IMF Working Paper

WP/97/121   INTERNATIONAL MONETARY FUND

Monetary and Exchange Affairs Department

Derivatives Effect on Monetary Policy Transmission

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September 1997

Abstract

This paper examines changes in the monetary policy transmission mechanism in the presence of derivatives markets. The effect of adding derivatives markets is analyzed independently for each of the main channels of monetary policy transmission: interest rates, credit, and exchange rates. Theoretically, derivatives trading speeds up transmission to financial asset prices, but changes in the transmission to the real economy are ambiguous. Using the structural vector autoregression methodology, an empirical study of the United Kingdom is used to assess the impulse responses of output and inflation, controlling for the size of the U.K. derivative markets. No definitive empirical support for a change in the transmission process is found.

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SUMMARY

This paper examines changes in monetary policy transmission in the presence of derivative markets. The underlying motivation for this topic stems from the current scale of derivative markets, which when combined with the risk and price hedging opportunities offered by derivatives suggests a possible change in both the transmission and effect of monetary policy.

The impact on monetary policy transmission due to derivative trading is analyzed first for the financial markets, and then for the real economy. Initially, a theoretical conjecture is presented, and this is followed by an empirical test. The empirical section uses a structural vector autoregression model of the United Kingdom to assess the impulse responses due to a monetary policy shock of interest rates, output and inflation, while controlling for the size of derivative markets.

For the financial markets, theory suggests that large scale derivative trading has a marginal effect on monetary policy transmission, by slightly speeding up the transmission across multiple asset types; this is confirmed by empirical results.

On the other hand, the theoretical conclusion for the real economy is more ambiguous regarding its net effect. An analysis of the three main monetary policy channels: the interest rate channel, the credit channel and the exchange rate channel, suggests that the impact on the real economy may be weaker overall, start earlier, and then continue for a longer time, relative to economies without derivative markets. However, the empirical results do not confirm this hypothesis. The results for the economy of the United Kingdom with and without derivatives are very similar, and fail to be statistically different.

I. INTRODUCTION

Arguably, the single largest innovation in global financial markets over the past fifty years has been the emergence and spectacular growth of derivative markets in the past ten years. In industrial countries, they are rapidly outstripping regular financial markets in size and importance—and every month new derivative products, exchanges and markets sprout up around the world. Derivatives markets can grow at rates in excess of 150 percent a year, maintaining this growth for up to a decade. Losses that put derivatives in the headlines include those of such well known globalbanks as Metalgeschelshaft, Barings, and Sumitomo's as well as Orange County California's experience with Bankruptcy Proceedings. But for all the low-cost, risk-hedging, profit-gaining and loss-making features derivatives provide, regulators have a difficulty in trying to manage and understand the opaque, off-balance sheet derivatives activities of many financial institutions. The problem is further compounded by derivatives' global nature, as evidenced by the German, British, U.S. and Japanese losses listed above, that very often involve trading in foreign markets or foreign products. Derivatives' sudden presence has possibly caught central banks unaware—only over the past three years have the Bank for International Settlements (BIS) and several central banks, including the Deutsche Bundesbank and the Federal Reserve, been seriously investigating the impact of derivatives on policy issues. Among industrialized countries, the lack of a definitive conclusion concerning the impact of rapid derivative growth on policy may pose a significant problem. The purpose of this paper is to examine *how monetary policy transmission changes in an economy with sizable derivative markets.*

An introductory overview of derivatives' nature is presented in the first section. The impact of derivatives on monetary policy is examined in the second section, with an emphasis on closely analyzing the "consensus" opinion as given by the BIS. The third section presents an empirical study of the impact of derivatives on monetary policy transmission in the United Kingdom. The fourth section summarizes the main results and offers some final remarks.

Global derivative market size is beginning to dwarf other financial sectors.[2] The BIS reported that the total outstanding notional principal for OTC markets alone at the end of March 1995 was $47.5 trillion,[3] an almost ten-fold increase from a similar, though less accurate, report in 1992, when the BIS estimated OTC notional principal outstanding at $5.3 trillion. In 1995 derivative exchange markets, on the other hand, revealed a total outstanding notional principal between $8 trillion (assuming *complete* double counting) and $16 trillion (assuming *no* double counting). The 1992 report, assuming no double counting, put exchange markets' notional principal outstanding at $4.6 trillion. However, notional principal

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[2]See Appendix I for further details on derivative markets.

[3]Bank for International Settlements, "Central Bank Survey of Foreign Exchange and Derivatives Market Activity," May 1996.

measurements can be misleading as an indicator of derivative market importance, and gross market value provides a more accurate representation of the size of derivative markets. Gross market value is defined as the sum of the negative and positive market replacement costs. The gross market value of OTC markets was $2.2 trillion on March 31, 1995. Note, however, that the gross market value is extremely sensitive to overall market volatility, and can double or triple in a more volatile environment.

Large-scale derivative usage results in greater market efficiency. These benefits derive from the following three financial characteristics of derivative instruments:

- *Hedging*. A derivative contract transfers a specific risk of the underlying security from the buying agent to the selling agent.

- *High Leverage*. The high leverage afforded by derivatives increases the volume of transactions and decreases the costs of capital.

- *Substitutability of assets*. Derivatives make arbitrage between two different assets much easier.

In terms of the *impact on the real economy*, the more preferable risk distribution through hedging combined with the lower cost of capital allows agents to better concentrate on their specific strengths, resulting in larger sustainable growth rates.

Derivatives can be considered a zero-sum game in that a derivative's largest positive aspect is its ability to precisely target the risk that is redistributed, although this risk redistribution through derivatives *may* cause adverse effects in capital markets.

- *Amplified price movements*. Dynamic hedging amplifies price movements.

- *Systemic risk*. Margin calls, actual realized losses and debtors' defaults may cause bankruptcy in an inadequately collateralized dealer.

- *Adverse global capital movements*. Poor policy choices can result in a rapid withdrawal of capital.

The fundamental cause of systemic risk is the dealer's desire and need to perfectly hedge market exposure. Large inter-dealer dependencies are created, and during times of stress credit risk between dealers may be high. The failure of any single dealer can cause a system-wide collapse.

II. IMPACT OF DERIVATIVES ON MONETARY POLICY TRANSMISSION

The objective of central bank monetary policy is to maintain price stability and low inflation by controlling the rate of monetary expansion. The central bank uses instruments such as base money and overnight interest rates to affect monetary growth by controlling market liquidity. Policy actions impact the financial markets directly, changing asset prices across the maturity and liquidity spectrum. As financial prices adjust, economic agents' spending and saving decisions are affected, and this in turn affects the overall price level and other macroeconomic indicators.

Derivatives alter the financial market place, offering not only new vehicles for investment and saving but possibly changing the impact of policy shocks on the real economy. At a minimum, derivatives offer new channels for transmission to the economy; at the most, derivatives dramatically change the regular transmission mechanism. Derivative markets are affected by monetary policy just like any other financial market, resulting in new transmission channels (although the new channels may not have a substantive impact on the real economy). But derivatives also alter the overall financial structure, causing possible significant changes in traditional transmission mechanisms. Furthermore, in countries such as Brazil and the United Kingdom, derivative market growth during the past ten years has been extremely rapid, increasing from a negligible size to one in which the potential effects are significant.

Hence from the policymaker's perspective, it is crucial to understand the way derivatives change policy transmission. A current issue, for example, is whether derivatives affect the sensitivity of aggregate demand to fluctuations in interest rates. Unfortunately, little research has been done in this area, the "Hannoun"[4] report published by the BIS being the major exception. A general consensus that has developed, although strictly speaking not empirically assessed, is that a policy change transmits throughout the financial marketplace more rapidly. The gain in market efficiency and the substitutability of assets afforded by derivatives both contribute to transmitting policy actions faster to all asset prices.

But a problem occurs when continuing the analysis to the real economy. The Hannoun report suggests that some agents may be temporarily sheltered from fluctuations in interest rates, exchange rates and other price indicators, thus increasing the lag with which monetary policy affects target variables. However, the report also observes that all agents will ultimately still bear the full brunt of policy changes. The effectiveness of policy to control inflation rates therefore remains unchanged, but the timing of the economy's response may change.

The objective of this section is to study this assertion in more detail. By examining the change to each transmission mechanism due to derivatives, it may be possible to

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[4]"Macroeconomic and Monetary Policy Issues Raised by the Growth of Derivative Markets," Bank for International Settlements, November 1994.

unambiguously support the Hannoun report conclusions. However, this paper will demonstrate that even the timing effect is theoretically ambiguous. An empirical study of derivatives' impact on the United Kingdom transmission mechanism is used to ascertain what effect, if any, derivatives have (in the United Kingdom).

A. The Rationale for Faster Policy Transmission to Financial Prices

Derivatives can affect policy transmission in financial markets in several ways. First, derivative markets and underlying markets are inherently linked. Second, derivative markets increase the market size in terms of security types, providing new price information. Third, derivatives can substantially alter international transmission by making arbitraging less expensive and more straightforward.

Derivative price changes to spot price changes

Keeping in mind the effect of policy transmission through the regular financial markets, this section examines the impact of derivative securities on spot markets. Ultimately, it is the spot market prices that affect real economic decisions such as investment and consumption spending. Spot prices also form the basis for derivative prices. By definition, the price of a derivative is dependent on the price of the underlying asset. Theoretically, there is a one-way relationship from the spot price to the derivative price. This is most apparent for options, whose theoretical value is determined through a formula such as Black and Scholes.[5] These methods make the *implicit* assumption that the underlying is independent of the derivative price.

Yet derivatives do have some feedback effect on spot prices. Derivatives are valued through both the demand and supply of the secondary derivative market in addition to the pricing formulae. An imbalance of buy and sell orders in the derivative market will lead to a disequilibrium between the theoretical derivative price, as determined by the formula, and the market derivative price. Arbitrageurs can profit from this situation by taking opposite positions in the derivative and the underlying market. For example, a portfolio may consist of a long position (or *vice versa*) in the derivative, and a short position in the derivative's dynamic hedge—that is, in the underlying asset. Thus, the prices of both the derivative and the underlying asset are driven back to the theoretical equilibrium, with a subsequent disequilibrium in the derivative market causing a price movement in the underlying spot market.

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[5]Black, F. and M. Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, 81, May-June 1973. This was the defining moment for derivatives, developing an analytical method to price European style options. The literature has grown enormously since the 1970's, and the general method (in particular its discrete time analogue) has been extended to value extremely complex derivatives.

A variety of studies have been undertaken to estimate the impact of derivative price movements on the underlying market, particularly in terms of increased volatility of the underlying asset.[6] Price movements are correlated in theory, however, causal relationships are difficult to estimate empirically. With regard to futures and forwards markets, studies generally find no increase in volatility, although for markets with options, results are inconclusive. An increase in volatility may indicate faster incorporation of new information in the spot prices, but it may also indicate less liquidity.

Effectively, the derivative and spot markets are linked by an "elastic band." The theoretical relationship, given by a formula such as Black and Scholes, determines the equilibrium relationship between prices, but temporary imbalances in either market have a rapid impact on the price level in the other market, pulling or pushing each market back to an equilibrium relationship.

Derivatives' impact on financial market transmission

Besides the uses of derivative markets for risk-hedging purposes, derivative markets offer substantially higher capital leverage than the underlying markets. For this reason, transacting in derivative markets is less expensive than in the underlying markets, particularly for hedging and short-term speculative purposes. In fact, the bid-ask spreads in derivative markets are often tighter than in spot markets, suggesting a greater level of liquidity for derivatives.[7] The greater liquidity serves to accelerate transmission of shocks to financial prices, so we may expect derivative prices to change earlier and more rapidly due to expectations in the run up to and following a policy shock. This in turn feeds through into spot price movements.

However, suppose that trading volume shifts from the underlying spot market into the less expensive derivative market. Then it is possible that total spot price movement will remain unchanged, although it is fundamentally driven by changes in the derivative market. This suggests that derivative markets will only contribute to greater spot price movement if turnover in the underlying markets has not shifted into the less expensive derivatives markets. This does not appear to be the case. For example, as reported in a recent BIS survey,[8]

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[6] See, for example, Ayuso, J. and S. Nunex, "Do Financial Derivatives Destabilize the Spot Market? The Spanish Experience in the Government Debt Market." *Banco de España Economic Bulletin*, April 1995 and D. Cronin, "Derivatives Trading and Spot Market Volatility: A Theoretical and Empirical Analysis," *Central Bank of Ireland Quarterly Bulletin*, Autumn 1993.

[7] See for example, Folkerts-Landau (1994), p. 580.

[8] "Central Bank Survey of Foreign Exchange and Derivative Market Activity 1995," BIS,

showing results for the global foreign exchange markets, the turnover of spot transactions grew by 7 percent annually between 1989 and 1995, whereas the turnover of derivative transactions increased by 19 percent annually over the same period. Daily spot FX turnover was $520 billion in April 1995, whereas daily derivative FX turnover was $740 billion during the same period. Since the global underlying market appears relatively unchanged in size, we can expect the regular market transmission mechanism to work as usual. Additionally, any changes in the derivative price following the shock will filter through into the underlying prices, thus increasing the speed of transmission.

Derivatives also offer relatively inexpensive arbitrage opportunities across asset types. Unlike underlying markets, only small amounts of collateral are required. In particular, spreads between (highly) correlated assets can be arbitraged. An example would be holding a short position in a 30-year treasury bond future and a long position in a 30-year mortgage bond future. Derivatives also increase the substitutability of asset types, and transmit shocks from one asset type to another. In fact, derivatives can even be priced on the spread between different asset prices (although the market effect is similar to the arbitrage effect). *Combined with financial innovation such as repackaging mortgages into mortgage backed securities, derivatives have made a significant impact in dramatically increasing asset substitutability across traditionally illiquid and slow responding asset prices.*

Transmission to and from abroad

Derivatives make international asset substitution relatively simple. By pricing away all currency risk, agents will demand identical returns on similar assets in different countries. Differences in each country's nominal returns can only be due to the expected exchange rate changes and a difference in country specific risk, such as default risk.

