Essays on Financial Aspects of Macroeconomics and
Monetary Policy

by

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in partial fulfillment of the requirements for the degree of
Doctor of Philosophy

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Canada

Abstract

The principal theme of this thesis is to examine how financial market imperfections affect the economy. This thesis consists of three chapters.

Chapter 1 examines the credit channel of monetary policy transmission mechanism. In particular I examine the credit channel's role as a propagating mechanism in Canada. A structural vector auto-regression (SVAR) framework is used to identify monetary policy shocks. The results suggest a propagating role of the credit channel. I also compare the responses of prices to monetary policy shocks between the most and least financially dependent firms. I find important differences that suggest a link between nominal rigidities and sensitivity to credit market imperfections.

Chapter 2 examines implications of finance constraints and corporate governance problems for investment. Finance constraints imply that some firms with good investment opportunities may under-invest because they cannot raise enough funds. Governance problems, on the other hand, refer to the agency problems arising between managers and owners in firms with high free cash flows but poor investment opportunities. Using a firm level balance sheet and income statement dataset from Statistics Canada I find that investment in some firms that are less likely to be finance constrained can yet show high cash flow sensitivity due to the potential presence of the corporate governance problems.

Chapter 3 explores the role of financial innovation in the moderation of macroeconomic volatility in Canada. Like most of the developed countries, Canada has also experienced a moderation in the business cycle in recent decades. Better

monetary policy, and improved inventory management are just some of the explanations usually put forward for this moderation. More recently, it has been argued that financial innovation may be yet another source of the decline in macroeconomic volatility. However, the recent financial crisis has raised the possibility that financial innovation might, under some circumstances, lead to substantially greater macroeconomic volatility. The findings in this chapter suggest that even if we look at the pre-crisis period data, it is difficult to find definitive evidence that financial innovation has played a role in the great moderation.

Dedication

To my father Late Md. Oheedun Noor, and my mother Late Ali Raushan.

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Chapter 1

The Credit Channel in a Small Open Economy

1. Introduction

Recent events – specifically, the subprime mortgage crisis and subsequent dislocations in financial markets – raise important questions about the role of credit in the macroeconomy. In the real world, many observers believe that disruptions in credit markets play an important role in macroeconomic fluctuations. This paper uses structural VARs to analyze the importance of the credit channel in a small, open economy. According to the conventional account of the monetary policy transmission mechanism, a contractionary monetary policy shock raises the nominal interest rate. Due to nominal rigidities, this raises the real interest rate. An increase in the real interest rate reduces the interest-sensitive components of aggregate spending. This shifts the aggregate demand curve to the left, reducing both real output and the nominal price level. A substantial literature examines whether there is an additional credit channel for monetary policy.¹ Two possible channels have been explored. The first is the broad credit channel, which works through balance sheet effects. The second is the narrow credit channel, sometimes also referred to as the bank lending channel. This paper is primarily about the broad credit channel.

Bernanke and Gertler (1995) document four sets of stylized facts about monetary policy. Their first stylized fact is that monetary policy has a transitory

¹ A partial list of influential papers on the link between credit market imperfections and aggregate fluctuations includes Bernanke (1983), Bernanke and Gertler (1989), Bernanke, Gertler, and Gilchrist (1999), Carlstrom and Fuerst (1997), and Kiyotaki and Moore (1997).

effect on the interest rate but a persistent effect on real output and the nominal price level. Second, final demand falls quickly in the wake of a contractionary monetary policy shock, but output falls more slowly, implying that inventories increase in the first quarter or two after a monetary-policy-induced increase in the interest rate. Third, early, sharp declines in final demand occur in residential investment and consumption. Fourth, business fixed investment declines after the initial interest rate shock has largely dissipated.

To a first approximation, these stylized facts seem consistent with the conventional story. The slow response of nominal prices is consistent with the idea that monetary policy affects the short-term real interest rate, even though monetary policy operates directly through the nominal interest rate. The declines in residential investment and business fixed investment are consistent with the idea that the increase in the real interest rate, induced by monetary policy, affects interest-sensitive components of aggregate spending.

There are puzzles with the conventional story, though. The first might be referred to as the “magnitude puzzle”. Small changes in the nominal interest rate seem to have large effects on real variables. But much empirical research on specific components of output (e.g., business fixed investment) suggests that the interest rate has relatively small effects.²

The second puzzle might be called the “timing puzzle”. The change in the nominal interest rate induced by a monetary policy shock is transitory. For example,

² See, e.g., the survey by Chirinko (1993) on business fixed investment and the survey by Ramey and West (1999) on inventory investment.

Bernanke and Gertler (1995) find that the interest rate is largely back to its initial level in three quarters. On the other hand, the peak effect of monetary policy on some components of spending occurs later. For example, the peak effect on business fixed investment occurs after the increase in the interest rate has largely dissipated. In fact, the poor correspondence in timing between interest rate movements and quantity movements in components of spending, such as business fixed investment, may help explain why it has traditionally been hard to find strong cost-of-capital effects.³

The third puzzle might be referred to as the “composition puzzle”. Monetary policy affects the short-term interest rate. It should therefore have the largest effect on short-lived assets. But the biggest effects of monetary policy are usually on investment, particularly fixed investment.⁴

Bernanke and Gertler’s focus is on a large economy (the US) in which external linkages play a relatively small role. We start by examining whether the stylized facts hold in a small, open economy. The specific country we focus on is Canada. We expand our focus beyond the “closed economy” transmission mechanism, examining the conventional open economy monetary policy transmission mechanism and checking to see how well it corresponds with the empirical evidence.

We find evidence that is supportive of the conventional “closed economy” monetary policy transmission mechanism. In particular, we find that nominal prices

³ This is consistent with recent evidence showing that the relationship between the capital stock and the real interest rate is stronger in the long run than at business cycle frequencies. See Caballero (1994, 1999) and Schaller (2006) on equipment capital and Maccini, Moore, and Schaller (2004) on the stock of inventories. All of these papers argue that high-frequency dynamics make it difficult to discern the long-run relationship between the interest rate and the capital stock using econometric techniques that emphasize high-frequency variation in the data.

⁴ All of these puzzles are documented by Bernanke and Gertler (1995).

tend to be sticky, that contractionary monetary policy shocks reduce the interest-sensitive components of aggregate spending, and that these reduce both real output and the nominal price level. We also find evidence that is consistent with the conventional open economy transmission mechanism. A contractionary monetary policy shock is followed by an appreciation of the Canadian dollar and eventually a decrease in net exports.

We also find that these stylized facts raise the three puzzles – about the magnitude, timing, and composition of the effects of monetary policy – that provide evidence for the credit channel, according to Bernanke and Gertler (1995).

A novel contribution of our paper is to examine differences in the response to monetary policy shocks between firms that might be expected to behave differently if credit market frictions are important for some firms. This approach is very much in the spirit of Gertler and Gilchrist (1994) who compare the response of small and large manufacturing firms to monetary policy shocks.

We use the Rajan and Zingales (1998) characterization of financial dependence to investigate the link between financial market imperfections and the effects of monetary policy. Rajan and Zingales (1998) develop a procedure for determining financial dependence in the context of looking at the relationship between financial dependence and growth. Their idea is to identify an industry's dependence on external finance using US data and then apply the resulting industrial classification to other countries. In particular, they examine whether industries that are more dependent on external finance grow faster in countries that are more financially developed. The Rajan and Zingales (1998) approach has been used to

study economic growth but has not (to the best of our knowledge) previously been used to study business cycle fluctuations. Our innovation is to apply the Rajan-Zingales measure of financial dependence to study the monetary policy transmission mechanism. The data show significant differences in the response of prices and output to policy shocks between the most and least financially dependent industries.

In the literature on the credit channel, there has been a discussion about whether movements in the quantity of credit are due to shifts in credit supply or credit demand.⁵ There is a strong theoretical basis for skepticism about interpreting a decrease in the quantity of credit as evidence of a shift in credit supply. For example, a negative demand shock might lead firms to lower their expectations about future demand and correspondingly scale back their investment projects. With less investment demand, firms might need to borrow less, leading to a leftward shift of the demand for credit. Similarly, an adverse technology shock might lead households to lower their expectations of permanent income. Depending on the aggregate time profile of consumption and labour income and the rate of time preference, among other factors, this might lead to a decrease in household credit demand.

In contrast, the credit channel involves a leftward shift in credit supply (due to balance sheet effects, such as the reduction in collateral, that make financial intermediaries less willing to lend at a given interest rate).⁶ It has proved difficult to

⁵ See, e.g., Kashyap, Lamont, and Stein (1994), p.568.

⁶ Here we focus on the simplest example, which involves the shift in a conventional supply curve, but there are other possibilities that could result in credit channel effects. For example, the reduction in internal finance could tighten constraints on finance-constrained households or firms, leading to an increase in the shadow cost of external finance (and the external finance premium). Stiglitz and Weiss (1981) provide a model of another possibility – a backward-bending loan supply curve.

provide evidence on whether a reduction in the quantity of credit was due to a shift in credit supply, rather than demand.⁷

We adopt two distinct approaches to distinguish between shifts in credit demand and credit supply. The first is based on using both prices and quantities. While shifts in credit supply and demand have the same implication for the quantity of credit, they have opposite implications for the price of credit.

The second is based on the reaction in domestic and foreign markets to a contractionary monetary policy shock. If there is a shift in credit demand – due, for example, to lower expectations of product demand and scaled-back investment projects – it should affect credit demand by domestic firms both in the domestic credit market and in the foreign market. On the other hand, a monetary policy shock in a small economy will have a negligible effect on credit supply in a large economy. Thus, if the quantity of credit for domestic firms falls in both the domestic and foreign market, it provides evidence of a shift in credit demand. If the quantity of credit for domestic firms falls in the domestic market but remains unchanged in the foreign market, it provides evidence of a shift in a domestic credit supply curve.

The paper is organized as follows. Section 2 reviews existing literature on the credit channel and issues involved with identification of shocks in small open economies. It also presents the identifying assumptions for our structural VAR and briefly describes the data. Section 3 presents the impulse response functions that are relevant to the “closed economy” transmission mechanism. Section 4 presents

⁷ One of the best pieces of evidence comes from Peek and Rosengren (1997), who use data on Japanese banks to distinguish shifts in credit demand by American firms from shifts in the supply of credit by Japanese banks.

evidence on the conventional open economy transmission mechanism. Section 5 uses the Rajan-Zingales measure of financial dependence to examine differences in the response of prices and output to monetary policy shocks. Section 6 discusses how we use price and quantity movements to identify credit market shifts. Section 7 shows how we use domestic and foreign markets to identify credit market shifts. Section 8 provides a summary and conclusion.

2. Empirical Methodology and Data

In order to investigate the credit channel in a small open economy context we need to address a couple of methodological issues. First, looking for evidence of the credit channel using aggregate data is challenging. It is hard to separate the effect coming through the credit channel from the effects coming through the conventional interest rate channel in aggregate data. As the credit channel is merely a propagation mechanism, it predicts almost the same response of economic variables to a change in the monetary policy as the interest rate channel and hence makes it difficult to examine whether the credit channel has played any significant role in the overall transmission of monetary policy. Section 2.1 below reviews strategies followed by previous studies in capturing the presence and significance of credit channel. Second, we need to come up with an identification scheme that would capture structural shocks in the VAR specification of the economy. As discussed in section 2.2 below, identification of structural shocks in a small open economy is particularly challenging.

2.1 Capturing Evidence on the Credit Channel

Literature classifies the credit view into two channels, the ‘bank lending channel’ and the ‘balance sheet channel’. The bank lending channel rests on the fact that for a wide range of borrowers, bank credit is the only source of external finance. According to this channel, following a contractionary policy action, total money available in the banking system shrinks, which in turn leads to a decline in the total quantity of funds banks are able to disburse as loans. If some borrowers are bank dependent, aggregate spending of these borrowers are affected due to the contraction in bank credit. According to the balance sheet channel, monetary policy affects firms’ balance sheets in at least three ways. First, a contractionary monetary policy shock affects balance sheets directly by increasing interest expenses (and thus decreasing the amount of internal finance available to firms). Second, contractionary monetary policy tends to decrease asset prices and thus the value of collateral. This is also a direct effect. Third, contractionary monetary policy indirectly affects firms’ balance sheets by decreasing demand and thus decreasing revenue (and internal finance).⁸

Although it is straightforward to analytically delineate these effects, it is an open question as to whether they make a quantitatively important difference to the monetary policy transmission mechanism. Kashyap, Stein and Wilcox (1993) relied on the composition of external finance to capture the credit channel. They find that commercial paper issuance rises while bank loans remain unchanged following each

⁸ In an open economy, monetary policy can also affect the nominal exchange rate. If debt is denominated in foreign currency, unexpected movements in the nominal exchange rate can affect net worth (as discussed, e.g., by Gertler, Gilchrist, and Natalucci (2007)).

date of tighter monetary policy stance (i.e. the Romer Dates identified by Romer and Romer (1990)). They interpret this as evidence of the bank lending channel (substitute bank loans with commercial paper as supply of bank credit decreases due to tight monetary policy). However, Gertler and Gilchrist (1993, 1994), and Oliner and Rudebusch (1996a, 1996b) argue that the results are more consistent with the presence of a broad credit channel. They looked at financing of small and large firms separately. They observe that the mix of bank and non-bank finance for both small and large firms, when looked separately do not show any noticeable change. However there is a shift of all kinds of financing from small firms to large firms. As large firms rely less on bank loan than small firms, this shift away from small firms to large firms causes a decline in bank loan's share in aggregate credit. However, it should be emphasized here that despite this debate about whether the results capture the bank lending channel or the balance sheet channel, the evidence presented in these studies supports the existence of an overall credit channel.

In Canada, using a recursive VAR scheme, Montplaisir, Kasumovich, Thurlow and Gupta (1995) examined the significance of the credit channel in the monetary policy transmission mechanism. In particular, they find that 'Mix', defined as the ratio of short term intermediated credit to total short term business credit actually rises (characterized by both a reduction in the intermediated credit and a more pronounced reduction in the commercial paper). Overall, they were unable to find any evidence of a bank lending channel in Canada, although they argue that their findings could be consistent with the potential presence of a broad credit channel.

A few studies attempt to employ structural VAR (SVAR) schemes to examine the credit channel. But an overwhelming majority of the studies primarily focus on the bank lending channel. Using a five-variable SVAR, Cameron and Safaei (2003) examine the impact of shocks or innovations in bank credit on output and other major macroeconomic variables in Canada. The small five-variable system does not take account of the open economy aspect of Canada. Their main focus is on examining whether changes in financial status could be an independent source of output fluctuations rather than just propagation mechanisms accelerating non-financial disturbances. They specifically focus on bank credit, so as to capture the special role of banks in financial intermediation. They also examine the response of credit aggregates to monetary policy shocks (either measured by a shock to the monetary base or deposit interest rate). Credit aggregates show positive response to an expansionary monetary policy shock. They interpret this as supporting evidence of a significant credit channel. Berkelmans (2005) uses an SVAR to investigate the relationship between credit aggregates and macroeconomic activities in Australia. Rather than focusing on examining the presence and extent of the credit channel, Berkelmans investigates the interaction between credit aggregates, monetary policy and macroeconomic variables. Although the seven-variable SVAR model generated large confidence bands (i.e. mostly insignificant) for the impulse responses, variance decompositions suggest that at short horizons, shocks to the interest rate, the exchange rate, and past shocks to credit matter in explaining credit movements. Over longer horizons, shocks to output, inflation and commodity prices dominate in explaining credit movements. On the other hand, following a positive shock to credit,

monetary policy reacts to effectively stabilize most of the macroeconomic variables except inflation, which shows a persistent positive response to the shock. Wrobel and Pawlowska (2002) investigates the bank lending channel and the interest rate pass through mechanism in Poland. Using both a recursive VAR model and a non-recursive SVAR model they note some distinguishing characteristics of the monetary transmission in Poland compared to the Euro zone. Short term credit to private individuals decreases following a contractionary monetary policy shock, although long term credit shows an initial increase and then a fall. On the other hand, short term credit to firms do not react to the contractionary shock, and long term credit initially rises but eventually falls. Markidou and Nikolaidou (2008) used Cameron and Safaei's SVAR model to examine the bank lending channel in Greece. Their evidence suggests that consumers rather than firms are more susceptible to the operation of the bank lending channel. However, several studies have questioned whether the strength of the bank lending channel has dwindled in recent decades; especially in more financially developed economies such as the US. For example, Romer and Romer (1990) point out that in the face of a contractionary monetary policy, banks can mitigate their funding shortages by issuing managed liabilities (such as certificates of deposit), and hence may not have to shrink the amount of loanable funds. Likewise, Bernanke and Gertler (1995), and Gertler and Gilchrist (1993) argue that due to financial innovation and deregulation (such as the removal of Regulation Q in the US), it has become easier for banks to overcome funding shortages. It is worth noting here that Canada never had anything similar to Regulation Q, which imposed ceilings on deposit interest rates in the US. Thus the

bank lending channel might be even less relevant for Canada. In any case, the existence of the bank lending channel does not require that banks are totally incapable of raising funds from alternative sources. As long as banks face an upward sloping supply curve for alternative funding sources, the bank lending channel can be operative.

Our paper is mainly about the broad credit channel, which relates monetary policy to aggregate economic outcomes through the balance sheet situation of borrowers. Rather than relying on the special role of banks (as assumed by the bank lending channel), the broad credit channel emphasizes the propagation mechanism that comes from informational asymmetries between borrowers and lenders.

2.2 The Identification Scheme

When applied to small open economy data, VAR studies using the recursive (i.e Choleski factorization) approach to identify monetary policy shocks frequently encounter two puzzles, namely the “price puzzle” and the “exchange rate puzzle”. Sims (1992) uses a 6-variable VAR system to study monetary policy transmission in five OECD countries (but not Canada). His impulse responses showed oddly persistent and positive response of price level in France and Japan to a positive shock in the interest rate. Similarly depreciation for the case of France and Germany were found following a positive innovation in the interest rate. As Cushman and Zha (1997) point out, the recursive identification scheme makes more sense in the case of US economy which is more impervious to developments outside the economy. For a small open economy one has to account for the sensitivity of the monetary policy

stance to foreign variables. Even if the Choleski identification scheme in a small open economy contains some representative variables of foreign shocks (such as world export commodity price index and exchanges rate in Sims (1992)), it apparently fails to capture the full significance of this consideration. Cushman and Zha follow a non-recursive structural VAR (SVAR) identification for Canada to overcome the problem. Similarly, Kim and Roubini (2000) address the identification problem for small open economies by using a structural vector auto-regression (SVAR) approach. Their non-recursive identification scheme involves seven-variables, and is able generate intuitive impulse responses for all non-US G-7 countries.⁹ Here we use a structural identification scheme similar in spirit to Kim and Roubini (2000).

Our identifying assumptions involve the contemporaneous coefficient matrix and can be summarized in the following equation that links the reduced-form errors to the structural shocks.

$$\begin{bmatrix} e_P \\ e_Y \\ e_M \\ e_i \\ e_s \\ e_{WP} \\ e_{FFR} \\ e_o \end{bmatrix} = \begin{bmatrix} 1 & g(P,Y) & 0 & g(P,i) & 0 & g(P,WP) & 0 & 0 \\ 0 & 1 & 0 & g(Y,i) & 0 & g(Y,WP) & 0 & 0 \\ g(M,P) & g(M,Y) & 1 & g(M,i) & 0 & 0 & 0 & 0 \\ g(i,P) & g(i,Y) & g(i,M) & 1 & g(i,s) & g(i,WP) & g(i,FFR) & 0 \\ g(s,P) & g(s,Y) & g(s,M) & g(s,i) & 1 & g(s,WP) & g(s,FFR) & g(s,o) \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & g(FFR,WP) & 1 & 0 \\ 0 & 0 & 0 & g(o,i) & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_P \\ u_Y \\ u_M \\ u_i \\ u_s \\ u_{WP} \\ u_{FFR} \\ u_o \end{bmatrix} \quad (1)$$

where the e_j represent the structural disturbances and the u_j represent the residuals in the reduced form VAR equations, P is the price level, Y is real output, M is money, i is the interest rate (overnight rate), s is the exchange rate (\$CAN/\$US), WP is the

⁹ However they report some deviations from uncovered interest rate parity.

world price of commodities (commodity price index in \$US), FFR is the Fed funds rate, and o is the “Other” variable. P, Y, M, and WP enter in the VAR in logs; i, FFR, and s enter as simple rates.

