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THE IMPACT OF CORPORATE RISK MANAGEMENT ON MONETARY POLICY TRANSMISSION:

SOME EMPIRICAL EVIDENCE

by

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Abstract

Quite an impressive amount of recent academic research focuses on the idea that financial factors may cause or reinforce real fluctuations. In these models, it is typically a monetary policy shock that serves to lower the value of an asset which is used to secure a firm's borrowing, thereby generating broad credit channel effects of monetary transmission. We empirically investigate the impact of corporate risk management strategies on this specific transmission channel by using the seminal paper of Gertler and Gilchrist (1994) as a benchmark. A potentially important impact of corporate hedging is suggested by corporate finance models that generate hedge incentives by introducing asymmetric information into the credit markets, the assumption at the very heart of the available theories of a broad credit channel. The advent of liquid US interest rate derivatives markets in the mid-1970s should, therefore, serve as something like a turning point in the history of US monetary transmission. Credit channel effects should have been in operation prior to the introduction of these markets, while any such effect should have tended to vanish afterwards. In addition, we should be able to detect marked differences in the behaviour of small and large firms up to the 1970s in contrast to a broadly identical behaviour on the part of these firms in the period thereafter.

Keywords: Derivatives, Monetary Policy Transmission, VAR Models

JEL Classification: E44, E52, G31, G32

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Contents

1. Introduction

Quite an impressive amount of recent academic research focuses on the idea that purely financial factors may cause or reinforce real economic fluctuations. The common notion of this research is that informational asymmetries may introduce imperfections into financial markets. Examples include Kiyotaki and Moore (1997) and Bernanke, Gertler and Gilchrist (1998). In the models concerned, it is typically some monetary shock that actually lowers the value of an asset which is used to secure a firm's borrowing, thereby aggravating asymmetric information problems. This serves to make external financing either more difficult to obtain or more expensive, which, in turn, lowers aggregate investment and output even further.

Bernanke and Gertler (1995), focusing on the monetary transmission mechanism, show that shifts in monetary policy affect not only market rates per se but also the financial position of borrowers, both directly and indirectly. A tight monetary policy weakens balance sheets in at least two ways. First, to the extent that borrowers have outstanding short-term or floating rate debt, by directly raising interest rate expenses. This reduces firms' net cash flows and hence the financial position of borrowers. Second, rising interest rates are also typically associated with declining asset prices, which will tend to reduce the value of the borrower's available collateral.

Substantial effort has been directed at testing these theories. The empirical literature, starting with Fazzari, Hubbard and Petersen (1988), finds that investment and cash flow are usually positively related, even after investment opportunities, represented by Tobin's q, are controlled for. This relationship is stronger for small firms, corporations with low dividend payments, and firms with low credit ratings. That is, firms which would usually be expected to have less access to the credit markets seem to display a greater sensitivity of investment demand to internal financing. Other authors, such as Gertler and Gilchrist (1994), BIS (1995), Oliner and Rudebusch (1996), and Bernanke, Gertler and Gilchrist (1996), investigate the monetary policy implications of these theories. They show that the responses of small and large firms to monetary impulses differ and that the reaction of small firms seems to be more pronounced than the respective response of large firms. This, again, is seen as evidence of the importance of financial propagation mechanisms, ie so-called financial accelerator effects, for monetary policy and aggregate activity (Walsh, 1998).

However, the story does not necessarily end at this point. A relatively new literature on corporate hedging argues that asymmetric information, the force at the very heart of the financial accelerator, will also create incentives for corporate risk management. This research, eg Froot et al. (1993), shows that if informational frictions make external financing more expensive than funds generated internally, this will serve to create incentives for corporate risk management, given that the firm's cash flow fluctuates over time. Due to recent developments in the markets for financial derivatives, there are now risk management techniques and instruments available to deal with financial risks very efficiently.[1]

Assuming that cash flows are subject to interest rate risk, firms can now use interest rate futures and options to deal with their exposures to interest rates. A firm, being subject to a financial accelerator, might therefore find it profitable to engage in risk management strategies aiming to stabilise corporate cash flow with regard to interest rate changes.[2] In doing so, it will certainly affect the impact of monetary impulses on investment spending as well as on real economic activity. As a result, financial accelerator effects of monetary policy are likely to be reduced and monetary authorities will lose some of their power to affect real economic activity by monetary policy measures.

This paper is organised as follows. To set the scene, we will briefly review the available evidence on corporate hedging in the non-financial sector based on survey data and similar information. Section 3, using Gertler and Gilchrist (GG, 1994) as a benchmark, provides empirical evidence on the impact of corporate hedging strategies on monetary transmission by estimating a series of VARs based on quarterly US data. The last section briefly summarises the results and provides a short conclusion.

2. Corporate use of derivatives in the non-financial sector

Use of derivative instruments in corporate risk management has grown rapidly in recent years, partly caused by the success of the financial industry in designing a great variety of OTC and exchange-traded contracts. The overall scale of interest rate hedging policies implemented by non-financial corporations appears to be substantial. The latest BIS (1999) survey reports US$61 trillion of notional amounts outstanding on the combined markets for OTC and exchange-traded interest rate derivatives as of end-June 1998. With 11.8% of the notional amounts falling to non-financial customers, this suggests that up to about one ninth of the derivatives outstanding at that time was held for corporate hedging purposes.

These figures are broadly in line with the available survey evidence on the corporate use of derivatives in the non-financial sector. Bodnar et al (1995), for example, examine a group of 530 US non-financial firms. Of these firms, 183 (35%) indicate to have used derivatives. Swaps are being used to deal with interest rate risk, while forward contracts seem to dominate exchange rate hedging. The most dominant

1 See von Hagen and Fender (1998) for a recent survey.

2 The effect of these strategies seems to be dramatic. Guay (1999) examines a sample of 254 non-financial corporations that began using derivatives between 1991 and 1994. He finds that firms primarily use interest rate instruments and that a company's interest rate exposure is, on average, reduced by 22% in the period following the initiation of a derivatives programme.

motive for the corporate use of derivatives is the "minimisation of fluctuations in firm cash flow". A share of some 67% of the surveyed users regards this as the primary goal of corporate risk management.

The Survey of Industry Practice provides some additional information on the end users of derivatives contracts (Group of Thirty, 1993). A share of 88% of the surveyed end users describes the purpose of risk management activities as hedging market risks arising from new financing. Another important rationale is the modification of characteristics of existing assets and liabilities (84%). The contract types most commonly used are interest rate swaps (88%), followed by foreign exchange forwards (72%) and currency swaps (64%). In the same survey, some 82% of the reporting end users considered the use of derivatives either very important (40%) or even imperative (42%) for the control of risk within their organisation. Other authors find similar evidence for New Zealand, the United Kingdom and Germany.[3] Depending on the actual sample and the respective country, these surveys find that some 50% or more of the surveyed non-financial firms reported to have used derivatives. A share of at least 90% of these firms seems to have done so for hedging purposes. Overall, the instruments and strategies used appear to mirror the US findings, with forwards and swaps being the dominant instruments.

The bottom line of all of these studies is that non-financial firms systematically engage in corporate hedging. There is a growing consensus that more and more firms are managing their exposure to various financial risks using derivatives, with interest rate risk being their dominant concern. The focus of corporate hedging is found to be primarily on near-term transactions. In addition, most of the results seem to be consistent with the general hypothesis that firms with low levels of liquidity and high growth opportunities tend to hedge more. Use of derivatives, however, is greater for large firms than for small ones and size seems to be an important determinant of derivatives use, suggesting that firms must overcome certain fixed costs before starting a hedging programme (Mian, 1996).

3. Empirical evidence based on QFR data

This section examines the impact of corporate risk management on the monetary transmission mechanism in the United States. It has been argued that corporate hedging by non-financial firms is very likely to have an important impact on the transmission of monetary policy (von Hagen and Fender, 1998, and Vrolijk, 1997). The starting point for this position is the assumption of asymmetric information in the credit markets, which serves to generate financial accelerator effects of monetary policy transmission.

This aspect of the monetary transmission mechanism, usually termed the broad credit channel, features prominently in the recent literature on the transmission of monetary policy measures. However, Froot et al (1993) argue that the very assumptions that are at the heart of every model featuring broad credit channel effects, namely informational asymmetries, will also create incentives for corporate risk management. According to this theory, firms operating under a financial accelerator will engage in cash flow hedging programmes that engineer their internal cash flows so as to meet their feasible investment needs and to avoid any further deadweight costs induced by underinvestment. Optimal risk management strategies thus manipulate the interest rate risk exposure of corporate cash flows in an attempt to stabilise agency costs. This, in turn, will diminish any credit channel effect of monetary policy and will hence reduce monetary policy transmission to the pure cost-of-capital effect. Given these results, there is no room for a sizeable credit channel in the presence of corporate risk management.[4]

The theory outlined above produces a number of testable hypotheses. The most important one is that, due to the introduction of interest rate derivatives and the rapid development of their markets, the financial accelerator (broad credit channel) effect in operation should have diminished over time. One should therefore be able to detect major differences in the monetary transmission process up to and beyond the mid-1970s. Recent research seems to point in this direction. Taylor (1995) estimates interest rate elasticities of investment for the US, Germany and Japan with data from two sample periods, one from the early 1970s through 1985 and the other from 1986 through the mid-1990s. A comparison of these two sets of estimates gives an idea of the magnitude of change in the monetary transmission mechanism over time. In the US, the interest rate elasticity of investment has declined. The same is true for real output, which responds differently to monetary policy in the three countries mentioned above. On balance, the monetary transmission mechanism has changed so as to reduce the impact of a given change in short-term interest rates. While this seems to be true for all three countries, the change in the US seems to be larger than the one in Germany and Japan.

The growing importance of corporate hedging also implies that any differences in the behaviour of small and large firms in response to monetary policy measures should vanish over time. This follows, because small and less mature firms are commonly regarded to be more affected by problems of asymmetric information than larger or more mature ones. Large firms will usually be able to replace any shortfall in internal funds with some other form of financing during a monetary tightening. However, this possibility might not be available to small firms. Under the conditions of a broad credit channel, small and large firms will hence respond differently to monetary policy shocks.