Without currency forwards and futures, agents bear the full exchange rate risk. This can result in a much greater divergence of returns on similar assets in different countries. However, if both countries have derivative markets, arbitrageurs can lock in on risk-free profits using covered interest rate parity arbitrage. The arbitrageur borrows in the low-interest-rate country (by going short a T-bill of a specific maturity), exchanges the money in the spot foreign exchange market, saves the money in the high-interest-rate country (by going long a T-bill with equal maturity), and buys a currency forward for the face value of the T-bill. This drives up the low-rate country's interest rate while driving down the high-rate country's interest rate. Additionally, the high-rate country's currency appreciates through the stock movement of money from the low rate country. Thereafter, assuming that the interest rate differential is maintained, covered interest rate parity implies that the high rate country's currency must slowly depreciate.

(...continued)
May 1996.

This arbitrage argument would tend to harmonize yield curves from different countries, and may therefore reduce the scope for monetary policy. Large interest rate differentials between countries will be hard to maintain without a constant depreciation of the currency, particularly for the smaller country for which the capital flows will be larger relative to monetary base. Taylor (1995) claims that the main swings of interest rates and exchange rates match the parity relationship, although high frequency deviations are observed.[9]

Summary of derivatives impact on transmission through financial markets

There is no question that liquid derivative markets[10] can react sooner than the higher transaction cost underlying markets to monetary policy shocks. In spite of this, there has been no evident substitution of market participation out of underlying markets into derivative markets, suggesting that established transmission mechanisms remain in place. But the feedback link between derivative prices and underlying prices serves to start underlying reaction sooner, and amplifies movements thereafter. The net result is a timelier and more rapid adjustment of financial market prices to a monetary policy shock. Bear in mind, however, that prior to large scale-derivative usage, underlying market prices, particularly *bond market interest rates, already reacted quickly to policy changes*. Therefore, *increased derivative usage can only have a marginal impact on further accelerating transmission to financial prices*. However, for more illiquid assets, such as bank lending and mortgage rates, the price changes may be noticeably more rapid. This increases policy impact, for example, on the housing component of inflation rates through the faster changes in mortgage rates.

The financial market aspect where derivatives do make a strong impact is on policy transmission across asset types, both through the foreign exchange channel and by leveraged arbitrage on correlated assets. International transmission of policy is now much stronger, and term structures cannot vary much from country to country without significant interest rate or exchange rate pressures. In fact, within an individual country, comparison of similar maturity asset prices is reduced to evaluating the difference in risk premiums (and liquidity premiums). In other words, *derivatives increase the "completeness" of financial markets.*[11]

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[9]The relationship holds specifically for covered interest rate parity. Contrary to Taylor, Throop (1994) provides evidence that the U.S. interest rates and exchange rates have been independent of foreign interest rates, countering particularly uncovered interest rate parity.

[10]An illiquid market has two, not mutually exclusive, types of features: either there is a very low trading volume so that prices change slowly, or the trading volume is in one direction so that the market price is not the equilibrium price. As markets gain liquidity, prices change more rapidly following new information and prices are more likely to be in equilibrium.

[11]A financial market place is complete when a market exists with an equilibrium price for every asset in every possible state of the world, with corresponding exchange rates between every

These results are consistent with the Hannoun report. However, unlike the Hannoun report which asserts that all relative asset prices changed quickly before derivative usage, this paper asserts that some traditionally slower responding prices, such as mortgages, change much more rapidly in the modern marketplace through a combination of increased derivative usage and other financial innovations.[12]

B. Ambiguous Real Economy Effects

This section extends the transmission mechanism from capital market asset price changes to the impact on agents in the economy. No attempt is made to rank the different transmission channels, but an analysis is made for the impact of derivatives on each channel. Building on the results from the previous section, this section will assume that the large-scale usage of derivatives slightly increases the speed of transmission in the financial markets so all asset prices incorporate the impact sooner.

Again, expectations form a major component of the overall effect on the real economy. A transitory increase in interest rates may have little effect on the real economy, partly because prices beyond short-term rates on the most liquid financial assets change little, and partly because agents perform some amount of intertemporal substitution of spending. For very transitory situations, such as the Swedish interest rate spike in 1992, spending can simply be postponed for several days, leading to little annual aggregate changes.

There are three generally acknowledged monetary transmission mechanisms (for a survey see Mishkin, 1996). For a summary of these channels, see Table 1. The interest rate channel and the credit channel operate domestically. For open economies, the exchange rate

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possible pair of assets. Hence, it can be theoretically proved that a complete financial market place is Pareto optimal, a situation in which no economic unit can be better off without another being made worse off. Incomplete markets either have insufficient financial contracts or incomplete participation for an equilibrium price to be maintained. Incomplete markets have identifiable contingencies without a financial contract to trade them that result in a wealth loss, or inaccurate prices that result in a wealth loss. Hence incomplete markets have some degree of welfare loss (some economic unit being worse off) relative to complete markets. In practical terms, the financial market place gains completeness when new contracts evolve for pricing assets under differing contingencies (such as the development of futures and options on assets); when the price discovery process is improved leading to more accurate equilibrium prices (through greater liquidity and increased participation); and when relative exchange rates become more accurate (through greater degrees of asset substitutability).

[12] For example, arbitraging using futures on both government bonds and mortgage-backed securities results in faster and stronger transmission of shocks to mortgage rates.

channel transmits both domestic and foreign monetary policy. The interest rate channel is also called the "money view of transmission," and the credit channel is called the "imperfect capital markets view of transmission." The overall transmission of monetary policy to the real economy is generally acknowledged to lag anywhere from 18 to 24 months until the main impact on prices is felt.[13] For a summary of these channels, see Table 1.

Interest rate channel and other asset price effects

The interest rate channel has been the mainstay of monetary policy transmission ever since the emergence of IS-LM analysis. In the traditional IS-LM model, a monetary contraction leads to interest rates increasing, which in turn increases the costs of capital and affects investment spending. Low-return investments, or less profitable investments, are put aside. Investment drops and directly leads to a decline in aggregate demand, slowing down economic growth and tempering inflationary pressures. An increase in the nominal interest rate would undoubtedly have little effect on investment, so the emphasis here is on a change in the real rate of interest, and in particular on the longer term interest rates with maturities equal to the investment decision. Clearly an implicit assumption in this framework is that prices (and wages) exhibit at least short-run rigidities. Thus a nominal interest rate change causes a temporary real interest rate change. We next consider the impact that derivatives have on real activity, particularly on consumption and investment demand. To do this, it is easiest to divide the interest rate channel into substitution, income and wealth effects.

Substitution effects

Following an interest rate increase, agents substitute saving for borrowing, intertemporally smoothing expenditure. Investment decisions are reassessed with the higher costs of capital. In terms of future investment expenditure, the effect of a rise in interest rates on investment is always negative and cannot be easily hedged. The extent of the impact will depend on the agents' preferences, particularly their ability to substitute intertemporally between borrowing and saving.

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[13] See for example Gerlach and Smets (1995), who empirically demonstrate this range of lags for the G-7 countries.

Table 1. Impact of Derivatives on the Real Economy

Transmission Channel	Type of Effect	Derivatives Impact
Interest Rate	Substitution	Some hedging is possible, although overall there is little usage. Agents face the new costs of capital sooner.
	Income	Large scale hedging occurs. Although unhedged investors are affected slightly sooner, hedged agents can experience no income effect from on-going expenditure for over ten years. Globally, up to $4.35 trillion notional principal may be hedged against the income effect.
	Wealth	Little hedging is possible. The impact of lower wealth occurs slightly sooner.
Credit	Bank Lending	Virtually eliminated through general financial innovation, including derivatives, and by alternative funding.
	Balance Sheet	Some net worth changes can be hedged, although agents still face higher borrowing costs sooner.
Exchange Rate	Exports	Large scale hedging possible, reducing the impact of the net export effect in the short run. Unhedged agents are affected sooner. Globally, up to $3.16 trillion notional principal may be hedged against the export effect. However, substitution effects associated with real exchange rate fluctuations are difficult to hedge.
	Interest Parity	OTC currency markets increase likelihood of covered interest rate parity holding. Some degree of interest rate harmonization or exchange rate changes can result.

It may be possible to hedge against the adverse impact of the substitution effect. Using structured derivatives such as options on futures, a hedger can lock in the current interest rate for potential future funding needs. However, there are still several unhedged uncertainties.[14] For example, the magnitude of the investment and the exact timing of the investment may be unknown. Part of the problem in analyzing the substitution effect is the lack of data. The IMF suggests that the volume of options on futures in the major exchange traded derivatives markets is approximately equal to 10 to 30 percent of the volume in plain vanilla futures.[15] However, there are many motivations for trading in these products besides hedging "substitution risk." The largest reason for trading in derivatives is probably as an alternative to trading options on spot interest rate instruments—futures being more liquid than the spot market and having lower capital requirements.

Given the remaining uncertainties and expense (through the option premium) of hedging such a risk, *derivatives can only have a marginal impact on reducing the substitution effect*. Most firms and households will face the increased costs of capital for future investment expenditure identically with or without derivatives. In addition, since asset prices change faster with derivatives, a particularly relevant consideration for more illiquid assets is that agents *are confronted with the impact sooner*, contrary to the conclusion in the Hannoun report which indicates that the rate of price changes has not been significantly altered.[16]

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[14]Theoretically, it is possible to hedge interest rate increases in future funding needs, such as a floating rate loan. An option to short a future (or forward) would be an example. The exercise date of the option would be the time of the funding requirement, and the strike price on the (short) future would be consistent with the desired cost of capital. The future would have a duration equal to the maturity of the loan, and would hedge any interest rate exposure from the loan. This hedge has two components. The option represents the first part, hedging against an increase in the initial interest rate. The future represents the second part, hedging against increases and decreases in interest rates during the life of the loan. There is some evidence to suggest that these "structured derivatives" are in use—a recent report by Bodnar and Marston (1996) revealed that 30 percent of non-financial firms used structured interest rate derivatives at some point. Note however that this referred to all combinations forwards, futures, swaps and options.

[15]"International Capital Markets 1995," IMF, 1995. Data for Chicago Board of Trade, Chicago Mercantile Exchange, Tokyo International Financial Futures Exchange, Marche a Term International de France and London International Financial Futures Exchange, in Appendix Table 4.

[16]See p. 24 of the Hannoun report.

Income effects[17]

The income effect is the change in income, or cash flows, associated by a change in the interest rate. Its primary effect is therefore on an agent's liquidity. The direction of the income effect depends on the net holdings of assets and liabilities. A net saver receives a positive income effect following an interest rate increase, whereas a net borrower has a negative income effect.

For unhedged agents in modern derivative enhanced markets, there is little change in the income effect. An interest rate rise redistributes income from borrowers to lenders. If borrowers have a higher marginal propensity to consume than lenders, as is usually assumed in the New Keynesian literature,[18] then the aggregate income effect is negative. However, derivatives aid in transmitting the shock more rapidly to interest rates, so unhedged agents are impacted by a negative income effect slightly sooner.

Additionally, for both hedged and unhedged agents, the relative interest rate sensitivity of assets and liabilities is an important determinant of the income effect. If payments are more interest-rate sensitive than receipts, the income effect on cash flows is negative, and *vice versa*. With derivatives, this added ambiguity is partially reduced because of the greater degree of completeness in financial markets. For example, asset substitution reduces price discrepancies between assets towards risk premium.

The largest single change in the transmission mechanism caused by derivatives is the *ability of agents to hedge*[19] *the income effect associated with interest rate fluctuations.* Hedged agents are either more interest-rate sensitive or more risk-averse than agents who end up holding the risk. This might imply that hedged agents have a higher marginal propensity to consume than unhedged agents, and therefore wish to maintain their high consumption (see also footnote 42). Derivatives allow these agents to hedge their interest-rate sensitive ayments

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[17]Income and wealth effects are closely intertwined, since wealth can be viewed as the sum of discounted future income flows.

[18]Net borrowers are generally more credit-constrained than net lenders. Credit constrained agents have a higher marginal propensity to consume than non-credit constrained agents. For a survey of related literature, see G. Elliehausen, "Consumer Credit" in the *New Palgrave Dictionary of Money and Finance*, MacMillan, 1994.

[19]A simple hedge example uses a future or forward to lock in an interest rate. The agent would take an opposite position in the future, so that a loss on an underlying floating interest rate asset is exactly compensated by a gain in the future position.

and receipts exposure. Note that hedges are designed to smooth fluctuations in interest rate flows of on-going investment projects.[20]

Bodnar and Marston (1996) surveyed all non-financial Fortune 500 firms, and found that 40.5 percent report using derivatives. The primary motivation is risk management, with 73 percent hedging interest rate risk through swaps, options, futures and forwards. Touche Ross (1995) surveyed 30 percent of the non-financial FT-SE 100 firms, and reported that at least 85 percent use some form of interest rate derivatives. Furthermore, they reported that only 8 percent speculate using interest rate derivatives.

The impact of interest rate hedged agents is significant. The BIS Survey of Central Banks reported that the global gross market value of OTC interest rate derivatives was $700 billion at end-March 1995, and the notional principal of OTC and exchange markets was $36.7 trillion on that date. Considering that 14 percent of gross market value was to non-financial institutions, this suggests that one-seventh of the principal is held by hedgers.[21] In fact, the BIS survey reports that $4.35 trillion of global underlying notional principal is held by non-financial institutions. Following the earlier assumption, this represents hedged principal against interest rate fluctuations. If monetary policy, after changing interest rates, cannot affect this amount of capital in the short run, this indeed represents a major new hurdle. However, for every hedged unit of underlying principal, a risk holder must have acquired the

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[20]There have always been forms of implicitly hedged assets, even before derivatives were extensively used. Any asset (or liability) with a fixed interest rate can be views as a hedged asset (or liability). These include credit card debt and mortgages. Credit card debt is notoriously inflexible following other interest rate changes, as noted by Radecki and Reinhart (1994) for the U.S. economy. During the period 1970 to 1994, credit card interest rates have fluctuated between 16 percent and 18 percent (from the Federal Reserve's survey of main credit card plans across 150 institutions) whereas the federal funds rate has fluctuated approximately between 3 percent to 19 percent. However, credit card debt only accounted for 2 percent of outstanding non-financial sector debt.

