholesale trade and retail trade industries (which I will broadly define as the 'goods distribution sector') is generally very short-term in focus because firms in the sector often face significant short-term fluctuations in sales and production.

Inventory investment is typically financed through a combination of short-term internal and external finance due to its short-term nature and a desire by firms to match the maturities of their assets and liabilities (Graham and Harvey 2001). Short-term internal finance includes firms' cash flows and stocks of cash and securities that can be easily liquidated. Short-term external finance can be divided into intermediated credit provided by financial institutions and trade credit provided by suppliers.

Short-term intermediated credit can be further separated into revolving (or 'open-end') credit and term (or 'closed-end') credit. Revolving business credit is the most common form of short-term intermediated debt and typically has the following characteristics:

- for a fee, the lender commits to provide credit up to an agreed limit to the borrower
- the borrower can borrow any amount up to the authorised limit
- any repayments made by the borrower (other than interest and charges) reduce the extent of used credit and increase the amount of unused credit available.

A revolving credit loan allows a borrower to draw down, repay and re-borrow funds (up to a maximum limit). Examples of revolving business credit include bank overdrafts, lines of credit, and credit cards. Revolving credit is 'open-ended'

because the length of the loan is not fixed, even if the length of the facility is finite, while a term loan is 'closed-ended' because it is drawn during a short commitment period and then repaid by a fixed date. Revolving credit lines are particularly suited to financing short-term production and inventory investment given their flexibility and convenience (Berger and Udell 1998).

Revolving credit lines typically have variable interest rates, and the loan rate is linked to a short-term rate such as the cash rate or the 90-day bank bill rate. Interest on a revolving credit line is calculated based on the outstanding principal balance. In other words, just like a personal credit card, interest is accrued and charged based on the amount of credit used rather than the amount that is available. A borrowing firm is also typically charged an annual fee on the unused portion of the credit facility (in some cases, fees are charged on the total facility).

Trade credit is the other common form of short-term external finance. Trade credit (or 'business-to-business lending') comprises short-term loans extended by suppliers to their customers. Under a trade credit agreement, a loan is automatically created when the customer delays payment of their bills to the suppliers. Trade credit is particularly popular as a method of short-term business finance in industries that are vertically integrated via supply chains. For example, manufacturers can have a comparative advantage over financial intermediaries in supplying short-term funds to wholesalers and retailers because they have an inherent interest to insure their customers against liquidity shocks that might endanger their own survival (Petersen and Rajan 1997).

For the median listed company in the Australian goods distribution sector, short-term debt and trade credit have accounted for about 6 per cent and 20 per cent of total liabilities, respectively, over the past decade. However, this understates the importance of revolving credit as a method of short-term financing because the balance sheet estimate only measures the *used* portion of revolving credit lines, rather than the total amount of credit committed, and hence available, to firms. Australian goods distribution firms only use a fraction of their committed credit lines, on average, such that total credit lines have represented nearly 60 per cent of total liabilities over the past decade.

4. Inventory Investment and the 2008/09 Financial Crisis

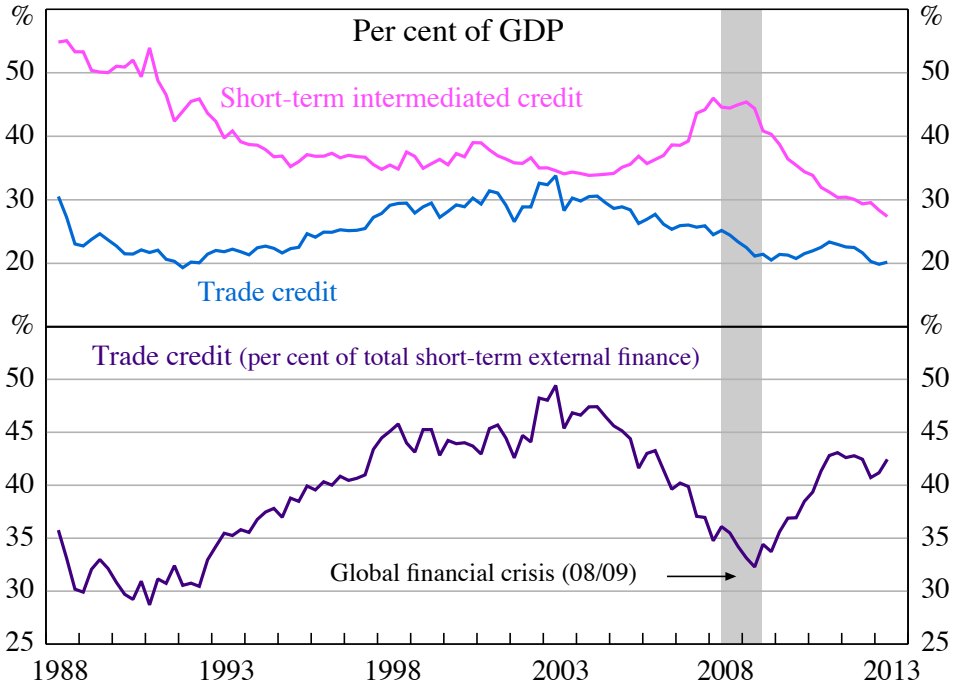
4.1 Short-term Business Finance during the Global Financial Crisis

It has been well documented that total intermediated business credit in Australia fell sharply in 2008/09 (Black, Kirkwood and Shah Idil 2009). However, the extent to which the aggregate decline was due to a fall in *short-term* credit has not been documented. Moreover, it is not well-known how the availability and use of revolving credit lines changed during the crisis period.

If there was an adverse credit supply shock stemming from the banking sector in 2008/09 then we should observe three phenomena. First, short-term intermediated credit should have fallen and/or its price risen substantially. Second, borrowing firms should have substituted into trade credit from bank credit. Third, if the supply of new bank credit became constrained, firms should have drawn down their *existing* credit facilities. In other words, we should have observed a decline in the *unused* portion of existing credit lines.

Financial accounts data point to a relatively rapid run-up in the stock of short-term intermediated credit between 2005 and 2008 (top panel, Figure 2). Trade credit also rose rapidly over the late 1990s and early 2000s. Bank credit peaked in late 2008, coinciding with the collapse of Lehman Brothers, while trade credit also fell during the crisis period. Short-term intermediated credit has remained on a downward trajectory since then, while trade credit (as a share of GDP) has been broadly flat since the crisis. The sharp fall in bank credit in late 2008 may have reflected a deliberate decision by banks to pull back on risky lending. The subsequent rise in trade credit relative to intermediated credit may have reflected substitution effects. This is consistent with financial institutions tightening credit supply by more than trade creditors (bottom panel).

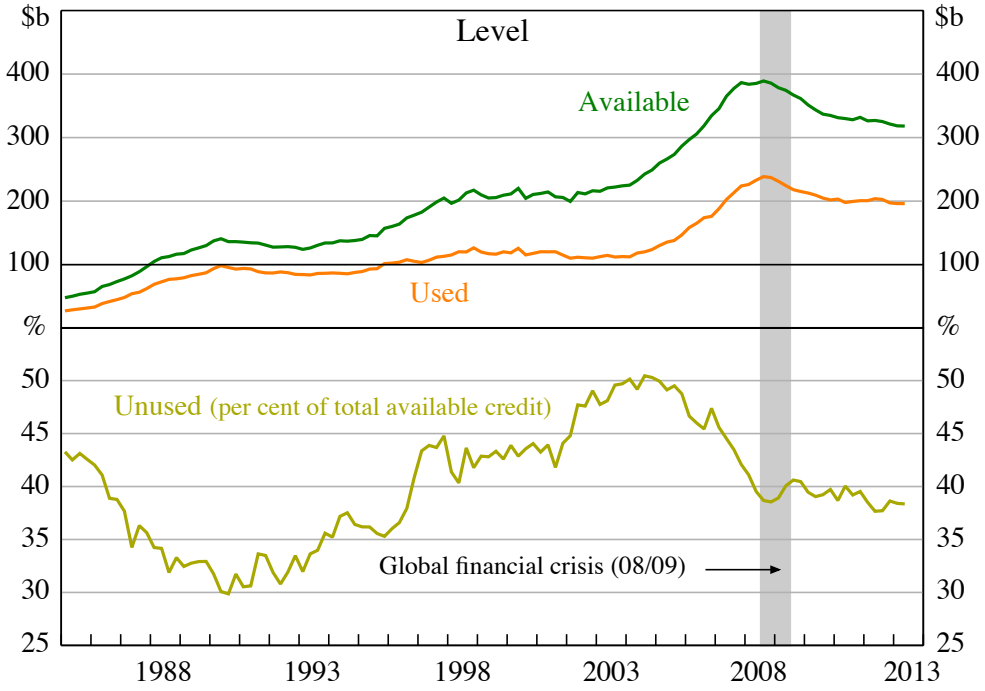
Figure 2: Short-term External Business Finance
Seasonally adjusted, quarterly



Sources: ABS; author's calculations

In aggregate, revolving business credit grew rapidly in the period preceding the crisis (Figure 3). However, the amount of revolving credit available to businesses fell sharply at the onset of the crisis and has continued to decline since that time. The amount of used revolving credit followed a similar pattern, except that it rose more rapidly in the period just before the crisis. The unused portion of credit lines broadly follows a procyclical pattern, indicating that firms draw down their facilities during downturns as liquidity problems emerge. Perhaps surprisingly, Australian businesses were using their credit lines most intensely in the period *prior to* the 2008/09 crisis.