Here the “Other” variable (o) refers to additional variables that we are interested in. We introduce these variables one at a time in the system. The purpose of including a single additional variable in the VAR is to maintain the VAR at a manageable size, while allowing us to examine the response of many different variables to monetary policy shocks. A similar strategy has been used by Bernanke and Gertler (1995) and Christiano, Eichenbaum, and Evans (1996), among others. The “other” variables enter in logs if they are prices, in simple percentage terms if they are interest rates, and as the ratio of six-year moving average of GDP if they are volumes. Although some of the variables in the system (such as P, Y, M, and WP) are most likely to be non-stationary, we do not make any transformation (such as first differencing) to make them stationary. This approach follows the existing literature on VAR, for example, Bernanke and Gertler (1995), Kim and Roubini (2000), Cushman and Zha (1997), Sims (1992), Berkelmans (2005), who prefer variables in levels in order to avoid misspecification.¹⁰

The first and second equations in the above system represent the domestic goods market. We allow output to affect the price level contemporaneously, as a recursive representation of a standard, textbook AD-AS system. In addition, we allow supply shocks (represented by commodity price index) and monetary policy

¹⁰ Perhaps the best way to verify if the nonstationarity issue is significant is to see if the resulting impulse responses conform with theoretical predictions. For more details see Sims, Stock, and Watson (1990), and the discussions in Hamilton (1994), pp. 651-652, and Enders (2004), pp. 270.

shocks to have a contemporaneous effect. We assume that other variables affect the domestic goods market only with a lag.¹¹

The third and fourth equations represent demand and supply in the money market. The third equation represents money demand, which is assumed to depend contemporaneously on the interest rate, the price level, and income. This is the standard assumption in the literature. The fourth equation represents the monetary policy reaction function. We assume that the domestic central bank (Bank of Canada) sets the interest rate after observing the current values of money, the price level, output, the exchange rate, the commodity prices, and the foreign interest rate.¹²

The fifth equation involves the exchange rate. Since the exchange rate is a forward-looking variable that evolves continuously through time, we allow shocks to all the other variables to affect the exchange rate contemporaneously. Cushman and Zha (1997) and Kim and Roubini (2000) follow similar strategies.

The sixth equation involves world prices. We treat commodity prices as exogenous (at least contemporaneously), an appropriate assumption for a small, open economy.

The seventh equation represents US monetary policy. We treat US monetary policy as being exogenous to domestic variables in the Canadian economy (at least

¹¹ Exchange rate shocks may well have an effect on the domestic goods market, but the literature on the J-curve suggests that the effect of changes in the exchange rate on quantities (the volume effect) involves a lag of several months, so we maintain the assumption that $g(P,s) = g(Y,s) = 0$.

¹² These assumptions are less restrictive than those of many papers in the literature. We allow monetary policy to respond contemporaneously to more variables for two reasons. First, we want to ensure that we capture monetary policy shocks, rather than the endogenous reaction of monetary policy to supply or other shocks. Second, our less restrictive assumptions reflect the fact that we are using quarterly data, while many papers use monthly data, where more restrictive assumptions may be more appropriate.

contemporaneously). Again, this seems like an appropriate assumption for a small, open economy. We do, however, allow supply shocks to influence US monetary policy contemporaneously, an assumption that is symmetric with our assumption that supply shocks may enter the Bank of Canada's monetary policy reaction function contemporaneously.

Finally, we include one "Other" variable in each VAR. In calculating the main impulse response functions, the "other" variable is business fixed investment. As is the case for output, we assume that the interest rate can affect business fixed investment within the quarter but restrict the contemporaneous response of business fixed investment to other variables to zero. Allowing supply shocks to affect business fixed investment makes little difference to the impulse response functions.

We examined the robustness of the results to the relaxation of some other restrictions. In particular, the impulse response functions are very similar if we allow the interest rate to be contemporaneously affected by business fixed investment. Again, the impulse response functions are very similar if we allow supply shocks to affect business fixed investment and allow business fixed investment to enter the contemporaneous monetary policy reaction function.

In all cases, we include four lags of the variables in the VAR. The only identifying assumptions involve zero restrictions on the contemporaneous coefficient matrix, as outlined in equation (1). We impose no restrictions on lagged coefficients.

To satisfy the order condition, $N(N-1)/2$ restrictions are required to identify the structural VAR using the contemporaneous coefficient matrix, where N is the number of variables in the VAR. The foregoing assumptions imply 33 zero

restrictions, so we have 5 overidentifying restrictions. We need to take account of the fact that the model is overidentified while computing confidence bands for impulse responses. Sims and Zha (1999) outline a method for constructing confidence bands for an overidentified system. We employ their method to construct confidence bands based on 10,000 replications (using RATS software).

We use Canadian data for the period 1980:1-2004:4. Because we examine components of expenditure, we must use quarterly, rather than monthly, data. Our sample is the longest time period for which we were able to obtain all the necessary data. The appendix describes data sources and the construction of variables in detail.

3. The “Closed Economy” Stylized Facts

In a closed economy, the conventional transmission mechanism works through the effect of monetary policy on interest-sensitive components of domestic spending, such as investment. To distinguish this mechanism from the effects that work through the exchange rate and net exports (the conventional open economy transmission mechanism), we refer to the effects through the interest-sensitive components of domestic spending as the “closed economy” mechanism.

Figure 1 shows the impulse response function of the overnight rate to a one standard deviation shock to itself, which can be considered as a contractionary monetary policy shock. The central line shows the impulse response function. The dashed lines represent the 95% confidence band. Consistent with the stylized facts for the US (a large economy in which imports and exports constitute a relatively small fraction of GDP), monetary policy in Canada has a transitory effect on the

interest rate. By two quarters after the shock, the interest rate is close to its pre-shock level and no longer significantly higher.

Figure 2 shows the effect of a contractionary monetary policy shock on the price level and output. Monetary policy clearly has a persistent effect on both the price level and output, an effect that lasts much longer than the increase in the interest rate.

Figure 3 shows the impulse response functions for business fixed investment, residential investment, and consumption. The impulse responses of these variables are obtained by plugging them one at a time into the SVAR system as the “other” variable (see section 2.2 for details). The peak effect on both types of investment occurs about four quarters after the monetary policy shock. Thus, the peak effect occurs after the effect on the interest has largely dissipated.

Figure 4 shows the impulse response function for final demand to a contractionary monetary policy shock. As we can see from the figure, final demand falls quickly and exhibits a hump-shaped pattern.

In summary, in Canada, a small open economy, as in the US, a large economy, the conventional account of the monetary policy transmission mechanism largely fits the facts. However, the same key puzzles that we discuss in the introduction – the magnitude puzzle, timing puzzle, and composition puzzle – are also present.

4. The Conventional Open Economy Channel

According to the conventional account, in an open economy, a contractionary monetary policy shock increases the interest rate. This tends to induce capital inflows,

which put upward pressure on the domestic currency. Under a floating exchange rate regime, the domestic currency tends to appreciate. In the very short run, this increases net exports (due to the value effect). Over time, the appreciation of the domestic currency tends to decrease the competitiveness of the economy, leading to a drop in net exports.

Figure 5 shows the impulse response function of the exchange rate, which is measured as Canadian \$/US \$. A contractionary monetary policy shock quickly leads to an appreciation of the Canadian dollar.

Figure 6 shows the effect of a contractionary monetary policy shock on net exports. There is a slight increase in net exports in the very short run due to the value effect. Over time, the competitiveness of domestic products is affected and net exports fall.

The stylized facts for the Canadian economy correspond well to the conventional analysis of the effects of monetary policy in an open economy.

5. Financial Dependence and the Response to Monetary Policy Shocks

As noted in the introduction, we use the work of Rajan and Zingales (1998) to define financial dependence. Rajan and Zingales defined external finance dependence for each firm in a particular industry as capital expenditures minus cash flow divided by capital expenditures. Then they use the industry median to reflect external finance dependence of the industry. In order to rank industries based on this measure of external finance dependence they focus on large listed firms in the US, which are likely to be operating in a frictionless financial market. They argue that in

such a frictionless market the measure of external finance dependence would capture each industry's 'technological demand' for external finance, rather than capturing endogenous choice of financing composition. Based on the Rajan-Zingales ranking of industries by financial dependence, we identify the top quartile industries as the most financially dependent and the bottom quartile of industries as the least financially dependent (further details are provided in the appendix).

Figure 7 presents the impulse response function of output prices to a contractionary monetary policy shock for the least financially dependent industries. It corresponds closely to the effect we would expect under the conventional monetary policy transmission mechanism. After a lag, prices decline and the price decline is significant. Interestingly, the lag in the response of prices is slightly shorter for the least financially dependent industries than for the economy as a whole. For the economy as a whole, the price level hovers around its pre-shock level for about four quarters before it begins to decline, as shown in Figure 2. For the least financially dependent industries, the price decline begins one quarter after the monetary policy shock. The price decline is already significant by three quarters after the shock, much sooner than for the economy as a whole.

For the most financially dependent industries, the path of prices is qualitatively different, as shown in Figure 8. Prices hover close to their pre-shock level for more than two years after a contractionary monetary policy shock. In fact, over the five years subsequent to a shock that are plotted in Figure 8, there is no significant price decrease. The price path of the most financially dependent industries suggests a link between nominal rigidity and financial dependence.

These results have potentially important implications for monetary economics. Standard theories of economic fluctuations (and particularly of the operation of monetary policy) are based on the idea that menu costs (or perhaps sticky information) are the explanation for apparent evidence of nominal rigidities. In fact, menu costs (or perhaps sticky information) may be the most important reason for nominal rigidity. But the evidence presented in this section suggests that the financial market imperfections could play a significant role in generating nominal rigidity, at least for some firms.

The reaction of the least financially dependent industries to a monetary policy shock corresponds to the conventional monetary transmission mechanism, which works directly through changes in the interest rate. If the credit channel is relevant, the most financially dependent industries should show a time path of output that reflects the secondary effect of interest rate changes on balance sheet variables. In particular, the peak response of output should be larger – and should occur later – for the most financially dependent industries.

Figure 9 plots the impulse response function of output for the least financially dependent industries. Output begins to decline in the second quarter after the monetary policy shock. The maximum response occurs approximately ten quarters after the monetary policy shock.

Figure 10 plots the impulse response function for the most financially dependent industries. Although output begins to drop quite quickly after the shock for these industries, the peak impact of a monetary policy shock does not occur until

eight quarters after the shock, long after the direct interest rate effects have dissipated.

Output does not start to recover for fourteen quarters after the monetary policy shock.

6. Using Price and Quantity to Identify Credit Market Shifts

Many credit markets shrink after a contractionary monetary policy shock.

According to the advocates of a credit channel, this may represent a decrease in credit supply. Disentangling shifts in credit demand and credit supply has been a controversial area in debates about the credit channel.

To distinguish shifts in credit demand from shifts in credit supply we use an approach based on simple economics and illustrated in Figure 11, where r represents the real interest rate (the price of credit) and L represents the quantity of credit. If the demand curve for credit shifts to the left, the quantity of credit decreases, as does the interest rate. If the supply of credit shifts to the left, the interest rate rises.¹³

A structural VAR provides a way of analyzing the movements of price and quantity in response to a shock, specifically a monetary policy shock. Figure 12 shows the movements in price and quantity for loans from banks (and others) to non-financial industries. The interest rate on loans clearly rises in response to a contractionary monetary policy shock.¹⁴ The increase in the interest rate is highly significant in the initial quarters after the shock. The quantity of loans falls immediately after a contractionary monetary policy shock. The decrease in quantity

¹³ In the Stiglitz-Weiss (1981) model of credit rationing, it is possible that the interest rate might remain constant if the market was initially rationed, in which case the interest rate might remain at the point of inflection of the backward-bending credit supply curve.

¹⁴ The interest rate is the prime rate charged by chartered banks.

becomes significant about three quarters after the monetary policy shock. The data point to a shift in the supply curve for loans in the wake of a contractionary monetary policy shock.

Figure 13 shows the movements in price and quantity for consumer loans. The interest rate on consumer loans clearly rises in response to a contractionary monetary policy shock. The increase in the interest rate on consumer loans is highly significant in the initial quarters after the shock. The quantity of consumer loans begins to fall shortly after a contractionary monetary policy shock. The decrease in quantity is significant for several quarters after the monetary policy shock. The data point to a shift in the supply curve for consumer loans in the wake of a contractionary monetary policy shock.

Figure 14 provides corresponding impulse response functions for residential mortgages. Again, a contractionary monetary policy shock significantly increases the interest rate on residential mortgages. The quantity of residential mortgage loans also falls in the wake of a contractionary monetary policy shock. Again, the decrease is significant for several quarters and suggests a leftward shift in the supply of mortgage loans.

For firms, previous research in corporate finance has suggested that trade credit is one of the most important sources of finance for small, young firms (and, more generally, for the firms that are the most likely to suffer from finance constraints).¹⁵ We therefore begin by examining the reaction of trade credit to monetary policy. Unfortunately, there does not appear to be any aggregate data on

¹⁵ See, e.g., Petersen and Rajan (1994).

the interest rate on trade credit. However, previous firm-level studies have documented that the nominal interest rate on trade credit is essentially constant at business cycle frequencies.¹⁶ Since economic theory (and the impulse response function plotted in Figure 2) suggest that contractionary monetary policy lowers inflation, this implies that the real interest rate on trade credit rises in the wake of a contractionary monetary policy shock. Figure 15 plots the impulse response function for trade credit. There is a clear decline in trade credit in the quarters following a contractionary monetary policy shock. The decline is highly significant for many quarters.

A reasonable concern about trade credit is that it is a limited source of funds, important perhaps for very small firms that may not account for a large proportion of aggregate output. To date, we have been unable to obtain comparable interest rate and quantity data for many other forms of credit that are relevant for firms. We have, however, been able to obtain data on both price and quantity for corporate bonds. Figure 16 plots the price and quantity impulse response functions. A contractionary monetary policy shock raises the interest rate on corporate bonds. The interest rate is above its pre-shock level for many quarters after the shock. The difference between the pre-shock and post-shock corporate interest rate is significant and persistent. The same is true for the quantity of corporate bonds, which declines quickly after a contractionary monetary policy shock and remains significantly below its pre-shock level for many quarters. Since the corporate finance literature suggests that bond issues are primarily available to relatively large, well established firms, the results in

¹⁶ See, e.g., Ng, Smith, and Smith (1999).

Figure 16 suggest that the credit channel may be important not only for very small firms but also for large firms.

7. Using Domestic and Foreign Markets to Identify Shifts

If monetary policy in a small economy leads to a shift in credit demand, it should show up in the quantity of credit associated with domestic borrowers in both the domestic market and in the foreign market. In contrast, if monetary policy leads to a shift in credit supply, it should show up in the domestic market but not in a large foreign market.

Because of the close integration between the Canadian and US economies, the relevant foreign credit market for Canadian firms is the US market. We have been able to obtain data on bond issues by Canadian non-financial businesses in the US. Figure 17 plots the impulse response functions for bond issues in Canada and in the US. In Canada there is a persistent although insignificant decline in bond issues in the wake a contractionary monetary policy shock. In the US market, there is little evidence of a significant decline in bond issues by Canadian firms. However the impulse responses for Canada and US are not different enough to make any definitive conclusion.

8. Conclusion

The goal of this paper is to examine whether there might be a credit channel in a small, open economy. Previous research on the credit channel has focused almost exclusively on the US, a large economy in which external linkages play a relatively

small role in the macroeconomy (as measured, for example, by the ratios of imports and exports to output).

We find evidence of the same stylized facts about the effects on monetary policy in Canada that previous research has documented for the US. These stylized facts are broadly consistent with the conventional “closed economy” monetary transmission mechanism in which an increase in the nominal short interest rate translates into an increase in the long real interest rate (due, in part, to nominal rigidities) and thereby affects interest-sensitive components of aggregate demand, such as residential investment.

Bernanke and Gertler (1995) argue that, although the key stylized facts are broadly consistent with the conventional transmission mechanism, they highlight three important puzzles – about the magnitude, timing, and composition of monetary policy – and suggest that the credit channel complements the conventional monetary policy transmission mechanism by helping to amplify and propagate the conventional interest rate effects. To the extent that this is true, the fact that the same stylized facts emerge in Canada suggest that the credit channel may also play an important role in a small, open economy.

We go beyond the existing large, “closed economy” evidence by looking at the conventional open economy monetary policy transmission mechanism, in which an increase in the nominal short interest rate leads to capital inflows and appreciation of the domestic currency and therefore – over time – leads to a reduction in net exports. We find that a contractionary monetary policy shock is, indeed, followed by an appreciation of the Canadian dollar and an eventual decrease in net exports.

The evidence therefore seems consistent with: 1) the conventional “closed economy” transmission mechanism; 2) the stylized facts cited in support of a credit channel that augments the conventional “closed economy” mechanism; and 3) the conventional open economy mechanism.

We go beyond these stylized facts in two ways. First, we examine differences in the reaction to monetary policy between the least financially dependent and the most financially dependent industries. Second, we analyze the source of credit market shifts in the wake of a monetary policy shock.

Our most striking finding involves the difference in the reaction of prices to a monetary policy shock between the least and the most financially dependent firms. The prices of the least financially dependent firms react somewhat more quickly to a monetary policy shock than the economy as a whole. In contrast, the prices of the most financially dependent firms remain essentially unchanged for more than two years after the shock.

We also find differences in the reaction of output to a monetary policy shock between the least and most financially dependent firms. The response of output to a monetary policy shock lasts much longer for the most financially dependent firms.

Leftward shifts in both credit demand and credit supply reduce the quantity of credit, but a leftward shift in credit demand lowers the interest rate, while a leftward shift in credit supply increases the interest rate. By using a structural VAR, we are able to map out the reactions of the interest rate and the quantity of credit to a monetary policy shock. In a variety of credit markets – both household and firm credit markets – we find evidence of a leftward shift in credit supply.

We use a second approach to distinguishing the sources of credit market shifts, an approach based on the idea that shocks in a small economy can affect that economy but will not affect global markets. Specifically, if a contractionary monetary policy shock shifts credit demand by domestic borrowers to the left, the quantity of credit associated with domestic borrowers will decline both in the domestic and foreign credit market. In contrast, if a contractionary monetary policy shock shifts domestic credit supply, the quantity of credit associated with domestic borrowers will decline in the domestic credit market, but not in the foreign credit market. However our impulse response results for US and Canadian bond issues were not powerful enough to identify the sources of credit market shifts. It would be interesting to investigate this approach more thoroughly in future work.

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Figure 1

Impulse response of the overnight rate to one standard deviation shock to itself (contractionary monetary policy shock)

A contractionary monetary policy shock is defined as one standard deviation positive shock to ε_i in equation (1). The impulse response was obtained from the baseline system where the variable " O " in equation (1) is set equal to "business fixed investment". The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 2

Impulse response of price (P) and output (Y) to a contractionary monetary policy shock

A contractionary monetary policy shock is defined as one standard deviation positive shock to e_t , as defined in equation (1). Above impulse responses for price level and output were obtained from the baseline system where the variable “ O ” in equation (1) is set equal to “business fixed investment”. The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 3

Impulse response residential investment, consumption, and business fixed investment to a contractionary monetary policy shock

The impulse responses are obtained by setting the variable " O " in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 4**Impulse response of final demand to a contractionary monetary policy shock**

The above impulse response is obtained by setting the variable " θ " in equation (1) equal to "final demand". A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 5

**Impulse response of exchange rate (Canadian dollars per US dollar)
to a contractionary monetary policy shock**

The above impulse response function for the exchange rate was obtained from the baseline system where the variable “ O ” in equation (1) is set equal to “business fixed investment”. Exchange rate appears in the fifth row of the system described in equation (1). A contractionary monetary policy shock is defined as one standard deviation positive shock to e_t . The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 6**Impulse response of net exports to a contractionary monetary policy shock**

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “net exports”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_t , where e_t is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 7

Impulse response of prices for least financially dependent industries to a contractionary monetary policy shock

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “prices for least financially dependent industries”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 8

Impulse response of prices for most financially dependent industries to a contractionary monetary policy shock

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “prices for most financially dependent industries”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 9

Impulse response of output for least financially dependent industries to a contractionary monetary policy shock

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “output for least financially dependent industries”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 10

Impulse response of output for most financially dependent industries to a contractionary monetary policy shock

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “output for most financially dependent industries”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 11
Shifts in Credit Supply and Credit Demand

Figure 12

Impulse response of loans to non-financial industries to a contractionary monetary policy shock

The impulse response functions are obtained by setting the variable “ O ” in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 13**Impulse response of consumer loans to a contractionary monetary policy shock**

The impulse response functions are obtained by setting the variable “ O ” in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 14

Impulse response of residential mortgage loans to a contractionary monetary policy shock

The above impulse response functions are obtained by setting the variable “ O ” in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_t , where e_t is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 15

Impulse response of trade credit to a contractionary monetary policy shock

Above impulse response function is obtained by setting the variable “ O ” in equation (1) equal to “trade credit”. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 16**Impulse response of corporate bonds to a contractionary monetary policy shock**

The impulse response functions are obtained by setting the variable “ O ” in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Figure 17

Impulse response of bond issues by Canadian, non-financial businesses to a contractionary monetary policy shock

The impulse response functions are obtained by setting the variable “ O ” in equation (1) equal to the variable of interest above. A contractionary monetary policy shock is defined as one standard deviation positive shock to e_i , where e_i is defined in equation (1). The dashed lines represent 95% confidence bands with 10,000 replications, constructed using the Monte Carlo method proposed by Sims and Zha (1999) for overidentified system.

Appendix: Data Source and Variable Constructions

Quarterly data from 1980 Q1 to 2004 Q4 are from three sources: Statistics Canada's Cansim (i.e. E-stat) data base, IMF's International Financial Statistics online data base and unpublished data collected from Bank of Canada.

Prices and Rates Series

CPI: Consumer prices: International Financial Statistics online data base:
15664...ZF...