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[3] Berkman et al (1997), Joseph and Hewins (1997) and Bodnar and Gebhardt (1998).

[4] See Fender (2000) for a model of corporate hedging under the conditions of a broad credit channel.

Empirical evidence based on partially disaggregated US data seems to support this effect. One of the most prominent papers in this area is Gertler and Gilchrist (1994). These authors examine the differential responses of small versus large US manufacturing firms to monetary policy. Applying the VAR methodology, an empirical study of the comprehensive QFR (Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations) dataset for the United States is used to assess the impulse response functions of corporate sales, inventories and short-term debt. The QFR provides quarterly aggregate income statement and balance sheet data for total manufacturing and for eight different aggregate size classes of firms within manufacturing.[5] Gertler and Gilchrist aggregate the eight size class time series into two series of growth rates, small and large, using the 30th percentile of sales each period as the cutoff for small firms. The firms' size is then used as a proxy for credit market access and the possible importance of informational asymmetries. Oliner and Rudebusch (1996) have also used OFR data for another study that actually yields similar results.

The impulse response functions estimated by GG (1994) show that small firms contract substantially, relative to larger ones, in response to tight monetary policy. Shocks have a greater cumulative impact on small than on large firms and the differences are reasonably significant for inventories and short-term debt, though not for sales. The evidence from the QFR data is thus consistent with a differential impact of monetary policy on small firms. Credit market imperfections are relevant to the story, to the extent that they may explain why small firms behave differently from larger ones (Gertler and Gilchrist, 1993). We will use Gertler and Gilchrist's dataset to examine the impact of corporate hedging on monetary policy transmission. The use of this dataset seems to be justified, because that paper has to be regarded as one of the most influential studies on broad credit channel effects and is seen as one of the papers to firmly establish this particular transmission channel for the US. In addition, due to the scarcity of data that might help to test the corporate hedging hypothesis directly, use of the QFR data allows for testing of whether corporate interest rate hedging is actually consistent with the US experience from the late 1950s to the mid-1990s.

3.1 The results of Gertler and Gilchrist (1994)

To set the scene, we start with a replication of the main results yielded by the original GG (1994) paper. The premise of their approach is that small firms are more likely to be subject to agency costs of borrowing. Differences between large and small firms may thus provide some indication of the importance of credit market frictions. The firms classified as small rely heavily on intermediated credit,

[5] See Oliner and Rudebusch (1996) and Gertler and Gilchrist (1994) for a detailed description of the dataset.

obtaining virtually all their short-term credit from banks. In contrast, firms classified as large use the commercial paper market to satisfy roughly half their short-term needs for financial resources.[6]

Using the data for the two size classes, the authors estimate the reactions of small and large firms to monetary policy shifts measured by the Romer and Romer (1990) dates as well as the federal funds rate as in Bernanke and Blinder (1992). Sets of multivariate fourth-order VARs are estimated for both of the two policy-stance indicators using the lower triangular Choleski decomposition[7] and the following ordering: growth rate in real GNP, inflation, large firm growth rate, small firm growth rate, monetary policy indicator (ie Romer dates or the federal funds rate).[8] Additional VARs are estimated using the difference in the growth rates of the two firm-based variables. The cumulated impulse responses to a one-standard deviation shock to the monetary policy indicator variable are then used to assess the differences between small and large firm behaviour. Shocks are found to have a greater cumulative impact on small than on large firms and the differences are reasonably significant for inventories and short-term debt, though not for sales.

We replicate the different impulse responses of small and large firms to shocks in the federal funds rate as in Figure V of the original paper. For this purpose, we estimate a set of VAR models. Each separate VAR includes the growth rate of the GDP, Inflation, the large firm variable, the small firm variable and the funds rate. Sims (1980) and Doan (1992) advise against the use of a deterministic trend. We decided to follow their advice and included a constant and four lags of each variable, but no trend. Additional systems were estimated replacing the two firm variables with the difference in the two growth rates.[9]

Before running the actual regressions, the data for the different variables were tested for non-stationarity using the ADF-test procedure. These tests show most of the different series to be stationary at the 5% level of significance, with the growth rate of the federal funds rate being marginally stationary at the 10% level. We also test the null hypothesis of stationarity using the procedure of Kwiatowski/Phillips/Schmidt/Shin (KPSS, 1992) and are able to reject trend stationarity of the federal funds rate at the 5% level of significance. The KPSS results for the other variables actually reinforce the findings of the respective DF tests. However, when there are structural breaks, the DF test statistics are biased towards non-rejection of a unit root. We thus carry on and check the funds rate series for stationarity over two subsamples and find the series to be stationary in each of the two periods. Finally,

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6 See Bernanke, Gertler and Gilchrist (1996).

7 A lower triangular decomposition implies that an orthogonal innovation has no contemporaneous influence on a variable coming prior in the causal ordering. See Sims (1980).

8 Gertler and Gilchrist (1994) do not include an exchange rate into their VAR system, which is equivalent to the assumption that the central bank does not react to changes in the foreign exchange markets.

9 The QFR data were kindly provided by Simon Gilchrist.

we use the procedure of Perron (1989) and allow for the presence of a structural break in 1979:4.[10] The t-value for the detrended series is –4.52 and, hence, clearly significant on the 5% level using the critical values tabulated by Perron (model B). We will thus regard all the variables used in our setup, including the federal funds rate series, as being stationary.

Bernanke and Blinder (1992) and Sims (1992) identify monetary policy disturbances directly with innovations in federal funds interest rates. The funds rate, arguably, is the policy variable most closely targeted by the Federal Reserve over the period of the sample. However, use of the funds rate as a monetary policy indicator usually means that a so-called price puzzle occurs. That is, a positive innovation in the interest rate, ie a monetary tightening, is associated with a strong and persistent increase in the price level.[11] Sims (1992) includes exchange rates and commodity prices in his specification to reverse this effect. Hereby, the commodity price index is meant to capture information about future inflation that the central bank might have in mind when choosing the policy stance.

In our setup a pronounced price puzzle only occurs as long as inflation is measured by changes in the CPI. However, an otherwise identical setup does not exhibit a sizeable price puzzle if inflation is measured by the growth rate of wholesale prices. The other impulse responses are remarkably stable, irrespective of the price index used to measure inflation. For reasons of parsimony, we thus measure inflation by the change in wholesale prices. The different responses seem to be consistent with the usual "stylised facts" of a contractionary monetary policy shock, as summarised by Bagliano and Favero (1998): (i) the aggregate price level initially responds very little and falls afterwards; (ii) interest rates (by definition of the shock) initially rise; and (iii) aggregate output initially falls, with a j-shaped response and with a zero long-run effect of the monetary impulse.

Figure I about here

Figure I replicates the results of the original paper for sales, inventories and short-term debt. Each column represents a separate VAR including the variables GDP growth, inflation, large firm, small firm (or the difference of the two variables replacing both, the large and small firm variables) and the federal funds rate. The variables are ordered as in Gertler and Gilchrist (1994), placing the monetary policy instrument at the end of the causal chain. Non-policy variables will, therefore, have a contemporaneous impact on the monetary policy reaction function.

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[10] In October 1979, the Federal Reserve changed the monetary policy operating procedure (Goodfriend, 1983).

[11] See also Gerlach and Smets (1995).

Due to the ordering used, a shock to the output variable, ie a supply shock, immediately affects all other variables. A demand shock operating on prices, however, will only affect prices, large/small firm variables, and the interest rate contemporaneously. A shock to the last variable, the federal funds rate, will immediately affect only the variable itself and is then transferred to all other variables only in the next quarter. While providing a minimal set of assumptions that can be used to identify the model, use of the Choleski decomposition actually imposes strong assumptions with regard to the underlying structural errors. Unless there is a theoretical reason for these assumptions, the underlying shocks will not be properly identified.

Our ordering specifically relies on the identifying restriction that policymakers have contemporaneous information about non-policy variables. This type of restriction was imposed by, among others, Bernanke and Blinder (1992) and Bernanke and Mihov (1995) and its validity clearly depends on the unit of observation. Given that we use quarterly data, immediate responses of the central bank to supply and demand shocks seem to be justified. Panel (a) of the figure reports the cumulative responses of the quarterly growth rates of small and large firms as well as the differential response of the two firm groups together with the respective 90% error bands.[12] In addition, panel two of the figure, labelled I (b), reports the responses of the growth in GDP, inflation, and the federal funds rate variable from the different VARs, which were not provided in the original paper.

The estimates cover the period from 1959:1 to 1991:4 (n = 132). The only notable difference between the original results of Gertler and Gilchrist and our replication occurs in the sales setup. The estimated response of the difference in growth rates (SalesDiff, panel (a)) deviates, although insignificantly, from zero after about 12 quarters, whereas GG’s response for differential sales returns to zero at that time.

3.2 Splitting the QFR sample

Our replication of GG (1994) supports the idea that firms of different size respond differently to monetary policy shocks. A broad credit channel for monetary policy thus seems to be in operation in the US during the period covered by the QFR sample. However, we have already argued that the availability of derivatives contracts enhances the possibilities for active corporate risk management, which is likely to change the way small firms will respond to monetary policy shocks.

We would expect the impact of derivatives on sales, inventories and short-term debt to be more pronounced for small firms than for large firms. Small firms are more likely to be exposed to informational asymmetries and, therefore, more likely to suffer from financial accelerator effects.

[12] See Doan (1992) for details.

Incentives for corporate risk management are, thus, higher for these constrained firms, implying that, with derivatives available, impulse responses of small firms should be similar to the respective responses of larger corporations. We expect firms to become more alike, actually smoothing the differences in large and small firm behaviour. With interest rate derivatives in active use, the differential responses of small and large firms reported in the lower row of Figure I (a) should, therefore, not significantly differ from zero.