Figure 3: Revolving Business Credit
Seasonally adjusted, quarterly



Source: ABS

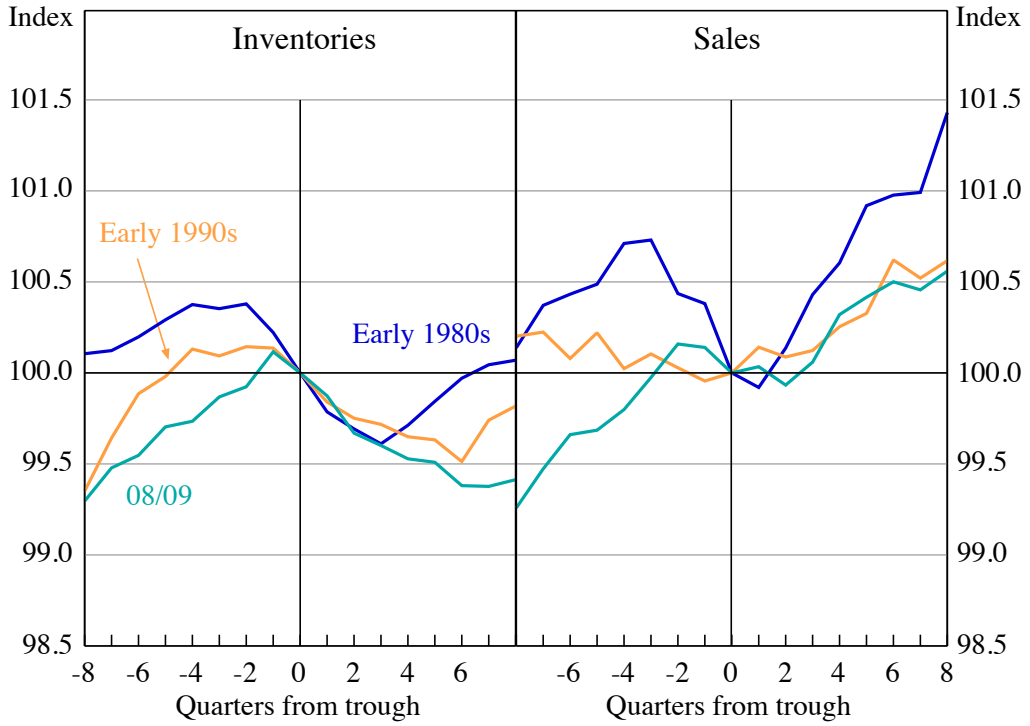
4.2 Inventory Investment and the Business Cycle

Inventory investment is highly procyclical and, despite comprising a very small share of GDP (around 0.1 per cent), its high volatility means that it explains a large share of the variability in GDP (Flood and Lowe 1993). Indeed, declines in inventory investment typically contribute half of the peak-to-trough fall in GDP during recessions (e.g. Blinder and Maccini 1991; Ramey and West 1999; Benati and Lubik 2012). This was true of the economic slowdown in 2008/09, as well as the early 1980s and early 1990s recessions in Australia.

There are a couple of notable differences about the 2008/09 slowdown compared to the 1980s and 1990s recessions (Figure 4). First, both inventories and sales were rising rapidly in the period preceding the crisis in 2008/09, whereas the 1980s and 1990s recessions were characterised by a gradual slowing in the pace of inventory investment and sales as the economy cooled. Second, the post-crisis recovery in inventory investment in 2008/09 appears to have been more delayed than in the recessions. In the earlier recoveries, firms typically replenished stocks as sales picked up after a few quarters. But, following the latest slowdown, inventories

continued to fall despite a recovery in sales. In fact, as of the June quarter 2013, inventories had still not reached the peak level observed in the September quarter 2008. The slower recovery in inventory investment may reflect a relatively high degree of uncertainty about the future course of demand. This is supported by the fact that there was only a mild recovery in sales, at least relative to the early 1980s recession. Alternatively, firms may be unable (or less willing) to replenish stocks because financing conditions remain tight.

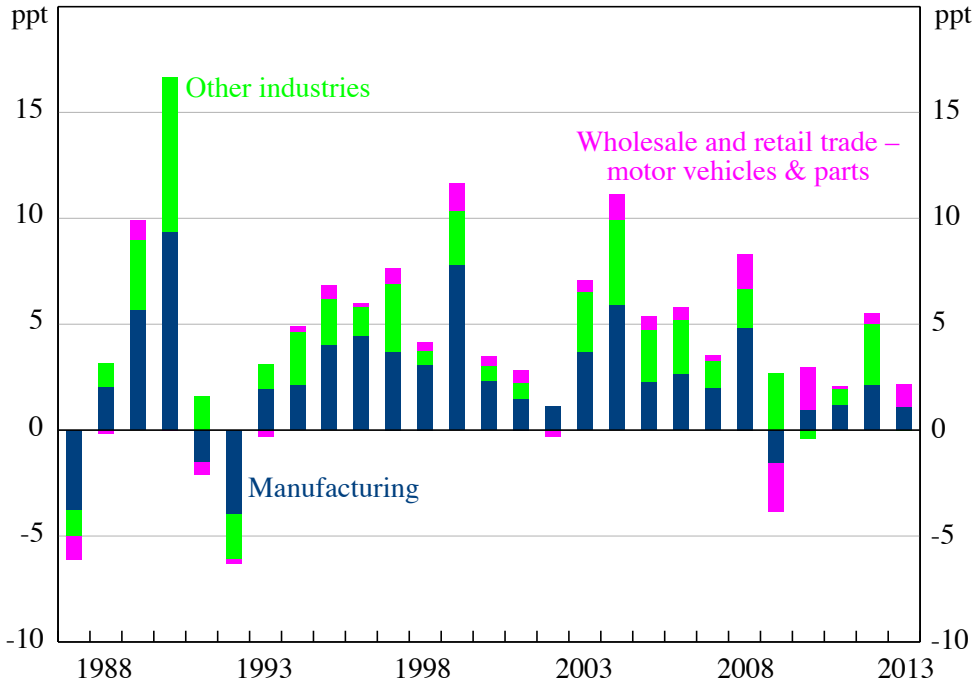
Figure 4: Inventories and Sales
Chain volumes, quarter of trough = 100



Source: ABS

Based on industry-level data, the decline in inventory investment in 2008/09 is explained by a reduction in manufacturing inventories and a fall in retail and wholesale stocks of motor vehicles (Figure 5). The large decline in motor vehicle inventories is notable given that motor vehicle dealerships are particularly dependent on the supply of short-term credit to support their inventory investments.