Some mortgages are on a fixed rate basis, hedging it's holders from interest rate fluctuation. Yet this proportion may be small. For example, in the United Kingdom in 1993 only 10 percent of the outstanding stock of mortgages were estimated to be fixed rate, even though almost 50 percent of new mortgages were issued with fixed exchange rates (see Paisley, 1994). Both credit card debt and fixed rate mortgages, although a form of hedged liability, have been in use well before the derivative explosion. Hence any changes in the transmission mechanism due to these liabilities has already occurred.

[21]The notional principal is net of local and cross-border double counting, and hence represents the sum of all hedgers to dealer and speculators to dealer notional principal.

risk. Except in the extreme case where every domestic interest rate sensitive agent is hedged abroad, some domestic agents must feel the policy impact. The difference between the marginal propensities to consume of the hedger and the risk holder is the actual transmission change, and herein lies a fundamental assumption. The risk-averse hedger is assumed to have a higher propensity to consume than risk holders.[22]

Compared to the income effect of a change in monetary policy prior to derivative usage, the aggregate income effect is less negative when agents can hedge. Consider that for the duration of the hedge, the complete income effect has been shifted from the hedged agents to the risk holding agents. The hedged agents receive no income effect, whereas the risk holders receive a double income effect consisting of their own regular income effect added to the extra income effect associated with bearing the interest rate risk from the hedgers. But since the risk holders propensity to consume is lower than that of the hedgers, the income effect is not as negative as if the hedgers had not been hedged.

The ability to hedge the income effect implies that derivatives may result in a weaker impact of policy. However, due to the faster transmission of policy to asset prices, the risk holding and unhedged agents are impacted by a negative income effect sooner. *Derivative markets thus cause a twofold change in the income effect, the sum of which is ambiguous.* First, the income effect begins earlier and second, the effect is weaker. Additionally, for agents with maturity mismatches, the income effect occurs with a delay.[23] The impulse response of aggregate demand would therefore be expected to shift and lessen, and possibly extend with a greater lag.

Wealth effects

Wealth effects are similar to income effects in the sense that wealth is equal to discounted future net income. There are two ways through which wealth can vary: through changes in income flows and through changes in the discount factor. This section focuses on a change in net worth due to a change in prices, and not to a change in income stream. A

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[22]Hedgers remove the need for precautionary saving, thereby increasing their propensity to consume. Some studies (see McCarthy, 1995) have also found that more risk averse consumers tend to have higher propensities to consume when given a consumption hedge in the form of insurance.

[23] Hedgers can be exposed to the income effect of a policy action if the hedge has a maturity mismatch with the underlying asset or liability. Assuming no maturity mismatch, hedged agents are never subject to an income effect, leading to a weaker overall impact of the policy shock on expenditure. However, given the difficulty of hedging against the substitution effect, all agents bear the increased costs of capital on future funding needs.

reduction in prices causes a decline in wealth, leading to a reduction in consumption. The types of prices under consideration include bonds, equity and real estate. Income effects relate to changes in flows arising from owning assets, whereas the wealth effect is determined by a change in the value of the asset. Considering a life cycle consumption model,[24] a decline in wealth leads to a direct decline in average consumption, reducing investment expenditure and hence aggregate demand.

Hedging techniques against detrimental wealth effects are identical to those for hedging an adverse income effect, particularly for financial assets. For example, options give holders the ability to hedge against a drop in equity prices. However, hedging price changes in illiquid assets such as real estate is extremely uncommon. As reported by the BIS survey, notional and gross market values of equity, stock index and commodity price OTC derivatives represented only 2 percent of the equivalent interest rate derivative figures. This suggests that there is much less wealth hedging than income hedging. In fact, in the Bodnar and Marston (1996) survey of non-financial U.S. firms, 91 percent of derivative users reported using derivatives for earnings or cash flow management as opposed to 9 percent for market-value maintenance. Although *wealth effect hedging does occur, it is small in size* compared to the potential changes in the income effect. Furthermore, considering that much of the wealth effect stems from changes in illiquid asset prices that cannot be hedged, the advent of derivatives markets will not significantly change the transmission mechanism through the wealth effect.

Credit channel

The credit channel arises from asymmetric information and costly enforcement of contracts in credit markets. The credit channel can be further divided into the bank lending channel and the balance sheet channel, although as Bernanke (1995) notes, it is difficult to empirically distinguish the two aspects.

Bank lending effect

The bank lending channel depends on banks playing a special role as the sole source of financing for smaller firms. A contractionary monetary policy reduces banks reserves and thus deposits. The decline in deposits lowers the amount of loans available, impacting small borrowers directly and reducing investment. Large firms with direct access to capital markets

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[24]Wealth effects are strongly advocated by Modigliani in his life cycle model (see Modigliani, F., "Monetary Policy and Consumption," in Consumer Spending and Monetary Policy: The Linkages, Federal Reserve Bank of Boston, 1971). A version of Modigliani's MIT-Penn-SSRC (MPS) model, incorporating the life cycle model, is in use at the Board of Governors of the Federal Reserve System.

are unaffected by this channel, and in fact there is ample evidence to suggest that small firms are also increasingly unaffected.

Edwards and Mishkin (1995) surveyed the evidence on the decline of traditional bank lending caused by financial innovation. From a high of 35 percent in 1974, bank lending fell to 22 percent of borrowing in 1994. In so far as derivatives contributed to financial innovation by providing additional funding avenues, *derivatives have reduced the importance of the bank lending channel.* An alternative explanation for a decrease in the importance of this channel concerns the hedging opportunities available to lenders such as savings and loan institutions. Derivative usage allows these institutions to safely hedge long-term lending, and to creatively circumvent contractionary policy by securitization of assets, resulting in less vulnerability to a policy shock.

The Deutsche Bundesbank (1994) claims that the bank lending channel (in the broader context interlinked with the interest rate channel) remains largely unchanged in Germany. Bank lending is the major source of finance in Germany and both small and large firms cannot hedge indefinitely against fluctuations in interest rates following changes in loan availability. However, the BIS survey reports that 41 percent of the OTC notional principal outstanding in deutsche mark-denominated interest rate derivatives[25] have maturities between one and five years, and 16 percent have maturities greater than five years. This suggests that, even in the universal banking system of Germany, firms can hedge interest rate changes for extended periods, in some cases longer than the business cycles that drive policy cycles.

Balance sheet effect

The balance sheet channel operates through changes in worth of agents, and is similar in many aspects to the wealth effect operating through the interest rate channel. Its main proponents are Bernanke and Gertler (1995), who argue that unlike the bank lending channel, financial innovation has little impact on the balance sheet channel. For example, a contractionary monetary policy causes a decline in asset prices, reducing agents' net worth and collateral. Less collateral means losses from adverse selection are higher, leading to a reduction in the desired lending level of creditors. Furthermore, lower net worth also increases the moral hazard problem. With a smaller stake in equity, owners will undertake riskier projects, increasing the default rate and thus reducing lending.

How have derivatives impacted the balance sheet channel? In the short run, until the derivative contracts expire, agents can hedge against declines in net worth due to asset price changes. The net result is that agents are still faced with the increased costs of capital, even if collateral levels are unaffected. Thus derivatives do offer the possibility of removing the

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[25]Total OTC deutsche mark interest rate derivatives notional principal outstanding at the end of March 1995 was $3.4 trillion.

balance sheet effect, contrary to Bernanke and Gertler. Like the changes in the income effect, this may serve to *weaken the impact of policy.*

Exchange rate channel

The final transmission channel of monetary policy is non-domestic: the exchange rate channel. There are two effects associated with this channel, namely the classical net exports effect and the interest rate parity effect.

Net exports effect

A contraction in the form of an interest rate increase attracts foreign capital, appreciating the exchange rate. The higher exchange rate makes domestic goods relatively more expensive than foreign goods, decreasing net exports and hence lowering output. There are two parts to the net exports effect: (1) a change in the nominal exchange rate and (2) a change in the real exchange rate.

Derivatives can impact the export effect. Both wholesale importers and exporters can hedge nominal exchange rate fluctuations in the short run. Given the size of the OTC currency markets, there may be a large degree of producer-based nominal *exchange rate hedging, reducing the impact of this transmission channel.* Results from the Bodnar and Marston survey of U.S. non-financial firms, indicate that more firms use currency derivatives (76 percent of total derivative users) than interest rate derivatives (73 percent of total derivative users). The Touche Ross survey of United Kingdom nonfinancial firms indicates that 85 percent of derivative users use foreign exchange derivatives to hedge cash flows, including balance sheet translation risks and profit translations. Only 12 percent of the United Kingdom derivative using companies used foreign exchange derivatives for speculation. The BIS survey reports that the total global OTC and exchange traded notional principal of foreign exchange derivatives is $17.8 trillion. Considering that 21 percent of OTC gross market value was to non-financial institutions, this suggests that one-fifth of the notional principal represents hedgers.[26] In fact, the BIS reports that globally, an underlying notional principal of $3.16 trillion is held by non-financial institutions. Following the earlier assumption, this represents hedged principal against nominal exchange rate fluctuations. If monetary policy after impacting exchange rates cannot affect this amount of capital in the short run, it has confronted a major new hurdle.

Real exchange rate fluctuations are significantly more difficult to hedge, particularly if the driving force behind the fluctuations are changes in the relative price level. In this case there is a substitution effect, which is not readily hedgeable using currently available

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[26]The notional principal is net of local and cross-border double counting, and hence represents the sum of all hedgers to dealer and speculators to dealer notional principal.

derivatives. Even when the real exchange rate changes due to a change in the nominal exchange rate and agents hedge foreign derived cash flows, they cannot hedge the substitution effect associated with the real exchange rate change. Agents are still faced with one country being relatively more reasonable for future investment or consumption flows.

Interest rate parity effect

The second aspect of the exchange rate channel is that of interest rate parity,[27] which is also pronounced. Interest rate parity transmits domestic policy abroad, and foreign policy home. Covered interest rate parity, using currency forwards, seems to hold well (see Taylor, 1995).[28]

It can be argued that the arrival of *large-scale OTC currency markets increases the strength of the covered interest rate parity* relationship and, through the link from derivative markets to spot markets, will ultimately strengthen the uncovered interest rate parity relationship. Increased derivative use has created more cross currency pairs that are readily hedgeable, as well as increased FX market liquidity, thus leading to less expensive and greater arbitrage trading across ever more currency pairs. In addition, the ability to hedge currency risk and the increased availability of funding through creative derivative usage will only serve to increase the level of international capital flows following policy changes that change interest rates. The more rapid movement of exchange rates therefore *increases the speed with which real import and export prices change, impacting the real economy sooner*.

Summary of derivatives impact on the real economy

Without empirically determined weights for each channel and effect, it is difficult to aggregate the impact of derivatives on policy transmission to the real economy. More rapid financial asset price adjustment is the only unambiguous change.

There are two broad results that can be deduced. First, all unhedged agents are exposed to the policy shock sooner, albeit a change of only a handful of days or hours (but for traditionally illiquid assets, the change may be very significant). Second, agents have the possibility to hedge against each transmission channel effect. In particular, evidence from the BIS survey suggests that large-scale hedging occurs for the income effect of the interest rate

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[27]Covered and uncovered interest rate parity as developed from the Mundell-Fleming model. See Fleming, J., "Domestic Financial Policies under Fixed and Floating Exchange Regimes," *IMF Staff Papers*, November 1962 and Mundell, R., *International Economics*, MacMillan, 1968.

[28] On the other hand, uncovered interest rate parity has little to no empirical backing (see Throop, 1994).

channel and the net export effect of the exchange rate channel. Agents most susceptible to interest rate and exchange rate shocks have the opportunity to hedge against fluctuations in the short to medium run. They can do this by locking in rates using futures, or by insuring themselves against a rise in rates by using options on futures. Additionally, some of the risk holders will be abroad, diluting the domestic impact, so that the total impact on aggregate demand may be less than before. In the same way, foreign monetary policy can affect the domestic economy through foreign risk held domestically.

Considering the impulse response function of aggregate demand and output, these features suggest that *response picks up earlier*[29] *and may continue for longer*[30] than before derivative usage, and that *the total response may be less.*[31] The changed impulse response has implications for a naive policy maker. In the medium term, variables may appear to indicate undershooting leading to further policy action. In the long term, this will result in overshooting as the hedges expire.

There is some empirical evidence for the additional lag and reduced impact, although no explicit account has been taken of the actual size of derivative markets. Taylor's (1995) results for the United States, Germany and Japan, indicate that pre-1986 impulse response functions are less lagged and greater in impact than post-1986 impulse response functions, confirming the taxonomical ideas suggested in this section.

C. Other Issues for Monetary Policy

This section covers further issues relating to the effect on monetary policy of increased derivative security usage in order to give more comprehensive coverage of derivatives, but are not the main focus of the paper. Each of these issues has generated great interest and a large body of literature.

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[29] Earlier response is due to faster transmission across financial markets maturity and asset spectrum.

[30] Extended response may be due to (i) delayed exposure to new interest rates through substitution effect hedging, and (ii) delayed exposure of the income effect for agents with maturity mismatches.

[31] Weaker response is due to income effect hedging shifting the impact of the interest rate change from hedgers to risk takers.

Monetary aggregate changes

Creative combinations of derivatives can create "synthetic" assets that are substitutes for actual securities. For example, a portfolio containing a long bond position and short 3-month future on the bond is identical to a 3-month time deposit. However, since the portfolio, or synthetic time deposit, can be traded, it is substantially more liquid than a regular time deposit. The synthetic time deposit is not included in a broad monetary aggregate like M3, although the less liquid regular time deposit is. For many financial market participants, the synthetic deposit may be more attractive, and will be held instead of a time deposit. This will lower the accuracy of the strictly defined broad monetary aggregates in estimating money, thereby reducing the logic of targeting broader monetary aggregates.