Actively traded financial derivatives are a relatively recent phenomenon. Although US futures markets have existed for over 100 years, contracts were initially limited to agricultural products and other commodities. Foreign currency futures were introduced at the Chicago Mercantile Exchange (CME) in 1972, while the first interest rate future followed three years later. Trading in this contract, based on GNMA certificates, began in 1975. The first ever swap contract, a currency swap involving IBM Corp. and the World Bank, dates back to 1981, while the first interest rate swap was entered into only in 1982 (see Kuprianov, 1993). The survey evidence reviewed above suggests that financial derivatives are now actively used by many non-financial firms. These firms predominantly use customised OTC swaps and forwards to manage their exposures to interest rate and currency risks. In doing so, they can, for example, enter into a fixed/floating interest rate swap to convert existing floating rate, short-term debt into a fixed rate obligation, hence avoiding interest rate risk. Likewise, other interest rate instruments can be used to offset any interest rate exposure by a counterbalancing position.

While OTC contracts are clearly the more important instruments from the perspective of corporate hedging, the following analysis is largely concerned with interest rate futures, ie exchange-traded derivatives contracts. This is due to data availability reasons and can also be substantiated with use of these instruments by OTC dealers, who seem to engage in cross-market hedging to meet demands generated by their OTC activities (Kambhu et al, 1996). Markets for interest rate futures were also among the first derivatives markets to gain sufficient liquidity. One of the most actively traded interest rate futures, the 90-day US Treasury bill futures contract, was introduced by the International Monetary Market (IMM) of the CME in January 1976. It was quickly followed by the CME's three-month eurodollar time deposit futures contract as well as the Chicago Board of Trade's (CBOT) 30-day federal funds rate futures contract in January 1982 and October 1988, respectively.

The CME US Treasury bill contract calls for delivery of 90-day maturity T-bills having a face value of $1 million. Because of the risk-free nature of Treasury bills and the unique liquidity of their markets, changes in the yield on T-bills reflect "pure" interest rate movements. The CBOT 30-day federal funds future offers an effective hedging tool for any financial intermediary or corporation that borrows or loans money in the short-term market. Hence, the federal funds future (FFF) may be used to protect market participants against interest rate volatility, which can impact their cost of funds and interest rate income. Because the FFF contract is based on one-month fed funds rates, it is useful for managing the risk associated with changing interest rates for virtually any short-term instrument and offers unique alternatives for managing risk in short-term maturity horizons. The contract calls for delivery of the interest paid on a principal of $5 million of federal funds held for 30 days.[13]

We will now check whether the differential behaviour of small and large firms is actually consistent with increased corporate hedging. The hypotheses to be tested are: (i) the existence of a structural break in the mid-1970s; and (ii) the (non-) existence of a broad credit channel in the (second) first subsample, as reflected by the relative behaviour of small and large firms. We test these hypotheses by splitting the original setup of Gertler and Gilchrist. The QFR time series are available from 1959:1 to 1991:4. With US interest rate futures markets effectively starting off in January 1976, we split the sample into two parts, with the first extending from 1959:1 to 1975:4 and the second covering the period from 1976:1 through 1991:4. The split, therefore, exactly halves the sample. The first part of the sample represents a period without large-scale derivatives trading and, hence, insufficient possibilities for interest rate risk management, whereas the second period allows for efficient corporate interest rate hedging strategies due to the availability of interest rate derivatives.

Before setting up our VAR systems, we have to determine the optimal lag length. In doing so, the usual order selection criteria (AIC, HQ, BIC) were supplemented by a number of likelihood ratio (LR) tests, ie by comparing the maxima of the log-likelihood function over the unrestricted and restricted parameter space. The idea of the VAR order used is to determine a filter that transfers the given data into a white noise series. All of these tests pointed to an optimal lag length between 4 and 6 for the different setups.[14] Given the limited time span covered by the two subsamples, we decided in favour of parsimony and, thus, follow Gertler and Gilchrist in opting for a lag length of 4. We also checked for stationarity of the different variables over the two parts of the sample. The respective ADF and KPSS tests actually support our earlier findings and point to stationarity of the different variables over the two subsamples.

We proceed by estimating a set of VAR(4) systems to determine the differential cumulative responses in sales, inventories and short-term debt over the two samples. To deal with the problem of a price puzzle in the first subsample, we supplement our earlier setup by the change in world commodity prices. The results of this exercise are reported in Figure II.

Each panel, ie II (a) through (c), represents two separate VARs of an identical setup, each extending over one of the two subsamples. Small firms in our model have an incentive and (in the second subsample) the opportunity to hedge against interest rate changes in the short and medium run. They

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[13] See Chicago Board of Trade (1997).

[14] A separate appendix detailing the entire regression output is available upon request.

will do so by locking in interest rates using swaps/forwards or by insuring themselves against a rise in interest rates using interest rate options. Considering the impulse response functions of aggregate output, use of derivatives suggests that the response may pick up earlier (due to an increased speed of adjustment across the maturity and asset spectrum of financial markets) and that the total response may be less pronounced (impact of interest rate changes shifted from hedgers to risk-takers) because of corporate risk management (Vrolijk, 1997). In addition, any difference in the behaviour of large and small firms should tend to vanish.

The impulse response functions reported in Figure II seem to be consistent with these propositions of the basic hedging hypothesis. The differential sales responses significantly deviate from each other, while not from zero. This suggests that, in both periods, large and small firms react more or less identically with regard to sales. Firms in both size classes experience significantly declining sales after being hit by a contractive monetary policy shock.[15] (The sign of the second-period response actually suggests that large firms react more strongly than small ones; however, the deviation of the impulse response from zero is statistically insignificant.) With sales being one of the most important factors of corporate cash flow, this result supports the line of reasoning of our hedging hypothesis. This becomes even more apparent when turning to the differential responses of inventories and short-term debt over the two sub-samples. In both cases, the cumulated impulse response functions are different from each other, but differ from zero only in the period up to 1975. This points to the existence of broad credit channel effects in the first sub sample, while any differences between small and large firms seem to vanish in the second sub sample, thus supporting our hedging hypothesis.

The responses of real GDP growth over the two samples appear to be stable over all of the three models estimated. Overall, it seems that the Federal Reserve's power to affect real GDP has been significantly reduced between the two subsamples, which is in line with our hypothesis and the findings of Taylor (1995). The response functions reported in the right-hand column of each panel significantly differ from each other as well as from zero, with the response of world commodity prices being the only exception. The interest rate shock, however, shows a very different persistence in the two subsamples. It seems that cumulated shocks start to peter out after about 10-12 quarters in the period from 1976 through 1991. The persistence is a lot higher in the first part of the sample, where the full impact of the original interest rate shock is being felt only after 14-15 quarters.[16] The responses of wholesale price inflation are also quite interesting. Again, there are significant differences between the two subsamples. The impulse responses indicate no sign of a price puzzle in the second period, whereas - in all three setups -

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15 See Figure I (a).

16 It may be interesting to note that other authors typically find a lower persistence. Bernanke and Gertler (1995), for example, report that the response of the funds rate is essentially back to trend after eight quarters.

a price puzzle (although only marginally significant) occurs in the first part of the sample. The existence of this price puzzle, ie the wrong sign of the estimated inflation response, casts some doubts on the applied identification procedure. However, to preserve comparability with the original GG results, we decided not to use another setup but to urge for a more careful interpretation instead.

To test the significance of the differences in the cumulative impact of monetary policy shocks on small and large firms, we implement a t-test for differences in means. The test statistic compares the differential impulse responses (growth rate for small firms minus growth rate for large firms) for the two subsamples on a step by step basis and examines the hypothesis of identical means (b_i) using the following setup:[17]

(1) $$t = \frac{d}{\sqrt{\mathrm{var}(d)}} = \frac{b_1 - b_2}{\sqrt{\mathrm{var}(b_1) + \mathrm{var}(b_2)}} \sim t_{(2(T-1))}$$

The variances of the posterior distribution of the orthogonalised impulse responses are based on T = 100 draws. The respective t-values as well as their 1%, 5%, and 10% critical values are graphed in the middle row of the left-hand column of Figure II (a) through (c). The differential impulse responses over the two subsamples appear to significantly differ from each other for all of the three variables considered. This points to a potentially important impact of derivatives on the differential behaviour of small and large firms and, thus, on the monetary transmission mechanism. It seems that a broad credit channel was in operation prior to 1976, but that it ceased to work during the second part of the sample.

However, our study tries to ascertain the impact of a particular structural change, namely the introduction of interest rate derivatives, by comparing the impulse responses in the subsample before the actual change and after the change. But the differences in the results across samples are, of course, attributable to all structural changes that have taken place between the two parts of the sample. Likely candidates for structural changes unrelated to issues of corporate risk management are, among others, the October 6, 1979 change of the Federal Reserve's monetary policy operating procedure, the removal of Regulation Q or, more generally, the two oil price shocks and the breakdown of the Bretton Woods exchange rate regime.

From October 1979, the Federal Reserve shifted to an operating procedure that relied on reserve targeting. Initially, the Federal Reserve selected non-borrowed reserves as the primary target, but after 1982 the operating target was modified to borrowed reserves.[18] The Fed finally returned to federal funds rate targeting in 1988. The operating procedure of open market operations thus shifted from interest

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[17] See Griffiths et al (1993).

[18] See Goodfriend (1983) for more details.

rates, ie the federal funds rate, to a pronounced reliance on monetary aggregates over the period from 1979 through 1988, and then back to the Federal Funds rate. It is well possible, that these major changes in operating procedures have triggered at least part of the differences in the estimated impulse responses over the two subsamples. The same is true for other structural changes in the mid-1970s.

Figure II about here

While this should urge us to interpret our findings with care, there is still some power in the results of our estimates. This is because we should not expect every observed structural change to have a significant impact on the differential response between the small and large firms in our sample. Such an impact is only to be expected for those changes that are likely to affect the importance of credit market frictions or other potential sources of observable differences in the behaviour of these firms.

Our results are unable, for example, to distinguish between the impact of corporate hedging and the general impact of financial innovations other than interest rate derivatives. Thornton (1994), for example, argues that financial innovations such as CDs (certificates of deposit) have undermined the very foundations of the bank lending channel of monetary transmission.[19] If this is the case, the introduction of CDs will probably account for at least a part of the change in the differential behaviour between small and large firms detected above.