Figure 5: Inventory Investment by Industry
Chain volumes, contribution to annual growth



Source: ABS

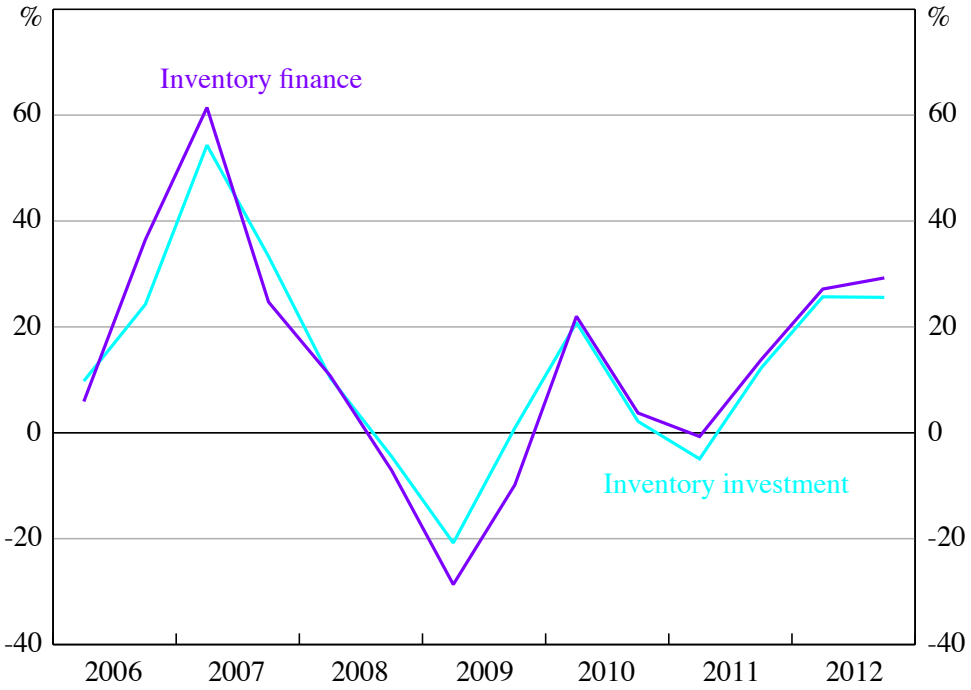
4.3 Floorplan Finance and the Motor Vehicle Industry

Floorplan (or bailment) finance is a type of short-term intermediated credit that is specifically designed to finance inventory investment and uses the underlying stocks as collateral. Floorplan finance is a small component of total business lending in Australia and is mainly used by motor vehicle wholesalers and retailers to purchase the stock of cars displayed on the showroom floors of motor vehicle dealers. The total floorplan finance market is estimated at around $8 billion, which is approximately the same value as the total stock of retail motor vehicle inventories in Australia.[3]

3 The limited use of this type of financing outside of the motor vehicle industry is supported by the 2012 CPA Australia Asia-Pacific Small Business Survey (CPA Australia 2012). This survey indicates that less than 10 per cent of small firms have used inventory financing. Instead, small businesses are more likely to use credit cards (73 per cent), secured bank loans (41 per cent), bank overdrafts (40 per cent) and leases (36 per cent).

Information on the floorplan finance market is relatively limited. However, we can glean some information about the state of the market during the crisis from the annual reports of the three publicly listed car dealers that were operating in Australia at the time (A.P. Eagers, Automotive Holdings Group and the Adtrans Group).[4] Based on these listed company reports, there is a very close link between inventory investment and floorplan finance (Figure 6).

Figure 6: Motor Vehicle Inventory Investment and Finance
Annual percentage change, semi-annual



Note: Estimates based on sample of three listed motor vehicle retailers' company reports
Sources: ABS; Adtrans Group; A.P. Eagers; Automotive Holdings Group

In the December quarter 2008, two large foreign motor vehicle financiers – GE Money Motor Solutions and General Motors Acceptance Corporation (GMAC) – ceased originating retail and wholesale motor vehicle loans in Australia as a result of the global financial crisis. This had a significant impact on the availability of floorplan finance, as the two finance companies provided finance for about 25 per cent of car dealerships (Parliament of Australia 2009). For the listed car

4 Together, these three companies had a combined market capitalisation of about $700 million in 2008/09 and accounted for about 12 per cent of total motor vehicle sales.

dealers, inventory investment declined by 21 per cent while floorplan finance declined by 29 per cent over 2008/09.[5]

The listed company reports also suggested that there was a relatively sharp increase in the cost of obtaining floorplan finance. The spread between the average floorplan financing rate and the 90-day bank bill rate rose by about 250 basis points over 2008/09. This is larger than the corresponding increase in the spread on the standard large business indicator rate, suggesting that there was a disproportionately large negative credit supply shock hitting the motor vehicle industry at the time.[6]

The listed car dealers also noted in their annual reports that smaller car dealers were even more adversely affected by the tightening in credit conditions. For example, the Adtrans Group noted in September 2010:

> As a result of the exit in 2008 of key industry financiers ... many dealers who were financially struggling were unable to secure new finance deals and have accordingly been forced to exit the industry. (KPMG 2010, p 82)

There are several other pieces of evidence to suggest that tighter credit conditions contributed to the sharp drop in motor vehicle stocks during the crisis. First, the motor vehicle industry's share of total wholesale and retail sales fell significantly over 2008/09, but the industry's share of inventories fell even more sharply, suggesting that factors other than demand are likely to have contributed (Figure 7). Second, during this period, sales of motor vehicles fell relative to overall manufacturing sales, but motor vehicle prices rose relative to overall manufacturing prices (Figure 8). The combination of falling relative sales and

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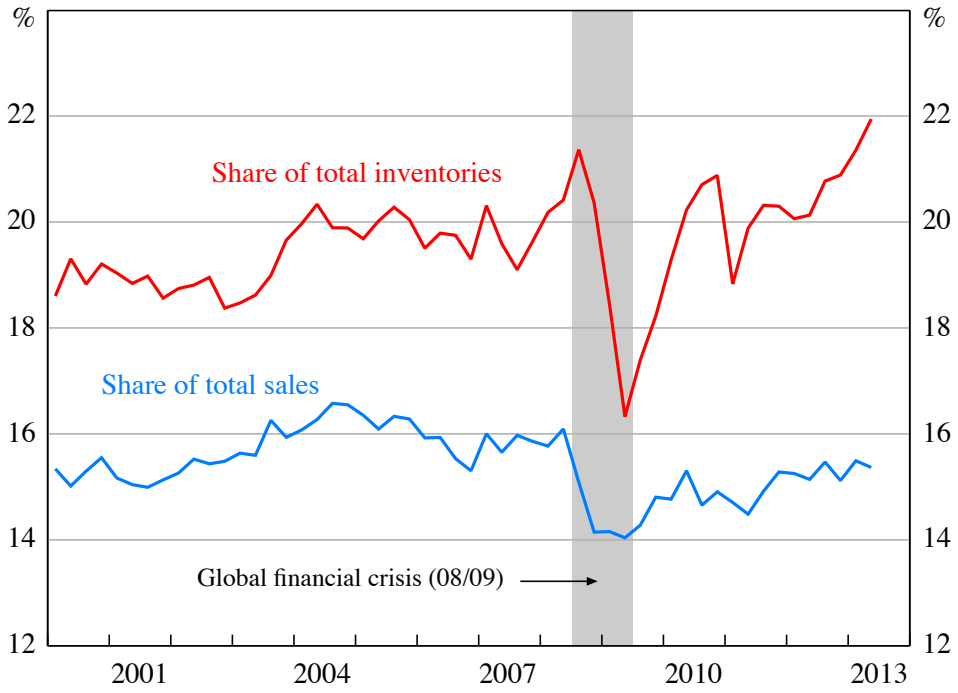
5 A tightening in credit conditions would have affected motor vehicle inventory investment through two channels. First, there would have been a direct effect as restrictions on the availability of wholesale finance forced car dealerships to scale back their investment in display stock. Second, there would have been an indirect effect as car dealerships could no longer sell retail finance, thereby constraining motor vehicle sales and hence the demand for inventories.

6 In response to the withdrawal of the two finance companies, the Federal Government set up a car dealership financing special purpose vehicle (known as OzCar) to provide financing for domestic car dealers. OzCar commenced in September 2009 and provided temporary liquidity support, with funding from the major banks, to eligible participating car dealership financiers. This government program may have helped to restore liquidity to the floorplan finance market in 2009/10 but, given it was introduced in late 2009, it was unable to prevent the sharp decline in inventories in 2008/09.

rising relative prices suggests that the decline in motor vehicle production was, at least in part, due to supply-side factors, such as a tightening in credit conditions.

