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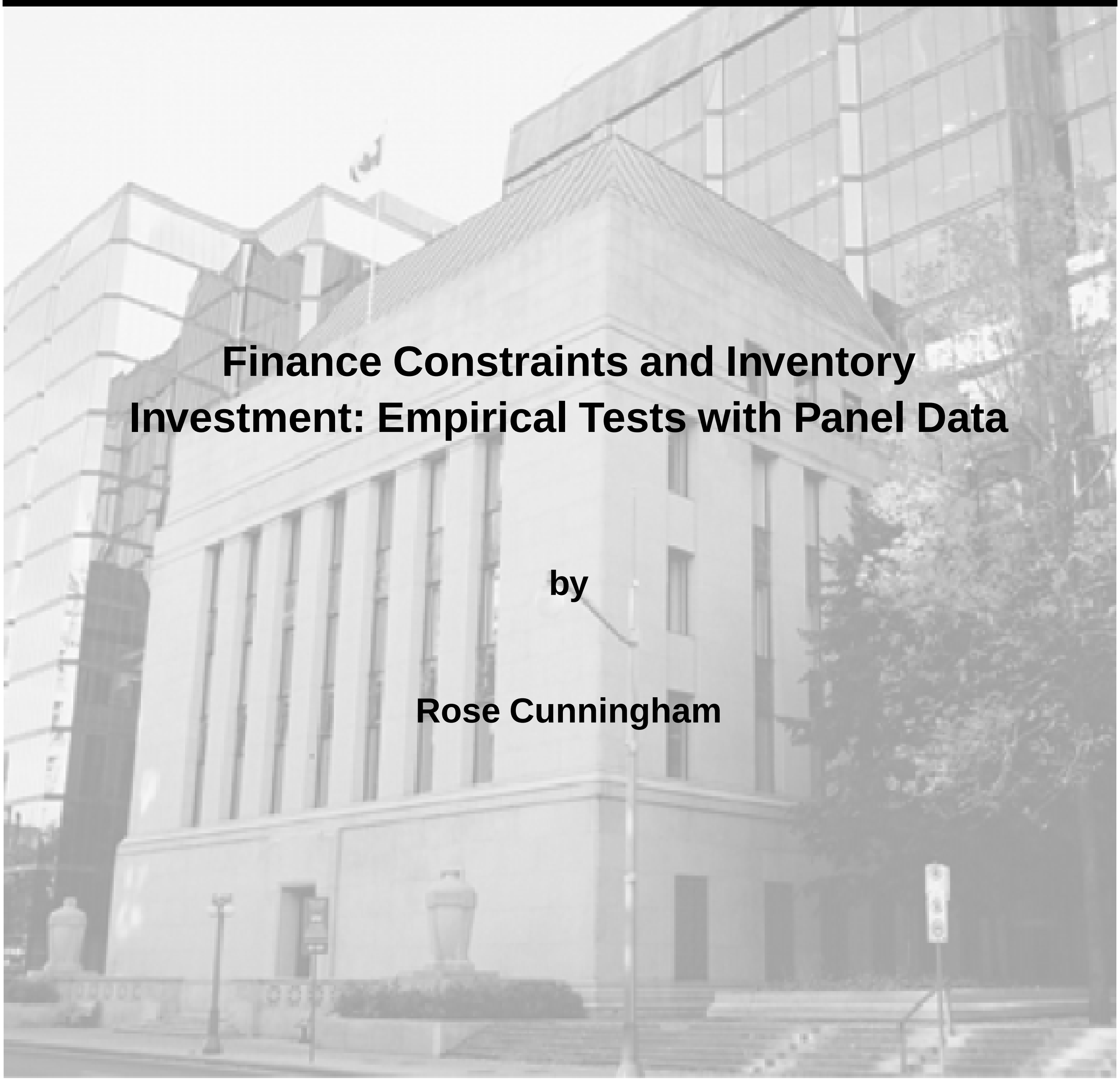

Finance Constraints and Inventory Investment: Empirical Tests with Panel Data

by

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Abstract

The author empirically tests two aspects of the interaction between financial variables and inventory investment: negative cash flow and finance constraints due to asymmetric information. This is one of the first studies of inventory investment and finance constraints using Canadian data. A sample of Canadian manufacturing firms over the period 1992Q2–1999Q4 is split into subsamples based on age, bond rating, and size to reflect expected differences in degrees of asymmetric information problems. The findings are consistent with a model in which inventory investment is a U-shaped function of cash flow. Higher degrees of information asymmetry do not appear to generate differences in the sensitivity of inventory investment to cash flow during the sample period.

JEL classification: E22, G14
Bank classification: Business fluctuations and cycles; Financial institutions

Résumé

L’auteure teste empiriquement deux aspects de l’interaction entre les investissements en stocks et les variables financières, à savoir le comportement de ceux-ci en présence, d’une part, de flux de trésorerie négatifs et, d’autre part, de contraintes de financement dues à une asymétrie d’information entre emprunteur et prêteur. Il s’agit de l’une des premières études menées sur le sujet à partir de données canadiennes. L’échantillon d’entreprises manufacturières qu’utilise l’auteure couvre la période allant du deuxième trimestre de 1992 au quatrième trimestre de 1999 et est subdivisé en fonction de l’âge, de la cote de crédit et de la taille des entreprises afin de tenir compte des différences attendues dans le degré d’asymétrie d’information. Les résultats obtenus cadrent avec un modèle où la relation entre les investissements en stocks et les flux de trésorerie décrit une courbe en U. Le degré d’asymétrie ne semble pas influencer la sensibilité des investissements en stocks aux flux de trésorerie durant la période d’estimation.

Classification JEL : E22, G14
Classification de la Banque : Cycles et fluctuations économiques; Institutions financières

1. Introduction

Models of finance constraints attempt to explain how information asymmetries between borrowers and lenders can cause some profitable investment projects to remain unexploited. Information asymmetries in capital markets arise when firms have private information that cannot be costlessly observed by outside lenders. In their seminal work on finance constraints, Fazzari, Hubbard, and Peterson (1988) show that such firms may have to pay a premium for external financing that is not fully collateralized by their internal funds. In models of finance constraints, the higher cost of external finance causes firms that have high degrees of information asymmetry to finance more of their investment activities with internal funds. Firms that have low degrees of information asymmetry and therefore low information costs do not face such premiums on external funds, and therefore their investment activities are less constrained by their internal funds.

Finance constraints are believed to bind most strongly when interest rates rise and during recessions, when internal funds decline and collateral values weaken. This means external finance becomes more expensive for firms that have high information costs. These more finance-constrained firms reduce investment spending and production, amplifying the business cycle downturn. Similarly, positive shocks can cause constrained firms to have greater access to external credit, which increases their investment and production and further strengthens an expansion.[1] Thus, understanding the extent to which finance constraints affect firms may shed light on business cycle fluctuations.