DEFL: GDP deflator: International Financial Statistics online data base:
(1997q3=100) 15699BIRZF...

i: Overnight money market rate: International Financial Statistics online data base:
15660B..ZF...

s: Canadian dollar per US dollar: Market rate (end of period): International Financial Statistics online data base: 156..AE.ZF...

WP: Commodity price index, total all commodities: Cansim Table 176-0001 -
Commodity price index, United States dollar terms, computed quarterly average
(Index, 82-90=100)

FFR: Federal funds rate: International Financial Statistics online data base:
11160B..ZF...

Prime business interest rate: Chartered bank administered interest rates - prime
business: Cansim Table 176-0043 - Financial market statistics, last Wednesday unless
otherwise stated, computed quarterly average from monthly data (percent)

Interest rate on consumer loan: Chartered bank consumer loan rate: Cansim Table
176-0043 - Financial market statistics, last Wednesday unless otherwise stated,
computed quarterly average from monthly data (percent)

Interest rate on mortgage loan: Average residential mortgage lending rate 5 year:
Cansim Table 176-0043 - Financial market statistics, last Wednesday unless
otherwise stated, computed quarterly average (percent)

Interest rate on corporate bonds: Scotia Capital Inc. – Average weighted yield: all corporations long term: Cansim Table 176-0043 - Financial market statistics, last Wednesday unless otherwise stated, computed quarterly average (percent)

Quantity Series

M: M1 monetary aggregate, seasonally adjusted: International Financial Statistics online data base: 15659MACZF...

Y: Gross Domestic Product (GDP) at market prices, Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based.

Final demand: Final domestic demand: Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Residential investment: Residential structures, Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Consumption: Personal expenditure on consumer goods and services: Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Business fixed investment: Business gross fixed capital formation: Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Net exports = Export – Imports

Exports: Exports of goods and services: Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Imports: Imports of goods and services: Chained 1997 dollars, Seasonally adjusted at annual rates: Cansim Table 380-0002 - Gross Domestic Product (GDP), expenditure-based. (Expressed as ratio of 6 year moving average real GDP)

Loans to non-financial industries: “Loans and overdrafts” liabilities of non-financial industries: Cansim Table 187-0003 - Financial statistics for enterprises, balance sheet and income statement, based on Standard Industrial Classification for Companies and Enterprises, 1980 (SIC-C), quarterly (Dollars x 1,000,000). Cansim Table 187-0001 - Quarterly balance sheet and income statement, by North American Industry Classification System (NAICS) (Dollars x 1,000,000, deflated by the GDP deflator with base quarter 1997:3, expressed as ratio of 6 year moving average real GDP)

Consumer loan: ‘Chartered banks personal loans’ deflated by the GDP deflator with base quarter 1997:3, expressed as ratio of 6 year moving average real GDP: Cansim Table 176-0011: Chartered banks, assets and liabilities, quarterly average; Canada; Personal loans (dollars - millions).

Mortgage loan: ‘Chartered banks residential mortgage’ deflated by the GDP deflator with base quarter 1997:3, expressed as ratio of 6 year moving average real GDP. Cansim Table 176-0011: Chartered banks, assets and liabilities, quarterly average; Canada; Residential mortgages, total (dollars - millions).

Trade credit: Average of “accounts payable and accrued liabilities” and “accounts receivable and accrued revenue” of non-financial industries. Cansim Table 187-0003 - Financial statistics for enterprises, balance sheet and income statement, based on Standard Industrial Classification for Companies and Enterprises, 1980 (SIC-C), quarterly (Dollars x 1,000,000). Cansim Table 187-0001 - Quarterly balance sheet and income statement, by North American Industry Classification System (NAICS) (Dollars x 1,000,000, deflated by the GDP deflator with base quarter 1997:3, and expressed as ratio of 6 year moving average real GDP).

Corporate bonds: Bonds and debentures + Commercial paper issued by non-financial corporations deflated by the GDP deflator with base quarter 1997:3,

expressed as ratio of 6 year moving average real GDP: B2318 + B2329. Cansim Table 176-0023: Selected credit measures.

New bond issues in US: Gross new issues of bonds by Canadian non-financial Businesses in the US (in millions of Canadian dollars per quarter, calculated by summing monthly new issues within the quarter), deflated by the GDP deflator with base quarter 1997:3, expressed as ratio of 6 year moving average real GDP: Unpublished data provided by the Bank of Canada.

Construction of “Financial Dependence” related series:

Table 1 of Rajan and Zingales (1998) lists 36 industries in the order of their financial dependence. Rajan and Zingales measure financial dependence using three-digit (or, in some cases, four-digit) ISIC industries. We define non-overlapping ISIC industries and use these to define the relevant SIC- and NAICS-based industries. In any case where a series is obtained at monthly frequency, we convert it to quarterly frequency by taking the quarterly mean of the monthly observations.

Data Availability Issues

The following table lists the starting dates for each of the industry-level series:

Variable	Starting Date
Nominal Shipments	1981:1
Output Prices	1980:1

Construction of Seasonally Adjusted Industry-Level Series

Some series (particularly shipments data by industry) are not provided in seasonally adjusted form by Statistics Canada, even though there is evidence of seasonality in these series. As a result, we take seasonally unadjusted series for all variables, and use a popular seasonal adjustment algorithm, namely X11-ARIMA, to remove the seasonal component from the series. We do this for all industry-level

variables that exhibit seasonality to ensure that a consistent procedure is used throughout.

The following table lists each of the variables and the CANSIM II tables that the seasonally unadjusted industry-level data were taken from:

Variable	SIC-based table	NAICS-based table
Nominal Shipments	304-0002	304-0014

We splice the SIC-based and NAICS-based series in the following way. We first take the NAICS-based data for the longest period of time that it is available. For shipments, the NAICS-based series cover 1992:1-2004:4. We then extend the NAICS-based series backwards using the percentage change in the SIC series. For example, let S denote the weekly earnings series. To obtain a continuous S series for the entire period we use the following formula for the SIC-based data:

$$S_t = S_{t+1} \left(\frac{S_t^{SIC}}{S_{t+1}^{SIC}} \right)$$

Accordingly, we start at $t = 1991:4$ using S_{t+1} equal to the value of the NAICS-based shipment series for 1992:1, and construct the series backwards to 1981:1. For 1992:1 to 2004:4 the shipment are taken directly from the NAICS-based series.

After we have constructed spliced series for 1980:1-2004:4 we apply the X11-

ARIMA algorithm to each spliced series. For detailed information on X11-ARIMA

see Dagum (1980, 1988).¹⁷ We implement this algorithm using the SAS software's

built-in X11 procedure (specifically, we use PROC X11 with the ARIMA option).

Industry-Level Data without Seasonality

The table below lists the series that do not exhibit seasonality, and the CANSIM II tables that the data were taken from:

¹⁷ Dagum, E.B. *The X11ARIMA seasonal adjustment method*. Catalogue No. 12-564E, Statistics Canada, 1980; Dagum, E.B. *The X11ARIMA/88 seasonal adjustment method - foundations and user's manual*. Time Series Research and Analysis Division, Statistics Canada, 1988.

Variable	SIC-based table	NAICS-based table
Nominal Output Prices (1997 base year)	329-0001	329-0038

For the output price data, the SIC-based and NAICS-based series are spliced to form a continuous series over the full 1980:1-2004:4 sample in the same way as for the seasonal series (described above).

ISIC-NAICS-SIC Concordance

The following table shows the concordance between the Rajan-Zingales ISIC codes, SIC industries, and NAICS industries.

Rajan-Zingales Industries (ranked by least to most financially dependent)	ISIC Code	SIC-E Industry	NAICS-2002 Industry
Tobacco	314	E12	3122
Pottery	361	E351	3271
Leather	323	E17	316
Spinning	3211	E18	313
Footwear	324	E1712	3162
Nonferrous metal	372	E295	3314
Apparel	322	E24	315
Petroleum refineries	353	E361	32411
Nonmetal products	369	E35	327
Beverages	313	E11	3121
Iron and steel	371	E29	331
Food products	311	E10	311
Pulp, paper	3411	E271	3221
Synthetic resins	3513	E373	3252
Paper and products	341	E27	322
Printing and publishing	342	E28	323
Other chemicals	352	E37	325
Rubber products	355	E15	3262
Furniture	332	E26	337
Metal products	381	E30	332
Basic excluding fertilizers	3511	E371	3251
Wood products	331	E25	321
Transportation equipment	384	E32	336
Petroleum and coal products	354	E36	324
Motor vehicles	3843	E323, E325	3361, 3363
Textiles	321	E19	314
Machinery	382	E31	333
Ships	3841	E327, E328	3366
Other industries	390	E399	3399
Glass	362	E356	3272
Electric machinery	383	E33	335
Professional goods	385	E391	3391
Radio	3832	E3351	3342
Office and computing	3825	E336	334
Plastic products	356	E16	3261
Drugs	3522	E374	3254

Chapter 2

Cash Flow Sensitivity of Investment: Does This Test the Presence of Finance Constraints or Corporate Governance Problems?

1. Introduction

In an efficient capital market, investment decisions should only depend on the net present value of projects. However, due to asymmetric information between lenders and borrowers some firms may face finance constraints and hence underinvest. The presence of finance constraints has important implications for the conduct and design of fiscal and monetary policy. For example it may explain why small changes in monetary policy can have large effects on investment and output.

A widely used test for finance constraint using panel data, popularized by Fazzari, Hubbard and Petersen (1988), is the sensitivity of investment to cash flow while controlling for quality of investment opportunities (captured by Tobin's Q). The intuition behind the test is that if the capital market was perfect, then investment should not react to cash flow after controlling for investment opportunities. On the other hand, if some firms were finance constrained (to the extent that they are not able to fully exploit their investment opportunities) then firms will employ any extra dollar of cash flow (i.e. internal finance) to investment. Thus investment would show sensitivity to cash flow in the presence of finance constraints.

Cash flow sensitivity of investment can also arise from another type of agency problem, called the corporate governance problems. This agency problem arises from the separation of ownership and control of firms. Due to asymmetric information

between managers and owners and the infeasibility of writing a contract contingent on all possible states of the world, managers are left with discretionary power that they can use to maximize their own payoff at the expense of owners' (i.e. shareholders') interests. Apart from maximizing profit, managers may also try to maximize on their privileges. As a result managers may over-invest to increase the firm size and hence the privileges they receive. Jensen (1986) observes that firms with high free cash flow and poor investment opportunities are more susceptible to this type of agency problem. Chirinko and Schaller (2004) find that managers of firms that are likely to possess corporate governance problems use a discount rate 350 to 400 basis points lower than shareholders' discount rate while taking up investment projects. Fazzari, Hubbard and Petersen (1988, pp 182-183) also observed this agency problem as a potential explanation for a finding in their study where high dividend paying firms have a statistically and economically significant cash flow coefficient. In this paper, I try to separate firms likely to face corporate governance problems and compare cash flow sensitivity with groups of firms that are usually thought of as facing finance constraints.

I find that investment in some firms that are less likely to be finance constrained can yet show high cash flow sensitivity due to the potential presence of the corporate governance problems.

The paper is organized as follows. Section 2 lays out a standard intertemporal model of investments, and derives the baseline empirical specification. Section 3 discusses the current debate on using cash flow sensitivity as a test for finance constraints. It also reviews previous studies on corporate governance problems, and

why it may imply excess sensitivity of investment to cash flow. Section 4 discusses the firm-level data set that is used. Section 5 discusses the econometric issues in estimating the cash flow sensitivity of investment and also reports the results for detecting finance constraints and corporate governance problems. Section 6 provides a summary and conclusion.

2. A Simple Investment Model with Adjustment Costs

In order to provide a framework for our analysis of agency costs, here we present a standard model of investment. We assume that firms choose investment to maximize expected present value of the stream of future profits. Thus the firm i at time t maximizes,

$$V_{it} = E_0 \left[\sum_{t=0}^{\infty} \beta^t [\pi(K_{it}, \varepsilon_{it}) - \psi(I_{it}, K_{it}, u_{it}) - I_{it}] \right] \quad (1)$$

subject to the capital accumulation identity,

$$K_{i,t+1} = (1 - \delta)K_{it} + I_{it} \quad (2)$$

Here $E_0[\bullet]$ is the expectations operator conditional on the firm i 's information set at $t = 0$, β is the discount factor, K_{it} is the beginning of period capital stock, I_{it} is investment, $\pi(K_{it}, \varepsilon_{it})$ is the profit function (with $\pi_K > 0$), $\psi(I_{it}, K_{it}, u_{it})$ is the investment adjustment cost function (with $\psi_K < 0, \psi_{KK} > 0, \psi_I > 0, \psi_{II} > 0$), ε_{it} and u_{it} are exogenous shocks to the profit and adjustment cost functions respectively (observable by the manager but unobserved by the econometrician at time t), and δ is the rate of capital depreciation. In the profit function, $\pi(K_{it}, \varepsilon_{it})$, we assumed that

capital is the only quasi-fixed factor of production, and all other variable factors of production have been maximized out of π . Also, here all the variables are in real terms, and the relative price of capital is normalized to unity.

The Lagrangian of the firm's maximization problem is,

$$L = E_0 \left[\sum_{t=0}^{\infty} \beta^t [\pi(K_{it}, \varepsilon_{it}) - \psi(I_{it}, K_{it}, u_{it}) - I_{it} + \lambda_{it} ((1 - \partial)K_{it} + I_{it} - K_{i,t+1})] \right]$$

First order conditions for maximization with respect to I_{it} and $K_{i,t+1}$:

$$\begin{aligned} I_{it} : -\psi_I(I_{it}, K_{it}, u_{it}) - 1 + \lambda_{it} &= 0 \\ \Rightarrow \psi_I(I_{it}, K_{it}, u_{it}) + 1 &= \lambda_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} K_{i,t+1} : -\beta^t \lambda_{it} + \beta^{t+1} [\pi_K(K_{i,t+1}, \varepsilon_{i,t+1}) - \psi_K(I_{i,t+1}, K_{i,t+1}, u_{i,t+1}) + \lambda_{i,t+1} (1 - \partial)] &= 0 \\ \Rightarrow \lambda_{it} = \beta [\pi_K(K_{i,t+1}, \varepsilon_{i,t+1}) - \psi_K(I_{i,t+1}, K_{i,t+1}, u_{i,t+1}) + \lambda_{i,t+1} (1 - \partial)] \end{aligned} \quad (4)$$

By iterative substitution,

$$\begin{aligned} \Rightarrow \lambda_{it} &= \beta [\pi_K(K_{i,t+1}, \varepsilon_{i,t+1}) - \psi_K(I_{i,t+1}, K_{i,t+1}, u_{i,t+1}) + \beta [\pi_K(K_{i,t+2}, \varepsilon_{i,t+2}) \\ &\quad - \psi_K(I_{i,t+2}, K_{i,t+2}, u_{i,t+2}) + \lambda_{i,t+2} (1 - \partial)] (1 - \partial)] \\ \Rightarrow \lambda_{it} &= E_0 \left[\sum_{j=1}^{\infty} \beta^j (1 - \partial)^{j-1} [\pi_K(K_{i,t+j}, \varepsilon_{i,t+j}) - \psi_K(I_{i,t+j}, K_{i,t+j}, u_{i,t+j})] \right] \end{aligned} \quad (4')$$

Combining equation (3) and (4'):

$$\Rightarrow \psi_I(I_{it}, K_{it}, u_{it}) + 1 = E_0 \left[\sum_{j=1}^{\infty} \beta^j (1 - \partial)^{j-1} [\pi_K(K_{i,t+j}, \varepsilon_{i,t+j}) - \psi_K(I_{i,t+j}, K_{i,t+j}, u_{i,t+j})] \right] \quad (5)$$

The left hand side of equation (5) is the marginal cost of obtaining an additional unit of capital, which is comprised of adjustment and purchasing costs of a unit of

capital. The right hand side of the equation is the expected stream of future marginal benefits from using the capital, which is comprised of additions to profits and reductions in installation costs (since $\psi_K < 0$). The right hand side of the equation is nothing but the shadow value (λ_{it}) of an additional unit of capital, referred to as ‘marginal Q’ in the literature. Thus equation (5) states that the firm should invest up to the point where marginal cost of installing a unit of capital is equal to its expected marginal benefit.

In order to estimate the model, we need an explicit functional form for the adjustment cost function. Let us assume the following functional form¹,

$$\psi(I_{it}, K_{it}, u_{it}) = (a_1 + a_2 u_{it}) I_{it} + a_3 \frac{I_{it}^2}{K_{it}} + K_{it} f(u_{it}) \quad (6)$$

Where, a_1 , a_2 , and a_3 , with $a_3 > 0$, and f is an integrable function.

Using this functional form in equation (5) gives us a linear regression equation:

$$\begin{aligned} a_1 + a_2 u_{it} + 2a_3 \frac{I_{it}}{K_{it}} + 1 &= E_0 \left[\sum_{j=1}^{\infty} \beta^j (1-\partial)^{j-1} [\pi_K(K_{it+j}, \varepsilon_{it+j}) - \psi_K(I_{it+j}, K_{it+j}, u_{it+j})] \right] = \lambda_{it} \\ \Rightarrow \frac{I_{it}}{K_{it}} &= \frac{-(a_1 + 1)}{2a_3} + \frac{1}{2a_3} \lambda_{it} - \frac{a_2}{2a_3} u_{it} \\ \Rightarrow \frac{I_{it}}{K_{it}} &= \alpha + \beta \lambda_{it} + \varepsilon_{it} \end{aligned} \quad (7)$$

where $\alpha = \frac{-(a_1 + 1)}{2a_3}$, $\beta = \frac{1}{2a_3}$, and $\varepsilon_{it} = -\frac{a_2}{2a_3} u_{it}$

¹ This functional form was taken from Erickson and Whited (2000).

Equation (7) is the baseline specification where investment is shown as a function of the shadow value of capital (i.e. marginal Q).

3. Finance Constraints vs. Corporate Governance Problems

This section reviews previous findings on the presence of finance constraints, and corporate governance problems. As discussed in the introduction, Fazzari, Hubbard and Petersen (1988) used cash flow sensitivity of investment as a test for finance constraints. Many other studies on different countries and using different sample split criteria have confirmed Fazzari, Hubbard and Petersen's (1988) finding that investments show higher sensitivity to cash flow for firms that are more likely to face finance constraints. But Kaplan and Zingales (1997) argue that theories of credit market imperfections do not necessarily suggest a monotonic relationship between the cash flow sensitivity of investment and the extent of finance constraint. Kaplan and Zingales focus on Fazzari, Hubbard and Petersen's low dividend paying firms, the group more likely to face finance constraints. Based on qualitative and quantitative statements in those firms' annual financial report, Kaplan and Zingales rank firms by a financial constraints scale. In their test, it appears that firms ranked less finance constrained show more cash flow sensitivity than firms that appear more finance constrained. Recently Kaplan and Zingales' conclusion was challenged by Bond and Soderbom(2006) and Whited and Wu (2006). Bond and Soderbom (2006) argue that Kaplan and Zingales' (1997) theoretical non-monotonic relationship was obtained in a static setting. They find that in a more realistic dynamic investment model with adjustment cost, the non-monotonic result goes away. Using simulated firm level data

they find that investment-cash flow sensitivity increases monotonically with the cost premium for external funds. Whited and Wu (2006) show that Kaplan and Zingales' (1997) ranking of finance constrained firms does not conform to some important attributes that we usually attach with finance constrained firms. Using Kaplan and Zingales' (1997) original parameter estimates to construct financing constraint ranking of a broader sample of firms, they find that the ranking does not capture some typical attributes of finance constrained firms and fails to isolate firms according to the extent of finance constraint. Whited and Wu also construct their own index of finance constraint and show that for Fazzari, Hubbard and Petersen's (1988) original 'constrained' sample of firms, their constructed index is more in line with attributes usually attached to finance constrained firms, and thus contradicting Kaplan and Zingales' (1997) ranking.

This paper explores another implication of cash flow sensitivity of investment. In particular, if I^* denotes the optimal level investment for a firm, then under the perfect capital market, optimal level of investment is determined fully by the fundamentals, $I^* = I^*(Q)$, where Q captures the investment opportunities available to the firm. However in the presence of corporate governance problems, interests of owners and managers diverge. In that case, actual investment is also influenced by the manager's objective of maximizing their own level of utility. As Jensen (1986) points out, this kind of divergence between owners' and managers' interests is most severe in firms with high free cash flow. Thus we can express actual investment as a function of optimal investment and free cash flow as follows:

$$I = f(I^*(q), FCF)$$

where FCF denotes free cash flow defined as $CF - I^*$. Thus FCF is the cash flow remaining after investing up to I^* . In a classic example, Jensen (1986) notes oil companies, during the high oil price regimes of the 1970s and mid 1980s with high free cash flow but little room for investment in positive net present value projects within the industry, investing in poor investment projects outside the industry. In Fazzari, Hubbard and Petersen's (1988) study, they found economically significant cash flow sensitivity of investment even for high dividend paying firms that they classified as unlikely to face finance constraints. They pointed out Jensen's type free cash flow agency problem as a potential explanation for this. Lamont (1997), using the 1986 negative oil price shock as a natural experiment to examine sensitivity of investment of non-oil subsidiaries of oil companies before and after the shock, also pointed out these two contesting agency problems in explaining the cash flow sensitivity. During the oil price shock of 1986, as the value of collateral and availability of internal finance fell due to the slump in the oil price, theories of finance constraints would suggest that investment in non-oil subsidiary would decline. Under such a case, non-oil subsidiaries might be underinvesting as they find it difficult to raise enough funds externally. Likewise, the agency problem of corporate governance would suggest that as the availability of free cash flow in the oil companies drop, they would decrease their investment in the non-oil subsidiaries, correcting for their initial overinvestment in these subsidiaries. Lamont (1997) found that investment in the subsidiaries declined substantially after the negative oil price

shock. The challenge here is to identify which of the two agency problems were in operation during the period. Lamont found evidence, although not decisively, in favor of the presence of agency problem of corporate governance kind. Lehn and Poulsen (1989) examined the relationship between publicly traded firms' decision to go private and their available free cash flow. They observe that for many of these firms, during this process of going private, shareholders gained large premiums by selling their shares to the bidders. They find evidence suggesting that one of the major reasons for such stockholder gains is the mitigation of free cash flow problem. Lang, Stulz and Walkling (1991) investigate firms that participate in bidding to take over other firms. They find that the bidders with high cash flow and low Tobin's Q have the lowest return from the acquisition, consistent with the agency problem of free cash flow.