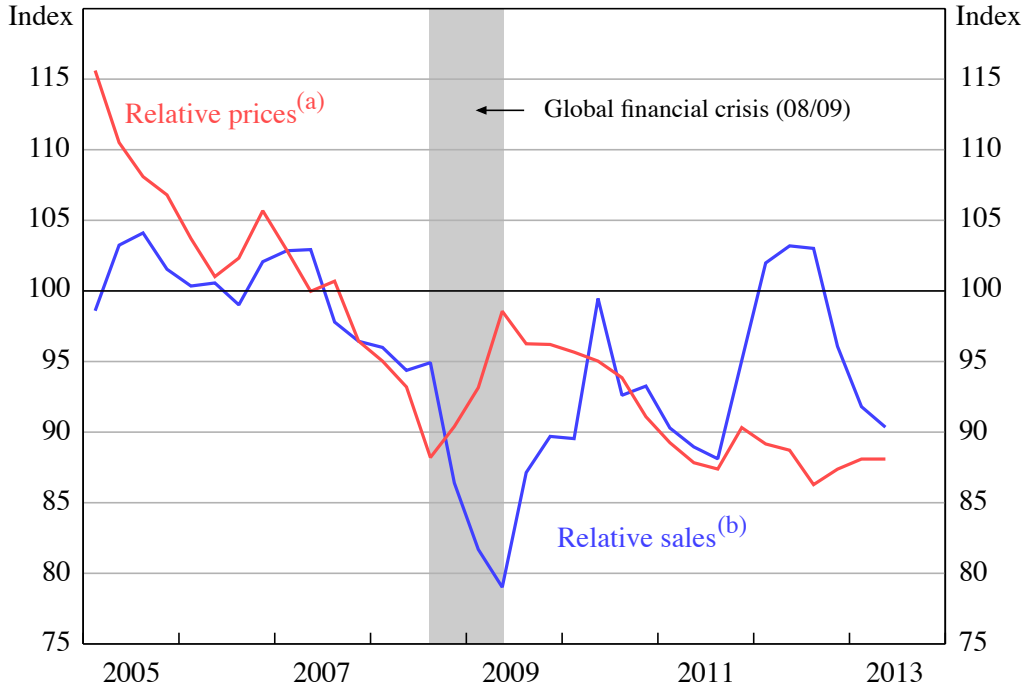
Figure 7: Wholesale and Retail Motor Vehicle Output
Share of total wholesale and retail trade output



Sources: ABS; author's calculations

However, this analysis is based on correlations and the decline in inventories cannot be attributed to the causal impact of tighter credit conditions. For instance, the apparent sharp decline in floorplan finance may have been caused by local car dealers choosing to borrow less rather than being forced to borrow less.

Figure 8: Motor Vehicle Sales and Prices
2007 average = 100



Notes: (a) Motor vehicle producer prices (divided by total manufacturing prices)
(b) Transport equipment sales (divided by total manufacturing sales)
Source: ABS

5. Econometric Analysis

5.1 Basic Framework

Firm-level data provide a quasi-experiment to determine the role of credit constraints in inventory investment. To understand the setup of the model, consider the following hypothetical example.

Suppose there is an experiment in which firms are randomly selected from the population of Australian businesses. During the experiment, the firms undertake their daily business of producing output, paying workers and investing in inventories. Furthermore, as part of their regular business operations, all the firms in the experiment must, at some point, take out a bank loan to invest in new stocks and maintain production. The firms are randomly allocated to either a control group or a treatment group. The experiment is deliberately designed so that the only difference between the two groups is that firms in the treatment group are

rejected by the bank for a loan, whereas firms in the control group obtain the loan. Therefore, loan rejection acts as the 'treatment' in this experiment.

The inventory investment behaviour of the two groups of firms is observed, both before and after the firms apply for the bank loan. If the rejected firms are observed to reduce their investment spending relative to the accepted firms after applying for a loan, then it would be safe to conclude that, due to the random assignment of firms, the fall in inventory investment was caused by the inability to get a loan. In other words, this experiment would provide strong evidence that firms' inventory investment is affected by constraints on the availability of bank credit.

In reality, it is not possible to conduct such an experiment. But it is possible to exploit a 'quasi experiment' which closely replicates the conditions of the laboratory in a real-world setting. I identify the effect of credit conditions on inventory investment using the variation in the maturity structure of the debt owed by Australian firms in the period before the global financial crisis. In particular, I separate listed companies into two groups; companies that were 'unlucky' to have a debt maturity structure such that a large share of their outstanding debt fell due at the peak of the crisis in 2008/09 and companies that were 'lucky' in that most of their debt fell due at some other (non-crisis) time.

The logic is that the unlucky firms would have been forced either to repay or refinance a higher proportion of their debt at a time when lenders were concerned about heightened credit risk, and hence looking to scale back the supply of credit. In this experiment, the unlucky firms are the treatment group and the lucky firms are the control group. If the unlucky firms reduced their inventory investment by more than the lucky firms during the crisis, then, all other things being equal, this would provide evidence that credit constraints significantly affected inventory investment. A similar methodology is used by Almeida *et al* (2009) to identify the effect of debt maturity on corporate fixed capital investment in the United States.

To understand the regression framework it helps to outline the steps that are required to get to the estimating equation. The model in levels is:

$$\begin{aligned} I_{ijt} = \alpha + CRISIS_t'\beta + STDEBT_i'\gamma + STDEBT_i'CRISIS_t\delta \\ + X_{ijt}'\rho + \underbrace{\theta_i + \lambda_{jt} + \varepsilon_{ijt}}_{\nu_{ijt}} \end{aligned} \tag{1}$$

where the dependent variable is the (log) stock of inventories of firm i that operates in industry j in year t (I_{ijt}). The explanatory variables include a dummy variable for whether the period is prior to the 2008/09 crisis ($t = 0$) or during the crisis ($t = 1$) ($CRISIS_t$) and a dummy variable for whether the share of outstanding debt of firm i in the pre-crisis period that is due within one year exceeds 80 per cent ($STDEBT_i$), as well as the interaction between both dummy variables ($STDEBT_i' CRISIS_t$). The reason for choosing a cut-off level for the short-term debt ratio of 80 per cent is discussed below.

The specification also includes a set of firm-level controls that vary over time (X_{ijt}), such as the size and profitability of the firm. The equation also includes a firm-level fixed effect (θ_i), which is designed to capture all unobservable firm characteristics that influence the average level of inventory holdings, and an industry-year fixed effect (λ_{jt}), which captures unobservable industry-level shocks to inventory investment that vary over time.

Before estimation, I collapse the data so that there are just two periods – the pre-crisis and crisis periods. I define the pre-treatment period to be 2007/08 and the post-treatment period to be 2008/09. I next transform each variable by taking the difference over time between the pre-crisis and crisis periods to obtain the following equation to be estimated:[7]

$$\triangle I_{ij} = \beta + STDEBT_i' \delta + \triangle X_{ij}' \rho + \lambda_j + \triangle \varepsilon_{ij} \tag{2}$$

where the dependent variable is the change in the (log) stock of inventories of firm i during the crisis ($\triangle I_{ij}$) and the key explanatory variable is the dummy variable for whether the share of outstanding short-term debt of firm i exceeds 80 per cent ($STDEBT_i$). Equation (2) is known as a difference-in-differences model. The main coefficient of interest is δ in Equation (2), which is the difference-in-differences estimator. Note that, by estimating the equation in first differences, I effectively eliminate the firm-level fixed effect. So this specification controls for factors that

7 To account for differences in reporting seasons across firms, I calculate the pre-treatment level of inventories by taking the average of the stock levels reported at the ends of December 2007 and June 2008. Similarly, I calculate the post-treatment level of inventories by taking the average of the stock levels reported at the ends of December 2008 and June 2009. I then calculate inventory investment as the difference between these two estimates. For the reported share of short-term debt, I calculate the average share of short-term debt outstanding reported at the ends of December 2007 and June 2008.

affect inventory investment and that vary across firms but are unobservable and do not vary with time.[8] Moreover, the specification includes an industry-level fixed effect, which implies that I identify the relationship between the shock to credit conditions and inventory investment through variation *within* each industry.

5.2 Data

The data underpinning the regression analysis are derived from the semi-annual financial reports of listed Australian companies provided by Morningstar. The sample includes 276 firms listed on the Australian stock exchange that operate in one of three sectors: industrials, consumer staples or consumer discretionary.[9] The original sample period covers from 1989/90 to 2011/12, although the regressions are only estimated on data from 2007/08 and 2008/09.

The (real) annual growth rate of inventories acts as the dependent variable in the regression model. In the semi-annual reports, each company reports the book value of the stock of inventories. As inventory investment is very short-term in nature, the book value is likely to be a good approximation for the market value of the stocks. There is a reasonable correlation between the growth in inventories reported in the national accounts and that based on the measure of inventory investment constructed on the basis of the company reports data (Figure 9). This suggests that any findings based on the firm-level data are likely to have a direct bearing on the aggregate economy.