Information from derivatives

Options provide a new source of information concerning market sentiment. Implied volatility can be extracted from option prices, indicating the markets' expected volatility until the contracts end. Empirically, the predictive power of implied volatility for actual volatility is significant (see Scott, 1991). Additionally, differences between call and put prices can be used to deduce the distribution of expected price changes. This information is particularly useful with reference to interest and exchange rates, and several central banks make use of this data. The BIS reports that the Bank of England, the Federal Reserve, the Bank of Japan, the Banque de France, and the Bank of Italy all analyze option prices on interest and exchange rates.[32]

Futures and forward markets provide an alternative method of obtaining expected price paths. Cash markets, such as forward interest rates implied from yield curves, can also be used, but the greater liquidity in derivative markets may result in superior information. The BIS reports that the Bank of England, the Federal Reserve, the Bank of Japan, the Banque de France, the Bank of Italy and the Deutsche Bundesbank all use information gathered from futures and forwards.

Derivatives as open market instruments

As a form of security, derivatives offer a new channel for open market operations. A theoretical application of derivatives would be the reduction of market volatility. By issuing below-market price options, with an associated implied low volatility, the central bank may be able to reduce actual market volatility. However, there are three problems with this mechanism. First, the central bank is effectively subsidizing market insurance against excess volatility. Second, the potential downside loss that the central bank faces may be unlimited.

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[32]The Hannoun report, pp. 41-42.

Third, direct price manipulation reduces the informational content of prices, grossly distorting the market.

Derivatives have been used recently by central banks in two ways, both concerning the foreign exchange market. At the beginning of August 1996, the Mexican authorities announced an option selling program to bolster their holdings of foreign reserves. The technique involves selling options that give market participants the right to sell the central bank dollars at the spot exchange rate when the option was sold. Thus if the peso appreciates, the option holders can sell dollars to the central bank and realize a peso capital gain in the amount of the appreciation. The motivation behind this method lies in signaling effects. Unlike direct spot market intervention to accumulate foreign reserves, the market participants control this channel of foreign reserve accumulation, thus mitigating any depreciating signals. The option writing scheme, however, may be more costly than accumulating foreign currency directly in the spot market. If the currency appreciates considerably before the options are exercised, the central bank incurs a sizable loss compared to buying foreign currency directly at the new rate.

The second type of derivative use regarding foreign exchange was by the Thai monetary authorities during the speculative attack on the baht in the beginning of August 1996. To sterilize the exchange market intervention, the authorities traded in the futures market. For every baht bought in the spot markets, one baht was sold in the futures markets with an expiration of just two weeks. Thus the effective reduction in liquidity lasted for only two weeks. However, given the link between spot and futures market prices, this type of sterilized intervention can only be effective in so far as capital market imperfections exist. Otherwise the speculative attack pressure is simply rolled over into the future and not absorbed.

III. CHANGES IN MONETARY POLICY TRANSMISSION IN THE UNITED KINGDOM

The framework used in the previous section can only suggest possible outcomes. This type of problem is inherently empirical, since it rests on the assertion that hedged agents are different from risk holders. Hence, this section uses a structural vector autoregression model of the United Kingdom in order to analyze the impact of derivative usage on monetary policy transmission. The United Kingdom was chosen for the empirical study because, along with the United States, derivatives have been in use there for over a decade, thus providing sufficient time series data. However, unlike the United States, where exchange traded derivatives developed in the early 70's, the first United Kingdom exchange traded derivatives appeared in 1982. This allows data to be taken from the mid-1970's until 1996, with half the sample falling during the time period with derivative usage, and half during the time period with no (large-scale) derivative trading. Derivative usage in most other industrial countries was not substantive until the later 1980s or even early 1990s.

A. Structural Vector Autoregression Methodology

Compared to large-scale macroeconomic models, structural vector autoregressions (SVAR) are useful tools to analyze the macroeconomic response of an economy to specific underlying shocks, because they require only a minimum of identifying restrictions in order to separate the movements of the model's variables into the parts due to underlying shocks. The basic method involves regressing each variable on every variable, including itself, lagged up to a given length. Impulse response functions and forecast error decompositions are easily computed from SVAR estimates. However, there are two key problems with using this technique to gauge the response to shocks. The first regards monetary policy response: the model by definition incorporates the "normal" response of policy makers to changes in the underlying variables, and hence the shocks under consideration represent "surprise" deviations away from the regular policy maker response. Thus by shocking the system, the results may not indicate the response of the economy to a typical policy action. The second problem with SVAR methodology is the sensitivity of the results to the type of restrictions used to identify the effect of each shock. Therefore, the identifying restrictions must be well motivated, and the results should be robust for several identification structures.

The empirical methodology closely follows that of Gerlach and Smets (1995) and Gali (1992), which in turn are based on Blanchard and Quah (1989). The model is comprised of four variables, measured quarterly: real gross domestic product (y), price level (p), overnight nominal interest rates (r) and a proxy for the derivative market size (d). The proxy for derivative market size is the transactions volume of sterling futures contracts on the London International Financial Futures Exchange (LIFFE) from its opening in 1982 onwards. The derivative market proxy is normalized to range from 0 to 1, where 0 represents no derivative market and 1 is the largest size, occurring in 1994 Q4 and again in 1996 Q1.

There are two separate structural setups used to assess the impact of derivative market size on policy transmission. The first method, in addition to output, prices and interest rates, uses a manufactured variable equal to the product of interest rates and derivative market size, which is represented by rd. Therefore, the (stylized) coefficient on interest rates alone can be reduced to $\beta_r + d\beta_d$. This is termed the "indirect approach," since derivatives by assumption work through the coefficient on interest rates. The second method simply adds the derivative market size variable as the fourth variable. This is termed the "direct approach," since derivative usage can affect all variables structurally. Both approaches also use quarterly dummies to remove any additive seasonal effects.

Three different methods were used to identify the impulse response functions of output, inflation, and interest rates to a temporary nominal interest rate shock. The first method uses the estimated vector autoregression (VAR) method that has existed since ordinary least squares was invented. The second, more sophisticated method, follows Sims' (1980) method on VAR's, and the third follows the recent SVAR methodology as developed by Blanchard and Quah (1989).

The problem with using impulse responses derived using the first VAR method is that shocks are not representative of an identifiable underlying economic shock. In fact, with this method the impulse response to a single variable shock represents the response to a combination of underlying economic shocks, and the impact of a specific shock, such as a monetary policy shock, cannot be identified.

Sims proposed a methodology to overcome this problem, by effectively imposing contemporaneous restrictions on the impact that shocks can have. This method is often termed "atheoretical," since no use is made of economic theory in identifying the underlying economic shocks. The results are particularly sensitive to the ordering of the variables in the model. An underlying shock to the first variable is contemporaneously transferred to all other variables, yet an underlying shock to the last variable only affects it contemporaneously. In the model used in this paper, the variables are ordered as output growth, inflation, interest rates, and derivative markets. Thus, a supply shock operating on output immediately affects output, prices, interest rates and derivative markets. Yet a demand shock operating on prices only impacts prices, interest rates and derivative markets immediately, and impacts output after one quarter. Proponents of this method assert that if impulse responses are insensitive to different orderings of the variables, then the results have a meaningful economic interpretation.

The SVAR methodology uses economic restrictions to identify underlying shocks. These economic constraints fall in two categories: contemporaneous constraints and long-run constraints. A contemporaneous constraint means that an underlying shock on one variable has no immediate impact on another variable, and a long-term constraint means that an underlying shock to one variable has no long-run impact on another variable. The problem with the SVAR method is it is substantially more complex to estimate than the other two methods.

The six economic constraints imposed for this model are: that monetary policy, represented by changes in interest rates, has no long-run and no contemporaneous impact on output level; that aggregate demand shocks, represented by changes in inflation, have no contemporaneous impact on output level; and that derivative growth shocks have no contemporaneous impact on interest rates. Technically, the one long-run restriction and the short-run restrictions on output allow supply shocks to be separated from other shocks. Demand shocks are separated from policy shocks by the constraint that policy has no long-run impact on output. Finally, derivative shocks are separated from policy shocks by the last constraint.

Many SVAR studies that try to ascertain the impact of a particular event or structural change compare the impulse responses in the sample before the change and after the change. The model estimated in this paper directly incorporates derivative market size. This method of assessing the impact of derivative markets on monetary policy is preferable to sample splitting. In particular, the differences in results across samples are attributable to *all structural changes* that occurred between the samples. However, in this model differences in policy transmission with and without derivative are attributable to at most the sum of the growth of derivative

markets and *structural changes that are co-integrated* with the growth of derivative markets. In the United Kingdom, these may include financial globalization, the conservative stewardship of the country and other such variables, but probably do not include "big bang," exogenous price shocks, free access to the European market, and other such non-cointegrated shocks. Finally, 95 percent confidence intervals for the estimated impulse response functions were computed.

However, a limitation of the direct approach used in this paper should be noted. Some of the considerations discussed earlier in this paper suggest that the presence and growing liquidity of derivatives markets could alter the coefficients of the VAR (rather than just having an additive effect within the VAR), and this would not be fully reflected in the comparison of some of the impulse response functions shown. In particular, the direct approach does not allow for any changes in coefficients associated with structural change resulting from the growth in derivatives markets. By contrast, in the indirect method (which involves the construction of a special variable by multiplying derivative market size times the interest rate variable), derivative markets structurally change the coefficient on interest rates, though not on other variables.

B. Results[33]

The model incorporated lags of four quarters for several reasons. It was found that six or more quarters introduced excessive noise in the results, whereas three or fewer quarters did not contain sufficient information to discern anything but a straight line impulse response. The Aaikes lag length estimator found the optimal lag length to be five quarters. However, results demonstrated that the statistically more significant impulse responses using a lag length of four quarters were almost identical in shape to those using five quarters—hence, four quarters was chosen.

The results here will focus on the change in policy transmission to inflation due to derivative usage. The first three graphs depict results from the indirect model, where derivative markets can only impact the economy through changing the coefficients on interest rates. Figure 1 shows the impulse response of inflation following a one-period 100-basis point increase in the nominal interest rate at time 0. The solid lines show the impulse response and bounds in the United Kingdom with derivative markets "toggled" off, and the dashed lines show the impulse response and bounds with derivative markets working. Notice that the 95

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[33]Appendix III contains a summary of the econometric stationarily and unit root properties of the variables.

Figure 1

SVAR Impulse Response of Inflation

Figure 2
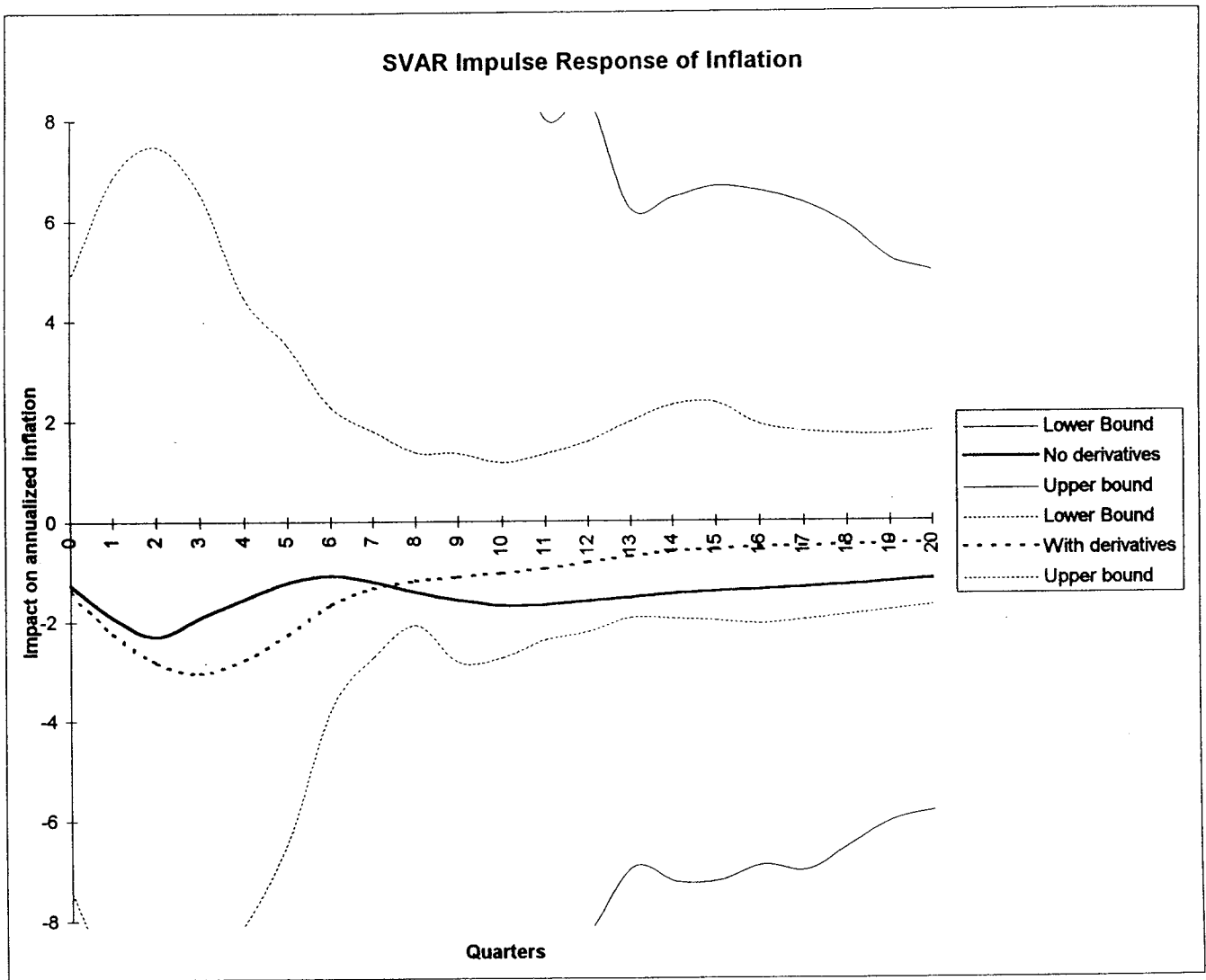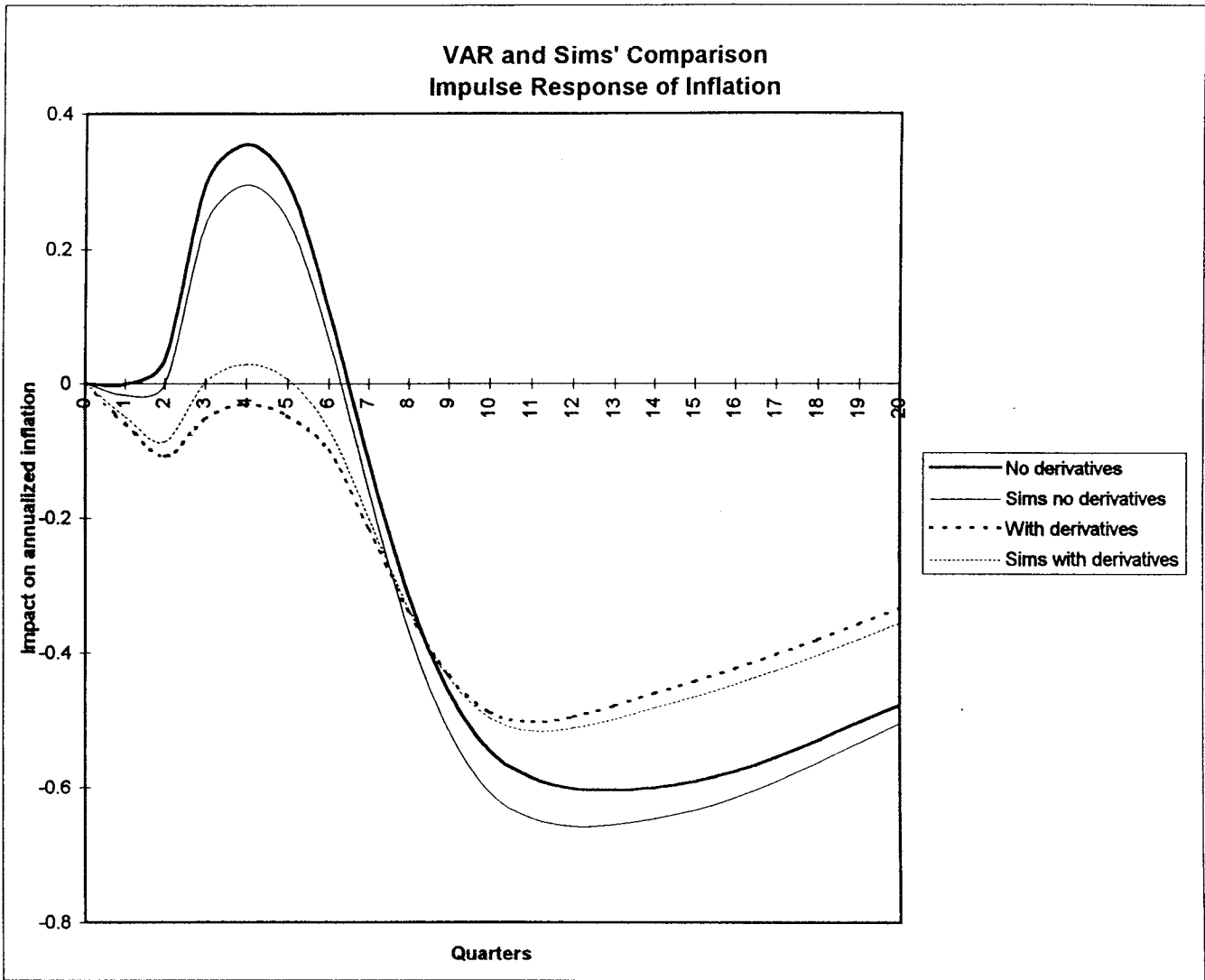