Care must also be taken for another reason. The hypothesis of normality of the VAR residuals implies a skewness of zero and an excess kurtosis of (ku - 3) = 0. To test for normality, we perform an analysis of the residuals of each equation in the above VARs. The results of our diagnostic tests are reported in a separate appendix, which is available upon request. The Jarque-Bera test statistic for zero skewness and zero excess kurtosis points to non-normality in up to three equations of each of the systems estimated. However, residual autocorrelation and ARCH do not appear to be a problem in most of the setups, at least not at the 5% level of significance.

Fortunately, innovations of VAR models need not be iid normal for impulse response estimates to be consistent and asymptotically normal.[20] The assumption of Gaussian innovations, however, is typically used in the construction of finite-sample distribution estimates and confidence bands for estimated impulse response functions.[21] This makes departures from normality a potentially serious concern for

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19 See, for example, Kashyap and Stein (1995) for a model of the bank lending channel.

20 See Lütkepohl (1993) and Kilian (1998a) for a thorough discussion.

21 See Geweke (1988) and Kloek and van Dijk (1978).

inference in VAR models, which also applies to our estimates. Given that the estimated error bands have been constructed using the method of Monte Carlo integration, which implicitly assumes Gaussian innovations, the error bands calculated for the impulse responses, especially the ones estimated for the first subsample, are likely to be biased (see Kilian, 1998). The results reported above should therefore be interpreted with due caution as far as the estimated error bands for the respective impulse responses are concerned.

3.3 A counterfactual analysis based on a measure of hedging activity

The following paragraph combines the approaches of Gertler and Gilchrist (1994) and Vrolijk (1997) in an effort to check the results from the split-sample approach for consistency. We will again use VAR systems to assess the differential impulse response functions of short-term debt, sales, and inventories for large and small QFR companies. However, this time we will estimate the respective VAR system over the entire sample while controlling for the size of US markets for interest rate derivatives and, thus, hedging activity.

Our empirical methodology follows that of Vrolijk (1997). The model directly incorporates derivatives market size in a standard VAR setting in order to examine the impact of derivatives markets and risk management techniques on the monetary transmission mechanism. Our aim is to estimate impulse responses for a regime with and without sizeable derivatives markets. But unlike Vrolijk, who was not able to find any significant impact of derivatives on the transmission mechanism using aggregate data for the United Kingdom, we are able to distinguish between two groups of firms, “small” and “large”, using QFR data for the United States.

By combining the approaches of Vrolijk and GG (1994), it is, hence, possible to check whether the emergence of derivatives markets and risk management strategies did actually have an impact on the monetary transmission mechanism. With our theory of corporate risk management and the broad credit channel in mind, we would again expect the impact of derivatives on sales and inventories to be more pronounced for small firms than for large firms. This implies that, in a regime with derivatives, impulse responses of small firms should be similar to the respective responses of large firms. Without derivatives, however, impulse responses should differ among small and large firms, a result which was already established by our split-sample approach.

Our analysis proceeds as follows. In order to check our results from sample-splitting, we re-estimate the original VAR using an additional, fifth, variable that proxies the amount of interest rate payments being hedged, or locked in, by use of interest rate derivatives. This indicator, termed DERIV, is defined as the sum of the quarterly averages of the number of contracts traded in two of the more important interest rate futures markets potentially used for corporate hedging, namely the 90-day T-bill futures market and the 30-day federal funds futures market. Each of these amounts is weighted by the respective implied interest rate extracted from the prices of these contracts. To account for differences in the notional amounts of the two contracts, the figures for the federal funds future are divided by five. Given that the T-bill future started trading in January 1976, the derivatives market indicator, DERIV, takes values of zero from 1959:1 to 1975:4 and positive values from 1976:1 until the end of the sample in 1991:4.[22] We start our analysis by estimating the new system over the entire sample. We assume that interest rate changes, due to the rapid speed of adjustment in financial markets, will affect the derivatives markets contemporaneously. We thus place DERIV at the end of the ordering in our VAR setup.

Our estimate generates impulse response functions for a regime that offers opportunities for efficient risk management in the latter part of the sample. In order to assess the impact of interest rate derivatives on the monetary transmission mechanism without actually splitting the sample, we simulate impulse responses for a regime without derivatives. We do so by manipulating the variance/covariance matrix (VCV) as well as the estimated coefficients. All elements of the VCV as well as the coefficients relating to the derivatives variable are set to zero, effectively removing the impact of derivatives from the system. We can, hence, calculate impulse response functions that simulate the behaviour of the different variables as if derivatives markets did not exist. A comparison of the impulse response functions under the two regimes will thus demonstrate the effect of the addition of interest rate derivatives markets, with all the other coefficients remaining constant (Vrolijk, 1997).

However, our approach is subject to some potentially severe criticisms. First of all, the power of the approach is, of course, limited in that the impact of derivatives markets might be expected to alter the coefficients of the VAR, rather than just having an additive impact within the VAR setup. If this is true, such changes would not be reflected in our results since the methodology used does not allow for changes in coefficients associated with any structural change resulting from the introduction and development of interest rate derivatives markets.

Another potential criticism relates to the problem of "VAR transplantation". Rasche (1995) shows that the omission of one of the estimated reduced form equations of a VAR system and the substitution of a counterfactual policy rule to complete the model severely limits the admissible structure of the economic model that could possibly have generated the historical data. However, given that we do not transplant the federal funds equation, ie the monetary policy rule, Rasche's criticism does not strictly apply to our setup. Moreover, as derived by Rasche, VAR transplantation is admissible under specific conditions. In his paper, these conditions are shown to amount to the transplanted variable to be placed last in the ordering of variables in a Choleski decomposition. If this is the case, as in our setup, the selected

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[22] The futures market data were kindly provided by Martin Friedrich of DRI McGraw/Hill.

variable, ie the derivatives indicator DERIV, cannot enter contemporaneously into any other equation in the VAR system and transplantation is possible.

Before estimating the system, we checked the DERIV series for stationarity using the ADF and KPSS procedures. The series appears to be stationary at the 5% level of significance when tested over the full sample (1959:1 through 1991:4) using the ADF test. In addition, the null hypothesis of trend stationarity cannot be rejected when tested by the KPSS procedure. But, given that roughly half the sample (1959:1 through 1975:4) takes values of zero, the result seems to be biased by the first subsample. We proceeded by checking the second subsample separately and were not able to reject the null hypothesis of a unit root at any reasonable level of significance.

The result of the ADF procedure is supported by a KPSS test that rejects the null of trend stationarity, though only at the 10% level of significance. While this points to non-stationarity of the series over the second subsample, we have to bear in mind that the short length of the sample probably biases the results towards finding the series I(1). Hence, we allow for the possibility of a structural break, which might limit the ability of rejecting non-stationarity of the series. Due to the construction of DERIV, this seems to be justified when taking into account that the introduction of eurodollar futures had a major impact on the T-bill futures market. The three-month eurodollar futures contract was introduced by the CME in December 1981 and started trading in 1982:1. The competition from this new market strongly influenced liquidity and prices in the T-bill market, with a pronounced break occurring in 1982:2. We thus repeat our stationarity tests of the DERIV series using the methodology of Perron (1989). The series is detrended according to Perron's model C, ie allowing for a change in the slope as well as the intercept, and then tested for stationarity, yielding a DF statistic of -6.05. With $\lambda = 0.4$, the critical values as tabulated by Perron are given as -4.22 and -4.81 at the 5% and 1% level, respectively. The hypothesis of non-stationarity is, thus, rejected at the 1% level of significance and the derivatives indicator time series is regarded as stationary during the remainder of our approach.

We proceed by testing the original four-variable VAR (based on real GDP, inflation, the differential response of small and large firms, and the federal funds rate) for inclusion of the derivatives indicator. In doing so, we run block exogeneity (likelihood ratio, LR) tests to check whether the DERIV variable belongs into the system. Our setup tests the restriction of the five-variable system that includes derivatives to a VAR with four variables and finds this restriction to be binding at the 1% level for the short-term debt setup and at the 5% level for the sales and inventories setup, respectively (Enders, 1995, and Engle, 1984).

In addition, we test the same set of hypotheses by applying the Wald and Lagrange multiplier (LM) statistics and, again, find the restriction to the smaller system to be binding. While the $\chi 2$ - distribution is the relevant one for testing cross-equation restrictions in large samples, the F - distribution might provide a better finite-sample approximation in some circumstances (Griffiths et al, 1993). We thus carry on to check the coefficients of the DERIV variable against the joint hypothesis of a zero value by using an F-test.

Table 1: Tests for inclusion of DERIV into the system

Setup	LR - test	Wald - test	LM - test	F - test
SalesDiff	34.8268*	41.2297**	35.2846*	2.0615**
InvDiff	37.4067*	44.8570**	37.4658*	2.2428**
StDebtDiff	48.3927**	61.3310**	46.1821**	3.0666**

Significance levels are given by * and ** (5%, 1%) and are based on the $\chi 2$ and F - distributions.

We conclude from Table 1 that the DERIV time series significantly influences the relationship between the other four variables and that it belongs into the VAR system. Hence, we carry on with our analysis by estimating a VAR system with five variables that includes the DERIV indicator. The impact of derivatives and, hence, of corporate hedging activity is then removed from the system by setting the relevant coefficients and the respective elements in the VCV matrix equal to zero. The results of this setup are reported in Figure III (a) through (c).

Figure III about here

Again, each panel represents a separate VAR that includes the growth rate in GDP, inflation, the difference between the small and the large firm variable, the federal funds rate, and the derivatives index DERIV (for the regime that, from 1976:1 onwards, includes the derivatives markets). The differences in the responses of small and large firms for sales and inventories appear to be significantly different from each other under the two regimes, although only at the 10% significance level.