This possibility of free cash flow dependence of investment has testable implications for the significance and magnitude of cash flow and free cash flow coefficients in an investment equation. Specifically, I estimate the following regression models and compare cash flow and free cash flow coefficients between different groups of firms:

$$\left(\frac{I}{K}\right)_{it} = \alpha_1 + \beta_1 Q_{it} + \gamma_1 \left(\frac{CF}{K}\right)_{it} + \varepsilon_{1it} \quad (8)$$

$$\left(\frac{I}{K}\right)_{it} = \alpha_2 + \beta_2 Q_{it} + \gamma_2 \left(\frac{FCF}{K}\right)_{it} + \varepsilon_{2it} \quad (9)$$

where Q is a measure of investment opportunities, CF is cash flow and FCF denotes free cash flow, and i is the index for firms and t is the index for time. The objective is

to compare economic and statistical significance of the parameters of interest, γ_1 and γ_2 , for different categories of firms.

4. The Data Set

I use Statistics Canada's annual Financial and Taxation Statistics for Enterprises (FTSE) unpublished micro data files. It is a combination of annual balance sheet and income statement data and corporate tax data. The data set covers the period 1988-1998 and encompasses non-financial, financial, government and other regulated industries. However, the analyses here specifically focus on non-financial firms.

All firm-year observations on and after any major reorganization (such as amalgamation) are excluded, using a structural change dummy available in the FTSE data set. All variables in the estimating equations are normalized by lagged value of total assets. In order to remove the outliers, I delete normalized values of operating revenue and operating expense greater than the 99th percentile. Also observations with negative or zero operating revenue and operating expense, negative dividend or negative cashflow are removed. Further, observations for which normalized values of investment and cash flow are greater than one were removed. The analyses are thus based on an unbalanced panel sample of 17,527 firms with 53,470 total observations. Further details on the construction of the dataset are provided in the Appendix A.

One important feature of the data set is that it covers a broader array of non-financial firms, as both public and private firms are sampled. Most micro-level studies rely on data from publicly traded firms, which are closely observed by

financial market participants. The mean total asset for firms in the sample is 49.4 million dollars and the median is 2.3 million dollars (both in 1997 constant dollars). The very different mean and median values are due to the fact that the data set contains many small firms with some large firms. In fact about 35% of firm-year observations have assets less than 1 million dollars. Thus this is a much more interesting sample to check for finance constraints since small private firms are more likely to be constrained than publicly traded firms with much larger asset size.

5. Empirical Results

5.1 Measuring Firm's Investment Opportunities

One essential part of delineating information on finance constraints by testing cash flow sensitivity of investment is to successfully control for investment opportunities in the estimating equation. As current cash flow is correlated with future profitability of firms, failing to properly control for investment opportunity might lead to cash flow coefficient capturing firms' investment prospect rather than finance constraints. Fazzari, Hubbard and Petersen (1988) used the standard Tobin's Q, defined as ratio of a firm's market value to the replacement cost of its assets, to control for investment opportunities in the estimating equations of finance constrained and unconstrained classes of firms. But, as many studies have claimed, Tobin's Q is likely to measure firm's investment opportunity with considerable error. Estimating cash flow sensitivity of different contrasting classes of firms can reveal the presence of finance constraints only if this measurement error is not systematically different between classes. However, as Poterba (1988) argued, there

can be indeed systematic difference in measurement error in high-dividend vs low-dividend payout firms. Moreover, stock market misvaluation can make Tobin's Q a noisy measure of investment opportunity for certain types of firms. In response to these problems, more exogenous sample split criteria and alternative measures of firms' investment opportunities have been proposed. For example, Schaller (1993) and Chirinko and Schaller (1995) used group membership and maturity to split the sample of firms subject and not subject to finance constraints. Cummins, Hasset and Oliner (2006) used a measure of Q based on security analysts' forecast of firm earnings. In this study, I use a measure of investment opportunities that is based on VAR forecast of future profitability of firms rather than stock market valuation. Abel and Blanchard (1986) first proposed this measure of investment opportunities, which relies on firm's current and lagged values of fundamentals in order to forecast future investment opportunities. Abel and Blanchard (1986) used this measure in an aggregate data setting. Gilchrist and Himmelberg (1995) and Chirinko and Schaller (2007) extended this measure of investment opportunities in the context of panel data structure, where taking account for firm-specific heterogeneity is important. Following these studies I call this measure 'fundamental Q'.

An added advantage of using fundamental Q to capture investment opportunities is that it allows us to include private firms in the analyses. Use of Tobin's Q or analysts' forecast based measure of Q (a la Cummins, Hasset and Oliner (2006)) restrict the sample to only publicly traded firms. As a lot of small firms are not publicly traded in my dataset, but are likely to be finance constrained, use of fundamental Q allows us to include these firms in the sample.

I use Discount Rate, Operating Revenue / Assets, Operating Expense / Assets, Price of investment / Price of output, Investment / Assets and CashFlow / Assets as observed fundamentals in the VAR forecasting equations. Then I use the estimates from this VAR to construct the expected value of marginal Q conditional on observed fundamentals. Operating revenue and Operating expense are components of marginal product of capital. Investment-output price ratio and investment also may contain information on future marginal products of capital. Lastly, cash flow is included as one of the observed fundamentals to ensure that the constructed measure of Q captures any information contained in cash flow about future marginal products of capital. As a result, any additional sensitivity of investment to cash flow in the estimating equation would then come from capital market imperfection.² The Appendix B provides more details on the fundamental Q construction methodology.

5.2 Testing Presence of the Finance Constraints

In the estimating equations (8) and (9), the error term, ε_{it} , can be thought of as the technology shock and composed of two terms: $\varepsilon_{it} = \phi_i + u_{it}$ where ϕ_i is the firm specific effect and u_{it} is the i.i.d. disturbance. If ϕ_i is uncorrelated with the regressors, pooled ordinary least squares estimates will be consistent but inefficient. Random effects specification can be employed in order to get more efficient estimates. On the other hand, if ϕ_i is correlated with the regressors,

² This is in line with Gilchrist and Himmelberg's (1995) method of constructing fundamental Q, who also include cash flow as an observed fundamental.

then both the pooled OLS and random effects estimates will be biased and inconsistent. In that case, in order to obtain consistent estimates, first difference or within (i.e. fixed effects) transformation is needed to remove the fixed effects. I performed a Hausman test that compares random effects and within transformation coefficients. Under the null that ϕ_i is uncorrelated with the regressors, both should produce consistent estimates. I found that there is strong evidence of correlation of ϕ_i and the regressors.

I start by reporting estimates based on first differenced transformation. Table 1 provides first differenced estimates of the fundamental Q and cash flow coefficients.³ Full sample results show that both Q and cash flow are highly significant in the investment equation. The magnitude of the coefficients are comparable to some previous studies (e.g. Gilchrist and Himmelberg (1995) and Cummins, Hasset and Oliner (2006)). I use firm size to distinguish between constrained and unconstrained firms. Small firms are more likely to be finance constrained compared to large firms, as they tend to be young and less known in the financial market. As reported in Table 1, the cash flow coefficient for small firms, defined as observations where total assets is less than \$10 million in 1997 constant dollars⁴, is 20 percent larger than the corresponding coefficient for large firms (total asset value greater than \$10 million in

³ Although not reported, we include a full set of year dummies in the regressions reported in this and subsequent tables.

⁴ Although this is the 66th percentile value of total assets in our sample, this cutoff point is significantly smaller than the cutoff used by some previous studies (Gilchrist and Himmelberg, 1995). We also test with cutoff points \$17 million and \$25 million, basic results described here still hold.

1997 constant dollars). The t-tests reported in Table 2 strongly rejects the null that the cash flow coefficient for small firms equals the coefficient for large firms.⁵

However, not all small firms are likely to face constraints, as some small firms may not have good enough investment opportunities to face a binding constraint. In order to capture small firms with a higher likelihood of facing binding finance constraints, I also look at the subsample of small firms with good investment opportunities (characterized by fundamental Q greater than 50th percentile). As can be seen in Table 1 and Table 2, the difference in the cash flow coefficients of the small firm subsample with good investment opportunities and the large firms subsample becomes more obvious. Again the t-test reported in Table 2 strongly rejects the null that the cash flow coefficient for small firms with good investment opportunities equals the coefficient obtained for large firms.

Given that my dataset has lots of tiny firms (up to about the 25th percentile of assets is less than one million), it could be argued that data coming from these firms may be noisy and may have inordinate influence on the regression results. In order to check the robustness of the results, I redefine the group of small firms as firms with assets less than \$10 million but more than \$1 million. Still the coefficient on cash flow appears significantly larger than the unconstrained sample.

Next I use dividend payout as another sample splitting criteria to identify finance constrained firms (similar to Fazzari, Hubbard and Petersen (1988)). I

⁵ Since fundamental Q used in the regressions is a ‘generated regressor’ (see appendix B for details on fundamental Q construction), the standard errors of the estimated coefficients, and hence the t-statistics reported here are prone to the generated regressor problem discussed in Pagan (1986). In future, I plan to take account of this issue while performing hypothesis testing.

conjecture that firms paying zero dividend are more likely to face finance constraints than firms paying positive dividends. As reported in the table, the cash flow coefficient for firms paying zero dividend (finance constrained subsample) is significantly bigger than the cash flow coefficient for firms paying positive dividend (unconstrained subsample).

5.3 Testing Presence of the Corporate Governance Problems

As observed in Table 1, investments of larger firms in general show smaller cash flow sensitivity than smaller firms. Like many other studies (such as Gilchrist and Himmelberg (1995), Bernanke, Gertler and Gilchrist (1996)) section 5.2 argued that the higher cash flow sensitivity of investment in small firms is evidence of the presence of finance constraints in these firms. Large firms on the other hand are less likely to face finance constraints as they tend to be well known and possess better access to financial market. But when we think of the corporate governance problems, the large firm group seem like the ideal candidate category for examining this agency problem. Because of their sheer size and possibly dispersed ownership, the agency problem arising from divergent interest of owners and executives is more likely to be present in larger firms. As discussed in section 2, in the spirit of Jensen's (1986) analysis, I conjecture here that executives of firms that currently have high free cash flow, may have the tendency to expand the size of their firms by investing in poor investment projects. In such a case these firms' investments may show excess sensitivity to cash flow that is very different in nature from the cash flow sensitivity originating from finance constraints.

Row I of Table 3 describes my first attempt to capture firms likely to face corporate governance problems. I try to capture firms likely to suffer from the corporate governance problems by looking at large firms with poor investment opportunity but high free cash flow.⁶ Row I reports Q and cash flow coefficients for firms with assets greater than \$25 million dollars (which is the 80th percentile asset size in my sample) with Q below the median and free cash flow level greater than the 66th percentile. Row II reports the coefficients for remaining firms with assets greater than \$25 million. By comparing coefficients reported in these two rows, we can see that the cash flow coefficient for firms likely to possess corporate governance problems is marginally higher than the coefficient for remaining firms in that asset size category. When we redefine the corporate governance category firms by looking at larger firms in subsequent rows the difference in coefficients becomes more pronounced. Row III reports results for firms with assets greater than \$42 million dollars (85th percentile asset size in my sample) with poor investment opportunity and high free cash flow (again defined by Q below the median and free cash flow above the 66th percentile). The cash flow coefficient is again larger than the coefficient obtained for remaining firms in this asset size class (row IV). Rows V and VII report the coefficients for firms with asset size \$75 million dollars (90th percentile asset size in my sample) and \$227 million dollars (95th percentile asset size in my sample)

⁶ Conceptually, **free cash flow** is the **cash flow** left after the firm has invested in all available positive net present value projects. However in empirical corporate finance literature no attempt is made to estimate the optimal level of investment. Instead, free cash flow is defined using readily observable accounting variables. We use a definition of free cash flow used in the previous corporate finance literature. We define free cash flow as cash flow (i.e. net income/loss plus depreciation, depletion and amortization) minus dividends. Similar definitions of free cash flow has been used by Chirinko and Schaller (2004), Lehn and Poulsen (1989), and Lang, Stulz and Walkling (1991). See Lang, Stulz and Walkling (1991) for a discussion on definitions of free cash flow.

respectively, with poor investment opportunity and high free cash flow. The cash flow coefficient for these corporate governance categories is strikingly larger than the remaining firms in the corresponding asset size categories (reported in row VI and VIII respectively). Thus it seems we are more successful at capturing corporate governance problems firms when we look at firms with larger size.

So far I have looked at the sensitivity of investment to Q and cash flow. However in order to examine corporate governance problems, it could be argued that 'free cash flow' rather than 'cash flow' is the more appropriate concept. Table 4, reports the corresponding 'free cash flow' coefficients for the contrasting groups. The correlation between cash flow and free cash flow in the sample is 0.60. Given this moderately high correlation between cash flow and free cash flow, similar differences in free cash flow coefficients between the corporate governance groups and the control groups are expected. Results in Table 4 support the basic implications drawn from Table 3. The magnitude of the free cash flow coefficient is about 1.7 to 9.5 times larger for firms likely to possess corporate governance problems compared to the control groups. Again, as we consider larger size classes of firms, the difference in coefficients become more noticeable.

In order to further check whether these higher cash flow coefficients for corporate governance categories are statistically significant, Table 5 reports the t-statistic and corresponding p-values on the difference in coefficients for various contrasting classes. The first column of Table 5 reports the t-statistics and p-values for difference in **cash flow** coefficients for contrasting classes reported in Table 3. Although the point estimates of cash flow coefficient reported in Table 3 are higher

for firms likely to possess corporate governance problems, the t-tests and corresponding p-values suggest that the difference in cash flow coefficients is statistically insignificant in three out of the four of the contrasting classes at conventional level of significance. Only for the contrasting class of firms with assets greater than \$227 million the t-test suggests the coefficient for corporate governance category is higher than the control category at less than 1 percent level of significance. This failure to find statistical significance of difference in cash flow coefficient for smaller asset size categories could be due to the fact that the likelihood of the presence of corporate governance problems increases with larger sized firms.⁷

The second column of Table 5 are the t-statistics and p-values for difference in **free cash flow** coefficients for contrasting classes reported in Table 4. The free cash flow coefficients for firms likely to have corporate governance are significantly higher than their respective control groups in all asset size categories. Thus it lends support to the conjecture that ‘free cash flow’ rather than ‘cash flow’ is the more appropriate concept in empirical test for corporate governance problems.

As noted in section 1, Fazzari, Hubbard and Petersen mentioned the presence of Jensen’s type agency problem as a potential reason for finding a statistically and economically significant cash flow coefficient for high dividend paying firms in their study. Now I would also like to examine whether by using dividends as a classifying criterion, I can capture firms likely to have corporate governance problems. As can be seen from Table 1; the firms paying zero dividends tend to show higher cash flow

⁷ Instead of considering larger and larger firms, in appendix C, I also try to capture firms likely to possess corporate governance problems by varying Q and free cash flow.

sensitivity than the firms paying positive dividends. This finding is conventionally taken as evidence of finance constraints, as financial markets tend to treat firms paying dividends as less risky. In Table 6, I compare the cash flow coefficient for firms that pay positive dividend but have poor investment opportunities and high free cash flow against the rest of the positive dividend paying firms. Naturally the firms paying positive dividends but having poor investment opportunities and high free cash flow can be considered as firms likely to possess corporate governance problems, indicated by a higher cash flow (or alternatively free cash flow) coefficient. As Table 6 (row I and II) reports, there is indeed evidence that the point estimate of cash flow coefficient for this category of firms is approximately two times as large as the coefficient obtained for the rest of the positive dividend paying firms. Also the free cash flow coefficient (reported on row III of Table 6) for the corporate governance problems group is approximately 4 times larger than the coefficient for other positive dividend paying firms (row IV). Interestingly the results in Table 6 also suggest that Q is not statistically significant for firms likely to have corporate governance problems (only the coefficients on cash flows and free cash flows are significant at conventional levels for these firms), while both Q and cash flow coefficients enter significantly for other firms paying positive dividend. This is consistent with the hypothesis that investment decisions in firms prone to corporate governance problems is dictated by additional ‘managerial’ considerations other than pure investment opportunity. Table 7 reports the t-statistics and p-values for the difference in coefficients between contrasting classes. The differences in cash flow coefficients and

free cash flow coefficients between firms likely to have corporate governance problems and firms less likely to have the problem is highly statistically significant.

5.4 Taking Account of the Measurement Error in Q

In the estimating equation (8)⁸,

$$\left(\frac{I}{K}\right)_it = \alpha_1 + \beta_1 Q_{it} + \gamma_1 \left(\frac{CF}{K}\right)_it + \varepsilon_{1it}, \text{ with } \varepsilon_{1it} = \varphi_i + u_{1it}$$

first differenced transformation was used in the previous section to remove one source of bias and inconsistency, which arises from the correlation of φ_i with the right hand side variables. However violation of the orthogonality condition may occur from another source as well. Measurement error in capturing true investment opportunities (Q_{it}) has been of particular concern in the investment literature. As discussed in section 5.1, to overcome the measurement error problems underlying the construction of Tobin's Q, researchers have resorted to using various other measures of investment opportunities. Fundamental Q (Q^F_{it}) eliminates one frequently mentioned source of measurement error in Tobin's Q, namely stock market misvaluation (see for example Gilchrist and Himmelberg (1995), and Cummins, Hasset and Oliner (2006)). Although fundamental Q provides us an alternative way of capturing investment opportunities it is also susceptible to the measurement error problem. Since we use fundamental Q both as a regressor and a classification variable, we devote this section to the analysis of the effect of measurement error in Q.

⁸ Following discussion uses equation (8) for exposition purposes, although the analysis applies to equation (9) equivalently.

Suppose we have a measure, called $\tilde{Q}_{it}$, of the true but unobserved investment opportunity (Q_{it}). The relationship between Q_{it} and $\tilde{Q}_{it}$ can be expressed as follows:

$$\tilde{Q}_{it} = Q_{it} + e_{it} \quad (10)$$

where e_{it} is the error in measuring Q_{it} , with $Cov(Q_{it}, e_{it}) = 0$, $E(e_{it}) = 0$, and

$$E(e_{it}^2) = \sigma_e^2.$$

Given these assumptions, we can see that $\tilde{Q}_{it}$ and e_{it} must be correlated:

$$\begin{aligned} Cov(\tilde{Q}_{it}, e_{it}) &= E(\tilde{Q}_{it} e_{it}) - E(\tilde{Q}_{it})E(e_{it}) = E(\tilde{Q}_{it} e_{it}) = E(\tilde{Q}_{it} + e_{it})e_{it} \\ &= E(\tilde{Q}_{it} e_{it}) + E(e_{it}^2) = \sigma_e^2 \neq 0 \end{aligned}$$

If we replace Q_{it} in equation (8) by the observable counterpart $\tilde{Q}_{it}$, then the equation becomes⁹,

$$\left(\frac{I}{K}\right)_{it} = \alpha_1 + \beta_1 \tilde{Q}_{it} + \gamma_1 \left(\frac{CF}{K}\right)_{it} + \varepsilon_{lit} - \beta_1 e_{it} \quad (11)$$

Since the correlation between $\tilde{Q}_{it}$ and the composite error term $\varepsilon_{lit} - \beta_1 e_{it}$ is non-zero, simple OLS estimates will be biased and inconsistent.

More importantly, the coefficient on cash flow could be biased upward, if Q and cash flow are positively correlated. In order to see this, let us rewrite equation (11) using matrix notation,

$$\frac{I}{K} = X\beta + \frac{CF}{K}\gamma_1 + \varepsilon_1 - \beta_1 e \quad (12)$$

⁹ For the sake of simplicity in the following exposition of the measurement error problem, we assume that there are no firm specific effects, and thus $\varepsilon_{lit} = u_{lit}$

where $X = \begin{bmatrix} c & \tilde{Q} \end{bmatrix}$ with c being a NT by 1 vector of ones, $\frac{I}{K}, \tilde{Q}, \frac{CF}{K}, \varepsilon_1 - \beta_1 e$ are NT by 1 vectors of observations respectively on $\left(\frac{I}{K}\right)_{it}, \tilde{Q}_{it}, \left(\frac{CF}{K}\right)_{it}, \varepsilon_{lit} - \beta_1 e_{it}$ for N firms with T periods (assuming a balanced panel for simplicity), and $\beta = \begin{bmatrix} \alpha_1 \\ \beta_1 \end{bmatrix}$.