This paper looks for evidence of finance constraints by examining inventory investment behaviour. Inventory investment is of interest because inventories have low adjustment costs compared with capital investment activities. Thus, one would expect that inventory investment would be used by finance-constrained firms to respond to negative shocks. For example, if cash

1. For a description of financial accelerator effects, see Bernanke, Gertler, and Gilchrist (1996), Bernanke and Gertler (1989, 1995), Gertler and Gilchrist (1994), Kashyap, Stein, and Wilcox (1993), and Kiyotaki, and Moore (1997). Older macroeconomics literature in this area includes Fisher (1933) Gurley, and Shaw (1955, 1960).

flow declines, the amount of external borrowing collateralized by internal funds also declines, and the firm must reduce its borrowing or pay a premium on loans in excess of cash flow. Rather than suspend a capital project, the firm may choose to hold fewer inventories. Empirically, Blinder, and Maccini (1991) show that inventory investment is one of the most volatile, procyclical components of output over the business cycle in the United States. Table 1 indicates that this is also true for Canada: inventory investment declines by almost 200 per cent more than the decline in output over an average business cycle. Finance constraints can amplify business cycle shocks and therefore they may help explain some of the observed volatility in inventory investment.[2]

Much of the existing empirical research on finance constraints has been criticized on at least two fronts. First, Kaplan and Zingales (1997, 2000) argue that many tests for finance constraints do not have proper theoretical foundations because they compare more finance-constrained with less finance-constrained firms, whereas the theory's predictions deal with finance-constrained and unconstrained firms. Second, many of the existing studies of finance constraints ignore the role played by firms that have negative cash flows, even though they are empirically important and account for 8 to 22 per cent of the observations in studies that keep them in the sample.[3]

This paper tests a model by Povel and Raith (2002) that addresses both these concerns. Their model derives optimal investment behaviour in the presence of negative internal funds and varying degrees of asymmetric information. Thus, it provides a more solid theoretical underpinning for conventional empirical tests for finance constraints. I test the predictions of Povel and Raith's model on Canadian firm-level data on inventory investment for the period 1992Q2–1999Q4. To the best of my knowledge, this is the first study of finance constraints and inventory investment using Canadian data. My findings indicate that negative cash flow observations have a significant effect on the sensitivity of inventory investment to cash flow, consistent with the U-shaped relationship predicted by the model. In the sample period, however, there is little evidence of finance constraints due to asymmetric information, since the

2. The finance-constraints hypothesis attempts to explain changes in inventory investment, in addition to the usual buffer stock role that inventories play.
3. These include Cleary, Povel, and Raith (2003), Allayannis and Mozumdar (2001), and this study.

coefficients on cash flow are not statistically different across firm groups believed to have different degrees of asymmetric information.

2. Recent Empirical Literature

Much of the empirical work on finance constraints faced by firms focuses on capital stock investment. Hubbard (1998) conducts a survey of the empirical literature on capital market imperfections and investment. These studies generally test the standard model of Fazzari, Hubbard, and Peterson (1988) by comparing the sensitivities of investment to cash flow across groups of firms. These firms are categorized a priori as finance-constrained or unconstrained, based on characteristics that proxy for information asymmetry. Characteristics commonly used to categorize firms include bond ratings, dividends, age, size, and membership in industrial groups. Evidence obtained by the majority of studies supports the theory that finance constraints reduce investment by firms that have high information costs.[4]

Nevertheless, an important debate on investment–cash flow sensitivities has arisen in the literature. Several recent studies do not find the predicted differences in cash flow sensitivities based on asymmetric information; in some cases, unconstrained firms' investment is *more* sensitive to cash flow than that of financially constrained firms (Allayannis and Mozumdar 2001; Cleary 1999; Kaplan and Zingales 1997; and Gilchrist and Himmelberg 1995). Allayannis and Mozumdar specifically examine the influence of negative cash flows in tests for investment–cash flow sensitivities. They find that negative cash flow observations can generate findings that contradict the standard theory. However, once they remove negative cash flow observations, the investment–cash flow sensitivities do not differ between the finance-constraint categories.

Povel and Raith (2002) develop a theoretical model of finance constraints that helps to explain some of these contradictory findings. Their model is explained in section 4. Cleary, Povel, and Raith (2003) test Povel and Raith's model using capital investment data and find evidence of a U-shaped relationship between investment and cash flow. They also find that investment is more sensitive to cash flow for firms that are expected to face greater finance constraints, consistent

4. Examples of these studies include Fazzari, Hubbard, and Peterson (1988) and Whited (1992), who use data from the United States; Schaller (1993), who tests Canadian data; and Hoshi, Kashyap, and Scharfstein (1991), who test finance-constraint models on Japanese panel data.

with the standard models. I test some of the implications of Povel and Raith's model on inventory investment data using methods similar to those of Allayannis and Mozumdar.

In the literature on inventory investment, the results more clearly support the theory of the finance constraints. Carpenter, Fazzari, and Peterson (1994, 1998), Guariglia (1999), Zakrajsek (1997), Gertler and Gilchrist (1994), Kashyap, Lamont, and Stein (1994), and Kashyap, Stein, and Wilcox (1993) examine data on inventory investment for evidence of finance constraints. They all test some form of partial-adjustment inventory model augmented with financial variables that proxy for internal funds, such as cash flow, interest coverage ratio, liquidity ratios, or other financial ratios. These studies typically feature firm-level data analyzed over periods of recession or periods when monetary policy was known to be restrictive.[5] The augmented model of inventory investment is estimated separately for the finance-constrained and unconstrained groups of firms. Most authors focus on manufacturing firms; the exceptions are Kashyap, Stein, and Wilcox (1993), who use aggregate data, and Zakrajsek (1997), who studies retail sector inventories. Six of the seven papers analyze data from the United States; Guariglia tests for finance constraints using data from the United Kingdom. Mine is one of the first inventory studies to explicitly consider the effect of negative cash flow observations.

Previous studies on inventory investment and finance constraints find that the financial variables have significant and larger coefficients for firms in the finance-constrained group compared with the unconstrained firms. Kashyap, Stein, and Wilcox (1993) also find that financial variables are significant in explaining inventory investment using aggregate data. Although the evidence in the literature on *fixed* investment and finance constraints is mixed, research to date on *inventory* investment is less ambiguous. Existing studies more clearly support the view that finance constraints lead to a positive relationship between cash flow and inventory investment.

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5. Kashyap, Stein, and Wilcox (1993) and Gertler and Gilchrist (1994) do not use firm-level data; instead, they use industry-level data or aggregate data.