The differential response with regard to short-term debt is insignificant. In all three cases, however, small and large firms appear to become more alike under the derivatives regime, which is in line with our hedging hypothesis as well as the evidence from the split-sample setup. The responses of the other variables perform reasonably well and are broadly similar to the respective responses estimated over the two subsamples. The impact of monetary policy measures on GDP seems to be smaller under the derivatives regime, which is again consistent with our hedging hypothesis. While a significant price puzzle does not occur in the presence of derivatives contracts, the response of inflation to a shock in the federal funds rate significantly rises above zero for the no-derivatives impulse response functions.[23]

It remains to be noted that the price puzzle found for the counterfactual regime certainly limits the reliability of our approach. As for the split-sample approach, it casts doubt on the assumption that the identification procedure used is indeed the correct one. Moreover, the diagnostic tests performed on the VAR residuals again detect departures from normality. The validity of our results thus relies on the assumption of asymptotic normality.

4. Conclusion

Models of corporate risk management based on the paper by Froot et al (1993) suggest that asymmetric information, the force at the very heart of the financial accelerator, will also create corporate hedge incentives. Due to recent developments in the markets for financial derivatives, there are now risk management techniques and instruments available to deal with financial risks very efficiently. Assuming that corporate cash flows are subject to interest rate risk, firms can now use interest rate futures and options to deal with their exposures to interest rates. A firm, being subject to a financial accelerator, might therefore find it profitable to engage in risk management strategies aiming to adjust the interest rate sensitivity of corporate cash flows (Fender, 2000). This, in turn, implies that the dynamic development of derivatives markets is likely to have a potentially important impact on those channels of monetary policy transmission that rest on the existence of asymmetric information.

This paper presents some empirical evidence on the impact of derivatives markets on the transmission mechanism based on Gertler and Gilchrist's QFR data for US manufacturing firms. The use of this specific dataset seems to be justified, given the prominence of the original GG (1994) paper. We show that the effects shown by GG vanish in the second subsample, indicating a structural break that might be due to the developments in the derivatives markets. The changes in the estimated impulse responses, when compared to the respective functions over the first subsample, are perfectly in line with the hypotheses generated by the theoretical models of corporate hedging, which served as a starting point for our analysis. Most importantly, the difference in the behaviour of small and large firms that is detected in the first part of the sample vanishes in the second. Small and large firms are, thus, more alike each other in the second subsample. The differential behaviour of large and small firms, as

[23] The price puzzle under the counterfactual no-derivatives regime does not vanish even when world commodity prices are included in the system. Given that this is the case, we proceed with the five-variable setup and note that our results should be interpreted with caution.

detected by GG and in our first subsample, is usually interpreted as evidence for broad credit channel effects. Our results for the post-1975 period, however, no longer suggest that a sizeable credit channel has been in place. This finding is also supported by our second approach, estimating impulse responses over the full sample and over two different regimes, while accounting for the availability or non-availability of derivatives contracts.

As a result, we may note that the broad credit channel of monetary policy transmission that appears to have been in operation in the United States the 1959-75 period disappeared in the post-1975 era. Our empirical findings suggest that monetary transmission effects like this do not seem to be stable over time and that the development of derivatives markets and the increased potential for corporate interest rate hedging might serve as an explanation for some of the instability of the broad credit channel of monetary policy transmission.

Annex 1

We perform ADF (Augmented Dickey/Fuller) and KPSS (Kwiatowski/Phillips/Schmidt/Shin) tests. In some cases, we also use the procedure of Perron (1989).[24] The results are as follows:

Table A.1: Testing for Stationarity

Variable	Setup	ADF	Setup	KPSS	Setup	Perron	Break
LSALES	C, T	-5.22018**	C, T	0.07669			
SSALES	C, T	-4.40789**	C, T	0.03432			
SALDIFF	C, T	-3.85891**	C	0.23211			
SALDIFF-I	C, T	-4.11427**	C	0.17216			
SALDIFF-II	C	-2.26788**	C	0.28086			
LINV	C, T	-5.60048**	C, T	0.03908			
SINV	C, T	-3.79133**	C, T	0.05706			
INVDIFF	C, T	-4.30687**	C	0.15814			
INVDIFF-I	C = 0	-2.10207**	C	0.14365			
INVDIFF-II	C = 0	-2.09958**	C	0.18561			
LSTDEBT	C, T	-5.10568**	C, T	0.03956			
SSTDEBT	C, T	-4.76178**	C, T	0.05865			
STDDIFF	C, T	-4.27042**	C	0.04784			
STDDIFF-I	C	-3.01843**	C	0.14998			
STDDIFF-II	C = 0	-2.23849**	C	0.10520			
FEDFUNDS	C	-2.70885*	C, T	0.16204**	T	-4.52**	(79:4)
FEDFUNDS-I	C, T	-4.92174**	C, T	0.04802			
FEDFUNDS-II	C, T	-3.21453*	C	0.17542			
CGDP90	C, T	-4.19634**	C, T	0.04426			
CGDP90-I	C, T	-3.13042*	C, T	0.08311			
CGDP90-II	C = 0	-1.80874*	C, T	0.09048			
CWSP	C = 0	-2.09465**	C	0.28137			
CWSP-I	C, T	-4.68168**	C, T	0.13363*	T	-3.95**	(73:4)
CWSP-II	C, T	-3.46978**	C, T	0.08760			
CWCP	C, T	-6.28509**	C, T	0.05300			
CWCP-I	C, T	-3.68122*	C, T	0.13083*	C	-4.37**	(73:4)
CWCP-II	C, T	-4.85787**	C, T	0.08502			
DERIV	C	-3.43586**	C, T	0.11520			
DERIV-II	C, T	-2.89151	C, T	0.14381*	C, T	-6.05**	(82:2)

Significance levels: * (**) = 10% (5% and below). Roman numerals indicate subsamples (1959:1 through 1975:4 and 1976:1 through 1991:4). We use a lag truncation parameter of l = 8 for the KPSS tests.

[24] Depending on the time series under consideration, we allow for a break in 1979:4 (change in the Fed's operating procedure), 1973:4 (first OPEC oil price shock) or 1982:2 (introduction of eurodollar futures).

Annex 2

Below are the figures from the main text:

Figure I (a): Replication of Gertler and Gilchrist (1994); sales, inventory and debt setups

Figure I (b): Replication of Gertler and Gilchrist (1994); sales, inventory and debt setups

Figure II (a): First (no-derivatives) vs second (derivatives) sample; sales setup

Figure II (b): First (no-derivatives) vs second (derivatives) sample; inventory setup

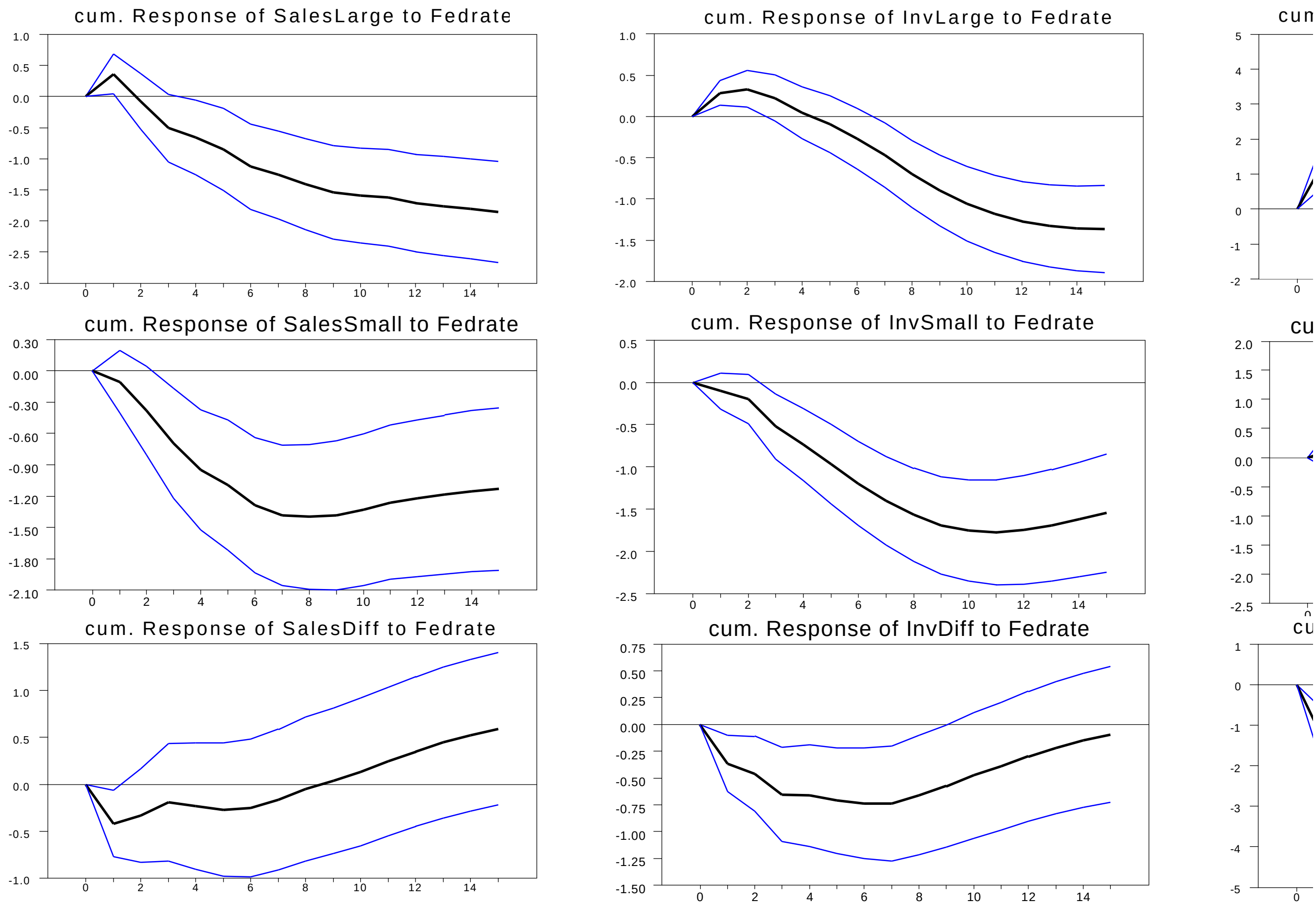
Figure II (c): First (no-derivatives) vs second (derivatives) sample; debt setup