Let us now regress cash flow on X :

$$\frac{CF}{K} = X\lambda + \eta \quad (13)$$

where λ is the vector of coefficients, and η is the vector of residuals.

We can write,

$$\hat{\eta} = (I - X(X'X)^{-1}X') \frac{CF}{K} \quad (14)$$

Let us define $M \equiv (I - X(X'X)^{-1}X')$ and rewrite equation (14) as,

$$\hat{\eta} = M \frac{CF}{K} \quad (15)$$

We can interpret $\hat{\eta}$ as the cash flow after partialing out the influence of $\tilde{Q}$.

Now multiplying equation (12) with M we get:

$$M \frac{I}{K} = MX\beta + M \frac{CF}{K} \gamma_1 + M(\varepsilon_1 - \beta_1 e) \quad (16)$$

By definition $MX = 0$, and thus the above equation can be written as,

$$M \frac{I}{K} = \hat{\eta} \gamma_1 + M(\varepsilon_1 - \beta_1 e) \quad (17)$$

Thus, in the presence of measurement error, the estimate of γ_1 would be,

$$\hat{\gamma}_1 = (\hat{\eta}'\hat{\eta})^{-1} \hat{\eta}' M \frac{I}{K} \quad (18)$$

$$\Rightarrow \hat{\gamma}_1 = (\hat{\eta}'\hat{\eta})^{-1} \hat{\eta}' [\hat{\eta}\gamma_1 + M(\varepsilon_1 - \beta_1 e)]$$

$$\Rightarrow \hat{\gamma}_1 = \gamma_1 + (\hat{\eta}'\hat{\eta})^{-1} \hat{\eta}' M(\varepsilon_1 - \beta_1 e) \quad (19)$$

Thus we can write,

$$\text{plim} \hat{\gamma}_1 = \gamma_1 + (\hat{\eta}'\hat{\eta})^{-1} \text{plim}(\hat{\eta}' M \varepsilon_1) - (\hat{\eta}'\hat{\eta})^{-1} \beta_1 \text{plim}(\hat{\eta}' M e) \quad (20)$$

In the above expression, $\text{plim}(\hat{\eta}' M \varepsilon_1) = 0$ since by assumption ε_1 is uncorrelated with the independent variables. However, $\text{plim}(\hat{\eta}' M e)$ could be nonzero.

To see this, let us rearrange equation (10) as follows,

$$\tilde{Q}_{it} - Q_{it} = e_{it} \quad (10')$$

Now let us suppose that a positive shock to the true Q_{it} has occurred. If the shock is not reflected in $\tilde{Q}_{it}$, then according to equation (10'), e_{it} would decrease. But suppose that cash flow captures some of the affects of the positive shock to the future investment opportunities, which is not unusual considering that a positive shock to investment opportunity also might imply increased cash flow. In such a case the positive shock would imply an increase in cash flow ($\hat{\eta}$), but a decrease in e - resulting in negative correlation between the measurement error and cash flow in equation (19), and thus the estimated cash flow coefficient $\hat{\gamma}_1$ will be biased upward.

Thus we can see from equation (19) and (20) that measurement error can cause upward biased and inconsistent estimate for cash flow.¹⁰

5.4.1 Comparing Fixed Effects Estimates with First Differenced Estimates

In this section I carry out empirical investigation of the measurement error issue. A good way to examine whether endogeneity (arising from measurement error) might be a problem in comparing cash flow coefficients between various groups would be to compare the first differenced estimates with the fixed effects estimates (i.e. within estimates). Under the assumption of exogeneity, fixed effects and first differenced estimates have the same asymptotic distribution; in contrast, in the presence of measurement error, fixed effect estimates and first differenced estimates will have a different asymptotic distribution (See Griliches and Hausman (1986)). Table 8 reports coefficient estimates from fixed effects regressions for finance constrained vs. unconstrained groups of firms. The estimates of the cash flow coefficient for different sample groups are very similar to the first differenced estimates reported in Table 1. Moreover as the t-tests in Table 9 suggest, the evidence that was obtained from the first differenced estimates about the presence of finance constraint still holds (compare with Table 2). Likewise results in Table 10 suggest that the cash flow coefficients are consistently significant and larger for corporate governance problem categories regardless of the asset size class considered. Again, the contrast in the magnitude of the cash flow coefficients is sharper for larger asset size classes. Fixed

¹⁰ See Erickson and Whited (2000) for a more detailed discussion of issues with measurement error in Q.

effects estimates of ‘free cash flow’ coefficient reported in Table 11 similarly show that corporate governance categories of firms have higher free cash flow coefficients. Table 12 reports the corresponding t-statistics and p-values for the contrasting classes discussed in Table 10 and Table 11. Again, similar to t-tests reported in Table 5 for first differenced estimates, cash flow coefficients for corporate governance firms are significantly larger for the asset size class greater than \$227 million. Also, ‘free cash flow’ coefficients for corporate governance firms are significantly larger than the respective control groups for any asset size class (reported in the last column of Table 12).

Table 13 reports the fixed effects estimates for positive dividend paying firms. The implications that can be derived from these estimates are similar to what were obtained with first differenced estimates. In Table 14 t-test results are reported. Although the difference in cash flow coefficient is statistically insignificant, the difference in free cash flow coefficient between firms likely to have corporate governance problems and firms less likely to have the problem is highly statistically significant.

Although the evidence from fixed effects estimates on the presence of corporate governance problems, manifested by higher cash flow coefficient for groups of firms more likely to have corporate governance problems, is similar to what were obtained from first differenced estimates, the estimates of coefficient on Q for some firm-groups are much smaller in magnitude than their corresponding first differenced estimates. This leads us to suspect that exogeneity assumption may not be holding in the within and first differenced regressions due to the measurement error problem. In

the following section we try address the measurement error problem using instrumental variable technique.

5.4.2 Instrumental Variable Estimates

Instrumental variable technique is the most frequently used method to address measurement error problem. In the context of our model, an instrumental variable z needs to satisfy two criteria. First, it has to be uncorrelated with the measurement error:

$$\text{Cov}(z, e) = 0 \quad (22)$$

Second, the suspected endogenous variable (say x) needs to be correlated with the instrumental variable (z). In other words we need to have

$$\text{Cov}(z, x) \neq 0 \quad (23)$$

Let us now examine how IV estimation will yield unbiased and consistent estimator in our investment model. Collecting the terms in equation (12) we can write:

$$\frac{I}{K} = W\theta + \varepsilon_1 - \beta_1 e \quad (12')$$

$$\text{where } W = \begin{bmatrix} X & \frac{CF}{K} \end{bmatrix} \text{ and } \theta = \begin{bmatrix} \beta \\ \gamma_1 \end{bmatrix}$$

Let us define a matrix Z of order NT by k , where k refers to the number of instrumental variables we have, with k greater than or equal to the number of endogenous variables.

Premultiplying equation (12') by Z' gives,

$$\Rightarrow Z' \frac{I}{K} = Z'W\theta + Z'(\varepsilon_1 - \beta_1 e) \quad (24)$$

Now we can write,

$$\text{plim} \left(Z' \frac{I}{K} \right) = \text{plim}(Z'W)\theta + \text{plim}(Z'(\varepsilon_1 - \beta_1 e)) \quad (25)$$

Since Z' is a matrix of IVs, by definition,

$$\text{plim}(Z'(\varepsilon_1 - \beta_1 e)) = 0$$

As a result equation (25) becomes,

$$\begin{aligned} \text{plim} \left(Z' \frac{I}{K} \right) &= \text{plim}(Z'W)\theta \\ \Rightarrow \theta &= \text{plim} \left(Z' \frac{I}{K} \right) [\text{plim}(Z'W)]^{-1} \end{aligned} \quad (26)$$

Thus the IV estimator would be,

$$\hat{\theta} = (Z'W)^{-1} Z' \frac{I}{K} \quad (27)$$

Let us now examine the regression results obtained by implementing the instrumental variable technique. Table 15 reports instrumental variable estimates of the finance constrained categories of firms. We use the current period implicit investment price deflator (P^I_t), and current period implicit output price deflator (P^Y_t) to instrument for fundamental Q .¹¹ The first and second lagged values of the ratio P^I_t/P^Y_t were used in the construction of fundamental Q (see Appendix B), thus P^I_t and P^Y_t are likely to be correlated with Q . Moreover, since P^I_t and P^Y_t are industry level price indices, presumably they are uncorrelated with the measurement error in Q_{it} .

¹¹ See Appendix A for data source and a detailed description of all these series.

Consistent with results reported above for first differenced and fixed effects estimates, the IV estimates show the patterns indicating the presence of finance constraints. The J-stat p-values reported in the last column of Table 15 are largely satisfactory in the sense that they do not reject the validity of instruments at conventional level of significance for most of the subsamples. Tables 16 and 17 report instrumental variable coefficient estimates for corporate governance categories. We see that cash flow and free cash flow coefficients for groups likely to possess corporate governance problems are consistently higher than the control groups, in line with the simple first differenced results reported in Tables 3 and 4. Table 18 reports corporate governance categories classified by dividends. Again, cash flow and free cash flow coefficients are much higher for firms likely to possess corporate governance problems.

6. Conclusion

Cash flow sensitivity of investment has been usually put forward as a test for the presence of finance constraints. Various studies have found a significantly higher cash flow coefficient estimates for groups of firms likely to be finance constrained than groups of firms less likely to be finance constrained. I use the same idea to test for another type of agency problem called, corporate governance problems. Due to asymmetric information between managers and owners of firms and due to imperfect monitoring and incomplete contracts, managers' interest may diverge from owners' interest. One manifestation of this divergent interest could be to invest a portion of cash flow to poor return projects (hence increasing the size of the firm) and spending

money on executive perks and benefits. While this lowers the overall return for the firm, managers benefit by being managers of bigger firms and by availing privileges at the expense of the owners. Using firm size, dividend, relative investment opportunity and availability of free cash flow, I try to distinguish firms likely to face finance constraints and firms likely to possess corporate governance problems. I find that zero dividend paying firms and smaller firms, especially those with good investment opportunities have significantly higher cash flow coefficients than larger firms and firms that pay positive dividends. These results are in line with previous studies that have used similar types of categorizations, and indicate possible presence of finance constraints. However, I find that within the larger firms or within positive dividend paying firms, cash flow sensitivity increases with the likeliness of corporate governance problems (characterized by low Q but high free cash flow). These findings provide another explanation for why cash flow might enter significantly in a Q investment equation regardless of whether a group of firms is considered finance constrained or unconstrained. Also, these findings contribute to the debate on using cash flow sensitivity of investment as a test for the presence of finance constraints.

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Table 1
Finance Constraints
First differenced (FD) estimates of investment equation

		Q	Cash flow
I	Full sample	0.132*** (0.012)	0.245*** (0.007)
II	Small firms	0.139*** (0.016)	0.256*** (0.008)
III	Small firms with good investment opportunity	0.129*** (0.023)	0.266*** (0.011)
IV	Large firms	0.122*** (0.018)	0.213*** (0.011)
V	Small firms with assets at least \$1 million	0.111*** (0.018)	0.274*** (0.012)
VI	Zero dividend paying firms	0.151*** (0.015)	0.270*** (0.009)
VII	Positive dividend paying firms	0.094*** (0.019)	0.203*** (0.010)

The dependent variable is the first difference of the ratio of investment to capital $\left(\frac{I}{K}\right)_t$.

Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regression in row I (full sample) has 35174 observations. Regressions in row II, III, IV, V, VI and VII contain 22080, 11845, 13094, 14009, 23633, and 11505 observations respectively. Year dummies were included in each regression.

Table 2
Finance Constraints
Hypothesis test on difference in coefficients (FD estimates)

		t-stat[p-value]
I	Difference in cash flow coefficient between small firms and large firms	2.81[0.005]
II	Difference in cash flow coefficient between small firms with good investment opportunities and large firms	3.12[0.002]
III	Difference in cash flow coefficient between small firms with assets at least \$1 million and large firms	3.39[0.001]
IV	Difference in cash flow coefficient between firms paying zero dividend and firms paying positive dividend	4.8[0.000]

For comparing cash flow coefficients of two groups of firms, a dummy variable is introduced. The dummy assumes a value of 1 for the firm-group of interest and 0 for the control group. The dummy is interacted with cash flow, and the t-statistics and p-values are obtained for the coefficient on the interaction term to test the null hypothesis that it is equal to zero.

Table 3
Corporate Governance Problem
First differenced (FD) estimates of investment equation with cash flow

	Q	Cash flow
I Assets>\$25m with poor investment opportunity and high free cash flow	0.350** (0.148)	0.211*** (0.046)
II Other firms with assets>\$25m	0.091*** (0.024)	0.201*** (0.015)
III Assets>\$42m with poor investment opportunity and high free cash flow	0.408** (0.188)	0.243*** (0.058)
IV Other firms with assets>\$42m	0.066** (0.027)	0.211*** (0.017)
V Assets>\$75m with poor investment opportunity and high free cash flow	0.772*** (0.264)	0.275*** (0.076)
VI Other firms with assets>\$75m	0.026 (0.030)	0.174*** (0.020)
VII Assets>\$227m with poor investment opportunity and high free cash flow	0.588 (0.407)	0.552*** (0.136)
VIII Other firms with assets>\$227m	0.051 (0.035)	0.165*** (0.028)

The dependent variable is the first difference of the ratio of investment to capital $\left(\frac{I}{K}\right)_{it}$. Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regressions in row I, II, III, IV, V, VI, VII and VIII contain 990, 7285, 707, 5502, 445, 3755, 198, and 1943 observations respectively. Year dummies are included in each regression.

Table 4
Corporate Governance Problem
First differenced (FD) estimates of investment equation with free cash flow

		Q	Free Cash flow
I	Assets>\$25m with poor investment opportunity and high free cash flow	0.313** (0.148)	0.141*** (0.035)
II	Other firms with assets>\$25m	0.088*** (0.025)	0.080*** (0.009)
III	Assets>\$42m with poor investment opportunity and high free cash flow	0.358* (0.188)	0.144*** (0.042)
IV	Other firms with assets>\$42m	0.068** (0.027)	0.084*** (0.011)
V	Assets>\$75m with poor investment opportunity and high free cash flow	0.792*** (0.265)	0.261*** (0.071)
VI	Other firms with assets>\$75m	0.033 (0.031)	0.071*** (0.013)
VII	Assets>\$227m with poor investment opportunity and high free cash flow	0.610 (0.410)	0.473*** (0.123)
VIII	Other firms with assets>\$227m	0.056 (0.035)	0.050** (0.021)

See the notes to Table 3 for information on estimation.

Table 5
Corporate Governance Problem
Hypothesis test on difference in coefficients (FD estimates)

	Cash flow t-stat[p-value]	Free cash flow t-stat[p-value]
I 'Assets>\$25m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$25m'	0.21[0.84]	2.06[0.04]
II 'Assets>\$42m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$42m'	0.50[0.62]	1.69[0.09]
III 'Assets>\$75m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$75m'	1.27[0.20]	3.01[0.00]
IV 'Assets>\$227m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$227m'	3.00[0.00]	3.71[0.00]

See the notes to Table 2 for information on t-tests.

Table 6
Corporate Governance Problem: classified by dividend
First differenced estimates of investment equation

	Q	Cash flow
I Positive dividend with poor investment opportunity and high free cash flow	0.125 (0.100)	0.319*** (0.036)
II Other firms with positive dividend	0.090*** (0.019)	0.177*** (0.011)
	Q	Free cash flow
III Positive dividend with poor investment opportunity and high free cash flow	0.067 (0.101)	0.213*** (0.031)
IV Other firms with positive dividend	0.070*** (0.020)	0.058*** (0.006)

The dependent variable is the first difference of the ratio of investment to capital $\left(\frac{I}{K}\right)_i$. Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regressions in row I, II, III, and IV contain 1135, 10370, 1135, and 10370 observations respectively. Year dummies are included in each regression.

Table 7
 Corporate Governance Problem: classified by dividend
 Hypothesis test on difference in coefficients (FD estimates)

	Cash flow t-stat[p-value]	Free cash flow t-stat[p-value]
'Positive dividend with poor investment opportunity and high free cash flow' vs 'remaining positive dividend firms'	5.05[0.00]	6.63[0.00]

See the notes to Table 2 for information on t-tests.

Table 8
Finance Constraints
Fixed effects (FE) estimates of investment equation

	Q	Cash flow
I Full Sample	0.056*** (0.008)	0.231*** (0.006)
II Small firms	0.063*** (0.011)	0.240*** (0.008)
III Small firms with good investment opportunity	0.097*** (0.038)	0.273*** (0.014)
IV Large firms	0.042*** (0.013)	0.200*** (0.011)
V Small firms with assets at least \$1 million	0.048*** (0.013)	0.256*** (0.011)
VI Zero dividend paying firms	0.058*** (0.011)	0.260*** (0.008)
VII Positive dividend paying firms	0.046*** (0.014)	0.206*** (0.011)

Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regression in row I (full sample) has 53470 observations. Regressions in row II, III, IV, V, VI and VII contain 35498, 16899, 17973, 21472, 36756, and 16658 observations respectively. Year dummies were included in each regression.

Table 9
Finance Constraints
Hypothesis test on difference in coefficients (FE estimates)

		t-stat[p-value]
I	Difference in cash flow coefficient between small firms and large firms	2.66[0.008]
II	Difference in cash flow coefficient between small firms with good investment opportunities and large firms	4.81[0.000]
III	Difference in cash flow coefficient between small firms with assets at least \$1 million and large firms	3.83[0.000]
IV	Difference in cash flow coefficient between firms paying zero dividend and firms paying positive dividend	4.23[0.000]

See the notes to Table 2 for information on t-tests.

Table 10
Corporate Governance Problem
Fixed effects (FE) estimates of investment equation with cash flow

		Q	Cash flow
I	Assets>\$25m with poor investment opportunity and high free cash flow	0.132 (0.124)	0.240*** (0.058)
II	Other firms with assets>\$25m	0.054*** (0.008)	0.203*** (0.016)
III	Assets>\$42m with poor investment opportunity and high free cash flow	0.209 (0.157)	0.245*** (0.075)
IV	Other firms with assets>\$42m	0.048** (0.020)	0.213*** (0.017)
V	Assets>\$75m with poor investment opportunity and high free cash flow	0.342 (0.229)	0.417*** (0.113)
VI	Other firms with assets>\$75m	0.054** (0.022)	0.202*** (0.020)
VII	Assets>\$227m with poor investment opportunity and high free cash flow	0.372 (0.410)	0.528** (0.209)
VIII	Other firms with assets>\$227m	0.053* (0.028)	0.243*** (0.030)

Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regressions in row I, II, III, IV, V, VI, VII and VIII contain 1418, 9488, 983, 7052, 610, 4754, 259, and 2417 observations respectively. Year dummies are included in each regression.

Table 11
Corporate Governance Problem
Fixed effects (FE) estimates of investment equation with free cash flow

		Q	Free Cash flow
I	Assets>\$25m with poor investment opportunity and high free cash flow	0.113 (0.124)	0.213*** (0.058)
II	Other firms with assets>\$25m	0.060*** (0.018)	0.081*** (0.010)
III	Assets>\$42m with poor investment opportunity and high free cash flow	0.195 (0.156)	0.211*** (0.076)
IV	Other firms with assets>\$42m	0.06*** (0.020)	0.085*** (0.011)
V	Assets>\$75m with poor investment opportunity and high free cash flow	0.324 (0.230)	0.376*** (0.113)
VI	Other firms with assets>\$75m	0.067*** (0.023)	0.082*** (0.014)
VII	Assets>\$227m with poor investment opportunity and high free cash flow	0.354 (0.412)	0.490** (0.212)
VIII	Other firms with assets>\$227m	0.066** (0.028)	0.092*** (0.022)

See the notes to Table 10 for information on estimation.

Table 12
Corporate Governance Problem
Hypothesis test on difference in coefficients (FE estimates)

	Cash flow t-stat[p-value]	Free cash flow t-stat[p-value]
I 'Assets>\$25m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$25m'	0.58[0.56]	4.06[0.00]
II 'Assets>\$42m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$42m'	1.04[0.30]	4.15[0.00]
III 'Assets>\$75m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$75m'	1.14[0.25]	3.48[0.00]
IV 'Assets>\$227m with Q below median and FCF above 66th percentile' vs 'remaining firms with assets>\$227m'	1.76[0.08]	2.76[0.01]

See the notes to Table 2 for information on t-tests.

Table 13
Corporate Governance Problem: classified by dividend
Fixed effects (FE) estimates of investment equation

		Q	Cash flow
I	Positive dividend with poor investment opportunity	0.056	0.422***
	and high free cash flow	(0.105)	(0.068)
II	Other firms with positive dividend	0.053***	0.173***
		(0.015)	(0.012)
		Q	Free cash flow
III	Positive dividend with poor investment opportunity	0.027	0.445***
	and high free cash flow	(0.105)	(0.075)
IV	Other firms with positive dividend	0.044***	0.077***
		(0.015)	(0.008)

Standard errors are in parentheses, and *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Regressions in row I, II, III, and IV contain 1879, 14779, 1879, and 14779 observations respectively. Year dummies are included in each regression.