3. Data Description

This study uses Compustat data on quarterly financial statement items from publicly traded Canadian manufacturing firms.[6] There are a total of 2,211 observations on 166 firms for the period 1992Q2–1999Q4. Firms with fewer than 6 consecutive quarters of data are not included, since lags of variables are used as instruments in the regression specification. The number of observations on each firm varies from 6 quarters to 30 quarters, so the panel is unbalanced. The average firm in the dataset has 13 quarters of data. I also omit observations where there is zero inventory investment for 3 or more consecutive quarters, since zero inventory investment may indicate a temporary shutdown or disruption in the firm's activities. Observations are also excluded for periods of merger activity, as identified by Compustat, since mergers may disrupt inventories or generate other anomalies. The variables of interest for regression testing are: inventories, cash flow, sales, and total assets. These variables are explained in more detail in the appendix. To ensure that the regression results are not driven by a few outlying observations, the upper and lower 1 per cent values of observations for inventory stock, sales, and cash flow are removed.

As in the other studies on finance constraints using panel data, firms are categorized as likely to be more or less finance-constrained based on proxies for a high or low degree of information asymmetry between the firm and outside lenders. Three different criteria proxy for information asymmetries: age, the presence of a bond rating, and size.

Based on its date of incorporation, a firm is classified as young if its age is less than that of the median firm in the sample at time *t*.[7] An old firm has an age equal to or greater than the median

6. The data are from Compustat's Research Insight North American database of firms actively traded on Canadian stock exchanges as of June 2000. This dataset includes companies that were publicly traded over the whole period and those that began trading at some point during the period. However, any firms that stopped trading during the period are not included. Firms are considered to be in the manufacturing sector if their primary (U.S.) Standard industrial classification (SIC) assigned by Compustat lies in the range 2000–3999.
7. I use the Financial Post/Mergent FIS Online database for data on the year of incorporation. Where the FIS database does not provide the year of incorporation, I use company Web sites and the SEDAR Web site from the Canadian Securities Administrators. SEDAR is an Internet database of Canadian publicly traded firms' financial statements, similar to the EDGAR database in the United States.

age of firms in the sample at time *t*. Depending on the composition of the sample at a given time, a firm may be classified as young in one period and old in another. Firms that are classified as young are expected to have more costly asymmetric information problems with borrowers, and a priori are assumed to be more finance-constrained.

Small firms are defined as those that have total assets of less than the median value of total assets in period *t*, and they are expected to be more finance-constrained. Firms that have total asset values greater than or equal to the median value are considered large, and expected to be less constrained. As in the split by age, firms may change size categories depending on the size of other firms in the sample in a given period. Splitting the sample at the median for size or age is an intuitive method and is consistent with several earlier studies. Nevertheless, the median may not necessarily be consistent with the true boundary between firms that are more finance-constrained and those that have little difficulty obtaining external finance.

Bond ratings provide a better, exogenous proxy for splitting the sample to reflect differences in information available to external lenders. Firms that have their corporate bonds rated by a bond rating agency are considered likely to face fewer finance constraints than unrated firms, since more information is available to lenders about the quality of the rated firms' investment opportunities. Firms are classified as bond-rated if they have a rating at the end of the sample period, based on the ratings available from the Dominion Bond Rating Service Web site (as of June 2001) and the ratings of Standard and Poor's provided in the *Financial Post Corporate Bond Record 1999*. Firms do not switch categories with respect to bond rating over the period. Using this method, 41 of the 166 firms in the sample are rated, and 125 are unrated.

Table 2 reports summary statistics for the full sample and subsamples by age, the presence of a bond rating, and size. One of the most important features of the data is the prevalence of negative cash flow observations; 93 of the 166 firms have at least 1 quarter with negative cash flow, and 32 firms have 4 or more quarters with negative cash flow. Three industries—telecoms, computer equipment, and biotech—account for 206 of the 342 firm-quarter observations where cash flow is negative.[8] These three industries make up 60 per cent of the negative cash flow observations. Overall, observations with negative cash flow account for 15.5 per cent of the full sample of

8. Identified by Compustat primary 2-digit SICs of 35, 36, and 38.

2,211 firm-quarter observations. This share appears consistent with the other studies that examine negative cash flows. Allayannis and Mozumdar find that 8 per cent of firm-year observations include negative cash flows in a sample of U.S. manufacturing firms over the period 1977–96. Cleary, Povel, and Raith (2003) use annual Compustat data on non-financial firms for 1980–99, in which 22 per cent of the observations have negative cash flows.

The absolute levels of all the variables differ significantly between the groups of firms, regardless of whether age, bond ratings, or size characteristics are used to split the sample. The firms in the groups expected to be more finance-constrained (young, unrated, or small) have much lower levels of total assets, inventory stock, sales, and cash flow. Scaling the variables by total assets, however, reduces the differences across finance-constraint categories considerably.

The mean of cash flow to total assets (*CF/TA*), shown near the bottom of Table 2, is much smaller for the firms in the more finance-constrained categories relative to the other firms. The mean of *CF/TA* is 0.005 for young firms, which is one-quarter of the mean value of *CF/TA* for old firms, 0.020. This ratio is 0.01 for unrated firms, or about half the mean *CF/TA* of rated firms, 0.019. For the average small firm, the ratio of negative cash flow to assets is, -0.001, compared with the much higher ratio of 0.022 for the average large firm. However, the standard deviations are also considerably larger for the more finance-constrained firms, and there are often fewer observations per firm for young, unrated, or small firms.

The dependent variable in the regressions is the ratio of inventory investment to total assets (*?N/TA*). This ratio is similar across young and old firms, but unrated firms and small firms have larger ratios than their counterparts for this variable. It is interesting that two types of firms expected to be more finance-constrained, the unrated and the small firms, tend to have larger ratios of inventory investment despite lower ratios of average cash flow. The ratio of sales to inventory stock (*S/N*) is used to reflect the firm's long-run target inventory. The mean of the sales-to-inventory ratios does not differ substantially across finance-constraint categories, which suggests that there are similar inventory targets for different categories of firms.

4. Theoretical Model of Finance Constraints

Povel and Raith's (2002) model of the optimal level of investment under finance constraints provides a theoretical basis for many existing empirical tests of finance constraints, and explains some of the recent contradictory findings on fixed investment and finance constraints. Two features of their model also make it well-suited to potentially explain the inventory investment behaviour of firms in my sample. First, it assumes that the firm may determine the scale of its investment rather than make a binary choice on whether to undertake an investment project. Scalable investment seems to be a more appropriate description of inventory investment than an all-or-none investment. Second, internal funds (often operationalized as cash flow) may be negative. This is useful in the context of my data, which have a large number of observations with negative cash flow.