Figure III (a): Derivatives vs counterfactual no-derivatives regime; sales setup

Figure III (b): Derivatives vs counterfactual no-derivatives regime; inventory setup

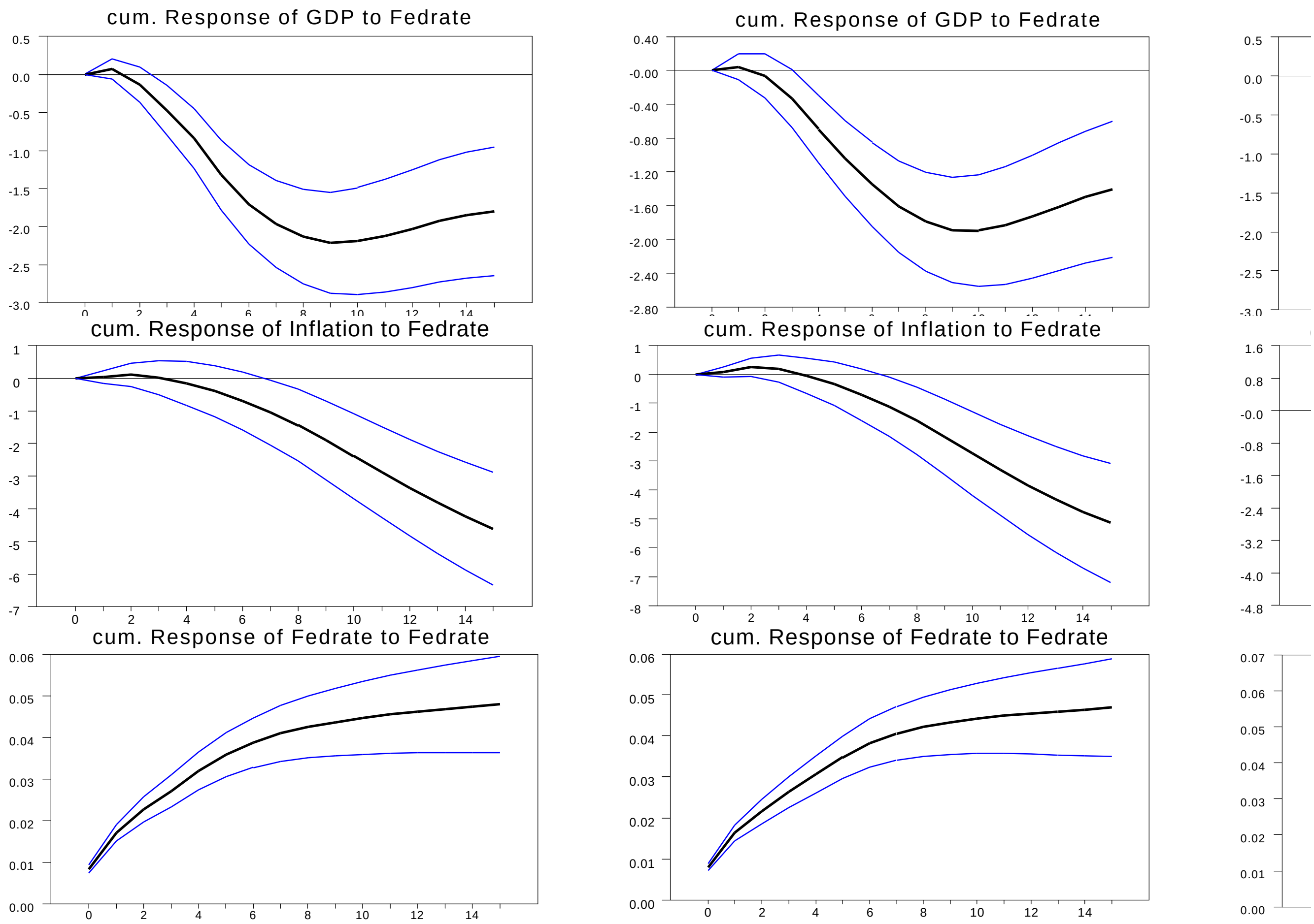
Figure III (c): Derivatives vs counterfactual no-derivatives regime; debt setup

Figure I (a): Replication of Gertler and Gilchrist (1994); sales, inventory, and



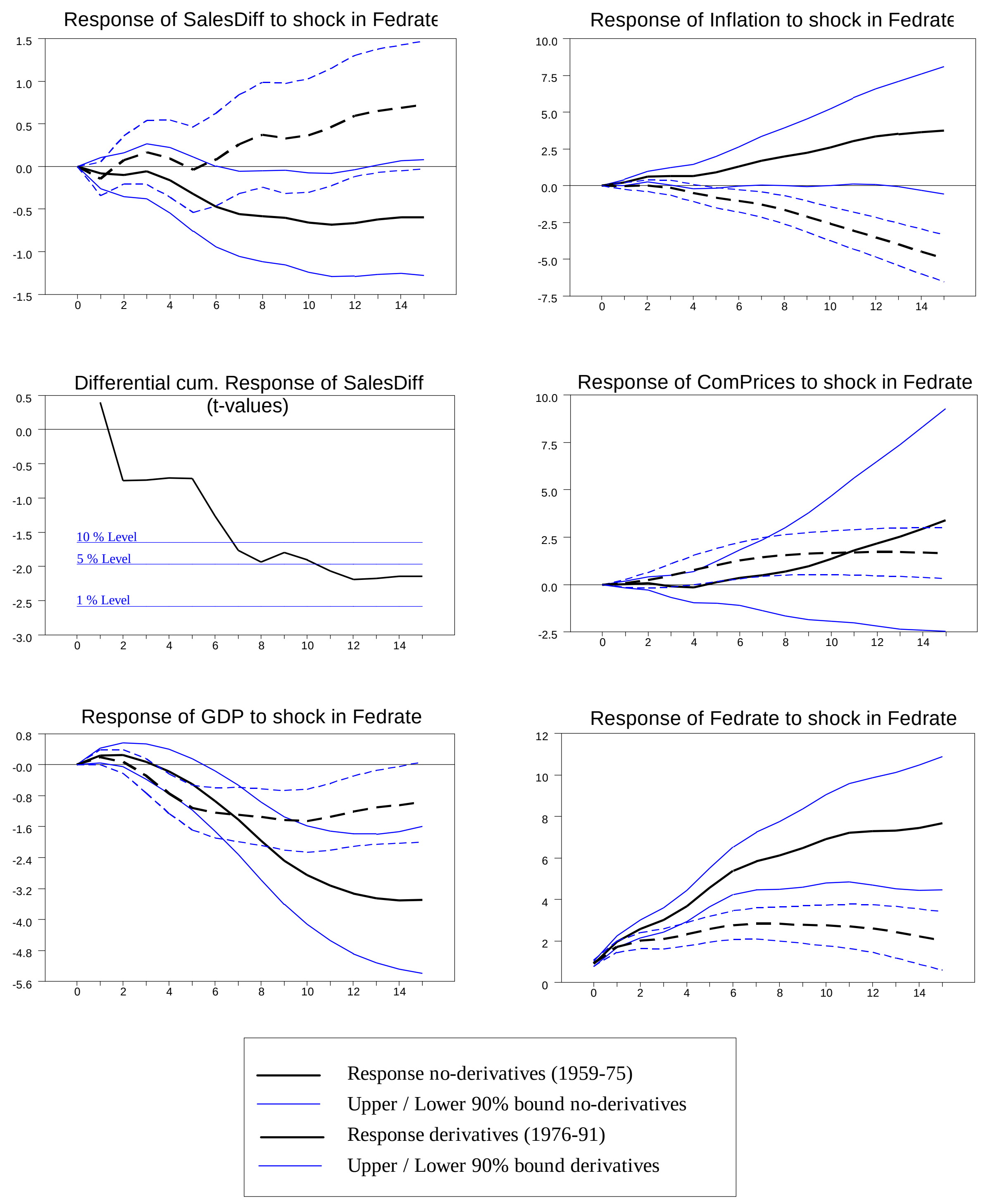
Each column of Figure I represents a separate VAR that includes the growth rate in GDP, inflation (growth rate of the wholesale price i
and the federal funds rate. The lower row reports the differential response of small and large firms as estimated by an additional VAR
with their difference. Upper and lower lines in each graph define 90 percent probability bands for the respective response.