Table 14
 Corporate Governance Problem: classified by dividend
 Hypothesis test on difference in coefficients (FE estimates)

	Cash flow t-stat[p-value]	Free cash flow t-stat[p-value]
'Positive dividend with poor investment opportunity and high free cash flow' vs 'remaining positive dividend firms'	0.19[0.848]	7.83[0.00]

See the notes to Table 2 for information on t-tests.

Table 15
Finance Constraints
Instrumental variable estimates of first differenced investment equation

		Q (se)	Cash flow (se)	J-stat p-value
I	Full sample	0.054*** (0.014)	0.242*** (0.011)	0.145
II	Small firms	0.053*** (0.018)	0.252*** (0.014)	0.145
III	Small firms with good investment opportunity	0.026 (0.028)	0.259*** (0.019)	0.052
IV	Large firms	0.053** (0.026)	0.212*** (0.018)	0.303
V	Small firms with assets at least \$1 million	0.060*** (0.019)	0.271*** (0.020)	0.517
VI	Zero dividend paying firms	0.066*** (0.019)	0.268*** (0.015)	0.355
VII	Positive dividend paying firms	0.032* (0.022)	0.200*** (0.016)	0.173

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Estimates obtained with two step GMM, and are robust to heteroscedasticity. The following were used as instruments for Q_{it} : current period implicit investment price deflator (P^I_t) for two digit NAICS industries, current period implicit output price deflator (P^Y_t) for two digit NAICS industries. See Appendix A for data source. Although not reported, year dummies were included in each regression.

Table 16
Corporate Governance problems
Instrumental variable estimates of first differenced investment equation with cash flow

		Q (se)	Cash flow (se)	J-stat p-value
I	Assets>\$25m with poor investment opportunity and high free cash flow	0.053 (0.154)	0.207*** (0.052)	0.614
II	Other firms with assets>\$25m	0.028 (0.031)	0.201*** (0.025)	0.822
III	Assets>\$42m with poor investment opportunity and high free cash flow	0.054 (0.178)	0.233*** (0.066)	0.804
IV	Other firms with assets>\$42m	0.020 (0.034)	0.211*** (0.028)	0.264
V	Assets>\$75m with poor investment opportunity and high free cash flow	0.259 (0.230)	0.256*** (0.082)	0.627
VI	Other firms with assets>\$75m	-0.008 (0.036)	0.175*** (0.029)	0.579
VII	Assets>\$227m with poor investment opportunity and high free cash flow	0.117 (0.242)	0.539*** (0.170)	0.664
VIII	Other firms with assets>\$227m	0.028 (0.041)	0.168*** (0.046)	0.627

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Estimates obtained with two step GMM, and are robust to heteroscedasticity. The following instruments were used: current period implicit investment price deflator (P_t^I) for two digit NAICS industries, current period implicit output price deflator (P_t^Y) for two digit NAICS industries. See Appendix A for data source. Although not reported, year dummies were included in each regression.

Table 17
Corporate Governance problems

Instrumental variable estimates of first differenced investment equation with free cash flow		Q	Free cash flow	J-stat p-value
		(se)	(se)	
I	Assets>\$25m with poor investment opportunity and high free cash flow	0.018 (0.151)	0.141 *** (0.038)	0.581
II	Other firms with assets>\$25m	0.027 (0.031)	0.081 ** (0.012)	0.797
III	Assets>\$42m with poor investment opportunity and high free cash flow	-0.006 (0.172)	0.141 *** (0.044)	0.745
IV	Other firms with assets>\$42m	0.023 (0.034)	0.085 *** (0.014)	0.302
V	Assets>\$75m with poor investment opportunity and high free cash flow	0.272 (0.228)	0.242 *** (0.069)	0.729
VI	Other firms with assets>\$75m	-0.002 (0.036)	0.072 *** (0.016)	0.605
VII	Assets>\$227m with poor investment opportunity and high free cash flow	0.143 (0.240)	0.455 *** (0.147)	0.651
VIII	Other firms with assets>\$227m	0.032 (0.042)	0.049* (0.027)	0.582

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Estimates obtained with two step GMM, and are robust to heteroscedasticity. The following instruments were used: current period implicit investment price deflator (P_t^I) for two digit NAICS industries, current period implicit output price deflator (P_t^Y) for two digit NAICS industries. See Appendix A for data source. Although not reported, year dummies were included in each regression.

Table 18
Corporate Governance problems: classifying by dividend

Instrumental variable estimates of first differenced investment equation			
	Q (se)	Cash flow (se)	J-stat p-value
I Positive dividend with poor investment opportunity and high free cash flow	-0.047 (0.106)	0.315*** (0.044)	0.955
II Other firms with positive dividend	0.037* (0.021)	0.172*** (0.018)	0.104
	Q (se)	Free cash flow (se)	J-stat p-value
III Positive dividend with poor investment opportunity and high free cash flow	-0.107 (0.112)	0.212*** (0.032)	0.927
IV Other firms with positive dividend	0.023 (0.021)	0.056*** (0.008)	0.089

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Estimates obtained with two step GMM, and are robust to heteroscedasticity. The following instruments were used for equations with cash flow: current period implicit investment price deflator (P_t^I) for two digit NAICS industries, current period implicit output price deflator (P_t^Y) for two digit NAICS industries. See Appendix A for data source. Although not reported, year dummies were included in each regression.

Appendix A: Data Source

In the FTSE database, firms are classified by SIC-C 1980 industries. This paper uses data for non-financial private unregulated firms only. I dropped the following sectors from the analysis:

Financial Industries: SIC-C 1980 codes 6000 - 6499

Government, education, health and social services: SIC-C 1980 codes 7000 -- 7999

Electricity generation, transmission and distribution: SIC-C 1980 codes 1200-1299

Real Estate Operators: SIC-C 1980 codes 4020-4029

Urban transit and other passenger transport: SIC-C 1980 codes 4900-4999

Postal and courier services: SIC-C 1980 codes 5600-5699

Telecommunication Broadcasting: SIC-C 1980 codes 5700-5799

Telecommunication Carriers: SIC-C 1980 codes 5800-5899

Government, education, health and social services: SIC-C 1980 codes 7000-7999

Also, all firm-year observations on and after any major reorganization were excluded, using a structural change dummy available in the dataset.

Total assets and capital expenditures series were deflated by using P^I (described below). All other series above were deflated by using P^Y (described below). Also, all variables were normalized by the beginning of the period total assets. An implicit output price deflator (P^Y) for two-digit NAICS industries were created by dividing the current dollar values of output by the 1997 constant dollar output. The data for current and constant dollar output for the NAICS industries were obtained from the following two Cansim tables:

Table 379-0023: Gross Domestic Product (GDP) at basic price in current dollars, System of National Accounts (SNA) benchmark values, by North American Industry Classification System (NAICS), annual. (dollars - millions).

Table 379-0017: Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS); 1997 constant dollars; (dollars - millions)

Likewise, an implicit investment price deflator (P^I) for two-digit NAICS industries were created by dividing the current dollar values of investment in two-digit NAICS industries by the corresponding 1997 constant dollar investment. The following Cansim table contains the current and constant dollar data:

Table 031-0002: Flows and stocks of fixed non-residential capital, by North American Industry Classification System (NAICS), annual (dollars x 1,000,000).

Since the price deflators are classified by NAICS industries and the firms in the FTSE dataset are classified by SIC-C industries, I needed to create a concordance between NAICS and SIC-C industries (concordance table is available upon request).

Discount factor was calculated using the Scotia Capital Inc. - average weighted yield: all corporations long-term. The yield series was obtained from Cansim table Table 176-0043 - Financial market statistics, last Wednesday unless otherwise stated, computed annual average.

Cash flow was defined as Net Income/Loss plus Depreciation, Depletion and Amortization.

Conceptually, free cash flow is the cash flow left after the firm has invested in all available positive net present value projects. However in empirical corporate finance literature no attempt is made to estimate the optimal level of investment. Instead, free cash flow is defined using readily observable accounting variables. Since this chapter addresses a corporate finance question, I use a definition of free cash flow used in the corporate finance literature. Free cash flow is defined as cash flow (i.e. net income/loss plus depreciation, depletion and amortization) minus dividends.

In order to remove outliers, I removed observations for which any of the following are true:

Total asset is missing or zero

Capital expenditures are missing or negative

Net fixed assets is missing or zero or negative

Total operating revenue is missing or zero or negative
 Total operating expenses are missing or zero or negative
 Sales of goods and services are missing
 Other expenses (including materials and supplies) are missing
 Cash flow is missing or negative.
 Dividend is negative
 Capital expenditures as a fraction of total assets are greater than 1
 Cash flow as a fraction of total assets are greater than or equal to 1
 Also operating revenue and operating expenses greater than the ninety-ninth percentile were deleted.

Appendix B: Fundamental Q Construction

Abel and Blanchard (1986) introduced a measure of investment opportunity which, unlike Tobin's Q, does not depend on the stock market value. Conceptually, this measure of investment opportunity (called fundamental Q) is the expected present value of future marginal product of capital:

$$Q_t = \lambda_t - \frac{P_t^I}{P_t^Y}$$

where

$$\lambda_t = E_{t-1} \sum_{j=0}^{\infty} \prod_{s=0}^{j-1} R_{t+s} (F_{K,t+j} - C_{K,t+j})$$

and P_t^I is the price of investment at time t and P_t^Y is the price of output at time t.

In the above expression, λ_t is nothing but the discounted sum of the expected marginal products net of adjustment costs. Here, E_{t-1} signifies expectation conditional on the information set in period t-1, R is the discount factor, F_K is the marginal product of capital and C_K is the derivative of the adjustment cost function with respect to the capital stock (i.e. it captures the reduction in adjustment costs from an additional unit of capital).

Ex post, fundamental Q can be defined as:

$$\tilde{Q}_t = \sum_{j=0}^{\infty} \prod_{s=0}^{j-1} R_{t+s} (F_{K,t+j} - C_{K,t+j}) - \frac{P_t^I}{P_t^Y} = \tilde{\lambda}_t - \frac{P_t^I}{P_t^Y}$$

and thus by definition, ex ante fundamental Q is:

$$Q_t = E_{t-1}[\tilde{Q}_t]$$

Let us define

$$M_t \equiv (F_{K,t} - C_{K,t})$$

Now linearizing λ_t around R and M (i.e. sample means of R and M) we get:

$$\tilde{\lambda}_t \approx \bar{M}(1 - \bar{R})^{-1} + \bar{M}(1 - \bar{R})^{-1} \sum_{j=0}^{\infty} \bar{R}^j (R_{t+j} - \bar{R}) + \sum_{j=0}^{\infty} \bar{R}^j (M_{t+j} - \bar{M})$$

To obtain observable counterparts of R and M we postulate that they are linear combinations of a vector Z of observed variables.

$$\begin{aligned} M_t &= a' Z_t \\ R_t &= b' Z_t \end{aligned}$$

where

$$a = [0 \ 1 \ -1 \ 0 \ 0 \ 0] \text{ and } b = [1 \ 0 \ 0 \ 0 \ 0 \ 0]$$

In this paper I include six variables, discount rate, operating revenue/assets, operating expenses/assets, $\frac{P^I}{P^Y}$, investment/assets and cash flow/assets in the Z vector.

Let us suppose Z_t follows an autoregressive structure with each element of Z expressed as deviation from its sample mean. Thus:

$$Z_t = \sum_{k=1}^l \alpha_k Z_{t-k} + v_t$$

In the empirical work I take $l=2$. Now let us form a companion matrix, A, for this autoregressive structure. For brevity, suppose Z has two elements, $Z_{1,t}$ and $Z_{2,t}$. Then the companion matrix is obtained by stacking as follows:

$$\begin{bmatrix} Z_{1,t} \\ Z_{1,t-1} \\ Z_{2,t} \\ Z_{2,t-1} \end{bmatrix} = \begin{bmatrix} \alpha_{z1z1,t-1} & \alpha_{z1z1,t-2} & \alpha_{z1z2,t-1} & \alpha_{z1z2,t-2} \\ 1 & 0 & 0 & 0 \\ \alpha_{z2z1,t-1} & \alpha_{z2z1,t-2} & \alpha_{z2z2,t-1} & \alpha_{z2z2,t-2} \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} Z_{1,t-1} \\ Z_{1,t-2} \\ Z_{2,t-1} \\ Z_{2,t-2} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ 0 \\ v_{2t} \\ 0 \end{bmatrix}$$

This can be written in companion matrix form as follows:

$$\tilde{Z}_t = A\tilde{Z}_{t-1} + \tilde{v}_t$$

Then, using rational expectation we get:

$$E_t[M_{t+j}] = aA^{j+1}\tilde{Z}_{t-1}$$

$$E_t[R_{t+j}] = bA^{j+1}\tilde{Z}_{t-1}$$

The above expressions just postulate expected values of M and R as linear projections on the variables in the information set.

Substituting these into the expression for Q_t , we get an empirical formula for the fundamental Q :

$$Q_t = E_{t-1}[\tilde{Q}_t] = \bar{M}(1 - \bar{R})^{-1} + \bar{M}(1 - \bar{R})^{-1}\bar{R}b(I - \bar{R}A)^{-1}A\tilde{Z}_{t-1} + \bar{R}a(I - \bar{R}A)^{-1}A\tilde{Z}_{t-1}$$

Appendix C: Robustness Checks

Identifying Corporate Governance Problems by Q and Free Cash Flow

In section 4.3, I tried to capture firms suffering from the corporate governance problems by testing cashflow and free cash flow sensitivity of investment for larger and larger firms with Q below the median and free cash flow above the 66th percentile. Now let us check what happens when we try to identify firms that might suffer from corporate governance problems by considering (i) decreasing investment opportunities (i.e. lower Q); and (ii) increasing free cash flow for a certain asset size class of firms. The table below reports t-statistics on difference in cash flow / free cash flow coefficients between firms with assets greater than \$75 million but with varying Q and free cash flow. The results in this table can be compared to row III of Table 5 (reproduced in the row I of the following table for convenience), where we

considered firms with assets greater than \$75 million and Q below median and free cash flow above 66th percentile.

Comparing t-statistics reported in row II and III with row I, we see that the larger cash flow coefficient for corporate governance problem category becomes statistically significant as lower and lower values of Q are considered.

In row IV and row V larger free cash flow values are considered. However, when we compare t-statistics from these rows with results in row I, it is not clear whether larger and larger values of free cash flows are better able to capture corporate governance for a certain asset size class (in this case asset > \$75 million).

Table C-1
Corporate Governance problems: Varying Q and FCF
Hypothesis test on difference in coefficients between groups (FD estimates)

		Cash flow t-stat[p-value]	Free cash flow t-stat[p-value]
I	'Assets>\$75m with Q below median and FCF above 66th percentile' vs. 'remaining firms with assets>\$75m'	1.27[0.200]	3.01[0.000]
	<i>Decreasing investment opportunities (lower Q)</i>		
II	'Assets>\$75m with Q below 33rd percentile and FCF above 66th percentile' vs. 'remaining firms with assets>\$75m'	1.97[0.048]	3.34[0.001]
III	'Assets>\$75m with Q below 25th percentile and FCF above 66th percentile' vs. 'remaining firms with assets>\$75m'	2.13[0.033]	3.05[0.002]
	<i>Increasing free cash flow (higher FCF)</i>		
IV	'Assets>\$75m with Q below median and FCF above 75th percentile' vs. 'remaining firms with assets>\$75m'	0.63[0.530]	2.44[0.015]
V	'Assets>\$75m with Q below median and FCF above 80th percentile' vs. 'remaining firms with assets>\$75m'	0.32[0.750]	1.74[0.082]

Chapter 3

Effects of Financial Innovation on Macroeconomic Volatility in Canada

1. Introduction

The business cycle volatility has decreased in most of the developed countries in recent decades. Canada has also experienced this moderation in the business cycle. Better monetary policy, smaller shocks (i.e. good luck), improved inventory management, more countercyclical fiscal policy, shifts in the output composition towards services are some of the factors that are usually put forward as explanations for the volatility decline. More recently, Dynan, Elmendorf and Sichel (2006, henceforth DES) have argued that financial innovation may be yet another source of the decline in macroeconomic volatility. Using US data, DES found that sensitivity of consumption to current income has declined in the recent decades. This results in a decline in consumption volatility as consumption would respond less to transitory fluctuations in income. They also examined the effects of financial innovation on residential investment. During the Regulation Q era, a given increase in the interest rate led to more non-price rationing and thus resulted in a bigger reduction in the residential investment. DES found evidence that the sensitivity of residential investment to 30-year fixed mortgage rate has noticeably declined after the mid-1980s (after Regulation Q was phased out).

Indeed, financial innovations, such as technological progress in processing and disseminating information, and introduction of new financial instruments (such as securitization) for risk sharing made it easier for households and businesses to

borrow. Rapid development of information technology since late seventies has significantly improved productivity in the financial sectors. Also, the arrival of personal computers and later, the expansion of the internet, provided a boon for a rapid expansion of scope for financial services.

On the other hand, the recent financial crisis has raised the possibility that financial innovation might, under some circumstances, lead to substantially greater macroeconomic volatility. But the focus of this paper is not specifically on the current financial crisis. Our objective is to better understand whether financial innovation has played any role in the declining macroeconomic volatility of Canada over the last few decades.

To set forth the motivation of our analysis, section 2 examines the volatility trends of major macroeconomic variables in Canada. Similar to findings in other developed countries, there has been a noticeable decline in GDP growth volatility in Canada. We also attempt to identify the sectors that have played the principal roles in this tempering of volatility. Volatilities of all of the GDP components (except net exports) have declined in the recent decades. The household sector and inventory investment appear to make the largest contributions in the GDP volatility decline.

Section 3 investigates whether financial innovation can explain the decline in volatility of consumption expenditure. Similar to DES, we estimate the marginal propensity to consume (MPC) out of disposable income. An implication of financial innovation is that it allows consumers to smooth their consumption while subject to transitory fluctuations in income. Thus consumption will show less sensitivity to current income if financial innovation significantly relaxes finance constraints faced

by households. However we do not find any conclusive evidence supporting this claim. Another way financial innovation can affect consumption is by lowering interest sensitivity of consumption. A contractionary shock, such as a higher interest rate, can make it difficult to borrow during the contraction, and thus can lead to a greater decline in spending. If financial innovation made it easier to borrow then it is possible that an unusually high interest rate will have a smaller impact on consumption in the recent decades. We find weak evidence of such a tempering of the interest rate's effect on consumption.

Section 4 examines whether deepening and broadening of the mortgage market has resulted in a reduction in interest sensitivity of residential investment and thus contributed to the tempering of volatility. Our evidence does suggest that this could be a channel through which financial innovation has contributed to the volatility decline.

Using a structural vector autoregression (SVAR) scheme, section 5 further investigates whether interest sensitivities of consumption, residential investment, and various credit aggregates have significantly declined in recent years. An implication of such a decline, if found, would be that financial innovation has made it easier to obtain credit and thus have caused a reduction in the sensitivity to contractionary shocks. However we were unable to find evidence that would support such a claim.

Section 6 provides a summary and conclusion.

2. Volatility in Canada

The top panel of Figure 1 shows the five year rolling standard deviation of the GDP growth rate calculated on a quarterly basis. The bottom panel shows the five year rolling standard deviation of the growth rate calculated on a four-quarter (i.e. year over year) basis. As can be seen in the figure, the volatility of GDP growth rates shows a similar pattern regardless of the growth rate measure used. The standard deviations of the growth rate show a clear declining trend over time. The declining trend has become more pronounced since the mid-1980s and by mid 1990s has settled below 2%. There were wide swings in volatility in the 1970s and early 1980s. Following a sharp decrease from mid-1970s to late 1970s, volatility started to increase in early 1980s. But in the late 1980s there was a step down in volatility, and a further drop in the mid 1990s. Since the mid 1990s, GDP volatility has been fluctuating within the band of 1% and 2%.

In order to understand the source of this volatility decline let us examine the volatility patterns of the components of GDP. Figure 2 shows the rolling standard deviation of the quarterly growth rates of the components of GDP, weighted by their share in GDP. The weighting is necessary since a very volatile component may have little impact on the volatility of GDP if it accounts for only a small share in GDP. As can be seen from Figure 2, over the last fifty years, the decrease in the volatility of the growth rates of consumption, fixed investment and government expenditure played key roles in the decline of GDP growth volatility. Net exports volatility seems to have a slightly upward trend and thus had a negative contribution to the GDP volatility decline. The contribution of inventory investment in the overall GDP volatility does

not show any clear trend until 1980. It showed large swings in the 60s and 70s. Inventory investment volatility dropped sharply in the early 1980s. Since then the share-weighted standard deviation of inventory investment growth seems to have settled within the band of 2% and 3%.¹

Figure 3 examines volatility of consumption and investment at further disaggregated level. Durable consumption volatility showed the strongest decline. The standard deviation of the annualized quarterly growth rates of durable goods consumption has come down from 1.5% in the 1960s to 0.5% in the current decade. Semi-durable and non-durable consumption also show clear declining trends in their volatility. Services consumption volatility does not show any clear declining trend and exhibits spikes in '70s and '90s. However, in more recent years, services consumption volatility has been keeping steady around 0.5%. Residential investment volatility has also declined. The standard deviation of residential investment hovered around 1% up until the end of 1980s. But since the late 1980s/early 1990s, there is a clear declining trend in the volatility of residential investment.² Likewise, there is a declining trend in the non-residential investment volatility since the early 1990s. DES have found similar volatility declines in residential and non-residential investment for U.S. They found evidence indicating that financial innovation may have played a role in this volatility reduction (especially for residential investment).