It should be possible to analyze inventory investment using Povel and Raith's model, since it applies to any debt-financed investment. A firm may finance inventory investment out of debt rather than internal funds if it plans to significantly increase inventory levels or the desired ratio of inventory to sales. This may occur in response to sales expanding rapidly or just becoming harder to predict; for example, if the firm is expanding into new markets or selling new product lines, or if increased competition increases its incentive to avoid stockouts by maintaining a larger inventory buffer.

In Povel and Raith's model, a firm earns revenues that are not observable to the external investor, creating a potential moral hazard problem due to asymmetric information. Thus, internal and external funds will not be equivalent in cost to the firm. The authors use the investor's break-even constraint to derive the costs of external funds. Their main finding is that the firm's optimal investment function is U-shaped over the range of feasible levels of internal funds (cash flow, *CF*). The solid line in Figure 1 shows this relationship for a firm that has no information asymmetry problems. The first-best level of investment, I^*, is undertaken if the firm can fund the investment internally with its own cash flow; i.e., when *CF* equals I^*. With cash flow positive and less than I^*, the optimal investment is also less than I^*, but positive and increasing in cash flow. This is consistent with earlier models based on Fazzari, Hubbard, and Peterson (1988) that imply a positive, monotonic relationship between investment and internal funds. In the range where internal funds are negative, however, investment may rise or fall as cash flow increases. In the most extreme case, the firm's cash flow is at the lower bound, where it is still possible to obtain financing, $\underline{CF}$. In this case, optimal investment would be as high as the first-best level, I^*.

The U-shaped investment–cash flow relationship is the result of two opposing effects: a cost effect and a revenue effect. In the case of the cost effect, higher levels of investment increase the firm's repayment costs and thereby raise its risk of default and liquidation, in turn raising the marginal cost of debt finance. In the case of the revenue effect, higher levels of investment generate more revenue, which increases the firm's chance of survival and lowers the marginal cost of debt finance.[9]

Povel and Raith prove that the cost effect dominates when the firm has positive or slightly negative cash flow, and that the revenue effect dominates when the firm has significantly negative cash flow. The dominance of the cost effect implies the familiar, positive monotonic investment–cash flow relationship such that an increase in cash flow leads to an increase in investment: as internal funds (cash flow) increase, the probability of default declines and the marginal cost of borrowing falls.

If the firm has a substantially negative cash flow, the revenue effect dominates. Negative cash flow means that part of the firm's borrowing must be used to offset its negative cash flow (e.g., to pay down existing debt, or to cover fixed costs), and, as cash flow becomes more negative, a larger share of any loan must be used to cover these non-revenue-generating expenses. For the investor to break even, the firm must be able to generate revenue. Therefore, the firm must increase the scale of its project, even as CF falls, to generate enough revenue to repay the loan; the revenue effect dominates and there is a negative relationship between cash flow and investment. With respect to inventory investment, this would mean that the firm increases its production and inventory levels more as cash flow falls, to generate enough sales to repay the loan. This seems plausible for firms in the industries that make up most of our negative observations (telecom, computer equipment, and biotech), because these industries were

9. In the region where the investment function reaches a minimum, it is relatively insensitive to changes in cash flow, because the revenue and cost effects essentially cancel each other out.

expanding rapidly during the sample period. Cash flow could be quite negative even as the prospects for increased sales were very good, and the financing of larger inventory investments for such firms would be consistent with a large revenue effect in this model.

Povel and Raith also demonstrate that a U-shaped investment function occurs when there is asymmetric information between the firm and the outside investor. The dashed line in Figure 1 shows the effects of information asymmetry on the investment function. As the degree of information asymmetry increases, the investment function becomes steeper almost everywhere, except in the region of the minimum. Asymmetric information leads to increased sensitivity of investment to cash flow.

This model yields at least two testable implications. In the presence of both positive and negative cash flow observations, the model predicts that the investment–cash flow function will be non-monotonic; specifically, it will be U-shaped. One can test for non-monotonicity by removing the negative cash flow observations. This should result in a positive monotonic relationship between cash flow and inventory investment for all firms. One can also test whether there is a negative relationship in the region where cash flows are negative. A third set of empirical tests can assess the influence of asymmetric information on inventory investment. Firms believed to have a higher degree of asymmetric information are predicted to have larger slope coefficients on the cash flow variable than firms that have fewer asymmetric information problems.

5. Regression Equation and Estimation Results

I use a regression equation based on partial adjustment inventory models by Lovell (1961). Gertler and Gilchrist (1994) point out that these types of models are most appropriate for aggregated inventory data (which is the case here) that are not broken down into work-in-progress, raw materials, or finished goods. Partial-adjustment inventory models describe a process of inventory investment whereby each firm has a desired or “target” level of inventories. Augmenting the model with variables to reflect the firm’s financial situation is a common technique used to test for finance constraints. I assume that the desired inventory level, N^*, depends on expected sales relative to existing inventories, the real interest rate, and cash flow.

Equation (1) shows the inventory investment equation:

$$\Delta N_{it} = b_1 \left[\frac{E_{t-1} S_{it}}{N_{it-1}} \right] + b_2 r_{t-1} + b_3 CF_{it-1}$$
$$+ \sum_{k=1}^{2} b_{4k} \Delta N_{it-k} + \sum_{k=1}^{2} b_{5k} \Delta S_{it-k} + \sum_{k=1}^{2} b_{6k} \Delta r_{it-k} + \sum_{k=1}^{2} b_{7k} \Delta CF_{it-k} \qquad (1)$$
$$+ n_i + n_t + e_{it}.$$

The variables N_{it}, S_{it}, and CF_{it} denote firm *i*'s real inventory, sales, and cash flow, respectively, for period *t*.[10] The dependent variable is inventory investment, N_{it} - $N_{it\text{-}1}$. The real interest rate, *r*, is defined as the prime rate less the inflation rate based on the GDP deflator. The effects of the firm's desired inventory stock are captured by the first three regressors (in levels): the ratio of expected sales to lagged inventory levels, the lag of the real interest rate, and the lag of cash flow. Along with the level terms, lagged differences of inventories, sales, the interest rate, and cash flow are included to capture the effects of short-run dynamics. The last three terms in the equation make up the firm-specific ($?_i$.), time-specific ($?_t$,), and idiosyncratic (e_{it}) components of the error term. A full set of time-dummy variables is used to capture the time-specific effects.[11]

This specification includes both long-run and short-run effects, so it has an error-correction format in which the ratio of expected sales to lagged inventories is the error-correction term. Thus, $ß_1$ should have a positive coefficient, since increases in the ratio (due to either increased expected sales or low levels of previous inventories) should raise N^* and therefore increase current inventory investment. Real interest rates affect the holding cost of inventories, so I expect $ß_2$ to be negative. The sign of $ß_3$ depends on whether the model includes negative cash flows, due to the predicted U-shaped relationship, as discussed below. The theoretical model is static and can be interpreted as explaining steady-state behaviour. Therefore, I expect the influence of finance constraints to be reflected primarily in the long-run behaviour of inventories, with the

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10. Since the data include some observations with negative cash flow, I cannot transform the data using logs. To control for possible heteroscedasticity, inventory investment, cash flow, and sales levels are divided by total assets first, in addition to differencing or other transformations. The "expected sales" category is already scaled by inventory in the previous period, so it is not scaled by total assets.
11. The regression model is based on those of Guariglia (1999), Gertler, and Gilchrist (1994) and Kashyap, Stein, and Wilcox (1993).

coefficient on CF_{it-1} being the main focus of the analysis. The variables that capture short-run dynamics do not have clear sign predictions.