VAR and Sims' Comparison
Impulse Response of Inflation

percent bounds are very wide, particularly in the case without derivatives. This implies that any conclusion based on the wider expected impulse curves are particularly weak. However, based on the expected curves the short-run impulse with derivatives is stronger, both immediately and for the first seven quarters, and the long-run impulse is significantly less.

The reason for the wide confidence bands in the SVAR model is probably due to overidentifying the problem. Note that in Figure 2 the impulse responses of the unrestricted VAR and Sims' methods are very similar Even though the two methods do not give an exact fit, the turning points and general shapes are very close. This suggests that although the VAR method has non-orthogonal shocks, these shocks are almost orthogonal. Further evidence for this observation comes from the close to diagonal estimated variance-covariance matrix.

Weaker results may result by imposing constraints to orthogonalize the errors through either a statistical method such as Sims' or an economic-based method such as a SVAR. Figure 3 shows the impulse responses again and adds the bounds derived from the unrestricted VAR model.

Note that the confidence bands are much tighter than those of the SVAR method and that there is a so-called "price puzzle."[34] Still no statistically conclusive results can be drawn; both the expected impulses fall within the two sets of bounds. The expected impulses alone suggest a stronger response for the first 9 quarters, and a weaker response thereafter. The results from the direct method are even weaker. Figures 4 and 5 demonstrate the impulse response of inflation in the SVAR and the VAR models:

The difference between the United Kingdom with and without derivatives markets, when derivatives are added structurally as an extra explanatory-variable is statistically, non-existent. Whether the estimated residuals are orthogonal or not is almost a moot point, since neither the SVAR model nor the VAR model attribute a difference in impulse response to derivative markets.

In terms of interest rates (Figure 6), we find that all methods show a faster return to equilibrium in an economy with derivatives rather than in the one without. This is consistent with the notion that *financial markets* react more rapidly when derivatives are used.

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[34]The "price puzzle" refers to the initially significant positive response of inflation to a positive interest rate shock. It is typically found in SVAR models that only impose contemporaneous constraints.

Figure 3

Unrestricted VAR
Impulse Response of Inflation

Quarters

Impact on annualized inflation

Upper bound
No derivatives
Lower Bound
Upper bound
With derivatives
Lower Bound

Figure 4

SVAR, Direct Approach
Impulse Response of Inflation

Figure 5

Unrestricted VAR, Direct Approach
Impulse Response of Inflation

Legend:
- Upper bound
- No derivatives
- Lower Bound
- Upper bound
- With derivatives
- Lower Bound

Y-axis: Impact on annualized inflation

X-axis: Quarters
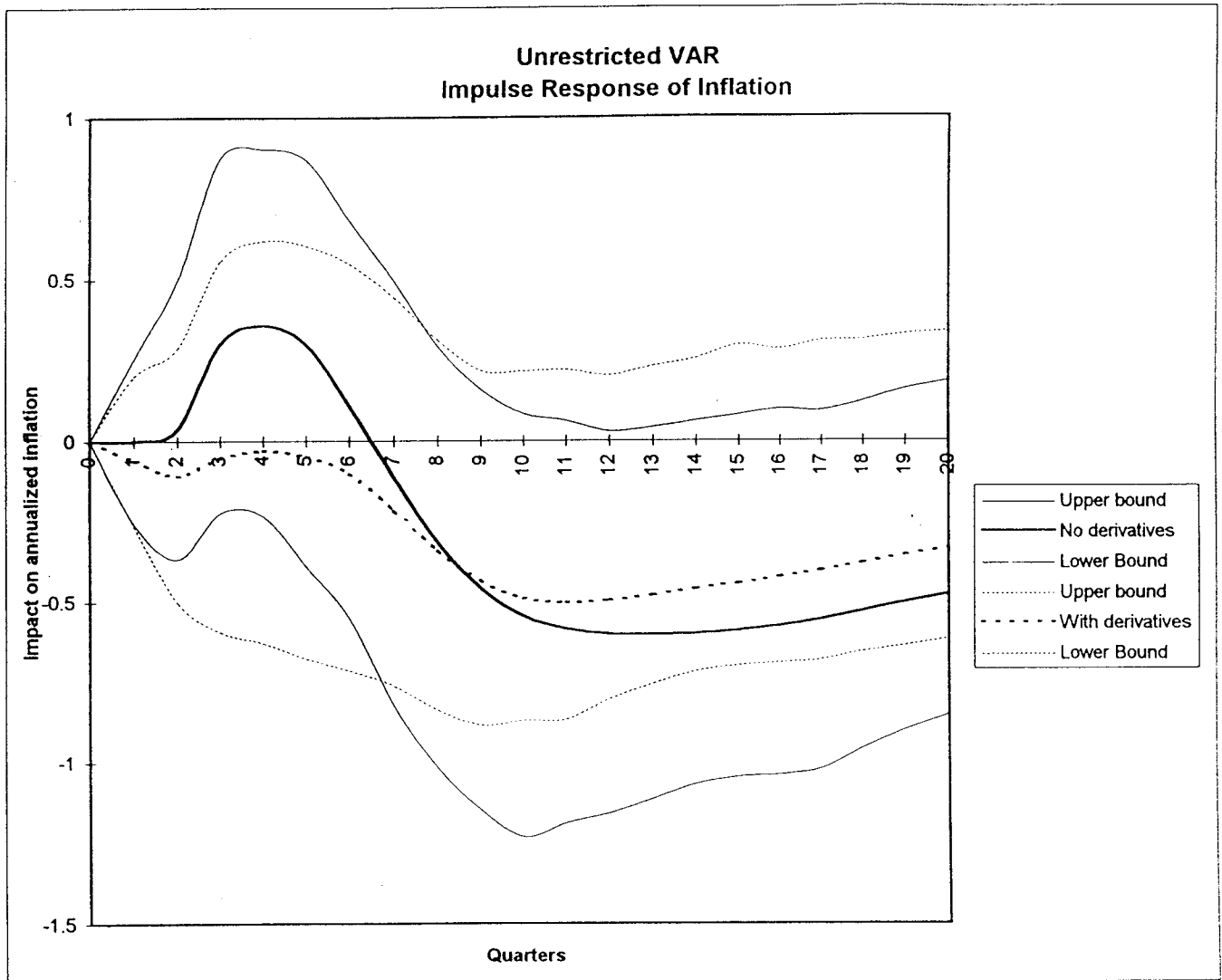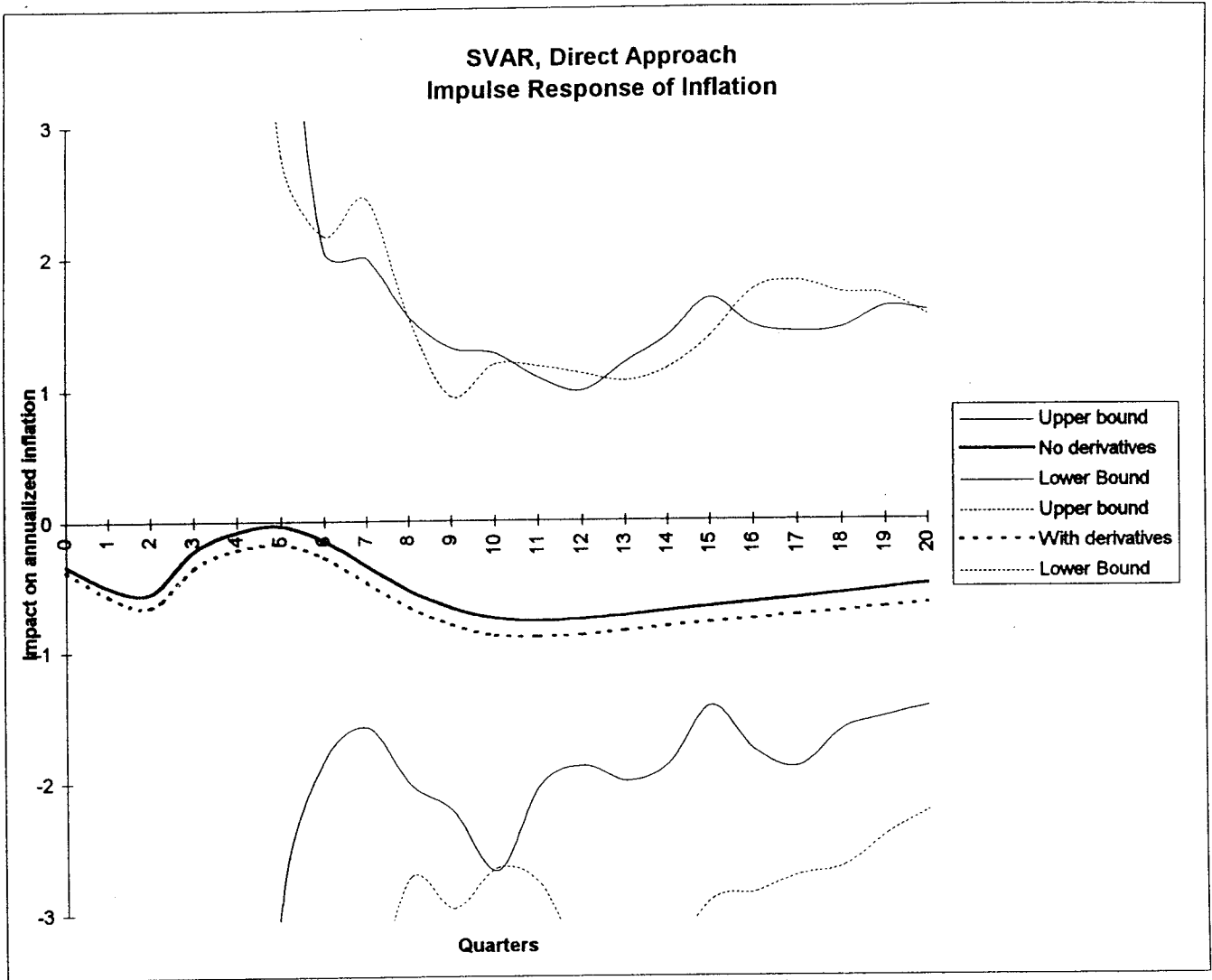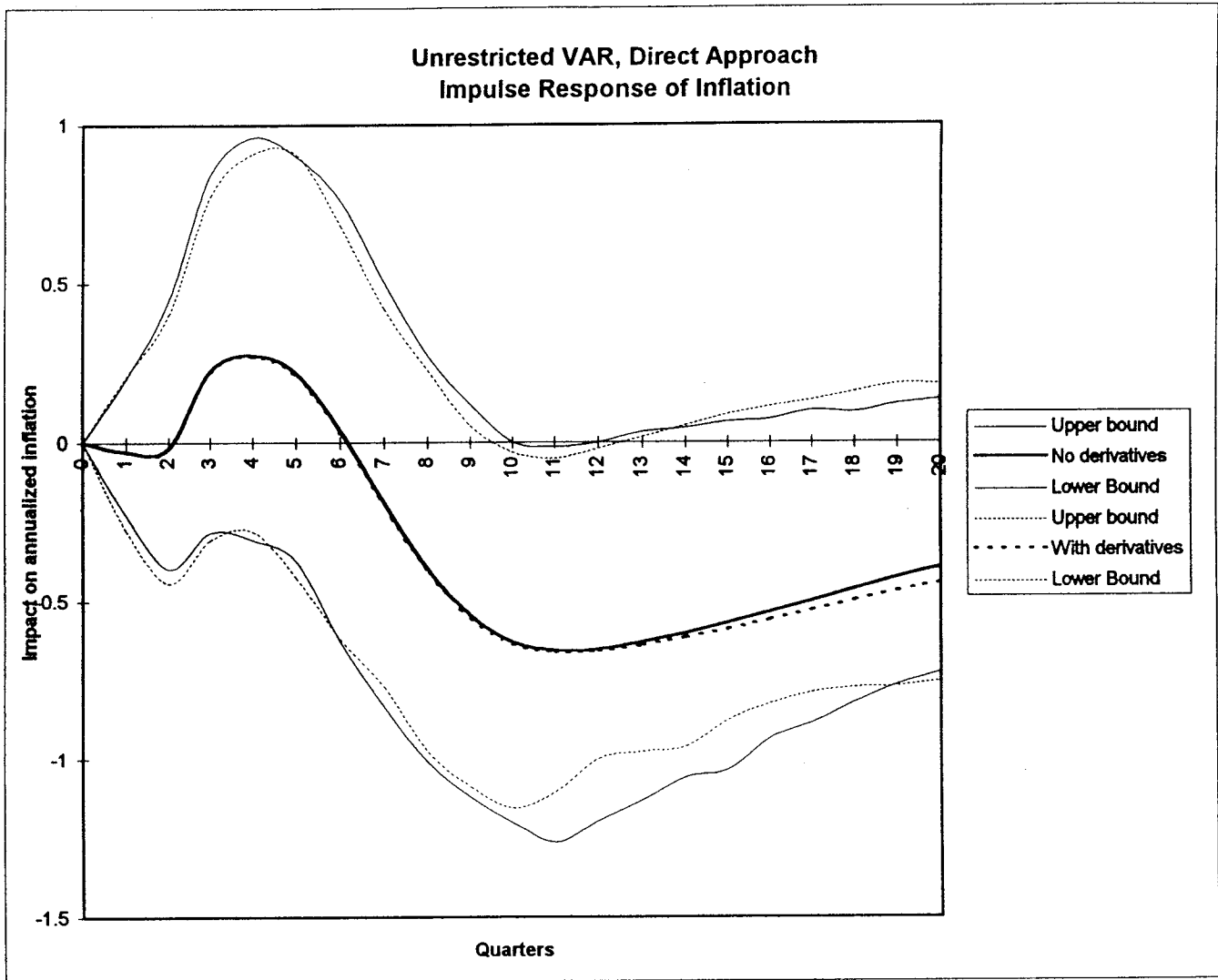
Backing up the notion that unrestricted errors are orthogonal, the SVAR results in the indirect method indicate a positive response for GDP growth, contrary to standard economic intuition (Figure 7). This suggests that imposing these constraints over identifies an already orthogonal system, leading to abnormal results. The results from the unrestricted indirect VAR model suggest that derivatives may cause a weaker and shorter response for GDP growth. Both expected impulse responses, however, fall within the two sets of upper and lower bounds, and hence fail to be statistically different.