¹ Since net exports and inventory investments can assume negative values, growth rates of these GDP components cannot be computed in the conventional way. However we can deduce their contributions to the GDP growth. Therefore, here we take the standard deviations of their growth contributions. Appendix discusses the methodology in detail.

² Since we take rolling standard deviation of the growth rates, the timing conventions in these figures are such that the value assigned to a period, say 1992Q1, represents the standard deviation during the period 1987Q2 to 1992Q1.

Aside from variance of the components, a part of the GDP volatility comes from the covariance between its components. Figure 4 reports the 5-year rolling correlation coefficient between the growths of final sales (GDP minus inventory investment) and various GDP components. The positive correlation of consumption with final sales shows a sudden drop in the early 1990s, and in recent years it has approached zero. Thus it seems consumption is becoming acyclical in recent years. A potential explanation for this acyclicity could be that financial liberalizations resulted in consumption smoothing, thus making it less sensitive to economic cycles. Business fixed investment and government expenditure have been procyclical most of the time. Net exports show increasing procyclicality. Due to the increasing openness of the Canadian economy, it appears net export is playing an increasingly important role in the determination of both the growth rate and volatility of final sales. Inventory investment has been countercyclical in general. Countercyclical inventory investment causes lower GDP volatility relative to final sales. Blanchard and Simon (2001) found that until the mid-1980s, inventory investment in the U.S. has been procyclical and then it became countercyclical. This shift in inventory behavior has been found as a major reason for lower volatility of U.S. output since 1980s. Blanchard and Simon attributed this behavioural shift to inventory management methods of firms. Provided that adoption of new inventory management technologies in Canada and US happened around the same time, it seems puzzling why we find inventory investment in Canada to be countercyclical even prior to 1980s. Nevertheless, the countercyclicality of inventory investment seems to be increasing in the recent decades, and thus contributing to the lower volatility of GDP.

In order to summarize the volatility trends discussed above, let us now move on to quantify the contribution of different components in the GDP volatility decline. The first and the second columns of Table 1 present the variance of the growth rates of GDP components (weighted by their share in the GDP) for the periods 1961-1987 and 1988-2006. Although volatility decline is a gradual process, for the purpose of exposition it is convenient to choose a particular break date. I chose 1988 as a break date based on Smith and Summers (2002). Using a regime switching framework, Smith and Summers identify the year 1988 as the switch date to the lower GDP growth volatility state in Canada. The last column of the table reports contribution accounting. Inventory investment has contributed the largest share (45%) in the decline of GDP growth volatility between the two periods. This is consistent with the explanations presented in various papers that better inventory management has played a significant role in the great moderation. The last column also shows that the household sector, composed of personal consumption expenditure and residential investment, contributes the second largest share (about 39%) in the decline of the GDP growth volatility.

Thus the findings discussed in this section provide a motivation for the examination of the potential role of financial innovation in smoothing of these GDP components. By allowing smoothing of consumption and investment expenditures, financial innovation may have played a significant role in the decline of growth volatility.

3. Financial Innovation and Consumption

The random walk hypothesis of consumption behavior proposed by Hall (1978) claims that the best prediction of tomorrow's consumption is today's consumption. However a large number of empirical studies found evidence contrary to this hypothesis. Consumption indeed shows sensitivity to predicted income changes based on lagged information. This has been termed as the excess sensitivity puzzle. The presence of income uncertainty, credit constraints, and habit persistence are some of the most widely cited reasons for why consumption may not follow a random walk.³

Following Campbell and Mankiw (1989) we can show how credit constraints might explain this excess sensitivity puzzle. If π is the fraction of credit-constrained households, then aggregate consumption C can be written as,

$$C_t = (1 - \pi)C_t^u + \pi C_t^c$$

Let C_t^u , the consumption of the unconstrained households, follow a random walk,

$$C_t^u = C_{t-1}^u + \varepsilon_t$$

On the other hand, C_t^c , the consumption of the credit constrained group of households would be given by their current income. Thus,

$$C_t^c = Y_t^c$$

Then, first differencing gives,

³ Muellbauer (1994) provides a survey of the debate.

$$\Delta C_t = (1 - \pi)\Delta C_t^u + \pi\Delta C_t^c = (1 - \pi)\varepsilon_t + \pi\Delta Y_t^c$$

From this equation we can see why consumption would show sensitivity to current income in the presence of credit constraints. Also, it is apparent from the above equation that marginal propensity to consume (MPC) out of current income will increase when the proportion of credit constrained household increases.

However, as Ludvigson (1999) points out, increased access to credit does not necessarily lead to lesser sensitivity of consumption to current income. If household debt rapidly run up to its higher limit, then the relaxed credit constraint will not result in a lower MPC. However, Ludvigson shows that in a model where borrowing is related to the exposure to credit market risk, households will not run up to the higher credit limit. Thus in that case, financial innovation can lead to less sensitivity of consumption to current income. Indeed, DES have found evidence that the marginal propensity to consume has been declining in the U.S. Estimated MPC out of a rolling 40 quarter regression of consumption on income show that MPC on average has been smaller in the recent decades.

In order to assess how financial innovation has played a role in the smoothing of consumption in Canada, I also examine the sensitivity of consumption to current disposable income and real interest rates. I start from the following error correction specification which closely resembles the framework of Davis and Palumbo (2001).

$$\Delta \ln C_t = \alpha_0 + \alpha_1 \hat{e}_{t-1} + \Gamma' x_t + \varepsilon_t \quad (\text{Specification I})$$

Here $\hat{e}_{t-1}$ is the estimated error term obtained from the long run specification,⁴ x is a vector of other variables that are believed to affect short run behaviour of consumption. More specifically in the regressions reported below, x consists of real interest rate (R_t), gap (A_t , defined as the percentage deviation of the actual GDP from the potential GDP⁵), current period disposable income growth ($\Delta \ln Y_t^d$), and previous period's growth rates of consumption ($\Delta \ln C_{t-1}^d$), and household net worth ($\Delta \ln W_{t-1}$).

Table 2 reports results for total consumption using this specification. OLS regression results are reported in the first column. As expected, disposable income growth has a positive and statistically significant effect and real interest rate has a significantly negative effect on the consumption growth. The second column of the table reports results when a time dummy (D) for years 1988 and onwards is introduced. As the interaction term of the dummy with disposable income growth indicates (i.e. the term $D \cdot \Delta \ln Y_t^d$), sensitivity of consumption to disposable income growth has slightly increased since 1988. However the increase is statistically insignificant. On the other hand, the negative effect of interest rate on consumption growth rate has slightly declined, although not in a statistically significant manner. Thus these results give us mixed evidence on the effect of financial innovation on reducing consumption volatility. The small increase in the sensitivity of consumption

⁴ The long run specification is, $\ln C_t = \beta_0 + \beta_1 \ln Y_t^d + \beta_2 \ln W_{t-1} + e_t$ where Y_t^d is the disposable income in period t and W_{t-1} is the household wealth in period $t-1$.

⁵ Potential GDP is the trend GDP obtained by applying the Hodrick-Prescott filter (with $\lambda = 1600$).

to disposable income runs contrary to the belief that financial innovation has played a role in smoothing consumption in recent years. But the slight decrease in the interest rate effect suggests that in recent years fluctuations in the interest rates had a smaller influence on consumption. The third column of the table reports instrumental variable (IV) regression results, which attempts to overcome plausible endogeneity problem in the regression results reported in the first and the second column. We see that the conclusions we drew above remains even with IV regressions.

Table 3 and Table 4 reports respectively the results for regressions with non-durable and durable consumptions as the dependent variables. Again we fail to find any evidence that indicates a decrease in the sensitivity of consumption to current disposable income.

In order to check robustness of our results, a specification that closely resembles DES is also estimated. They consider a specification where consumption growth rate depends on the previous period's consumption growth ($\Delta \ln C_{t-1}$), current period's disposable income growth ($\Delta \ln Y_t^d$), current period's real interest rate (R_t), current period's business leading indicators growth ($\Delta \ln B_t$), and previous period's levels of wealth, government transfer payments, consumption as a ratio of disposable income ($\frac{W_{t-1}}{Y_{t-1}^d}$, $\frac{T_{t-1}}{Y_{t-1}^d}$, and $\frac{C_{t-1}}{Y_{t-1}^d}$ respectively). Thus the estimating equation can be expressed as follows,

$$\Delta \ln C_t = \alpha_0 + \alpha_1 \Delta \ln C_{t-1} + \alpha_2 \Delta \ln Y_t^d + \alpha_3 R_t + \alpha_4 \Delta \ln B_t + \alpha_5 \frac{W_{t-1}}{Y_{t-1}^d} + \alpha_6 \frac{T_{t-1}}{Y_{t-1}^d} + \alpha_7 \frac{C_{t-1}}{Y_{t-1}^d} + \varepsilon_t \quad (\text{Specification II})$$

With the growth rate of total consumption as the dependent variable, we see in the second column of Table 5 that sensitivity of consumption to disposable income slightly decreased (indicated by the negative value of the interaction term $D.\Delta \ln Y_t^d$). However, this decrease is insignificant, as is the decrease in the negative effect of interest rate on consumption (indicated by the positive value of interaction term $D.R_t$). Moreover these results do not hold when we use IV regressions, as reported in the third column of Table 5. Table 6 and Table 7 report results for non-durable and durable consumption respectively. The results obtained pretty much conforms to the conclusion drawn from the earlier specification.

As an alternative to having an econometric specification of the consumption equation as above, Figure 5 examines the relationship between unusual changes in the consumption growth with unusual changes in the disposable income growth for the periods 1961-1987 and 1988-2006. Unusual changes in consumption and income growths are defined as the deviations of quarterly growth rates from their respective growth over the preceding 12 quarters. As the almost identical slopes of fitted lines for the two periods show, there is no noticeable difference in the responsiveness of changes in consumption growth to changes in the disposable income growth in the two periods. Unlike Dynan et al (2006), we do not find evidence in Figure 5 that consumption growth is less sensitive to income growth in recent decades.

In a similar fashion, Figure 6 plots unusual changes in the consumption growth with unusually high or low level of real interest rate. Unusually high or low level of interest rate is defined as the deviation of the current level from the average

of previous 12 quarters' interest rate. As can be deduced from the fitted lines, a higher than usual real interest rate (positive values on the horizontal axis) leads to a decline in the consumption growth rate relative to previous 12 quarters and a lower than usual rate (negative values on the horizontal axis) leads to an increase in the consumption growth rate relative to previous 12 quarters. Slopes of the fitted line for the sample period 1988-06 is slightly more negative, and thus implies a greater sensitivity of consumption spending to interest rate. However this figure could be masking asymmetries in the effect of interest rate on consumption. One implication of credit market imperfection is that there can exist asymmetries in the effect of interest rate on spending. For example, in the presence of credit rationing consumption may show more sensitivity to a higher interest rate than to a lower interest rate. A contractionary shock, such as a higher interest rate, can make it difficult to borrow during the contraction, and thus can lead to a greater decline in spending. If financial innovation made it easier to borrow then it is possible that an unusually high interest rate will have smaller impact on consumption in the recent decades.

To test this, Figure 7 plots unusual changes in the consumption growth corresponding only to the higher than usual real interest rate levels (positive values of the interest rate deviations) for the two sample periods. The negative effects on consumption growth of a higher than usual interest rate are indeed lower in the 1988-06 period, as manifested by the smaller slope of the fitted line. Next, Figure 8 plots unusual changes in the consumption growth corresponding only to the lower than usual real interest rate levels (negative values of the interest rate deviations) for the two sample periods. The fitted line for the sample period 1988-06 has a higher slope

implying that a given decrease in the interest rate led to a greater increase in the consumption growth in the latter sample period. Thus an expansionary shock, such as a lower interest rate, has led to higher consumption growth in the latter period. To summarize the results in these three figures, it appears that there is indeed asymmetry in the effect of interest rate on consumption. A higher interest rate leads to a comparatively smaller decline in the consumption spending in the latter sample period. On the other hand, a lower interest rate leads to a comparatively larger increase in the consumption spending in the latter sample period.

4. Financial Innovation and Residential Mortgage Market

Peek and Wilcox (2006) examined how much the rapid emergence of the secondary mortgage market may have dampened the response of residential investment to income and interest rates in the U.S. They claim that by broadening and deepening the mortgage market, the rapid development of the secondary mortgage market has tempered the responses of residential investment to fluctuations in income and interest rates. They find that the growth of secondary mortgage market in the U.S. has significantly reduced the sensitivity of residential investment to interest rate and income. As a result volatility of residential investment has reduced; which in turn contributed to the great moderation.

Innovations in the Canadian housing market, on the other hand, were comparatively moderate. In the US, the removal of regulation Q in the early 1980s is considered as a significant landmark in financial liberalization. Regulation Q, which imposed interest rate ceilings on checking and savings deposits at banks, had led to

severe disintermediation when the market interest rate rose sharply in mid 1970s. This in turn resulted in the rapid growth of the money market mutual funds and securitization of mortgages in the US, as banks and savings and loan associations (S&Ls) struggled to raise funds in the conventional way. In contrast, there were no ceilings on the interest rate offered on deposits in Canada. As a result money market mutual funds and securitizations markets in Canada have not experienced as high a growth as in the US. Nevertheless, the Canadian financial system has gone through significant changes during this time.⁶ The National Housing Act Mortgage-Backed Securities program was introduced in 1985 by the Canadian Mortgage and Housing Corporation (CMHC). Before 1985, the securitization of mortgages in Canada was virtually absent. Financial innovations, such as securitizations and low or zero down payment mortgages, surely have enhanced the supply of funds for residential mortgages by releasing funds tied up in long term mortgage credits. Also, greater competition has improved households' access to the residential mortgage loan market. As was illustrated in section 2, the volatility of residential investment in Canada has also declined in recent decades. Thus it would be interesting to investigate what role the recent innovations in the mortgage market in Canada has played in this volatility decline.

In order to assess the impact of financial innovation on residential investment in Canada, let us outline an empirical specification:

$$I_t^{res} = \alpha_0 + \alpha_1 A_t + \alpha_2 D.A_t + \alpha_3 R_t + \alpha_4 D.R_t + \alpha_5 H_{t-1} + \alpha_6 P_t + \alpha_7 D + \varepsilon_t$$

⁶ For a survey of regulatory changes in Canada, see Freedman (1998).

Here I_t^{res} is the residential investment, A denotes the deviation of the actual GDP from its potential as a percentage of the potential GDP, D denotes a dummy which assumes a value of 1 starting from a specified break date, R is the 5-year term real mortgage interest rate, H is housing stock, and P is the growth rate of the population. We normalize the trending variables, I^{res} and H , by potential GDP. The empirical specification outlined above closely follows that of Peek and Wilcox (2006).

Table 8 reports both OLS and instrumental variable regression results for this specification. The dummy variable D is set to equal 1 for year 1988 onwards. The results clearly show that the negative effect of the mortgage interest rate on residential investment has declined significantly since 1987. This is consistent with the story that financial innovation has in fact dampened the response of residential investment to interest rate. Interestingly, starting in late 1980s, the secondary mortgage market in Canada started to experience high growth. Thus the results obtained here nicely corroborates the Peek and Wilcox's finding that development of secondary mortgage market has lead to lower sensitivity of residential investment to income and interest rate.

5. Effects of Interest Rate Shocks on Household Expenditure and Credit

One test of the effects of financial innovation on the economy could be how the response of various economic variables to shocks have changed overtime. Haan and Sterk (2008) find that financial innovation had the greatest effect on cyclical behaviour of consumer credit and durable expenditures than on home mortgages and

residential investment. They compare time series properties between the periods 1953Q3-1978Q4 and 1984Q1-2008Q1 and find that responses of consumer credit, GDP and durable expenditures to a monetary policy shock changes from significantly negative to roughly zero. However home mortgages and residential investment still show significantly negative although smaller responses to a monetary policy shock in the latter sample period.

Figure 9 shows five year rolling correlation of the annualized quarterly growth rates of consumer credit and residential mortgage credit with the growth rates of GDP. Positive correlation of these credit aggregates with GDP started to decline in early-1990s. In fact by late 1990s the correlation turned negative. This could imply that easier access to credit due to financial innovation has facilitated households to obtain credit during downturns and thus dampened the effect of the slowdown in the recent years.

Indeed, financial innovation can have a significant role in affecting the monetary policy transmission mechanism. The effect of a monetary tightening will be dampened if individuals and firms in the economy find it easier to borrow due to financial innovation. Here I use a structural vector autoregression (SVAR) to assess the impact of monetary policy shock on different macroeconomic and financial variables. The following equation outlines our identifying assumptions in the VAR. Here e_j represent the structural disturbances and u_j represent reduced form residuals from the VAR. This system of equations has eight variables, consumer price index (P), real GDP (Y), M1 monetary aggregate ($M1$), 3-month treasury bill interest rate

(i), Canadian dollar exchange rate with US dollars (S), oil price (WP), US federal funds rate (FFR) and an “other” variable (o) representing the variable for which we are interested in obtaining the impulse response.

$$\begin{bmatrix} e_P \\ e_Y \\ e_M \\ e_i \\ e_s \\ e_{WP} \\ e_{FFR} \\ e_o \end{bmatrix} = \begin{bmatrix} 1 & g(P,Y) & 0 & g(P,i) & 0 & g(P,WP) & 0 & 0 \\ 0 & 1 & 0 & g(Y,i) & 0 & g(Y,WP) & 0 & 0 \\ g(M,P) & g(M,Y) & 1 & g(M,i) & 0 & 0 & 0 & 0 \\ g(i,P) & g(i,Y) & g(i,M) & 1 & g(i,s) & g(i,WP) & g(i,FFR) & 0 \\ g(s,P) & g(s,Y) & g(s,M) & g(s,i) & 1 & g(s,WP) & g(s,FFR) & g(s,o) \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & g(FFRWP) & 1 & 0 \\ 0 & 0 & 0 & g(o,i) & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_P \\ u_Y \\ u_M \\ u_i \\ u_s \\ u_{WP} \\ u_{FFR} \\ u_o \end{bmatrix}$$

Figure 10 reports the impulse responses of the interest rate, GDP, consumer credit, residential mortgage credit, durable goods consumption and residential investment for the entire sample period, 1962Q1-2006Q. These impulse responses were generated by a one standard deviation monetary policy shock, as identified by the SVAR scheme outlined above.⁷ As expected, following a contractionary monetary policy shock, output, consumption, residential investment and two credit measures (i.e. real consumer credit and residential mortgage credit outstanding) decline.

Figure 11 reports the impulse responses of interest rate and GDP for the two sub-samples (1962Q1-1987Q4 and 1988Q1-2006Q4). Likewise, Figure 12 reports impulse responses of the credit aggregates, and the expenditure components for the two sub-samples. The differences in the impulse responses between the two sample periods do not provide support for the view that the effects of monetary policy on the real and financial variables have declined in the recent decades. In fact, the impulse

⁷ Impulse responses for interest rates and GDP reported in the figure were generated from an SVAR system where the ‘other’ variable is consumer credit.

responses in Figure 11 and Figure 12 indicate that the negative effect of a contractionary monetary policy shock has become more persistent recently. However the impulse responses for the sub-samples, especially for the 1988Q1-2006Q4 sub-sample, suffer from low degrees of freedom and should not be taken as strong evidence against the moderating effects of financial innovation.

6. Conclusion

There has been a considerable decline in the volatility of aggregate economic activity in most of the developed countries over the last couple of decades. The potential explanations for this “Great Moderation” include better inventory management, smaller and infrequent shocks, better monetary and fiscal policies etc. From a policy maker's perspective it is important to understand the underlying causes of the moderation. If better fiscal or monetary policy were responsible, then policy makers should take note of the specific policy aspects that are driving the phenomenon. If structural changes in the economy (such as improved inventory management) played the driving role, then it make sense to come up with appropriate policy and regulatory framework that encourage such changes and innovations. Recently, financial innovation has been put forward as an added reason for the observed moderation in the volatility of economic activity. By allowing consumers and businesses better access to external finance, financial innovation may allow smoothing of consumption and investment. Moreover development of new financial products, such as securitization of mortgages, enhances liquidity of financial assets and thus facilitates supply of low-cost external funds to borrowers.

But financial innovation does not always imply a decline in the macroeconomic volatility. For example, financial innovation that allows easier access to credit can facilitate households and businesses to achieve their target level of spending quickly during boom, and thus increase volatility. On the other hand, during a slump, it can lessen the sensitivity of spending to the current income and cash flow. In light of the current economic crisis, it is an interesting exercise to investigate the historical role of financial innovation in the Great Moderation. Moreover, as the current financial crisis has demonstrated, financial deregulation and liberalizations may increase the fragility of the overall economy by increasing exposure of households and businesses to financial market bubbles.