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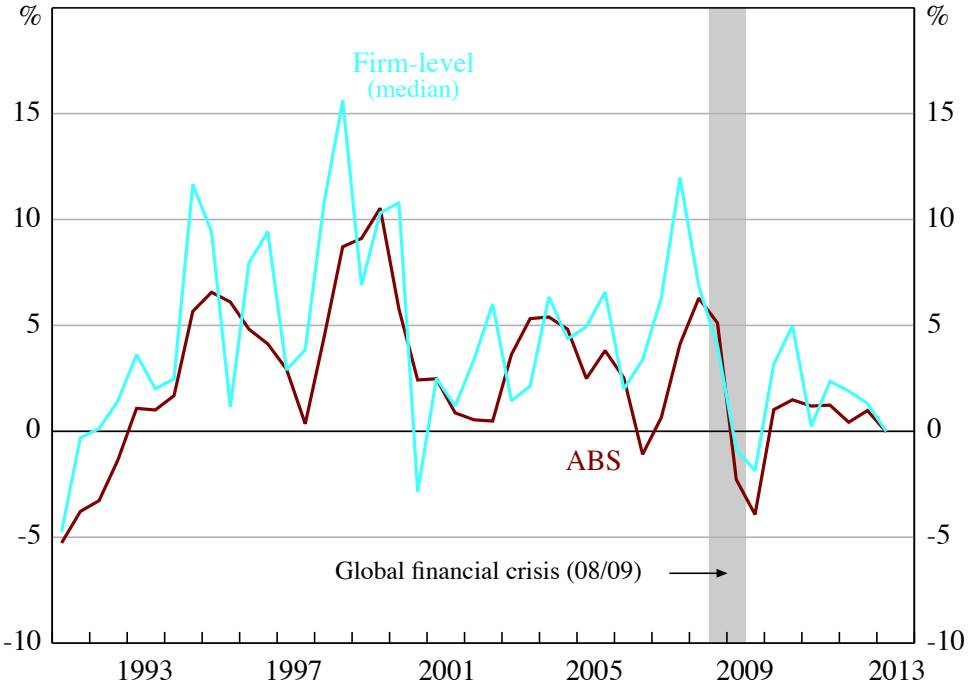
8 The specification will control for certain characteristics of the products typically sold by each firm. For example, food manufacturers typically produce goods that are perishable and hence have a short shelf life. These firms will typically hold relatively low levels of stocks, on average.

9 According to the Global Industry Classification Standard (GICS), the consumer staples sector comprises manufacturers and distributors of food, beverages and tobacco as well as producers of non-durable household goods and personal products. It also includes food and drug retailing companies as well as supermarkets and department stores. The consumer discretionary sector includes manufacturers of motor vehicles, household durable goods, clothing, textiles and leisure equipment. It also includes services companies that cover hotels, restaurants and other leisure facilities, media production and services, and consumer retailing and services. The industrials sector includes manufacturers of capital goods (e.g. machinery and electrical equipment), companies that provide transportation services (e.g. airlines) and companies that provide commercial services and supplies (e.g. employment services). These sectors were chosen to reflect the goods distribution sector (i.e. retail trade, wholesale trade and manufacturing).

Figure 9: Inventories
Constant prices, annual percentage change, semi-annual

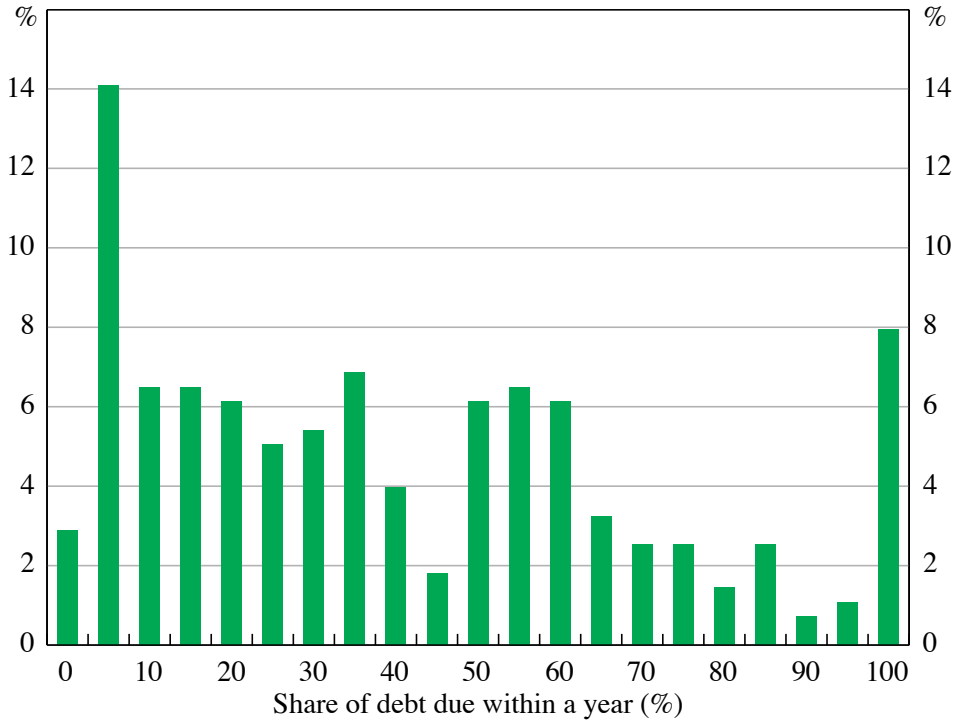


Sources: ABS; Morningstar; author's calculations

The key explanatory variable in the model is a firm-level dummy variable indicating whether the share of total debt due within one year in the pre-crisis period is greater than 80 per cent or not. The results are not sensitive to this cut-off level; I obtain similar results if the cut-off is defined at either 70 per cent or 90 per cent. Looking at the cross-section in 2007/08, Australian companies generally either held very little short-term debt (as a share of total debt) or they held a lot of short-term debt in 2007/08 (Figure 10). The clear divide between firms with relatively high and low shares of short-term debt supports the identification strategy to split firms into 'lucky' and 'unlucky' groups.

The underlying firm-level data also indicate that firms with a relatively high share of debt due within a year (the top quintile of the debt maturity distribution) were much more likely to scale down inventories than firms with a relatively low share of short-term debt falling due (Figure 11).[10]

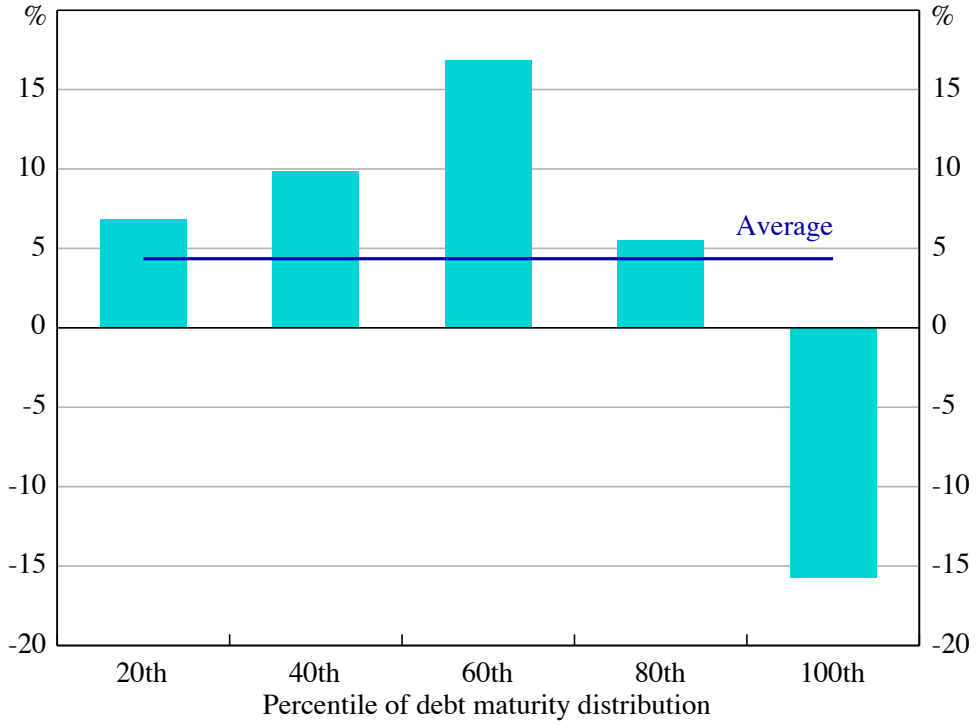
Figure 10: Corporate Short-term Debt
Share of total corporate debt – 2007/08



Sources: Morningstar; author's calculations

10 To minimise the impact of outliers, I 'winsorise' all the variables used in the regression analysis at the bottom and top 1 per cent of their respective distributions. Winsorising involves replacing extreme values with certain percentiles. So, for example, if the top 1 per cent of a distribution is winsorised, any value beyond the 99th percentile is replaced by the value at the 99th percentile. The main results in the paper are little affected by this procedure.