Overall, the empirical results do not support the hypothesis that the presence of derivative markets has changed the transmission of policy to the real economy in the United Kingdom, defined by the variables of inflation and growth. In fact, the opposite is true with no impact of derivatives. Note that there is evidence that derivatives have affected transmission through financial markets (interest rates respond faster), yet there appears to be, at most, a marginal impact on real economy variables. This answer, however, should be treated with some skepticism for several reasons. First, the data from LIFFE[35], as shown in Figure 8, show that significant derivative market turnover has only occurred since late 1989. More robust results will be possible with more extended time series. Second, the model used was a closed economy model, and took no account of exchange rates and foreign exchange derivative turnover.

Finally, it is possible that the Bank of England already takes account of derivative market responses, and that the VAR model is simply picking up the new response in its "normal" response function.

Thus the question of derivative market impact on monetary policy transmission is still far from closed. The empirical methodology used in this paper can be easily extended to analyze other countries and to use different SVAR constraints such as imposing long-run neutrality of policy both on output and on inflation. In particular, the United Kingdom may be a special case. Perhaps its relatively liquid, liberal and well-developed financial markets, which enabled the early development of derivative markets there, may also have implied the result that derivatives markets did not make as much difference to monetary policy transmission in the United Kingdom as they would have if introduced in other countries. For instance, derivatives would tend to play a less important role in completing markets in a country where markets were already fairly complete, and a less important role in circumventing regulations (e.g., exchange controls) in a country where regulations were already fairly liberal.

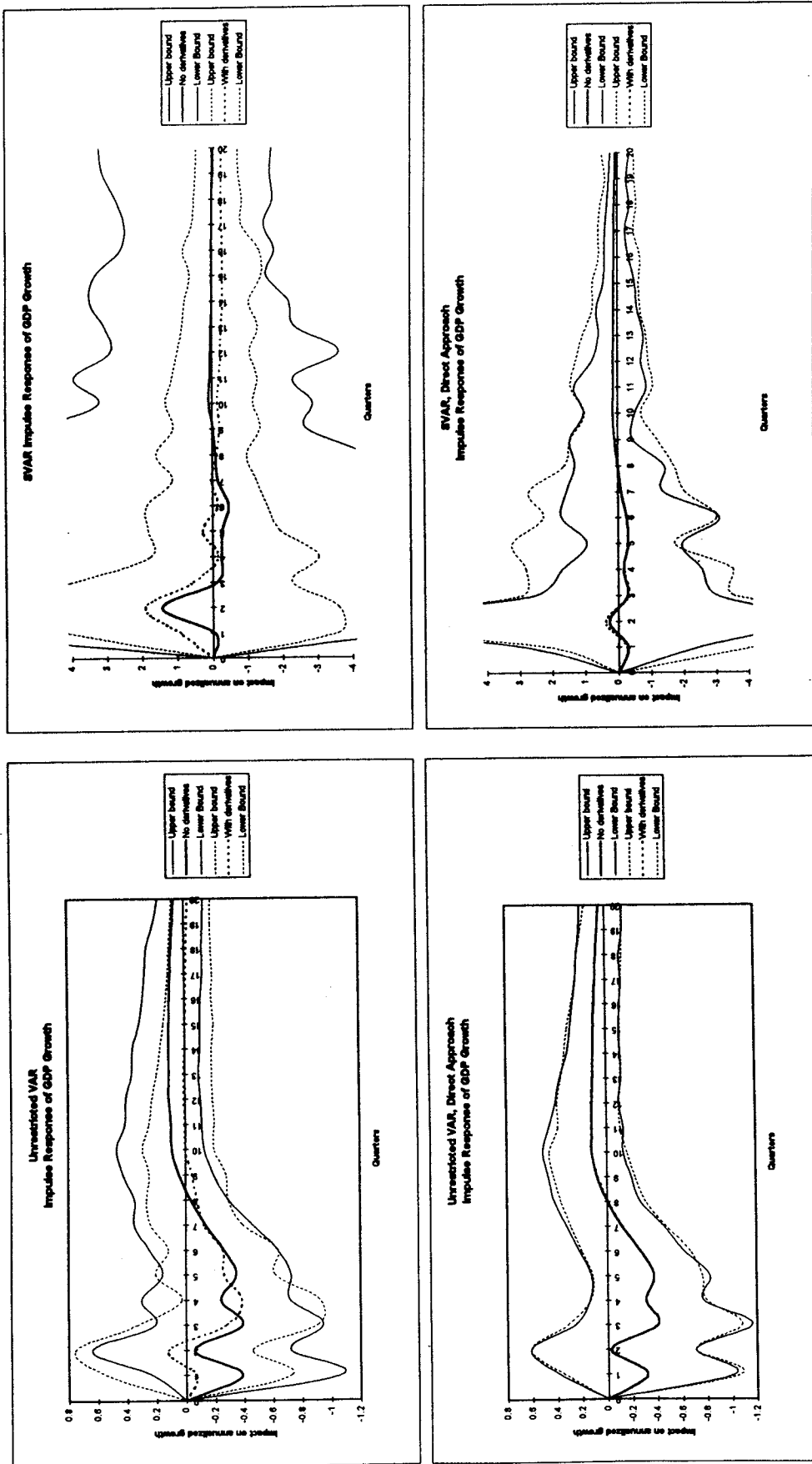[35]"LIFFE" stands for Quarterly Sterling Interest Rate Derivatives Turnover on the London International Financial Futures Exchange (LIFFE).

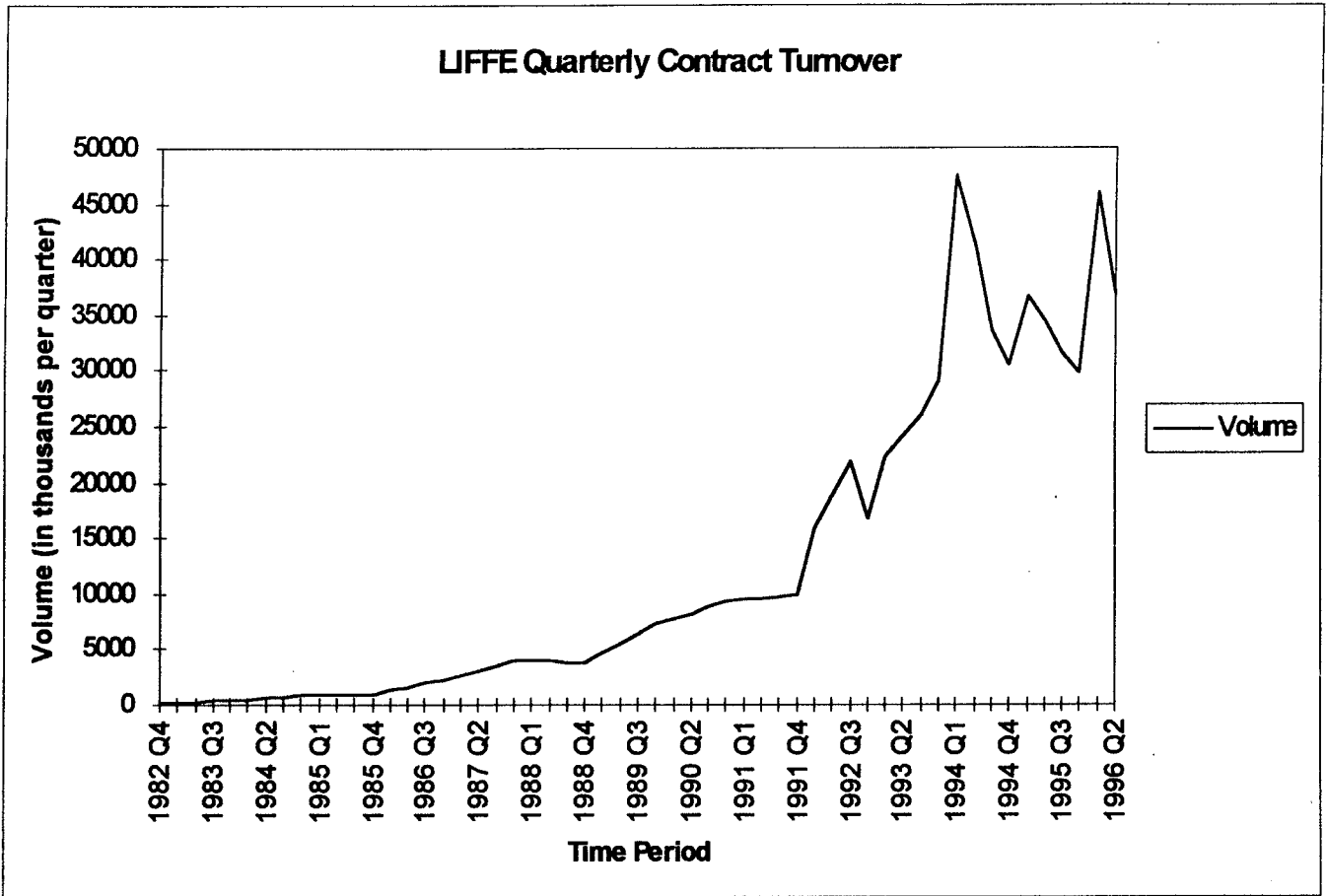Figure 6: Impulse Responses of Interest Rates*
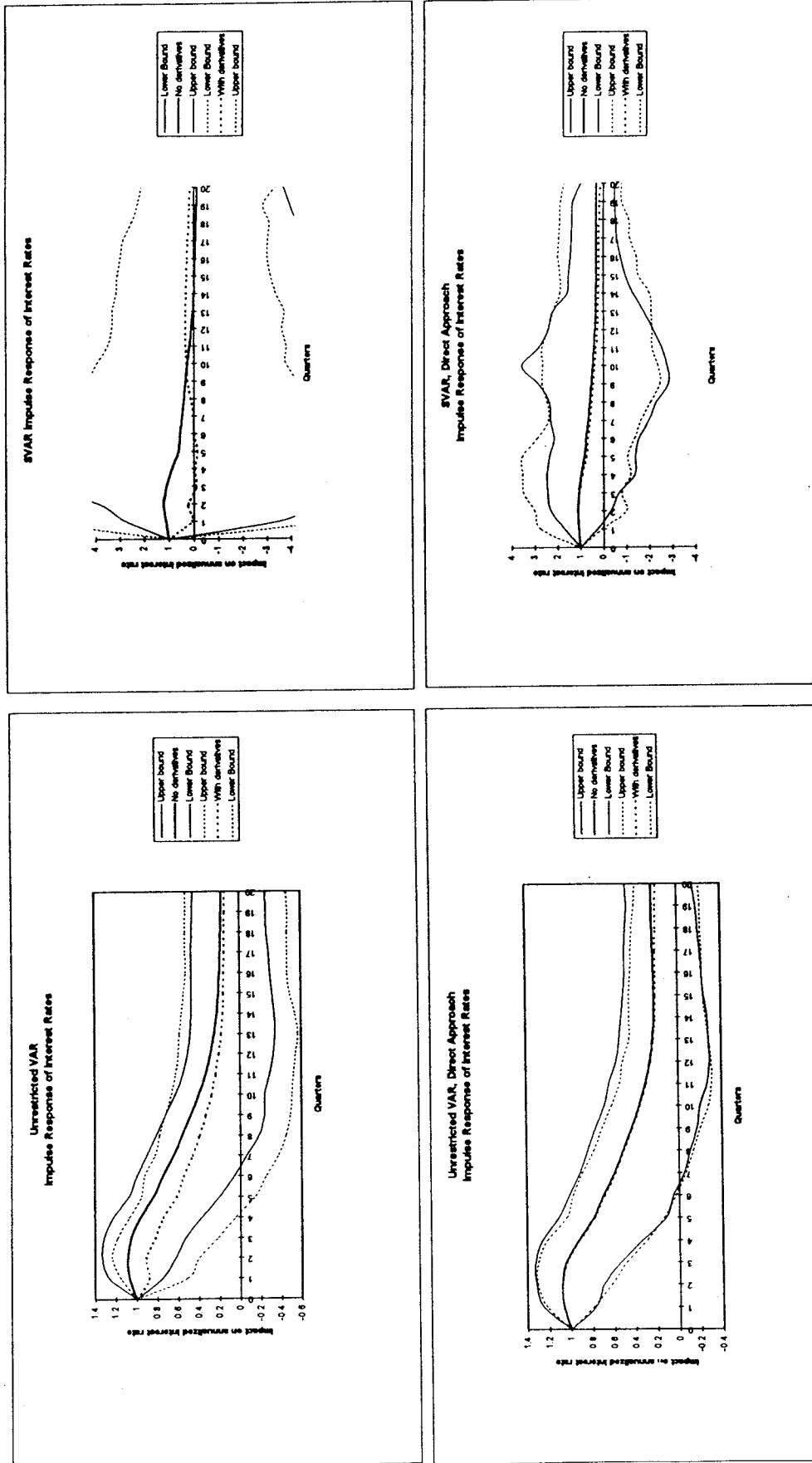
* Scales vary to accomodate differences in upper and lower bounds. Note that the SVAR model has particularly wide confidence bands.