Similar to the evidence obtained for the U.S. we find that the household sector (comprising of consumption and residential investment) was the second largest contributor to the tempering of output volatility. We investigate the potential role of financial innovation in causing moderation of the household sector activities. Unlike the findings in the U.S. we do not find any conclusive evidence that financial innovation was in particular responsible for the smoothing of consumption. The marginal propensity to consume out of disposable income does not appear to have declined in recent decades. Also, interest rate sensitivity of consumption does not show any significant tempering. Residential investment does appear to be less sensitive to mortgage rate movements in recent decades. This conforms to the claim that the growth of the secondary mortgage market and development of mortgage based financial products has relaxed financing constraints and made it easier for households to make housing investment. Using a structural vector autoregression

(SVAR) scheme, we also investigate the sensitivity of various credit aggregates to interest rate shocks. However, we were unable to find any significant changes in recent years, with respect to how credit aggregates respond to interest rate shocks.

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Figure 1
Volatility of GDP growth rate

Figure 2
Rolling standard deviation of growth rates of GDP components

5-Year Rolling St. Deviation of Growth Rates of GDP Components

Figure 3
Volatility of growth rates of consumption and investment components

Figure 4
Rolling correlation of expenditure components with final sales

Figure 5
Unusual consumption growth vs. unusual income growth

Figure 6
Unusual consumption growth vs. unusually high/low level of interest rate

Figure 7
Unusual consumption growth vs. unusually high level of interest rate

Figure 8
Unusual consumption growth vs. unusually low level of interest rate

Figure 9
Rolling correlation of credit aggregates with GDP growth

5-Year Rolling Correlation with GDP Growth

Figure 10

Impulse responses of macroeconomic variables and credit aggregates (1962-2006)

Figure 11
Impulse responses of macroeconomic variables in sub-samples
Sample period 1962-1987 Sample period 1988-2006

Figure 12
Impulse responses of credit aggregates and expenditure components in sub-samples
 Sample period 1962-1987 Sample period 1988-2006

Table 1
Contribution to the decline in GDP volatility

Component	Variances and Covariances of Quarterly Growth Rates		Change	Contribution (%)
	1961-1987	1988-2006		
Variance of GDP	16.61	5.80	-10.81	100
Variance of household sector			-4.19	38.71
Variance of PCE	5.05	2.22	-2.82	26.11
Variance of residential investment	1.13	0.45	-0.68	6.29
Covariance of PCE and residential investment	0.72	0.38	-0.68	6.31
Variance of business investment on non-residential structures and equipments	2.51	1.62	-0.90	8.29
Inventory			-4.91	45.41
Variance of inventory investments (Business + Govt.)	8.89	5.66	-3.23	29.88
Covariance of final sales and inventory investments	-3.92	-4.76	-1.68	15.53
Other variances and covariances			-0.76	7.00
Variance of remaining components of final sales (net exports and government sector)	6.88	8.60	1.72	-15.94
Covariance of HH sector and Non-residential structural and equipment	1.42	0.42	-2.00	18.46
Covariance of household sector + business non-residential investment with remaining components of final sales	-2.15	-2.39	-0.48	4.48

Table 2
Sensitivity of total consumption to income and interest rates
(Specification I)

	$\Delta \ln C_t$		
	OLS	OLS with dummy	IV
$\hat{e}_{t-1}$	-0.0698*** (0.0210)	-0.0933*** (0.0249)	-0.0735*** (0.0281)
$D.\hat{e}_{t-1}$		0.0661 (0.0437)	-0.0530 (0.0784)
$\Delta \ln Y_t^d$	0.170*** (0.0519)	0.151** (0.0622)	0.0987 (0.204)
$D.\Delta \ln Y_t^d$		0.0124 (0.116)	0.661 (0.423)
R_t	-0.123*** (0.0193)	-0.131*** (0.0233)	-0.102*** (0.0310)
$D.R_t$		0.0255 (0.0386)	-0.107 (0.0916)
$\Delta \ln C_{t-1}$	-0.103 (0.0700)	-0.120* (0.0710)	-0.0158 (0.0715)
$\Delta \ln W_{t-1}$	-0.0102 (0.0949)	-0.000882 (0.0971)	-0.122 (0.151)
A_t	0.000835* (0.000452)	0.000844* (0.000469)	0.000507 (0.000699)
D		0.00207 (0.00182)	-0.00210 (0.00388)
<i>Constant</i>	0.0113*** (0.00149)	0.0123*** (0.00173)	0.0125*** (0.00284)
Observations	178	178	176
Adj. R-square	0.238	0.239	0.002
J-stat p-value			0.464

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

$\Delta \ln Y_t^d$, R_t , and A_t were instrumented by 1st to 3rd lags of $\Delta \ln Y^d$, R , A ; 2nd and 3rd lags of $\hat{e}$, $\Delta \ln C$; first lag of $\ln Y^d$, current values of US federal funds rate, and oil price.

Table 3
Sensitivity of nondurable consumption to income and interest rates
(Specification I)

	$\Delta \ln C_t^{nd}$		
	OLS	OLS with dummy	IV
$\hat{e}_{t-1}$	-0.0494*** (0.0176)	-0.0576*** (0.0202)	-0.0887*** (0.0204)
$D.\hat{e}_{t-1}$		0.0243 (0.0456)	-0.101 (0.103)
$\Delta \ln Y_t^d$	0.191*** (0.0632)	0.223*** (0.0760)	0.543* (0.283)
$D.\Delta \ln Y_t^d$		-0.157 (0.140)	0.422 (0.615)
R_t	-0.113*** (0.0231)	-0.109*** (0.0267)	-0.122*** (0.0388)
$D.R_t$		0.00842 (0.0550)	-0.177 (0.160)
$\Delta \ln C_{t-1}^{nd}$	-0.239*** (0.0691)	-0.245*** (0.0697)	-0.258*** (0.0863)
$\Delta \ln W_{t-1}$	-0.0242 (0.117)	-0.00776 (0.121)	-0.345** (0.167)
A_t	0.000879* (0.000522)	0.000919* (0.000551)	0.00156* (0.000885)
D		-0.00077 (0.00228)	0.00152 (0.00508)
<i>Constant</i>	0.00846*** (0.00169)	0.00863*** (0.00201)	0.00935** (0.00367)
Observations	178	178	176
Adj. R-sq	0.189	0.183	-0.252
J-stat p-value			0.62

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

See notes to Table2 for information on IVs.

Table 4
Sensitivity of durable consumption to income and interest rates
(Specification I)

	$\Delta \ln C_t^d$		
	OLS	OLS with dummy	IV
$\hat{e}_{t-1}$	-0.136*** (0.0360)	-0.169*** (0.0426)	-0.114** (0.0468)
$D.\hat{e}_{t-1}$		0.0920 (0.0675)	-0.0630 (0.114)
$\Delta \ln Y_t^d$	0.577** (0.226)	0.569** (0.272)	0.463 (0.755)
$D.\Delta \ln Y_t^d$		-0.209 (0.515)	1.384 (1.634)
R_t	-0.433*** (0.0813)	-0.445*** (0.0974)	-0.339*** (0.126)
$D.R_t$		0.0675 (0.165)	-0.365 (0.376)
$\Delta \ln C_{t-1}^d$	-0.201*** (0.0700)	-0.206*** (0.0704)	-0.208*** (0.0641)
$\Delta \ln W_{t-1}$	-0.0828 (0.412)	-0.0175 (0.423)	-0.356 (0.580)
A_t	0.00206 (0.00209)	0.00209 (0.00219)	0.000637 (0.00289)
D		-0.00587 (0.00790)	-0.00427 (0.0142)
<i>Constant</i>	0.0252*** (0.00589)	0.0275*** (0.00695)	0.0303*** (0.0115)
Observations	178	178	176
Adj. R-sq	0.190	0.186	0.082
J-stat p-value			0.02

Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01
See notes to Table 2 for information on IVs.

Table 5
Sensitivity of total consumption to income and interest rates
(Specification II)

	$\Delta \ln C_t$		
	OLS	OLS with dummy	IV
$\Delta \ln C_{t-1}$	-0.316*** (0.0725)	-0.318*** (0.0734)	0.103 (0.139)
$\Delta \ln Y_t^d$	0.154*** (0.0477)	0.156*** (0.0575)	0.274** (0.138)
$D.\Delta \ln Y_t^d$		-0.0128 (0.105)	0.538 (0.413)
R_t	-0.0587*** (0.0168)	-0.0700*** (0.0211)	0.0117 (0.0359)
$D.R_t$		0.0421 (0.0457)	-0.203 (0.128)
$\Delta \ln B_t$	0.334*** (0.0490)	0.339*** (0.0509)	0.261*** (0.0752)
$\frac{W_{t-1}}{Y_{t-1}^d}$	0.00000446 (0.0000390)	0.0000323 (0.0000492)	-0.000135 (0.0000920)
$\frac{T_{t-1}}{Y_{t-1}^d}$	-0.000444 (0.000380)	-0.000522 (0.000472)	-0.0000931 (0.000557)
$\frac{C_{t-1}}{Y_{t-1}^d}$	0.00000363 (0.000284)	-0.0000730 (0.000322)	0.000212 (0.000405)
D		-0.00279 (0.00456)	0.0137 (0.00954)
<i>Constant</i>	0.0118 (0.0154)	0.00880 (0.0218)	0.0376 (0.0299)
Observations	178	178	176
Adj. R-sq	0.360	0.352	-0.114
J-stat p-value			0.24

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

$\Delta \ln C_{t-1}$, $\Delta \ln Y_t^d$, R_t , $\Delta \ln B_t$, $\frac{W_{t-1}}{Y_{t-1}^d}$, $\frac{T_{t-1}}{Y_{t-1}^d}$, $\frac{C_{t-1}}{Y_{t-1}^d}$ were instrumented by 1st to 3rd lags of $\Delta \ln Y^d$, R , $\Delta \ln B$;

current and 1st lag of US federal funds rate, oil price; current, 1st, and 2nd lags of A ; 2nd and 3rd lags of $\Delta \ln C$, $\frac{W}{Y^d}$, $\frac{T}{Y^d}$, $\frac{C}{Y^d}$.

Table 6
Sensitivity of nondurable consumption to income and interest rates
(Specification II)

	$\Delta \ln C_t^{nd}$		
	OLS	OLS with dummy	IV
$\Delta \ln C_{t-1}^{nd}$	-0.278*** (0.0717)	-0.278*** (0.0720)	0.111 (0.148)
$\Delta \ln Y_t^d$	0.171*** (0.0633)	0.226*** (0.0764)	0.366** (0.171)
$D.\Delta \ln Y_t^d$		-0.173 (0.142)	0.357 (0.663)
R_t	-0.0495** (0.0215)	-0.0530** (0.0257)	-0.0347 (0.0376)
$D.R_t$		0.00168 (0.0599)	0.0415 (0.158)
$\Delta \ln B_t$	0.0766 (0.0618)	0.0980 (0.0630)	0.0607 (0.0835)
$\frac{W_{t-1}}{Y_{t-1}^d}$	0.0000282 (0.0000246)	0.00000547 (0.0000437)	-0.00000756 (0.0000897)
$\frac{T_{t-1}}{Y_{t-1}^d}$	-0.000408 (0.000632)	-0.000837 (0.000678)	0.000442 (0.000886)
$\frac{C_{t-1}^{nd}}{Y_{t-1}^d}$	0.000423 (0.000617)	0.000211 (0.000631)	0.00112 (0.000791)
D		0.00555 (0.00607)	-0.000345 (0.0123)
<i>Constant</i>	-0.0107 (0.0209)	0.00764 (0.0270)	-0.0307 (0.0419)
Observations	178	178	176
Adj. R-sq	0.175	0.177	-0.174
J-stat p-value			0.75

Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01
See notes to Table 5 for information on IVs.

Table 7
Sensitivity of durable consumption to income and interest rates
(Specification II)

	$\Delta \ln C_t^d$		
	OLS	OLS with dummy	IV
$\Delta \ln C_{t-1}^d$	-0.426*** (0.0742)	-0.429*** (0.0746)	-0.134 (0.101)
$\Delta \ln Y_t^d$	0.557*** (0.205)	0.557** (0.243)	0.365 (0.510)
$D.\Delta \ln Y_t^d$		-0.0963 (0.454)	3.388** (1.692)
R_t	-0.258*** (0.0758)	-0.314*** (0.0922)	-0.200 (0.143)
$D.R_t$		0.269 (0.196)	-0.353 (0.434)
$\Delta \ln B_t$	1.353*** (0.219)	1.337*** (0.221)	1.191*** (0.248)
$\frac{W_{t-1}}{Y_{t-1}^d}$	0.0000655 (0.0000824)	0.000235 (0.000146)	-0.000213 (0.000282)
$\frac{T_{t-1}}{Y_{t-1}^d}$	-0.00167 (0.00105)	-0.00127 (0.00120)	-0.000995 (0.00107)
$\frac{C_{t-1}^d}{Y_{t-1}^d}$	-0.00857*** (0.00288)	-0.00884*** (0.00297)	-0.00876** (0.00360)
D		-0.0258 (0.01958)	0.0147 (0.0373)
<i>Constant</i>	0.106*** (0.0334)	0.0411 (0.0591)	0.207** (0.0981)
Observations	178	178	176
Adj. R-sq	0.329	0.326	-0.117
J-stat p-value			0.26

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

See notes to Table 5 for information on IVs.

Table 8
Sensitivity of residential investment to interest rates

	I_t^{res}	
	OLS	IV
A_t	0.00102** (0.000450)	0.00107*** (0.000360)
$D.A_t$	0.00166** (0.000703)	0.00126 (0.00108)
R_t	-0.0801*** (0.0189)	-0.0570** (0.0245)
$D.R_t$	0.0592* (0.0330)	0.0773** (0.0380)
H_{t-1}	0.0292*** (0.00997)	0.00641 (0.0195)
P_t	0.00532*** (0.00167)	0.00312 (0.00225)
D	-0.0154*** (0.00269)	-0.0129*** (0.00414)
<i>Constant</i>	0.0355*** (0.0100)	0.0579*** (0.0189)
Observations	176	174
Adj. R-sq.	0.448	0.430
J-stat p-value		0.2214

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

Two lags of P , three lags each of A and R were used to instrument for the housing stock.

Appendix: Data Source and Variable Constructions

Current dollars, constant 2002 dollars and chained 2002 dollars values of the following variables were obtained from the Cansim Table 380-0002. All series were seasonally adjusted at annual rates.

- Gross Domestic Product (GDP)
- Personal expenditure on consumer goods and services
- Personal expenditure on durable goods
- Personal expenditure on semi-durable goods
- Personal expenditure on non-durable goods
- Personal expenditure on services
- Government current expenditure on goods and services
- Government gross fixed capital formation
- Government investment in inventories
- Business gross fixed capital formation
- Residential structures
- Non-residential structures and equipment
- Non-residential structures
- Business investment in inventories
- Exports of goods and services
- Imports of goods and services

Other variables

Prime corporate paper rate: 3 month. Cansim Table 176-0043 - Financial market statistics, last Wednesday unless otherwise stated, computed quarterly average (percent)

Current transfers from government=Employment insurance benefits + Social security and other benefits. Cansim Table 380-0004 - Sector accounts, persons and unincorporated businesses.

GDP deflator is defined as $(\text{Current price GDP} / \text{Chained 2002 dollars GDP}) * 100$

Nominal disposable income. Table 380-0004 - Sector accounts, persons and unincorporated businesses, quarterly

Oil price. International Financial Statistics Online (henceforth IFS) series 00176AAZZF... (petroleum: average crude price)

United States federal funds rate. IFS series 11160B..ZF...

Canadian Dollar per US Dollar (market rate, period average). IFS series 156..RF.ZF...

Canada M1, seasonally adjusted IFS series 15659MACZF...

Canada CPI: all cities pop ovr.30,000. IFS series 15664...ZF...

Conventional mortgage lending rate, 5-year term (computed quarterly average). Cansim Table 027-0015.

Nominal residential mortgage credit total outstanding balances of major private institutional lenders (computed quarterly average, seasonally adjusted). Cansim Table 176-0069.

National Housing Act (NHA) mortgage backed securities (outstanding balances of major private institutional lenders, computed quarterly average, seasonally adjusted). Cansim Table 176-0069.

Total population in Canada. Cansim Table 051-0005.

Calculating the quarterly housing stock

From Cansim Table 030-0002 we obtained end of the year net stock of residential capital for 1960 in 2002 constant dollars. From the same table we also obtain the average residential depreciation rate during the period 1961-2006. Since this is the annual depreciation rate, we approximate the quarterly depreciation rate by dividing it by 4. Then we compute the quarterly housing stock by using the perpetual inventory method:

$$hstock_t = hstock_{t-1} + resinv_t - d * hstock_{t-1}$$

Here, $hstock_t$ is the housing stock at quarter t , $resinv_t$ is the residential gross fixed capital formation at quarter t in 2002 constant dollars (obtained from Table 380-

0002), and d is the quarterly depreciation rate (as defined above). The computed quarterly stock series corresponds well with the actual annual stock series.

Computing the quarterly growth rate

For a variable x_t , annualized quarterly growth rate g_{x_t} is computed as follows:

$$g_{x_t} = \left(\left(\frac{x_t}{x_{t-1}} \right)^4 - 1 \right) 100.$$

In calculating growth rates we used *chained 2002 dollars* values of each variable, as chained dollars give a better measurement of the growth rates.

Calculating the contribution of a GDP component to the GDP growth rate

Let g_{x,y_t} be the contribution of x to the growth rate of GDP (y). Then,

$$g_{x,y_t} = h_{x_t} g_{x_t}$$

$$\text{where } h_{x_t} = \frac{\left(\frac{x_{t,nom}}{y_{t,nom}} + \frac{x_{t-1,nom}}{y_{t-1,nom}} \right)}{2} \text{ is the nominal share of } x \text{ in } y.$$

$x_{t,nom}$ is the nominal value of x in quarter t ; $y_{t,nom}$ is the nominal value of GDP in quarter t .

Inventory investment growth rate cannot be defined in the above mentioned way. To calculate the contribution of inventory investment (Δn), which includes both the government and business inventory investment, we define final sales, $s_t = y_t - \Delta n$.

Then the contribution of inventory investment to the growth rate of GDP can be indirectly computed by the following formula (see Davis and Kahn (2008) and Whelan (2000)):

$$g_{\Delta n, y_t} = g_{y_t, y_t} - g_{s_t, y_t}$$

Calculating the growth rate of final sales series

Chained series for the final sales s_t is not available in Cansim database. Moreover, as shown in Whelan (2000), additivity property does not hold for chained series. Thus we cannot obtain final sales by adding chained values of the relevant GDP components. In order to calculate the contribution of final sales growth to the GDP growth correctly we follow the following steps:

Step 1 Use the 2002 constant dollar values of relevant GDP components to construct final sales series.⁸ Thus final sales in 2002 constant dollars are defined as:

$$s_{t,2002} = y_{t,2002} - \Delta n_{t,2002}$$

where $s_{t,2002}$ is the final sales in quarter t in 2002 prices, $y_{t,2002}$ is the GDP in quarter t in 2002 prices and $\Delta n_{t,2002}$ is the inventory investment in quarter t in 2002 prices.

Step 2 Let $s_{t,t-1}$ be the final sales in quarter t in prices of quarter $t-1$. We can find $s_{t,t-1}$ as follows:

$$s_{t,t-1} = \frac{s_{t,2002} s_{t-1,nom}}{s_{t-1,2002}}$$

where, in accordance with the notational convention set out above, $s_{t,2002}$ is the final sales in quarter t in 2002 prices, $s_{t-1,nom}$ is the final sales in quarter $t-1$ in current dollars.

Step 3 Calculate the growth rate-1 of the final sales using the following formula:

$$g_{s_t} = \left(\left(\frac{s_{t,t-1}}{s_{t-1,nom}} \right)^4 - 1 \right) 100$$

By definition, this will give us the growth rate of final sales, as if we have used a chained series for the final sales in the calculation.⁹

⁸ Unlike the chained series, additivity property does hold for the constant dollar denominated series.

⁹ See chapter 2 of the OECD manual "Understanding National Accounts" (2006), written by Lequiller and Blades.

Step 4 Calculate contribution of final sales growth to the GDP growth using the formula:

$$g_{s,y_t} = h_{s_t} g_{s_t}$$

$$\text{where } h_{s_t} = \frac{\left(\frac{S_{t,nom}}{Y_{t,nom}} + \frac{S_{t-1,nom}}{Y_{t-1,nom}} \right)}{2}$$

Calculating the real interest rate series

The real interest rate is defined as: $R_t = i_t - \pi_{t+4}$

where t refers to the quarter, i is the nominal rate on 3-month prime corporate paper and π is the year over year inflation rate,

$$\pi_t = \left(\frac{P_t}{P_{t-4}} - 1 \right) 100$$

where P is the GDP deflator obtained by dividing nominal GDP by chained 2002 GDP.

Calculating the quarterly wealth series

The quarterly wealth series is obtained from the annual wealth series using the Boot-Feibes interpolation method available in the ECOTRIM software.