Figure 11: Inventory Investment
Firm-level average within each percentile



Note: Difference in the (log level of) inventories between 2007/08 and 2008/09
Sources: Morningstar; author's calculations

5.3 Covariate Matching

To establish a causal effect of short-term debt on inventory investment, ideally the firms would be randomly assigned to the treatment and control groups. Otherwise, any differences in investment behaviour between the two groups during the crisis could be due to confounding factors, such as unobservable differences in business models and riskiness.

To address this issue I estimate the model using 'covariate matching'. Specifically, each treated firm is 'paired' with the untreated firm that is most similar in terms of observable characteristics. There is a range of available matching estimators; I use the Abadie and Imbens (2011) matching estimator. This estimator minimises the difference between a vector of observed covariates across treated and untreated firms, finding controls based on matches for which the difference between the vectors is smallest. Matching on covariates, by definition, removes any differences between the treatment and control firms and hence eliminates any bias in estimating causal (or 'treatment') effects. But when there are many

covariates, it is not practical to match directly on all covariates, particularly when the variables are continuous. Instead, the multiple covariates generally need to be summarised by a scalar through some metric, which measures the closeness of two observations.[11] The estimator allows those firms chosen as controls to serve as matches more than once.[12] I select one matched control firm for each treated firm (although more firms could be chosen).

The vector of matching variables includes the pre-crisis levels of real inventories and real sales for each firm. The inclusion of lagged inventory and sales terms arises from a target adjustment motive; firms are assumed to want to lower inventories when the inventory-to-sales ratio is high, so there should be a negative coefficient on the lagged level of inventories and a positive coefficient on the lagged level of sales. The real annual growth rate of sales is also included to control for firms' expectations of demand. The effect of higher expected sales growth is somewhat indeterminate; if inventories are primarily used to smooth production then the coefficient should be negative, but if inventories serve mainly to avoid running out of stocks then the coefficient should be positive.

The matching procedure also includes controls for firm size (the log level of assets) and leverage (the debt-to-assets ratio), as well as indicators that capture a firm's ability to offset external financing shocks, such as its level of liquid asset holdings (the cash-to-assets ratio) and its use of trade credit (the trade credit-to-assets ratio). More detailed information on the construction of each variable is included in Appendix A. The estimator produces exact matches on categorical variables (e.g. industry classification), but only imperfect matches on continuous variables (e.g. size) so an adjustment is made to correct for such a bias. In addition, the estimator produces standard errors that are robust to heteroscedasticity.

As an example of the matching procedure, two of the listed motor vehicle dealers – Automotive Holdings Group and the Adtrans Group – are classified as treated companies because they had short-term debt ratios exceeding 80 per cent

11 The Abadie and Imbens (2011) estimator matches observations in the treatment and control groups based on the Mahalanobis distance. The Mahalanobis distance is a descriptive statistic that provides a relative measure of a data point's distance from a common point. It is different to Euclidean distance because it accounts for correlations in the dataset and is scale-invariant.

12 This lowers the estimation bias (but increases the variance) compared to matching without replacement.

(83.5 per cent and 85 per cent respectively). The matching procedure estimates that, for both treated companies, the best matched control is the other listed motor vehicle dealer – A.P. Eagers – which had a short-term debt ratio less than 80 per cent (58.7 per cent). This matching makes sense given the firms are in the same industry and operate with similar business models.

Summary statistics for the key variables across the treatment and matched control groups are shown in Table 1 below.

Table 1: Treatment Group Summary Statistics

Variable	Mean		Median		Std dev	
	Treated	Control	Treated	Control	Treated	Control
Pre-crisis, 2007/08						
Assets (log level)	4.2	4.2	4.2	4.0	1.7	1.5
Cash-to-assets ratio (%)	8.7	8.6	5.0	6.0	9.5	9.3
Trade credit-to-assets ratio (%)	39.8	41.0	40.2	37.1	20.5	21.2
Debt-to-assets ratio (%)	25.7	23.7	24.3	23.9	19.1	13.3
Cash flow-to-assets ratio (%)	0.9	3.6	2.4	5.6	11.2	10.1
Post-crisis, 2008/09						
Real inventories (% change)	–23.5	–10.1	–9.0	–3.2	57.3	44.7
Real sales (% change)	0.0	–6.8	–4.0	–3.8	57.3	43.4

Sources: Morningstar; author's calculations

As the summary statistics indicate, the treated and control firms are very similar in all relevant characteristics. In terms of the control variables, the main notable difference between the two types of firms is that the control firms are more profitable than the treated firms, as shown by the higher cash-flow-to-assets ratio.

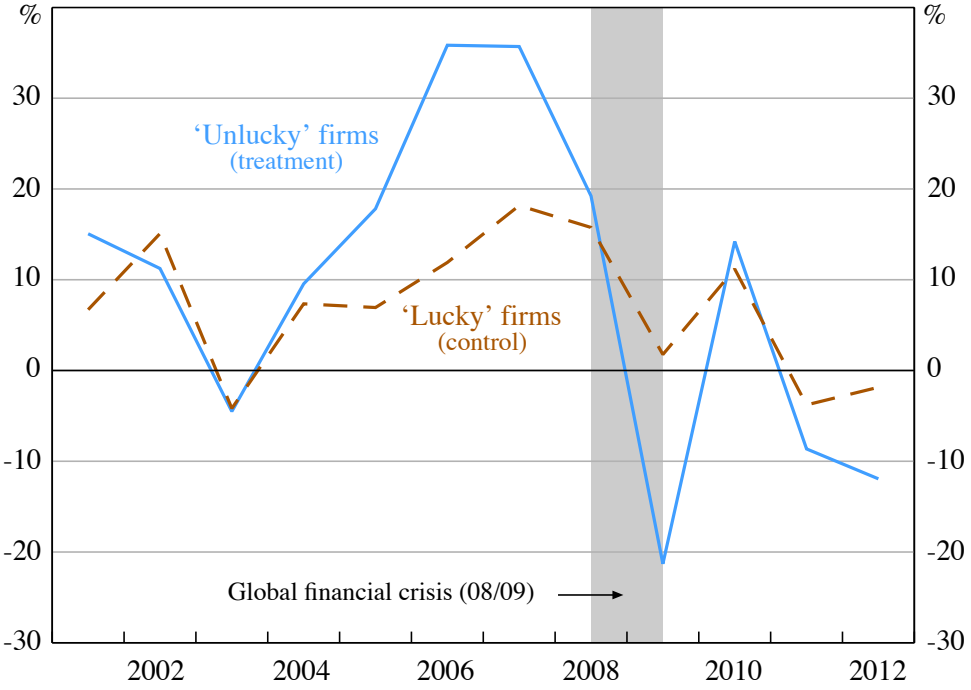
5.4 Parallel Trends Assumption

The key assumption of the difference-in-differences modelling strategy is that the inventory investment behaviour of the treated and control firms would have followed the same trend had the 2008/09 crisis not occurred (i.e. in the absence of treatment). This is known as the 'parallel trends' or 'common trends' assumption.[13]

13 The identifying assumption does not require that the *level* of investment is the same for the two groups, as such differences are eliminated in estimation.

To see if this assumption is justified, it is instructive to consider how inventory investment of the treated firms evolved before and after the crisis relative to that of the control firms (Figure 12). Overall, inventory investment follows a similar cyclical pattern for both groups. Inventory investment clearly fell more sharply for the treated firms than for the control firms during the crisis period, which is consistent with the hypothesis that binding short-term credit constraints caused investment to fall. However, there is also some evidence that investment diverged in the period just prior to the crisis, with inventories growing more rapidly for the treated firms. While this pre-crisis divergence raises some doubts about the validity of the parallel trends assumption, it appears that, overall, the graphical analysis supports the proposed identification strategy.