Figure 7: Impulse Responses of GDP Growth*

Figure 8

IV. CONCLUSIONS, POLICY IMPLICATIONS AND LESSONS FOR TECHNICAL ASSISTANCE

This paper demonstrates, both empirically and theoretically, that changes in financial market asset prices will be more rapid following policy actions with derivatives. Furthermore, theoretically there is a weaker response of output, and hence inflation, to policy shocks. However, the empirical section does not support the theoretical assertion that output and inflation response may be weaker and more lagged.

This section summarizes the main policy implications and points for technical assistance of the growing use of derivatives, particularly for developing countries.

Large global size and potential impact

Global derivative market size is beginning to dwarf other financial sectors. As reported by the BIS central bank survey, total outstanding notional principal at the end of March 1995 was $47.5 trillion in OTC markets alone, and at least a further $8 trillion in exchange markets. Under certain assumptions, this paper demonstrates that up to $7.5 trillion of underlying capital in industrial countries may be hedged against exchange rate or interest rate movements through OTC markets alone. This suggests that derivatives may have a significant impact on monetary policy transmission, objectives or feasibility.

Derivatives provide risk transfer tools and increase market completeness

Besides hedging purposes, the benefits of derivative markets include general risk transfer tools, greater market efficiency and lower costs of capital, thus increasing the completeness of capital markets. Key derivatives to develop are domestic commodity futures, derivatives on short-term paper and currency derivatives. These form the basis for hedging price risk. However, developing competing derivative products in already established markets, such as currency forwards that are already offered by international banks, should not be a high priority.

Derivatives only part of global financial innovation

It is difficult to attribute structural changes in economies solely to the emergence of derivative markets. Empirically it is very difficult to isolate effects due to derivatives alone. General financial market liberalization, such as relaxation of capital controls and the globalization of financial markets have occurred simultaneously with the growth of derivatives, and each change is closely intertwined with the other. For example, globalization of markets is, among other things, a result of the increased currency derivative use. A net effect of the increased capital flows is an increase in liquidity and availability of capital on a global level.

Policy effective on overnight rates

One area in which derivatives have not had a substantial effect is the management of overnight liquidity. Although new sources of funding are available, banks require net cash positions at days' end, and substitute synthetic derivatives are not accepted by central banks in settlement. Thus from an operational perspective, there is no change in policy effectiveness via overnight rates. It is true, however, that derivatives contribute by transmitting short-term rate changes rapidly to other asset prices. Derivatives do affect liquidity at the day's end, and so may affect the demand for overnight liquidity as a whole.

Theoretically real economy impulses differ with derivative usage

The Hannoun report and this paper demonstrate changes in the impulse response structure of the main economic indicators, due to derivatives. In particular, traditionally more illiquid financial variables may respond sooner than previously. However, empirical evidence from the United Kingdom suggests any changes to the impulse responses of inflation and output in response to monetary policy shocks are ambiguous. Furthermore, theoretically the impact of policy may be stretched out in time, although again this is not clear from the empirical study of the United Kingdom.

Large-scale derivative usage reduces domestic policy scope.

Derivatives allow zero-risk arbitrage portfolios to be set up, forcing harmonization of the relationship between exchange rates, foreign and domestic interest rates. This in turn reduces the scope for domestic monetary policy, particularly for small countries with a small capital base. Monetary policy inconsistent with domestic fundamentals *or* with foreign interest rates (and/or with the pegged exchange rate) will cause strong capital inflows or outflows. This can severely pressure domestic interest rates and the exchange rate.

Complex OTC derivatives aid circumvention of capital restrictions and macroprudential regulation

Derivatives can often ease the circumvention of capital controls. They also allow positions to be set up that cannot normally be held in cash positions, but that mimic cash payoffs. Furthermore, derivative positions can be held off-shore, whereas capital controls aim at managing on-shore cash positions and flows. Similarly, prudential regulation is often concentrated on-balance sheet activities, with the result that off-balance sheet derivative activities effectively circumvent even the best intentioned regulation (see Garber, 1996).

Regulators need to be able to issue cease and desist orders to prevent specific actions being undertaken by banks and other financial intermediaries in order to avoid circumvention of regulations.

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OVERVIEW OF GLOBAL DERIVATIVE MARKETS

The global derivative market is beginning to dwarf other financial sectors. As reported in May 1996 by the BIS, total outstanding notional principal at the end of March 1995 was $47.5 trillion[36] in OTC markets alone, after adjustments for double counting[37] (in a similar, though less accurate, report from 1992, the BIS estimated OTC notional principal outstanding at $5.3 trillion). Derivative exchange markets had a total outstanding notional principal between $8 trillion, assuming complete double counting, to $16 trillion, assuming no double counting (the 1992 report, assuming no double counting, put exchange markets notional principal outstanding at $4.6 trillion). In the OTC markets, 61 percent of the outstanding notional principal was in interest related derivatives, 37 percent in foreign exchange (FX) related derivatives, and only 1.25 percent and 0.75 percent in equity and commodity derivatives, respectively (see Table 2).

Table 2. Global Notional Principal Outstanding

	$ Trillions	Interest	FX	Equity	Commodity
OTC	47.5	61%	37%	1¼%	¾%
Exchange	8 to 16	96%	1%	3%	1%

However, notional principal measurements can be misleading as an indicator of derivative market importance. It is possible for a derivative to have a notional principal of $1 million, but a value of zero. Gross market value provides a more accurate representation of the economic significance of derivative markets. Gross market value is defined as the sum of the negative and positive market replacement cost, that is, the sum of the costs and gains of replacing all the derivative contracts at a particular point in time. The gross market value of OTC markets was $2.2 trillion on March 31, 1995 (see Table 3). Note however that the gross market value is extremely sensitive to overall market volatility, and can double or triple in a more volatile environment.

Table 3. Global Gross Market Value

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[36]Bank for International Settlements, "Central Bank Survey of Foreign Exchange and Derivatives Market Activity," May 1996.

[37]The central banks surveyed the main OTC dealers—hence each interdealer transaction was counted twice—once by each dealer. The OTC figures that are reported net out the double counting of both local and international interdealer transactions.

Table 3. Global Gross Market Value

	$ trillions	Interest	FX	Equity	Commodity
OTC	2.2	32%	64%	2.5%	1.5%
Exchange	no data	no data	no data	no data	no data

Daily turnover of notional principal in FX and interest rate OTC markets was $880 billion during April 1995, of which 82 percent was in FX derivatives. Turnover for exchange traded FX and interest rate derivatives was $570 billion per day, of which 99 percent was in interest rate derivatives.

For OTC derivatives only, the BIS report splits derivative contracts by counterparty and by counterparty location. Dealers can have contracts with other dealers, financial institutions (mainly investment funds and non-dealer banks), and non-financial customers (mainly corporate firms). Counterparties can be local or foreign. This data thus provides some information on the OTC market structure.

In OTC FX markets, 68 percent of gross market value was attributed to intra-dealer trading, 11 percent to financial institutions and 21 percent to non-financial customers. 33 percent of gross market value was positive intra-dealer trading and 35 percent was negative intra-dealer trading. These should be the same—the discrepancy is attributable to dealers using their own valuation systems and to different dealers being surveyed in different countries, affecting cross-border intra-dealer totals. The 32 percent financial and non-financial, gross market value represents the underlying derivative demand. As dealers attempt to hedge these transactions through other dealers, they increase the total market size approximately threefold.

In OTC interest rate markets, 36 percent of gross market value was represented by positive intra-dealer and 34 percent by negative intra-dealer trading, for a total of 70 percent intra-dealer. 16 percent of gross market value was to financial institutions, and 14 percent to non-financial firms. Thus total underlying derivative demand is 30 percent of gross market value, and dealers increase market size approximately threefold, as with the FX markets.

For the combined OTC FX and interest rate markets, 59 percent of non-dealer gross market value is to non-financial firms, and 41 percent to financial institutions. Combining these values with the assumptions below, there is a substantial usage of derivatives for hedging amounting to a 59 percent market share, as opposed to speculation, accounting for a 41 percent market share:

(i)   dealers are simply market makers, and attempt to remain perfectly
       hedge, that is, they take no speculative positions,

(ii)   non-dealers are all end-users and hold open positions,

(iii) financial institutions use derivatives to take speculative positions, and

(iv)   non-financial firms use derivatives to hedge non-firm specific risk. This
       assumption is backed up by the 1995 report of derivatives usage by U.S.
       non-financial firms.[37]

Of the 41 percent of firms using derivatives, 99 percent were using derivatives primarily
for hedging purposes although 35 percent "sometimes" held speculative open positions (see
Table 4). In a similar survey by Touche Ross of the United Kingdom, non-financial firms in
the FT-SE 100, 10 percent reported using derivatives for speculative purposes.[38] Another
survey by the University of Waterloo of Canada reported that of non-financial firms listed on
the Toronto Stock Exchange, 94 percent used derivatives for hedging purposes.[39]

Table 4. Firm Level Derivative Usage

	Respondents	Use Derivatives	If Use, Used for Hedging
		(In percent)	(In percent)
The United States	149	41	99
The United Kingdom	30	85	90
Canada	243	55	94

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[37]1995 Survey of Derivatives Usage by U.S. Non-Financial Firms, Bodnar and Marston,
Wharton School, University of Pennsylvania.

[38]Survey of the Corporate Use of Derivatives, Touche Ross, January 1995.

[39]1995 University of Waterloo Survey of Canadian Derivatives Use and Hedging Activities.

A final observation concerns the concentration of the OTC market. The intra-dealer market, accounting for 69 percent of the total gross market value in OTC markets, is highly concentrated in only a handful of banks. In each country surveyed, an average of 90 market makers took part and reported derivative market information. However, 75 percent of the notional turnover of each domestic market is covered by an average of only 10 market makers, indicating the large degree of concentration of the market in just a handful of main players. Furthermore, some dealers fall in the top 10 dealers in several countries, indicating some degree of global concentration.

Advantages of derivatives usage
Large scale derivative usage results in greater market efficiency. These benefits derive from the following three financial characteristics of derivative instruments:

- *Hedging*. A derivative contract transfers a specific risk of the underlying security from the buying agent to the selling agent, essentially allowing risk transfer from more risk averse agents to less risk averse agents. Risk unbundling has three main economic implications:

  a.   Allows smoothing of income due to fluctuations in interest, currency and asset prices.

  b.   Allows domestic agents to concentrate on their strengths since non-core risks such as interest rate and currency risk are priced away.

  c.   Increases capital inflows since foreign agents can price away currency risk.

- *High Leverage*. The high leverage afforded by derivatives increases the volume of transactions and decreases the costs of capital, improving market efficiency. Low margin requirements and low premiums provide high leverage. Using derivatives, agents may be leveraged between 5 to 20 times their capital.[40]

- *Substitutability of assets*. Derivatives make arbitrage between two different assets, or two similar assets denominated in different currencies, much easier. The extra trading caused by arbitrage transactions increases liquidity and improves market efficiency.

Extensive derivative usage also produces greater efficiency in *capital markets* through the improved price discovery process that results. The increase in liquidity through leverage,

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[40]In fact, George Soros of the Quantum Fund noted in his recent book, *Soros on Soros*, that he uses derivative based leverage of up to 50 times the underlying capital.

dynamic hedging transactions and the larger capital flows produces faster and more accurate price discovery. In addition, the substitutability of assets results in the arbitraging away of price discrepancies between different assets, which leads to more accurate prices in otherwise illiquid markets.