Since lagged dependent variables are included as regressors and there are a relatively small number of time periods for each firm, both fixed effects and generalized least squares (GLS) random-effects estimators will be inconsistent. Their inconsistency arises from the correlation of the lagged dependent variable with the fixed-effect component of the error term.[12] First-differencing removes the firm-specific effect, which provides the model to estimate:

$$\Delta\Delta N_{it} = b_1 \Delta\left[\frac{E_{t-1}S_{it}}{N_{it-1}}\right] + b_2 \Delta r_{t-1} + b_3 \Delta CF_{it-1} + \sum_{k=1}^{2} b_{4k} \Delta\Delta N_{it-k} + \sum_{k=1}^{2} b_{5k} \Delta\Delta S_{it-k} + \sum_{k=1}^{2} b_{6k} \Delta\Delta r_{it-k} + \sum_{k=1}^{2} b_{7k} \Delta\Delta CF_{it-k} + \Delta n_t + \Delta e_{it}. \qquad (2)$$

Equation (2) is estimated using the Arellano-Bond (1991) generalized method of moments estimator. In the desired sales term, expected sales, $E_{t-1}S_{it} / N_{it-1}$, is proxied by S_{it-1}/N_{it-1}. The consistency of the Arellano-Bond estimator requires that there is no second-order autocorrelation in the residual, so the results of an *m*2 test are reported in the results below. Also reported are the results of a Sargan test of the validity of the overidentifying restrictions used by the Arellano-Bond estimator.[13]

5.1 Negative cash flow observations

Table 3 reports the results of testing for a U-shaped relationship between cash flow and inventory investment by estimating the model using: all observations (first column), observations with only non-negative cash flows (second column), and observations with only negative cash

12. See Baltagi (1995,125–26).
13. Since the Sargan test tends to overreject the null hypothesis of valid instruments in the one-step Arellano-Bond estimator, the two-step estimator results are reported for the *m*2 and Sargan tests. The coefficient estimates and standard errors reported, however, are from the one-step estimation procedure, since Arellano and Bond recommend using one-step results for inference. I assume that all variables except the lagged dependent variable are exogenous. It may be more accurate to treat sales and cash flows as predetermined, a weaker assumption than exogeneity, but this would require more observations per firm than are available. Stata software is used to perform the regressions.

flows (third column). The *p*-values for the Sargan tests do not reject the hypothesis that the moment restrictions used in the model are valid, which suggests that the model is correctly specified. Similarly, the *m*2 test statistics in all three columns imply that one cannot reject the hypothesis of no second-order autocorrelation in the residuals, so the estimates are consistent. Note that, although there are many observations in the sample where cash flows are negative, several lags are required to estimate the model. Therefore, relatively fewer firms and observations are available for the regression in column three.

The theoretical model does not clearly imply the nature of the short-run movements in inventory investment in response to changes in cash flow, so the primary variable of interest is the first regressor in each table, *?CF*, which is intended to capture the steady-state nature of the inventory investment–cash flow relationship. The first column of Table 3 contains only two variables that are significantly different from zero: the sales-to-inventory ratio, and lags of the dependent variable. When all observations are included in the regression, the cash flow variables are not significantly different from zero. This is consistent with changes in slope if there is a U-shaped relationship between inventory investment and cash flow, because the sign may change as cash flow becomes negative. In the second column, when the negative cash flow observations are removed, the long-run cash flow term has much a larger, positive coefficient, 0.38, which is significant at the 1 per cent level. In the third column, the regression using only observations with negative cash flows, the coefficient on *?CF* is negative, as expected, but the standard errors in this regression are large and the coefficient is not significantly different from zero. These results provide some moderate, albeit partial, support for the U-shaped function predicted by Povel and Raith's model.

Tables 4 through 6 show the regression results for estimating equation (2) when the sample of firms is split by age, bond rating, or size, respectively. In this set of tables, the first two columns of each table contain the regression results with all cash flow observations included. The third and fourth columns show the regression results when negative cash flow observations are removed. (Regressions using only negative cash flow observations are not possible for each subgroup, because of the small number of observations.) In each group of firms, the coefficient on *?CF* increases when the negative cash flow observations are removed. For young, unrated, small, and large firms, *?CF* is not significant when all observations are considered, but removing negative cash flows leads *?CF* to become significant. Old firms' long-term cash flow coefficient is significant at the 10 per cent level in the initial regression, but the coefficient more than doubles to 0.585, which is significant at the 1 per cent level in the regression without negative cash flows. Only the estimates for rated firms show little change in the *?CF* coefficient, 0.267 to 0.273, and the coefficient is positive and significant at the 1 per cent level in both regressions.

The regression results with and without negative cash flow observations suggest that, when firms are not undergoing financial distress, inventory investment increases as cash flow increases. These findings support the first prediction of Povel and Raith's model and are consistent with the results of similar tests by Allayannis and Mozumdar using data on fixed investment.[14]

5.2 Finance constraints and asymmetric information

The primary concern in the finance-constraints literature is the effect of asymmetric information in capital markets on investment behaviour. Tables 4 through 6 show the estimation results when firms are grouped a priori to reflect information asymmetries. Ignoring the negative cash flow observations, Povel and Raith's model and earlier models of asymmetric information in capital markets imply that the young, unrated, and small firms would have positive and significant coefficients on the cash flow term, and that the cash flow coefficients for these firms would be larger than the cash flow coefficients estimated for the old, rated, and large firms. Table 4 compares young and old firms. The point estimates on the long-run cash flow coefficient are actually larger for the old firms (0.585) than for the young firms (0.278). However, the difference in the point estimates for the *?CF* coefficient for young and old firms is not statistically significant. Similarly, in the regressions that have only non-negative cash flow observations, the estimated cash flow coefficients are nearly identical for unrated and rated

14. The long-run relationship between inventory investment and cash flow is the primary concern. In several regressions, however, the second differences of the cash flow term, which are intended to show the influence of short-run dynamics, have negative and significant coefficients. This is somewhat puzzling, but similar conflicting signs between long-run and short-run cash flow variables are also found in Zakrajsek (1997).

firms, 0.283 and 0.273, respectively.[15] These estimates suggest there is no evidence of finance constraints due to asymmetric information when I split the sample by age or bond rating. Allayannis and Mozumdar obtain similar results. Testing the sensitivity of inventory investment to coverage ratio, Guariglia (1999) finds that the U.K. data on total inventories do not show significant differences between finance-constraint groups when the sample is split based on financial ratios (coverage, and net leverage ratio). She does, however, find evidence supporting the predictions of finance-constraint models when she uses cash flow rather than the coverage ratio as a proxy for the financial health of the firm.