Figure 12: Inventory Investment by Treatment Status



Notes: Treatment group includes firms with a short-term debt ratio greater than 80 per cent in 2007/08; control group includes firms that are matched to the treatment group based on covariates
Sources: Morningstar; author's calculations

6. Results

6.1 Benchmark Model

The results indicate that the treated companies reduced inventories by nearly one-quarter during the crisis, while the matched control companies lowered inventories

by about 10 per cent, on average (Table 2). The difference-in-differences estimate, which is the difference between these two trends, indicates that the treated firms reduced inventories by 13.4 per cent relative to the matched control firms. The Abadie-Imbens matching estimator for the 'average treatment effect' is the same as the difference-in-differences estimate, except that it adjusts for the bias caused by matching on continuous variables. This estimate indicates that the treated firms reduced inventories by about 18.9 per cent relative to the control firms. The effect is statistically significant at the 10 per cent level.

Table 2: Inventory Investment during the Crisis

Treatment group	**Pre-crisis**	**Post-crisis**	**Difference**
	Mean, $m	Mean, $m	% change
Treatment firms	8.0	6.3	–23.5
Control firms	7.1	6.4	–10.1
Difference-in-differences (% pts)			–13.4
Average treatment effect (% pts)			**–18.9***

Note: *, ** and *** indicate significance at the 10, 5 and 1 per cent level, respectively

To gauge the economic significance of the estimate I note that 34 out of the 276 companies in the sample are treated and that companies in the treatment and control groups are observably very similar in size due to the matching process. Therefore, based on the firm-level data, tighter credit conditions reduced aggregate inventory investment by 2.3 percentage points (–0.189*34/276 = –0.023). Under the maintained assumption that debt maturity is a proxy for financial constraints, the results are therefore consistent with the hypothesis that an adverse credit supply shock had a notable impact on inventory investment during 2008/09.

6.2 Varying Treatment Intensity

To examine the robustness of the main results, I make two changes to the model. First, I allow the key explanatory variable – the ratio of short-term debt to total debt – to take on any value between zero and one, rather than restricting it to be a binary indicator. This effectively measures the 'intensity' of treatment in the model. So, for instance, firms with very high ratios of short-term debt receive very high treatments while firms with very low ratios of short-term debt receive very low treatments. Second, I estimate Equation (2) by OLS to provide a simple point of comparison to the matching estimates. This requires an assumption that the share of short-term debt owed by firms prior to the crisis is not correlated with

the error term (i.e. $corr(STDEBT_i, \triangle\varepsilon_{ij}) = 0$). That is, the identification strategy assumes that firms did not adjust the maturity structure of their debt holdings in anticipation of the global financial crisis.[14]

The results are shown in Table 3. In the first column, I present the results of estimating the equation with the dummy variable for whether a firm is in the treatment group or not. In the second column, I present the results with the continuous short-term debt ratio variable.

Table 3: Effect of Debt Maturity on Inventory Investment

	Dummy	Continuous
	(1)	(2)
Short-term debt ratio	–0.231**	–0.250**
	(–2.28)	(–2.34)
Lagged inventories	–0.0863**	–0.0864**
	(–2.00)	(–2.06)
Lagged sales	0.0618*	0.0675**
	(1.77)	(1.97)
Sales growth	0.239***	0.236***
	(2.68)	(2.60)
Size	–0.0124	–0.0225
	(–0.26)	(–0.46)
Cash-to-assets ratio	0.237	0.264
	(0.73)	(0.82)
Trade credit-to-assets ratio	–0.858***	–0.892***
	(–2.79)	(–2.83)
Debt-to-assets ratio	–0.733**	–0.806**
	(–2.24)	(–2.35)
Cash flow-to-assets ratio	0.377	0.334
	(1.28)	(1.12)
Constant	0.517**	0.641**
	(2.18)	(2.34)
R^2	0.271	0.269
Observations	276	276

Notes: *t* statistics are in parentheses; *, ** and *** indicate significance at the 10, 5 and 1 per cent level, respectively; standard errors are are clustered at the firm level; industry dummies excluded

14 I have also estimated quantile regression models, which show that the relationship between debt maturity and inventory investment holds across the entire cross-section of firms and is not specific to certain points in the distribution. These results are available upon request.

The negative coefficient estimates for the short-term debt ratio in both columns confirm that firms that had a relatively high share of debt falling due in 2008/09 significantly reduced their inventories. The OLS estimate in column 1 indicates that the treated firms reduced inventories by 23.1 per cent relative to the untreated firms. This is larger than the estimated effect obtained from the matching approach.

The estimate in column 2 suggests that the effect of debt maturity on inventories increases with the intensity of the treatment. The estimate implies that a 1 percentage point increase in the share of debt that is due within one year is associated with a 25 per cent decline in inventories, on average. At the firm-level, during the crisis period, the standard deviation of the share of short-term debt was about 30 percentage points (with a mean of 38 per cent), so a one standard deviation increase to the share of short-term debt is estimated to lower inventories by about 7.5 per cent (= –0.250*0.30*100). This suggests that a one standard deviation increase to the share of short-term debt has a relatively large negative impact on inventories.

The coefficient estimates on the control variables are generally signed as expected and statistically significant. For instance, firms with higher sales growth, lower levels of leverage, and lower stock levels generally experienced higher levels of inventory investment during the crisis, on average. The level of inventory investment is negatively related to the ratio of trade credit to assets, which suggests that trade credit did not act as an alternative source of financing for firms constrained by intermediated credit. In contrast, firm size and liquidity (as measured by the cash flow-to-assets ratio) are insignificant determinants.

6.3 The Endogeneity of Debt Maturity Choice

The preceding analysis assumes that firms' choices about their debt in 2007/08 were exogenous to investment and financing decisions in 2008/09. Moreover, the analysis assumes that having a large share of debt fall due in 2008/09 *caused* firms to become more financially constrained and this, in turn, caused inventory investment to fall. But there are a couple of reasons why the debt maturity choice may not be truly exogenous.

First, firms that are particularly reliant on short-term debt may be riskier, on average, and this unobservable credit risk may explain the link between debt

maturity and inventory investment. To see this, consider the following example. Suppose the 'unlucky' firms had established access to revolving credit facilities, but the prospects of these firms deteriorated by relatively more than other firms as the economy weakened. If these firms became concerned about solvency they may have liquidated their inventories *and* drawn down their existing credit facilities, causing a rise in short-term debt obligations. In this case, financial constraints contributed to the decline in inventory investment, but the observed debt maturity choice would be an outcome of the financial constraints rather than a cause.

Second, if an adverse shock to fundamentals caused investment opportunities to dry up, the 'unlucky' firms may have found it harder to secure long-term financing and lenders may have forced them to increase short-term borrowing instead. Short-term debt would be again a symptom of adverse economic shocks rather than a cause (Benmelech and Dvir 2013).

To examine these alternative explanations for the observed relationship between debt maturity and investment, I adapt the simple OLS regression from the previous section by splitting the key explanatory variable – the share of debt that is short-term – into two components – the share of *fixed-term* debt and the share of *revolving* debt falling due within the year. I then examine which component is most correlated with inventory investment.

The logic is that there are at least two reasons why a firm could have a high share of short-term debt. The firm may have issued a fixed-term loan several years ago and it just so happens that a large proportion of this long-term debt falls due within the coming year. Alternatively, the firm may have drawn down on its revolving credit facilities during the year so a large share of debt is outstanding by the end of the year. If the debt obligations were undertaken by the firm several years before the crisis they are unlikely to represent an endogenous response to deteriorating economic conditions. Using the share of maturing long-term debt rather than just the outstanding share of short-term debt may help to gauge whether the effect of debt maturity on investment is causal or not.

To undertake this test, I use an alternative source of company accounts information as Morningstar do not provide the necessary firm-level split between revolving and fixed-term credit. Instead, I collect the firm-level credit data on an annual basis from Compustat. Estimating Equation (2) using the Compustat dataset provides

a useful cross-check on the main results based on the Morningstar dataset. More information about the Compustat data is reported in Appendix A.

The results again provide strong evidence of an inverse relationship between the share of short-term debt and inventory investment. This is shown by the negative coefficient estimate on the short-term debt variable in column 1 of Table 4. But the results indicate that this inverse relationship reflects a negative association between short-term *revolving* debt and inventory investment (column 2). There is also a negative correlation between short-term fixed debt and inventory accumulation but this relationship is not statistically significant.