Figure I (b): Replication of Gertler and Gilchrist (1994); sales, inventory and



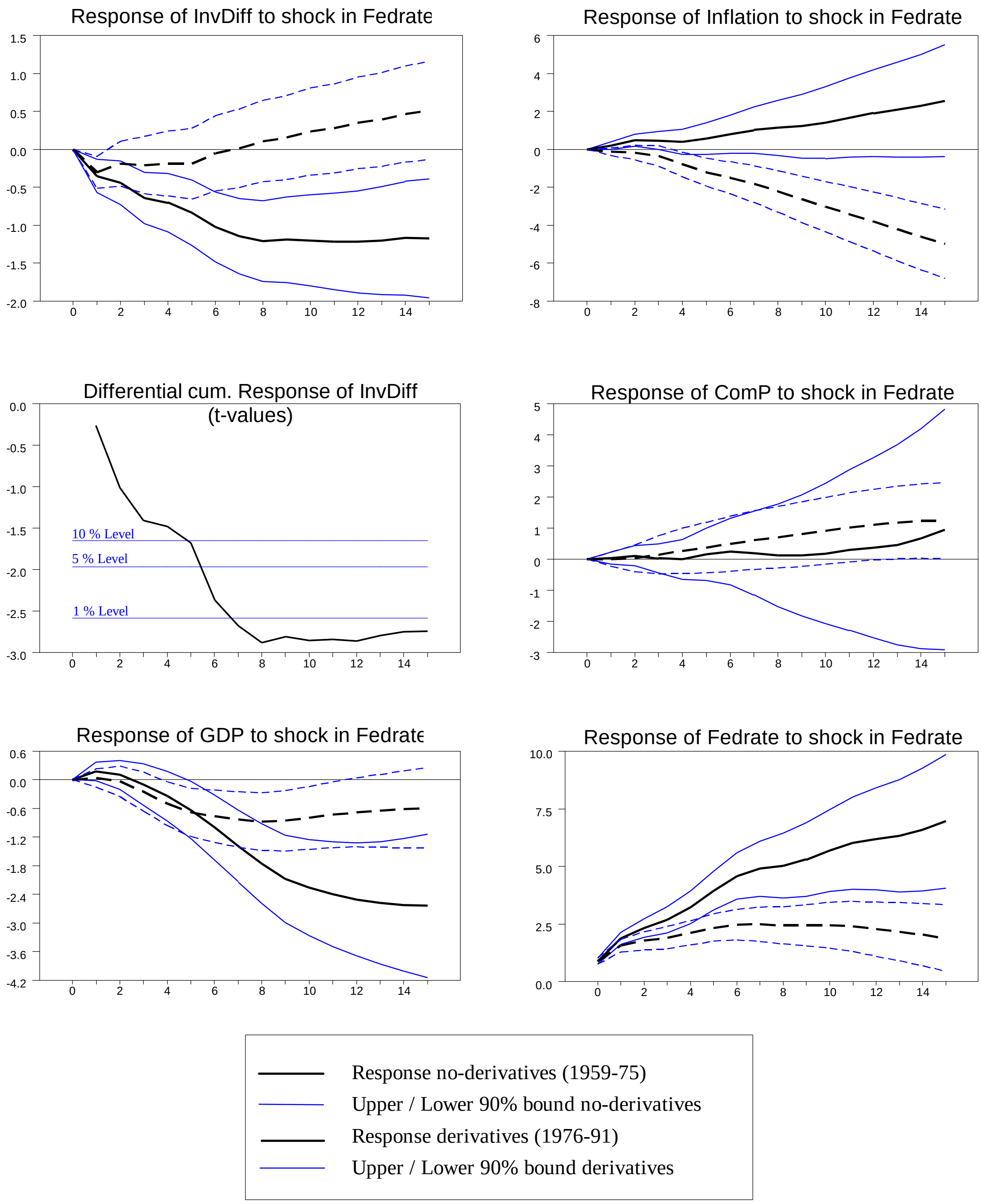
Each column of Figure I represents a separate VAR that includes the growth rate in GDP, inflation (growth rate of the wholesale price in and the federal funds rate. The respective responses from the second setup replacing the two firm variables by their difference are almost reported. Upper and lower lines in each graph define 90 percent probability bands for the respective response.

Figure II (a): First (no-derivatives) vs second (derivatives) sample; sales setup



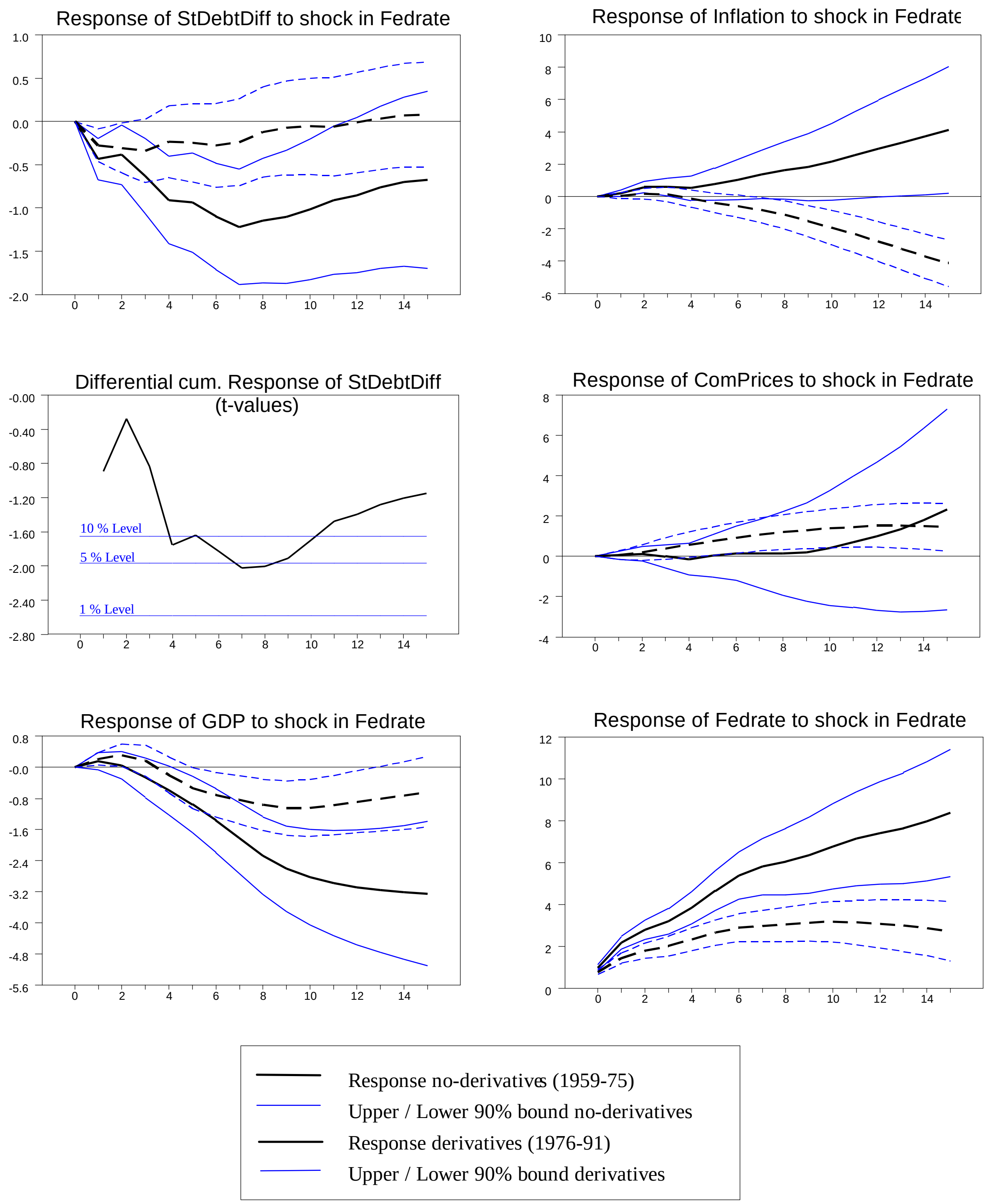
This panel of Figure II represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and large firms with regard to the SALES variable, the change in world commodity prices, and the federal funds rate. Upper and lower lines in each graph define 90 percent probability bands for the respective response.

Figure II (b): First (no-derivatives) vs second (derivatives) sample; inventory setup



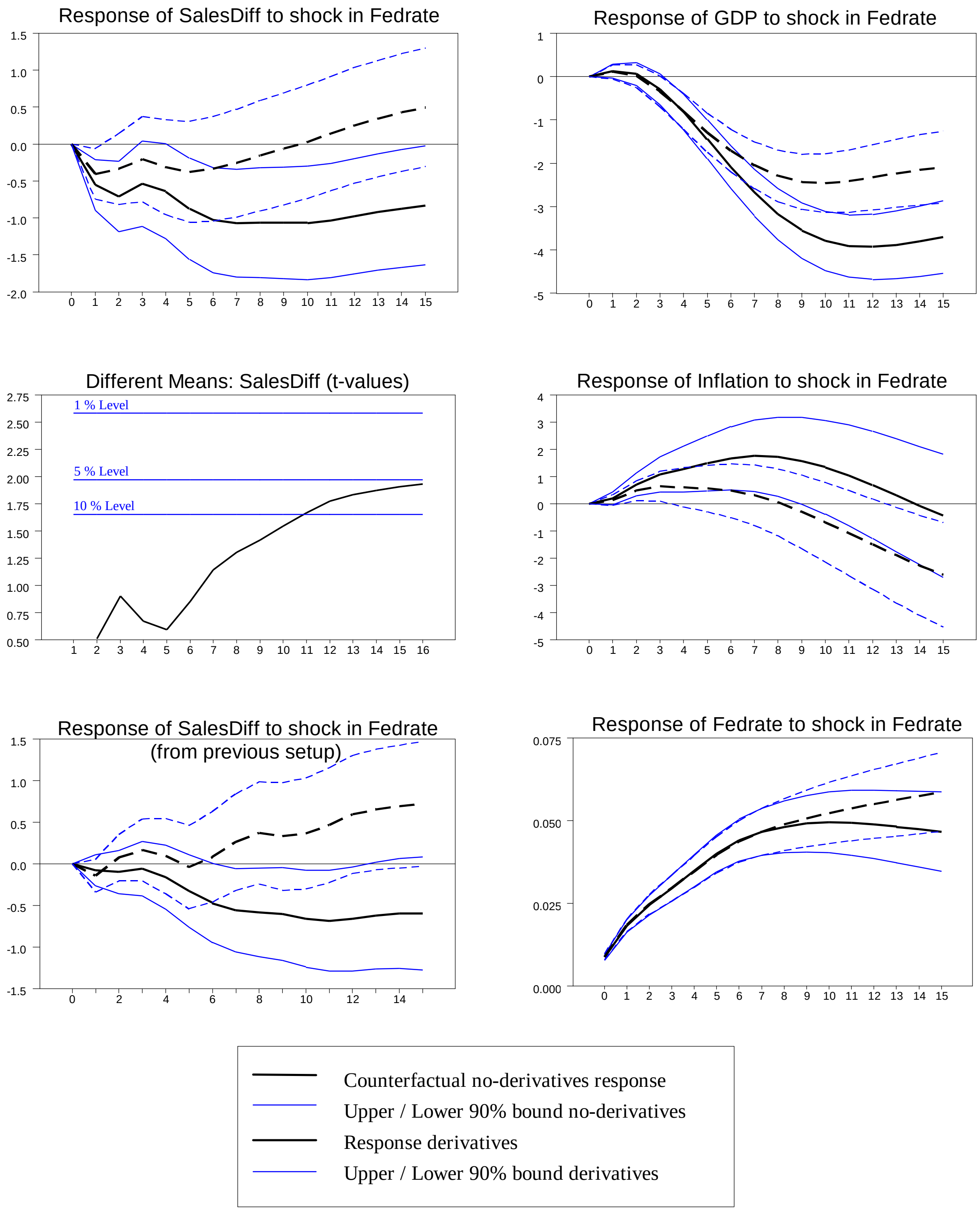
This panel of Figure II represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and large firms with regard to the INVENTORIES time series, the change in world commodity prices, and the federal funds rate. Upper and lower lines in each graph define 90 percent probability bands for the respective response.