Table 6 reports the estimates of inventory investment–cash flow sensitivities when the sample is split by size. These findings also contradict the theoretical models, since the inventory investment by large firms appears to depend more on cash flow than does that by small firms. The coefficient on *?CF* for small firms is 0.365, which is significantly less than the estimate of 0.464 for large firms. These findings are similar to those of Cleary (1999), who finds that the least finance-constrained firms have the largest fixed investment–cash flow sensitivities.

Overall, my results do not support the view that information asymmetries generate greater sensitivity between inventory investment and cash flow.[16] Moreover, it appears that the ongoing debate about cash flow sensitivities in the fixed-investment literature also extends to inventory investment.

My findings differ from most previous research on inventory investment and finance constraints, but the period under study also differs. Most previous inventory papers focus explicitly on recessions or low-growth periods. One possible reason for my not finding evidence of finance constraints due to information asymmetries is the sample period. The latter years of the 1990s

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15. To test whether the coefficients on *?CF* are statistically different between young and old firms, I estimate the model for the full sample including a dummy variable, *YOUNG*, and interacting all the regressors with the dummy variable. I then test whether the dummy variable and the interaction variable, *?CF*YOUNG*, are jointly equal to zero. The *p*-value for this F-test is 0.42, indicating no statistical difference. The same method and tests for bond ratings generate an F-test with *p*-value of 0.159, indicating statistical difference only at the 15.9 per cent level. The test for small versus large firms has a *p*-value of 0.00, which implies that the cash flow coefficients are significantly different for these groups of firms.
16. Similar regressions using OLS and fixed-effects (not shown) estimates generate the same conclusions.

were a period of strong business cycle expansion, a time when finance constraints may not bind. Moreover, during this period there may have been a speculative bubble in financial markets, which could have meant unusually generous access to capital for firms that one expects to be finance-constrained, such as young start-up firms. Allayannis and Mozumdar demonstrate that the sensitivity of investment to cash flow declined over the period 1977–96. They suggest that improvements in information available to capital markets or an increase in the supply of funds to primary capital markets may have improved the access to external funds for smaller and younger firms. In the inventory literature, Carpenter, Fazzari, and Peterson (1994) also observe smaller coefficients on cash flow variables in the period 1988–92 compared with 1981–83 and 1984–88. They attribute the reduction in the sensitivity of inventory investment to changes in business practice, such as the introduction of just-in-time inventory management.

6. Conclusions

This paper has contributed to the research that examines the effect of financial variables on investment, including inventory investment. I have estimated an error-correction model for inventory investment augmented with cash flows. An important factor that has only recently begun to be studied is the effect of negative cash flow observations. Povel and Raith demonstrate that the relationship between investment and cash flow in the presence of negative cash flow is non-monotonic and U-shaped, contrary to earlier linear models. The regression model was first estimated with all cash flow observations and then with negative cash flows removed. My findings imply that Povel and Raith's model may also apply to inventory investment, because cash flow coefficients are positive and significant only when negative cash flow observations are omitted. Estimating the model only with observations where cash flow was negative yielded a negative but not significant relationship between inventory investment and cash flow.

A second set of regressions were conducted to test for finance constraints due to information asymmetries between firms and external lenders. These regressions estimated the model separately for old versus young firms, bond-rated versus unrated firms, and large versus small firms. In each pair of regressions, the latter group of firms was expected to be more finance-constrained. My findings, however, did not conform to the predictions of the theory. Once the negative cash flow observations were removed, there was no statistically significant difference between estimated cash flow coefficients for young and old firms, nor for rated and unrated firms. The cash flow coefficient estimates were significantly different between large firms and small firms, but the findings were the reverse of the theoretical prediction. The estimated cash flow coefficients were larger for large firms than for small firms, implying that the less finance-constrained firms rely more on internal funds to finance inventory investment than the firms with poor access to external finance. Therefore, it does not appear that information asymmetries between borrowers and lenders generated a stronger link between cash flow and inventory investment for Canadian manufacturing firms over the sample period, 1992Q2–1999Q4. Previous work on inventory investment has mostly supported theories of asymmetric information and finance constraints, but my findings show that some of the puzzles noted in the literature on fixed-investment finance constraints also arise with inventory investment.

Further research could build on these findings by using data for a longer time period. The effects of finance constraints may be relatively hard to detect in my sample period of, 1992–99, since the Canadian economy did not experience a recession during those years and finance constraints are likely to bind most strongly in recession periods. Other sectors of the economy may have more volatile inventory investment than the manufacturing sector, so additional inventory studies that examine other sectors would also be helpful.

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Table 1: Inventory Investment in Canadian Recessions, Millions of 1992 Canadian dollars

Real GDP peak to trough	Change in real GDP	Change in inventory investment	Change in inventory investment as a % of change in real GDP
1947Q2–1948Q1	-1,847	-4,577	248%
1951Q1–1951Q3	-3,484	-937	27%
1956Q4–1958Q1	-1,963	-10,805	550%
1969Q4–1970Q2	-2,458	-3,083	125%
1980Q1–1980Q3	-3,497	-12,401	355%
1981Q2–1982Q4	-32,360	-26,194	81%
1990Q1–1991Q1	-21,608	-588	3%
Average	-9,606	-6,598	198%

Notes: All figures are converted to 1992 Canadian dollars using the GDP deflator. Recession dates are based on two consecutive quarters of negative GDP growth, identified by Cross (1996).

Source: Statistics Canada Cat.13-355 for the period 1946–86, and Cat. 13-001 for the period 1987–91.