Table 4: Effect of Type of Debt Maturity on Inventory Investment

	No split	Split
	(1)	(2)
Short-term debt ratio	–0.312**	
	(–2.39)	
Revolving short-term debt ratio		–0.428***
		(–2.95)
Fixed short-term debt ratio		–0.0768
		(–0.45)
Lagged inventories	–0.0921**	–0.0939**
	(–2.11)	(–2.13)
Lagged sales	0.143*	0.140*
	(1.84)	(1.81)
Sales growth	0.341**	0.380**
	(1.97)	(2.24)
Size	–0.0906	–0.0853
	(–0.98)	(–0.92)
Cash-to-assets ratio	–0.127	–0.142
	(–0.28)	(–0.31)
Trade credit-to-assets ratio	–1.745**	–1.761**
	(–2.28)	(–2.25)
Debt-to-assets ratio	–0.428	–0.407
	(–1.52)	(–1.53)
Constant	0.391	0.355
	(1.53)	(1.36)
R^2	0.255	0.267
Observations	265	265

Notes: *t* statistics are in parentheses; *, ** and *** indicate significance at the 10, 5 and 1 per cent level, respectively; standard errors are are clustered at the firm level

So this test casts some doubt on a causal interpretation of the link between debt maturity and inventory investment. Instead, the results suggest that the 'unlucky' firms were unobservably different to the 'lucky' firms in terms of credit risk, and that these unobservable characteristics may be driving the link between debt maturity and investment. More specifically, the evidence is consistent with the least creditworthy firms drawing down their existing revolving credit facilities while also cutting back their stocks in order to free up liquidity.

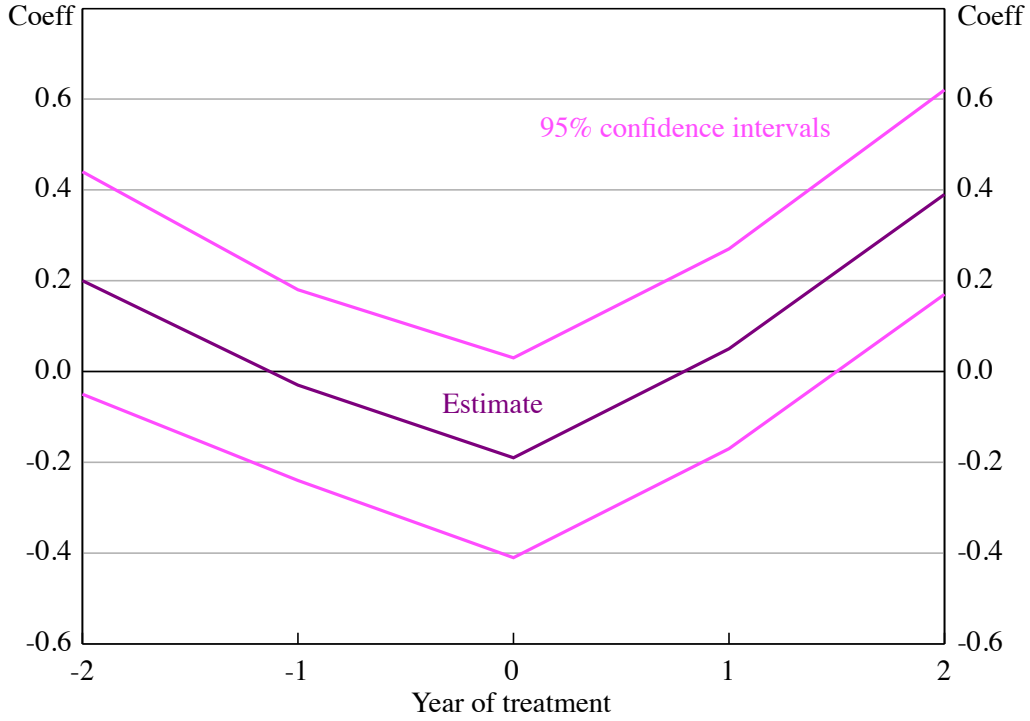
6.4 Placebo Test

I also conduct a 'placebo test' in which I 'pretend' the shock to credit conditions occurred at a point in time other than the global financial crisis. The experimental design assumes that the actual shock to credit conditions occurred in 2008/09 and examines how inventory investment was affected that year. But, suppose instead that the experiment is run on the assumption that the shock occurred in 2005/06 and we examine how inventory investment was affected at that time. If we still find evidence of a significant effect of debt maturity (the proxy for credit conditions) on inventory investment, then this would suggest there is some confounding factor driving the correlation, rather than a causal relationship.

To conduct the placebo test I estimate the Abaide-Imbens matching regression, but separately run the model on each of the two years before the global financial crisis as well as the two years after the crisis. If the model is capturing a genuine causal effect of the credit supply shock, then the effect should be largest (and only statistically significant) in the actual year of the crisis. The coefficient estimates from each year are shown in Figure 13.

As expected, the coefficient estimate from the model is largest (and only statistically significant) when the treatment is assumed to occur in 2008/09. This coincides with the 'actual' crisis period. So, in this case, the results support the claim that the regression estimates are capturing a true causal relationship between debt maturity and inventory investment.

Figure 13: The Effect of Debt Maturity on Inventory Investment
Abadie-Imbens matching estimator



Sources: Morningstar; author's calculations

7. Conclusion

A sharp decline in inventory investment was an important contributor to the 2008/09 slowdown in Australia. I identify the extent to which this was due to a tightening in credit conditions as opposed to a fall in actual, or expected, demand.

Industry-level analysis also indicates that a large fall in motor vehicle inventories contributed to the big decline in aggregate inventories. Based on a case study of the domestic motor vehicle industry, I find suggestive evidence that indicates the withdrawal of two large international finance companies had an adverse effect on credit supply and, subsequently, motor vehicle inventory investment.

Looking across a range of industries, and using the pre-crisis variation in the debt maturity structure of Australian listed companies as a proxy for credit constraints, I find that companies that were forced to refinance or repay a relatively large share of debt in 2008/09 reduced inventory investment by significantly more than companies that were due to refinance or repay their debt at some other time.

But, potentially arguing against a causal interpretation, the link between debt maturity and inventory investment is particularly pronounced for firms that had a relatively large share of short-term revolving credit due in 2008/09. This suggests an alternative explanation for the observed link between debt maturity and inventory investment; as economic conditions deteriorated and firms became concerned about the outlook, they chose to reduce inventories and draw down their existing debt capacity in order to remain solvent. In other words, the sharp decline in inventory investment was due to firms becoming credit constrained but this reflected weaker economic prospects, rather than being purely due to a tightening in credit supply. This would suggest that the decline in inventories was due to a combination of tight credit and a weakening economy.

Appendix A: Variable Construction

Table A1 outlines the construction of each of the main variables used in the paper. The relevant data item codes in each dataset are indicated by either a number (for Morningstar data) or a short abbreviation (for Compustat data).

Table A1: Main Variable Construction

Variable	Details
Morningstar	
Inventory investment	Change in the log level of real inventories. Total inventories calculated as the sum of current inventories (5000) and non-current inventories (5029). Real inventories is constructed by dividing nominal inventories by the implicit price deflator (IPD) obtained from the ABS' Quarterly Business Indicators Survey. The IPD, in turn, is calculated as the aggregate nominal value of all inventories in the manufacturing, wholesale and retail trade industries divided by the aggregate real value of inventories in those industries.
Sales growth	Change in the log level of (real) total trading revenue (7070). Real sales is calculated as nominal sales divided by the IPD obtained from the ABS' Quarterly Business Indicators Survey.
Short-term debt ratio	Current debt (6000) divided by the sum of current debt (6000) and non-current debt (6020).
Size	Log level of total assets (5090).
Cash-to-assets ratio	Total stock of cash (including short-term deposits) (4990) divided by total assets (5090).
Debt-to-assets ratio	The sum of current debt (6000) and non-current debt (6020) divided by total assets (5090).
Trade credit-to-assets ratio	The sum of current accounts payable (5095) and non-current accounts payable (6019) divided by total assets (5090).
Cash flow-to-assets ratio	Total earnings before interest, tax, depreciation and amortisation (EBITDA) (8000) divided by total assets (5090).
Compustat	
Revolving short-term debt ratio	Notes payable due within one year (NP) divided by the sum of current debt (DLC) and non-current debt (DLTT).
Fixed short-term debt ratio	Fixed-term debt due within one year (DD1) divided by the sum of current debt (DLC) and non-current debt (DLTT).

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