The *costs of capital decrease* through the increase in capital market efficiency and its associated reduction in the prices of capital. Larger capital inflows raise the level of capital supply again reducing the prices of capital. Finally, certain types of derivatives, such as swaps, allow two or more agents to enjoy gains from trade through comparative advantages in obtaining either fixed or floating rates of interest on loans. By banding together, both pay less interest than independently. Typical gains represents a 25-basis point reduction in interest rates.

In terms of the *impact on the real economy*, the more preferable risk distribution through hedging combined with the lower cost of capital allows agents to better concentrate on their specific strengths, resulting in larger sustainable growth rates. For example, hedging using derivatives allows producers to focus on physical capital investment and output, while at the same time having less concern about interest rate, currency, and even commodity price fluctuations.

Dangers of derivative use

Derivatives are not all gains though. In terms of cash flows, they are a zero-sum game. For each agent's gain, an identical and offsetting loss occurs for the counter party. The greatest positive aspect that derivatives provide, in a welfare sense, is the ability to precisely target the risk that is redistributed. This risk redistribution through derivatives, however, *may* possibly cause adverse effects in capital markets.

- *Amplified price movements.* Dynamic hedging (see glossary) amplifies price movements. As the underlying price falls, the dynamic hedger sells the underlying, amplifying the price drop.[41] In times of stress dynamic hedging increases illiquidity in both the underlying and derivative markets, a situation which may lead to a complete financial market collapse.[42]

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[41]Some unpublished research has begun investigating the possibility of making dynamic hedging "stabilizing." The scenario would entail that policy makers create a net "long" option position for market participants as a whole, thus letting the market participants automatically stabilize excess volatility.

[42]There are arguments to support this theory with respect to the October 1987 stock market collapse.

- *Systemic risk.* Margin calls, actual realized losses and debtors' defaults may
  cause bankruptcy in an inadequately collateralized dealer. Due to the high
  leverage of derivative instruments, sudden large losses can appear rapidly,
  particularly during times of stress in the underlying markets. Noting that
  69 percent of the OTC market is intra-dealer, the collapse of just one dealer
  can affect other dealers. The collapse of multiple OTC dealers would have
  extremely grave repercussions on the financial marketplace as a whole.

- *Adverse global capital movements.* Just as quickly as foreign capital can safely
  enter the country through FX derivatives, poor policy choices can result in a
  rapid withdrawal of capital, even if the policy changes are in a geographically
  proximate or similar country (as was the case for the Argentinean capital
  markets after the Mexican peso crisis). The loss of financial market credibility
  may take a long time to recover.[43] However, there is some recent evidence, for
  example Bekaert and Harvey (1996) and Richards (1996), to suggest that
  overall market volatility drops following liberalization of capital markets.
  Successful development of derivative markets by definition involves a large
  degree of integration with global capital markets. Hence this point might be
  mute.

The fundamental cause of systemic risk is the dealer's desire and need to perfectly hedge
market exposure. Dealers hedge by taking an exact opposite position, often via another dealer,
or by dynamically hedging (see glossary) in the underlying market. Both hedging techniques
expose the dealer to risk during times of stress. Dynamic hedging is only necessary when an
opposite position cannot be found. Since dynamic hedging requires daily trading in the
underlying market, liquidity in the market for the underlying asset is crucial. If the underlying
market becomes illiquid, for example, due to one way price movements, dynamic hedging is
not possible and dealers are exposed to the complete market risk of their unhedged positions.
The losses incurred due to this may cause failure.[44] The preferable technique to dynamic
hedging is to hedge through an exact opposite position with other dealers. Large interdealer
dependencies are created, and during times of stress credit risk between dealers may be high.
The failure of any single dealer, either through losses incurred by an inability to dynamically
hedge, or, by insufficient funds to cover margin calls to other dealers (and exchanges), can
hence cause a system wide collapse, as dealer after dealer fails to meet its obligations.

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[43]The capital flight comes from both domestic and foreign agents. Given the information
asymmetry in developing countries, and assuming no capital controls, domestic agents tend to
withdraw and return capital sooner around a financial crisis (see IMF August 1995).
[44]Although not due to an inability to dynamically hedge, the Barings failure highlighted the
impact of a large market risk exposure.

SVAR EMPIRICAL METHODOLOGY

To formalize the discussion for the indirect approach, let $x_t=\{\Delta\ln(y_t), \Delta\ln(p_t), r_t, rd_t\}$ be defined as the vector of variables at time t. The vector of orthogonal shocks $\epsilon_t=\{\epsilon_{yt}, \epsilon_{pt}, \epsilon_{rt}, \epsilon_{rdt}\}$ has a normalized variance-covariance matrix given by the identity matrix. A supply shock, such as an increase in productivity, is represented by ϵ_{yt}; a demand shock, such as a shift in consumption preferences, by ϵ_{pt}; a monetary policy shock by ϵ_{rt}; and a combination of a monetary policy and derivative market shock by ϵ_{rdt}. With this notation, the underlying moving average (MA) representation of the model is given by:

$$x_t=A(L)\epsilon_t \qquad (1)$$

where $A(L)$ is the coefficient matrix operated on by the lag operator L. To obtain impulse responses to the vector of shocks ϵ_t, $A(L)$ needs to be estimated.

Unfortunately, it is not feasible to directly estimate the moving average representation. What can be feasibly estimated is the VAR representation of the model given by:

$$D(L)x_t=v_t \qquad (2)$$

where v_t are the residuals and $D(L)$ is the estimated coefficient matrix operated on by the lag operator. The VAR representation in (2) can be inverted to yield the unrestricted moving average representation:

$$x_t=C(L)v_t \qquad (3)$$

Note that the estimated residuals v_t are not orthogonal. Since the estimated VAR representation in (2) has $D(0) = I$, then by definition, $C(0)$ is also equal to the identity matrix. Combining the latter with (1) and (3) gives the relation between the unobserved orthogonal shocks ϵ_t and the observed residual shocks v_t

$$v_t=A(0)\epsilon_t \qquad (4)$$

The relation between the estimated MA coefficients and the unobserved MA coefficients is determined by (1), (3) and (4):

$$A(L)=C(L)A(0) \tag{5}$$

Thus to compute the impulse responses to ϵ_t, $A(0)$ needs to be obtained. First note that the estimated residual variance-covariance matrix is given by

$$v_t v_t' = \Omega \tag{6}$$

From (4) and (6)

$$\Omega = A(0)\epsilon_t \epsilon_t' A(0)' \tag{7}$$

and by assumption $\epsilon_t \epsilon_t' = I$. Hence

$$\Omega = A(0)A(0)' \tag{8}$$

In this 4 variable model, Ω contains 10 unique elements, so 6 additional restrictions are required to obtain an estimate for $A(0)$.

Three different methods were used to identify the impulse response functions of output, inflation, and interest rates to a temporary nominal interest rate shock. The first method uses the estimated vector autoregression (VAR) method that has existed since ordinary least squares was invented. The second, more sophisticated method, follows Sims' seminal 1980 method on VARs, and the third follows the recent SVAR methodology as developed by Blanchard and Quah (1989).

The problem with using impulse responses derived directly from (3) is that shocks to v_t are not necessarily representative of a shock to a single element of ϵ_t. From (4) it is clear that a single element shock to v_t represents a linear combination of shocks to ϵ_t given by $A(0)$. Thus the impulse response to a shock in v_t represents the response to a set of orthogonal shocks, and the impact of a specific shock, such as a monetary policy shock, cannot be identified.

Sims proposed a methodology to overcome this problem, by estimating $A(0)$ as the unique lower triangular Cholesky decomposition of Ω. Effectively, the 6 additional restrictions are setting the above diagonal elements equal to zero, that is, by effectively imposing contemporaneous restrictions on the impact that shocks can have. This method is often termed "theoretical" since no use is made of economic theory in exactly identifying $A(0)$. The results are particularly sensitive to the ordering of the variables. A shock to the first variable in the

vector x is contemporaneously transferred to all other variables, yet a shock to the last variable only contemporaneously affects the last variable. In the model used in this paper, the variables are ordered as output growth, inflation, interest rates, and derivative markets. Proponents of this method assert that if impulse responses are insensitive to different orderings of the variables, then the results have a meaningful economic interpretation.

The SVAR methodology imposes six economic-based constraints on $A(0)$, and combined with the 10 unique elements of Ω, this exactly identifies $A(0)$. Economic constraints fall in two categories: contemporaneous constraints and long run constraints. A contemporaneous "no immediate impact of a shock to variable j on variable i" constraint is imposed by directly setting $A_{ij}(0)$ to zero. A long term constraint is imposed by applying linear constraints on several elements of $A(0)$. For example, a "no long term impact of a shock to variable j on variable i" constraint implies that $\Sigma A_{ij}(L) = 0$. The linear constraint imposed on $A(0)$ is derived from (5) : note that $\Sigma A_{ij}(L) = 0 = \Sigma [C_{i.}(L)A_{.j}(0)]$. A complex non-linear set of equations can then be solved to obtain an estimate for $A(0)$.[45]

In this four variable model indirect approach, a monetary policy shock is represented by a change in ϵ_r. If derivative markets exist, this shock is transmitted to both r_t and rd_t. If derivative markets do not exist, this shock is only transmitted to r_t.[46] In the direct approach,

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[45]This paper used a new method to arrive at the estimate for $A(0)$. After the imposition of constraints on $A(0)$, the 10 free elements where estimated using a non-linear optimization technique. The objective function minimized was sum of the elements of $(A(0)A(0)' - W).*(A(0)A(0)' - W)$, where $.*$ is the element by element multiplication operator. Constraints that are not consistent with (8) yield a positive optimal objective function value. For example, $A(0)_{12}=A(0)_{13}=A(0)_{14}=A(0)_{21}=0$ is inconsistent with $W_{12} \neq 0$.

[46]To demonstrate this, consider the following simple AR(1) representation of derivative market size and interest rates:

$$r_t = ar_{t-1} + e_{rt}$$

$$d_t = bd_{t-1} + e_{dt}$$

$$rd_t = abrd_{t-1} + ar_{t-1}e_{dt} + bd_{t-1}e_{rt} + e_{rt}e_{dt}$$

If derivative markets do not exist, $d_t = 0$ and only r_t is affected by a shock to e_{rt}. If derivative markets similar in size to those during the period 1994-96 do exist, then $d_t = 1$. Hence both r_t and rd_t are affected by the shock, except that rd_t is only affected by be_{rt}. However, estimates place b close to 1, so for convenience both r_t and rd_t are shocked by equal amounts. Note that technically speaking this is not a perfectly accurate method, since assumptions on the error distribution are violated. However we assert that the difference between the exact method and this will be very little.

(continued...)

the derivative variable is either added or not during the impulse analysis.[47] Both methods of assessing the impact of derivative markets on monetary policy is preferable to the sample splitting often used to compare regime switches. The differences in results across samples is attributable to *all structural changes* that occurred between the samples. However, this model takes explicit account of the size of derivative markets at all points in time, and hence differences in policy transmission with and without derivative are attributable to at most the sum of the growth of derivative markets and *all co-integrated structural changes* with the growth of derivative markets. For the United Kingdom these may include financial globalization, the conservative stewardship of the country and other such variables. But they probably exclude the "big bang," exogenous price shocks, free access to the European market and other such non-cointegrated shocks.

Finally, 95 percent confidence intervals for the estimated MA coefficient matrix $A(L)$ were computed using a bootstrap technique. This assumes that the estimated residuals v_t are representatively drawn from the true multivariate restricted residual distribution. Using the estimated coefficients from the original data and using the first four observations of data, random residuals are drawn, with replacement, from the original estimated residuals to create a new data set. A new set of coefficients for $A(L)$ is estimated from the constructed data set. The process is repeated 1000 times, and 95 percent bounds for each $A_{ij}(L)$ are observed.

(...continued)

[47] Initially the regression is run with all 4 variables. During the impulse analysis, if derivative markets do not exist, (i.e., $d_i = 0$, all appropriate coefficients are set to zero, and the variance/co-variance matrix elements that include derivative markets are set to 0). Thus the impulse response graphs demonstrate the addition of the derivative market variable, all other variables and coefficients remaining constant.

DATA USED FOR THE STRUCTURAL VECTOR AUTOREGRESSION

Real income is measured by real gross domestic product in 1990 prices. Price changes are measured by consumer price inflation, and short term nominal interest rates are measured by the interbank overnight interest rates. Quarterly GDP, prices and interest rates are all from the International Financial Statistics published by the IMF and are obtained from 1973 Q1 to 1996 Q1. The proxy for derivative market size is given by the quarterly amount of contract turnover as published by the London International Financial Futures Exchange.

In order to use long-run restrictions in the SVAR methodology, the (difference) data must be stationary and contain no unit roots so that shocks have long-run effects on (integrated) variable levels.

Table 5. Augmented Dickey-Fuller Tests With Five Lags

	No Time Trend[1]	Time Trend[2]
GDP	0.49	-3.09
Δ GDP	-2.72 *	NA
Δ lnGDP (GDP growth)	-3.07 **	NA
Price	-0.83	-2.72
Inflation	-1.88	-3.89 **
Nominal Interest	-2.23	-1.88
Real Interest	-1.13	-1.34
Derivative times Interest	0.00	-2.30

[1]Critical values without time trend at 1%, 5% and 10% are: -2.58, -2.91, -3.43.

[2]Critical values with the time trend at 1%, 5% and 10% are: -3.15, -3.46, -4.01.

These results indicate the hypothesis of a unit root can be rejected at the 95 percent level for GDP growth and inflation (with time trend), although it cannot be rejected for price level and GDP. This suggests that output and prices are integrated of order (1). Hence long-run restrictions on output level and price level are possible, since shocks have long-run effects on levels and non-long-run effects on the stationary differences.

Nominal interest rates and derivative times interest may have unit roots. However, other studies such as Gerlach and Smets (1995), find stationarily for 3-month interest rates. Furthermore, the power of unit root tests is in generally not strong. Therefore, this paper asserts that nominal interest rates and derivative times interest are also stationary.