Table 2: Summary Statistics for Sample of Canadian Manufacturing Firms 1992Q2–1999Q4, Millions of 1992 Canadian dollars

	Full sample	Young	Old	Unrated	Bond rating	Small	Large
Total assets (*TA*)	1920.33	628.60	2948.68	458.39	4591.84	65.49	3142.05
	(4224.31)	(1164.96)	(5347.39)	(1034.23)	(6122.34)	(61.90)	(5083.63)
Inventory stock (*N*)	259.42	60.06	418.12	458.39	4591.84	65.49	3142.05
	(621.26)	(108.97)	(791.93)	(1034.23)	(6122.34)	(61.90)	(5083.63)
Sales (*S*)	389.18	117.06	605.82	123.30	875.05	18.49	633.35
	(782.42)	(208.60)	(979.45)	(241.21)	(1122.57)	(20.91)	(930.15)
Cash flow (*CF*)	35.35	11.15	54.61	10.37	80.99	1.07	57.92
	(80.05)	(36.08)	(98.19)	(36.01)	(111.96)	(3.16)	(96.65)
N/TA	0.165	0.156	0.173	0.179	0.140	0.195	0.146
	(0.098)	(0.095)	(0.100)	(0.103)	(0.082)	(0.112)	(0.081)
?N/TA	0.004	0.004	0.004	0.004	0.003	0.005	0.003
	(0.029)	(0.035)	(0.023)	(0.034)	(0.017)	(0.040)	(0.018)
S/N	2.150	2.248	2.072	2.108	2.227	1.856	2.343
	(2.237)	(2.833)	(1.609)	(1.844)	(2.816)	(1.691)	(2.515)
S/TA	0.255	0.241	0.266	0.282	0.206	0.268	0.247
	(0.123)	(0.133)	(0.113)	(0.131)	(0.088)	(0.133)	(0.115)
CF/TA	0.013	0.005	0.020	0.010	0.019	-0.001	0.022
	(0.044)	(0.056)	(0.031)	(0.053)	(0.017)	(0.064)	(0.020)
Number of obs.	2211	980	1231	1429	782	878	1333
Number of firms	166	94	89	125	41	104	88

Notes: Sample means are shown with standard deviations in parentheses. The total number of firms and observations for the subsamples do not add to totals for the full sample, since a firm can shift categories. "Young" refers to observations where age is lower than the median age of firms in the sample at that time. "Unrated" contains observations on firms that did not have a bond rating as of the end of the sample period, and "Bond rating" refers to those that did. "Small" consists of observations on firms with total assets less than the median value in a given quarter, while the remaining observations make up "Large."

Table 3: Regression Results for Full Sample of Firms: Regressions Using All Cash Flow Observations versus Non-negative Cash Flow and Negative Cash Flow Observations

	All cash flow observations, full sample 166 firms 2211 obs.	Non-negative cash flow observations only, full sample 135 firms 1475 obs.	Negative cash flow observations only, full sample 30 firms 134 obs.
$?CF_{it-1} / TA_{it-1}$	0.046	0.380***	-0.048
	(0.069)	(0.141)	(0.057)
$?S_{it-1} / N_{it-1}$	0.008***	0.012***	0.001
	(0.003)	(0.002)	(0.002)
$?r_{t-1}$	-0.002	0.005	0.031***
	(0.004)	(0.003)	(0.005)
$S??N_i / TA_i$	-0.144*	-0.323***	-0.281*
	(0.079)	(0.079)	(0.150)
$S??S_i / TA_i$	-0.032	-0.024	0.0722
	(0.055)	(0.036)	(0.083)
$S??CF_i / TA_i$	-0.087	-0.523***	0.060
	(0.077)	(0.195)	(0.096)
$S??r$	-0.001	-0.006	-0.018
	(0.005)	(0.004)	(0.008)**
Sargan test	130.5	105.2	0.00
	(1.00)	(1.00)	(1.00)
*m*2 test	0.80	1.45	-0.13
	(0.42)	(0.15)	(0.90)

Notes: The dependent variable is the first-difference of inventory investment divided by total assets in period *t*, $??Nit/TA_{it}$. $S??X$ provides the sum of coefficients for two lags of the second difference of *X*. All equations are estimated with the Arellano-Bond GMM estimator with $?S_{it-1}/N_{it-1}$, $?r_{t-1}$, $?CF_{it-1}/TA_{it-1}$, two lags of $??S_{it}/TA_{it}$, $??CF_{it}/TA_{it}$, $??r_t$, and $??N_{it-3}/TA_{it-3}$, and further lags as instruments. Differenced time dummies are also included in the instrument set. Standard errors are shown in parentheses. Standard errors and test statistics for coefficients are robust to heteroscedasticity. The significance of coefficients at various levels is indicated by *** for the 1 per cent level, ** for the 5 per cent level, and * for the 10 per cent level. Two-step results for the Sargan test and *m*2 test are reported with *p*-values in parentheses. One-step results are presented for coefficients and test statistics.

Table 4: Regression Results with Sample Split by Age of Firms: Regressions Using All Cash Flow Observations versus Non-negative Cash Flow Observations Only (standard errors shown in parentheses)

	All cash flow observations		Non-negative cash flow observations only	
	Young firms 94 firms 980 obs.	Old firms 89 firms 1231 obs.	Young firms 78 firms 621 obs.	Old firms 72 firms 854 obs.
$?CF_{it-1} / TA_{it-1}$	-0.060	0.248*	0.278*	0.585***
	(0.069)	(0.135)	(0.161)	(0.185)
$?S_{it-1} / N_{it-1}$	0.006***	0.018***	0.008***	0.009***
	(0.002)	(0.005)	(0.003)	(0.003)
$?r_{t-1}$	-0.006	0.001	-0.008**	-0.001
	(0.006)	(0.003)	(0.003)	(0.002)
$S??N_i / TA_i$	-0.204*	-0.136	-0.318***	-0.390***
	(0.108)	(0.102)	(0.105)	(0.096)
$S??S_i / TA_i$	-0.055	-0.079	-0.042	-0.060
	(0.064)	(0.060)	(0.047)	(0.053)
$S??CF_i / TA_i$	0.045	-0.190	-0.423	-0.467*
	(0.072)	(0.154)	(0.271)	(0.257)
$S??r$	0.001	0.001	0.000	0.002
	(0.005)	(0.002)	(0.005)	(0.003)
Sargan test	58.91	54.44	41.90	35.63
	(1.00)	(1.00)	(1.00)	(1.00)
*m*2 test	1.27	-1.11	0.69	-0.52
	(0.20)	(0.27)	(0.49)	(0.61)

Note: See notes to Table 3.