Figure II (c): First (no-derivatives) vs second (derivatives) sample; debt setup



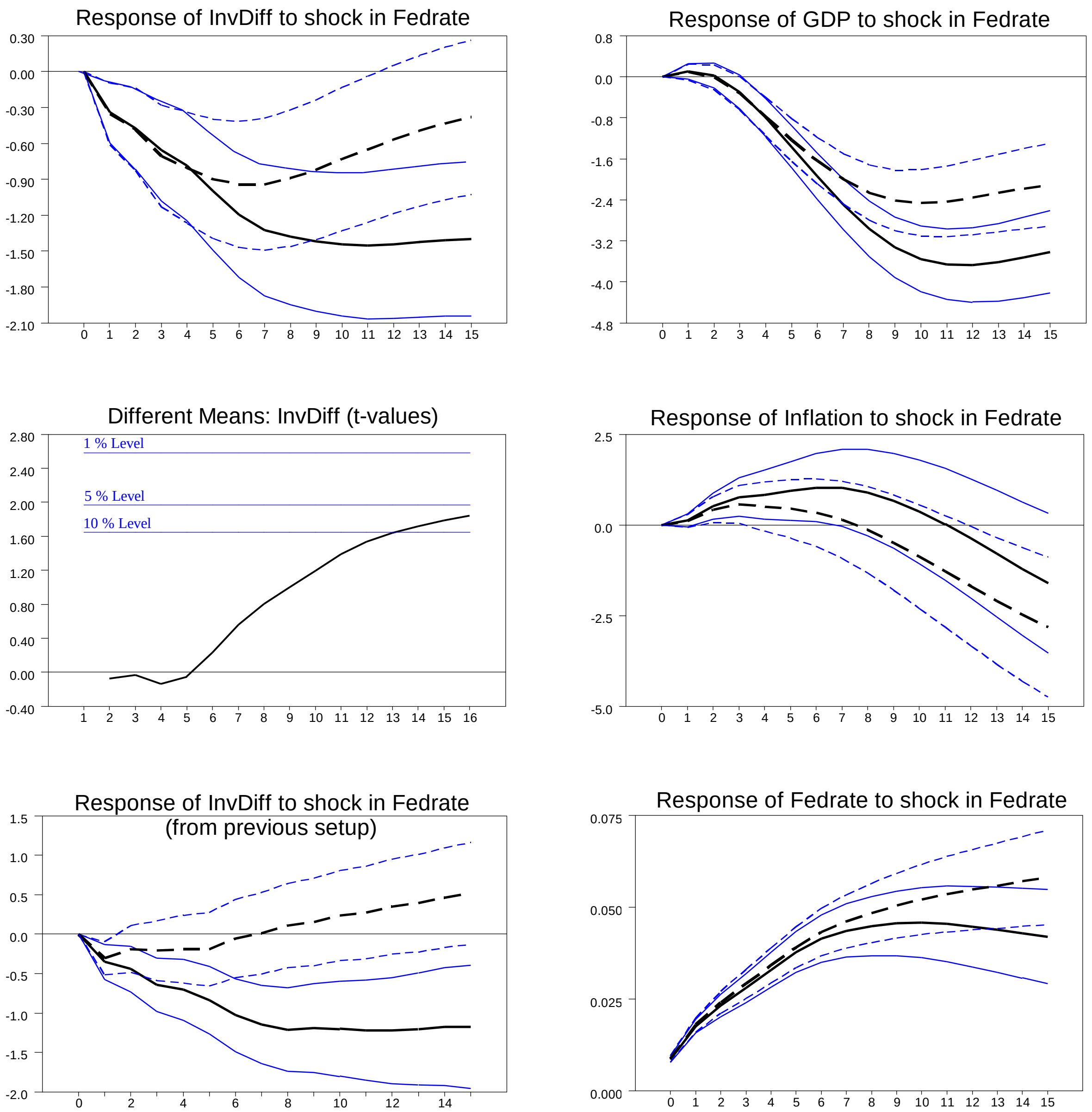
This panel of Figure II represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and large firms with regard to the SHORT-TERM DEBT variable, the change in world commodity prices, and the federal funds rate. Upper and lower lines in each graph define 90 percent probability bands for the respective response.

Figure III (a): Derivatives vs counterfactual no-derivatives regime; sales setup



This panel of Figure III represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and large firms with regard to the SALES variable, the federal funds rate, and the derivatives index (for the regime that includes derivatives markets). For purposes of comparison, the lower left field of the figure also reports the differential responses from the sample-splitting approach. Upper and lower lines in each graph define 90 percent probability bands.

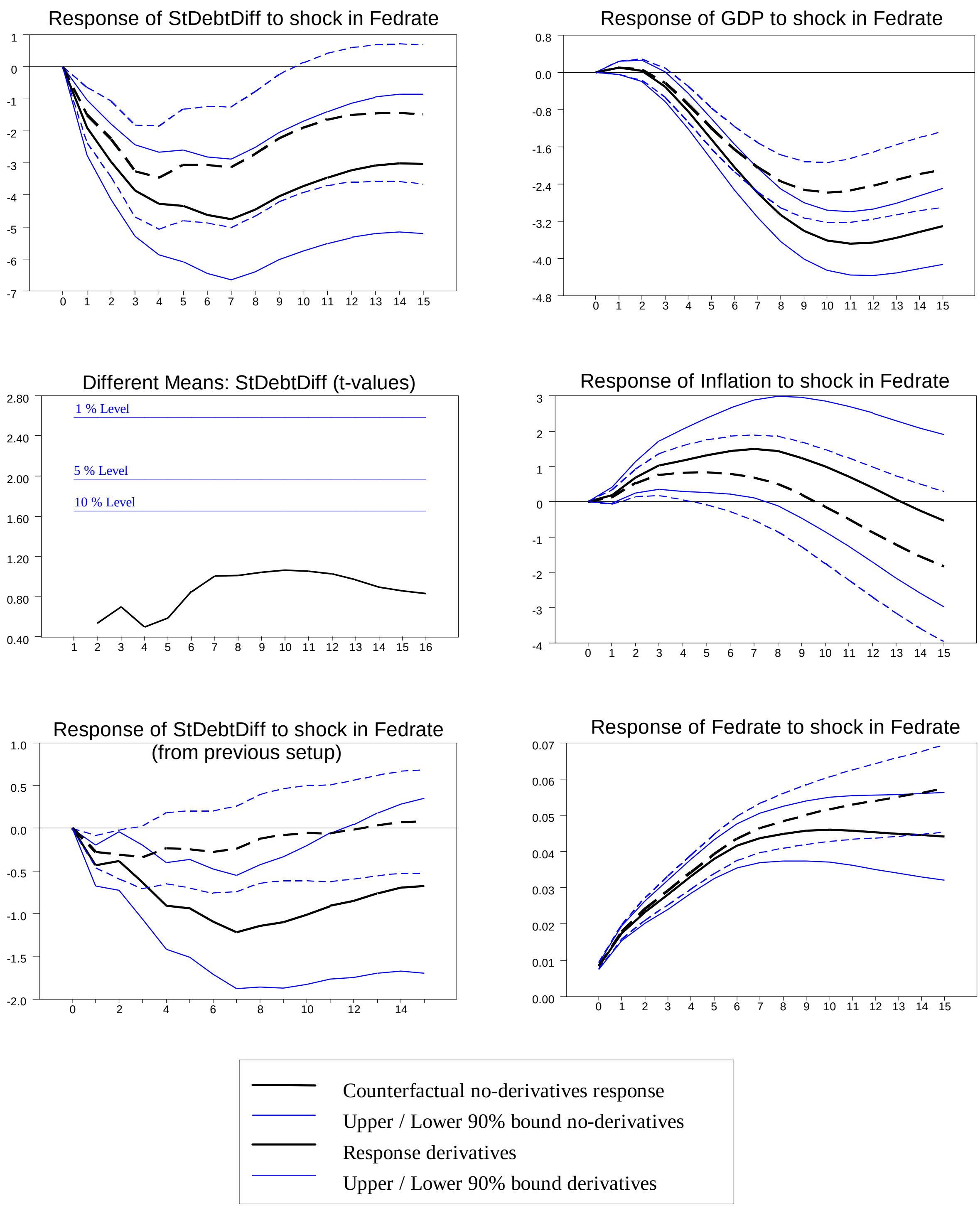
Figure III (b): Derivatives vs counterfactual no-derivatives regime; inventory setup



(black solid line)	Counterfactual no-derivatives response
(blue solid line)	Upper / Lower 90% bound no-derivatives
(black dashed line)	Response derivatives
(blue dashed line)	Upper / Lower 90% bound derivatives

This panel of Figure III represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and large firms with regard to the INVENTORIES variable, the federal funds rate, and the derivatives index (for the regime that includes derivatives markets). For purposes of comparison, the lower left field of the figure also reports the differential responses from the sample-splitting approach. Upper and lower lines in each graph define 90 percent probability bands for the respective impulse response function.

Figure III (c): Derivatives vs counterfactual no-derivatives regime; debt setup



This panel of Figure III represents a separate VAR that includes the growth rate in GDP, inflation as measured by the growth rate of the wholesale price index, the difference between small and the large firms with regard to the SHORT-TERM DEBT variable, the federal funds rate, and the derivatives index (for the regime that includes derivatives markets). For purposes of comparison, the lower left field of the figure also reports the differential responses from the sample-splitting approach.

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