Table 5: Regression Results with Sample Split by Bond Rating: Regressions Using All Cash Flow Observations versus Non-negative Cash Flow Observations Only (standard errors shown in parentheses)

	All cash flow observations		Non-negative cash flow observations only	
	Unrated firms	Rated firms	Unrated firms	Rated firms[a]
	125 firms	41 firms	94 firms	40 firms
	1429 obs.	782 obs.	923 obs.	488 obs.
$?CF_{it-1} / TA_{it-1}$	0.055	0.267***	0.283*	0.273***
	(0.069)	(0.102)	(0.165)	(0.104)
$?S_{it-1} / N_{it-1}$	0.008***	0.007**	0.012***	0.000
	(0.003)	(0.003)	(0.003)	(0.001)
$?r_{t-1}$	-0.004	-0.002	-0.003	-0.002
	(0.006)	(0.002)	(0.004)	(0.002)
$S??N_i / TA_i$	-0.169**	-0.229**	-0.358***	-0.411***
	(0.085)	(0.101)	(0.080)	(0.091)
$S??S_i / TA_i$	-0.038	-0.093**	-0.022	0.012
	(0.065)	(0.044)	(0.040)	(0.042)
$S??CF_i / TA_i$	-0.081	-0.291***	-0.364	-0.048
	(0.081)	(0.117)	(0.230)	(0.279)
$S??r$	-0.003	0.002	0.001	0.005
	(0.006)	(0.002)	(0.004)	(0.003)
Sargan test	89.70	5.34	63.77	1.81
	(1.00)	(1.00)	(1.00)	(1.00)
$m2$ test	0.45	-0.88	1.06	-1.89
	(0.66)	(0.38)	(0.29)	(0.06)

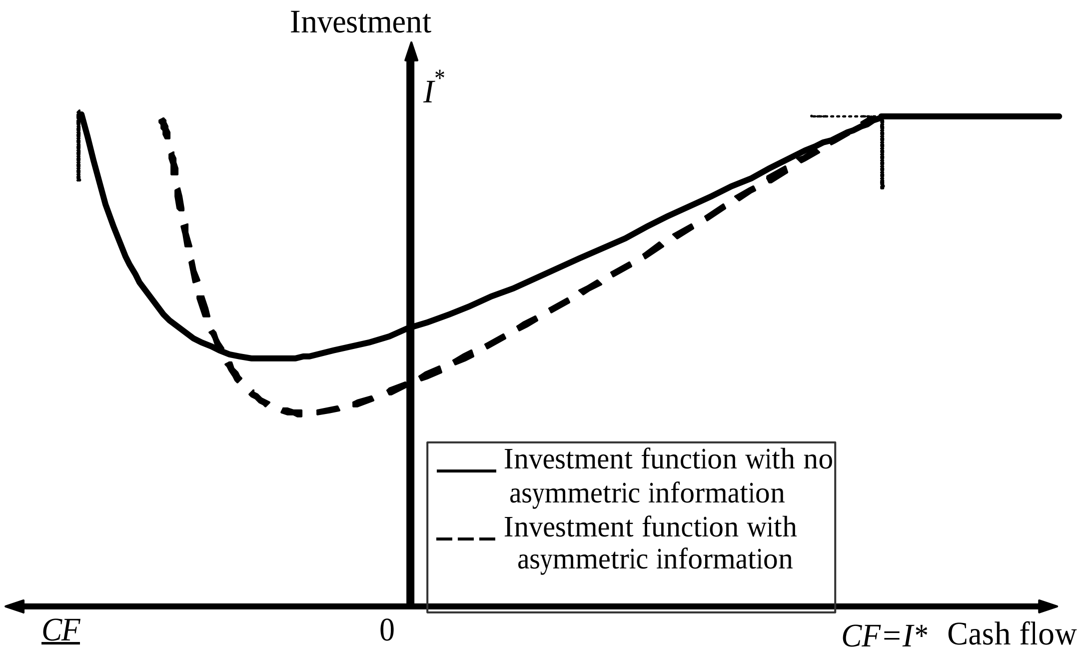
a. The $m2$ test for the original regression equation shows that the residuals are AR (2). I correct for this by using the same long-run variables as the original instrument set, but using the earlier lags (t-2 and t-3) of the short-run variables for sales, cash flow, and interest rates as instruments. See notes to Table 3.

Table 6: Regression Results with Sample Split by Size of Firm: Regressions Using All Cash Flow Observations versus Non-negative Cash Flow Observations Only (standard errors shown in parentheses)

	All cash flow observations		Non-negative cash flow observations only	
	Small firms 104 firms 878 obs.	Large firms[a] 86 firms 1231 obs.	Small firms 77 firms 582 obs.	Large firms 75 firms 893 obs.
$?CF_{it-1} / TA_{it-1}$	0.021	0.046	0.365**	0.464***
	(0.077)	(0.032)	(0.161)	(0.144)
$?S_{it-1} / N_{it-1}$	0.010***	0.004**	0.008***	0.009***
	(0.004)	(0.002)	(0.002)	(0.004)
$?r_{t-1}$	-0.002	0.001	-0.001	-0.003
	(0.008)	(0.001)	(0.004)	(0.002)
$S??N_i / TA_i$	-0.194*	-0.275***	-0.379***	-0.407***
	(0.103)	(0.069)	(0.095)	(0.112)
$S??S_i / TA_i$	-0.052	0.008	-0.018	-0.079**
	(0.077)	(0.035)	(0.047)	(0.033)
$S??CF_i / TA_i$	-0.048	0.000	-0.495**	-0.487**
	(0.090)	(0.045)	(0.253)	(0.235)
$S??r$	-0.008	0.000	-0.007	0.003
	(0.009)	(0.002)	(0.006)	(0.004)
Sargan test	64.57	52.02	42.54	39.76
	(1.00)	(1.00)	(1.00)	(1.00)
*m*2 test	0.000	1.30	0.64	0.52
	(1.00)	(0.20)	(0.53)	(0.60)

a. The *m*2 test for the original regression shows that the residuals may be AR (2). I correct for this by using the same variables as the original regression, but each variable is lagged one further period. See notes to Table 3.

Figure 1: The Effect of Cash Flow and Asymmetric Information on Investment in Povel and Raith's Model



Appendix: Variable definitions

Variable	Description
GDP deflator	Implicit price index, all items. Statistics Canada, Cansim series label D15612.
Inventory stock (*N*)	Compustat data on total inventories. Defined as merchandise bought for resale and materials and supplies purchased for use in production of revenue, including work in progress. Total nominal inventory stock converted to real terms using GDP deflator.
Inventory investment (*DN*)	Calculated from nominal Compustat data on total inventory stocks deflated using the GDP deflator. Defined as change in real inventory stocks N_{it}-N_{it-1}.
Cash flow (*CF*)	Compustat data defined as income before extraordinary items (income after all expenses except dividends) plus depreciation and amortization charges. Nominal cash flow is converted to real using the GDP deflator.
Sales (*S*)	Compustat data defined as sales net of cash discounts, trade discounts, returned sales, and allowances. Nominal sales converted to real terms using GDP deflator.
Total assets (*TA*)	Current assets plus net property, plant, and equipment plus other non-current assets (including intangible assets, deferred items, investments, and advances). Nominal values converted to real terms using GDP deflator.
Real interest rate (*r*)	Calculated as the prime lending rate less the inflation rate. The inflation rate is calculated using the GDP deflator. Prime interest rate data are from the Bank of Canada.

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