Remarks on Economic, Supervisory, and Regulatory Issues Facing Foreign Banks Operating in the United States

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The following remarks were given by Mr. McDonough before the Comptroller of the Currency Conference on "Foreign Banks in the United States: Economic, Supervisory, and Regulatory Issues" in Washington, D.C., on July 13, 1995.

I am delighted to be here today to address this important conference on economic, supervisory, and regulatory issues facing foreign banks operating in the United States. I also very much appreciate the efforts of my colleague Gene Ludwig and his staff at the Office of the Comptroller of the Currency in organizing these sessions. Foreign banks contribute importantly to the depth and breadth of financial markets throughout the United States, enhancing the sophistication and flexibility of our markets. It is a special pleasure for me to be here because so many of your institutions are located in the Second District and have close working relationships with us at the Federal Reserve Bank of New York.

What I would like to do in my remarks to you this morning is to stand back and take a look at the environment for foreign banks in the United States and comment on some recent developments. I will also touch on some of the challenges facing the banking industry.

I am very aware that the prospects for banks are linked closely to the overall economic performance of the United States. As has been widely reported, the near-term outlook for the U.S. economy is uncertain. Particularly in this environment, it is essential that the Federal Reserve pursue a disciplined monetary policy, one aimed at fostering a sustained, noninflationary growth environment in which the economy continues to shift from a higher to a lower inflation climate. Only with price stability can productivity, real income, and living standards achieve their highest possible levels and thereby enable both households and businesses to function as efficiently as possible. The key, of course, is to instill a sense of confidence that inflation is trending lower in the long term. It is the path that in the long run creates the most hospitable environment for businesses to grow and households to thrive.

Fostering such an environment remains the number one job of the Federal Reserve and is a key element in maintaining the status of the United States as an attractive market for domestic and foreign banks alike. Another very important element contributing to an attractive climate for banks in the United States—and especially for foreign banks—is this country's longstanding policy of providing national treatment to foreign banks operating in the U.S. markets.

What does national treatment do? Most fundamentally, national treatment accords foreign banking institutions the same rights and privileges as domestic institutions in participating in our markets for financial services. In practice, national treatment seeks to create a level playing field for foreign and domestic banking institutions by giving them substantially equal access to benefit from participating in our economy and by subjecting them to substantially similar regulations and supervisory oversight. The national treatment policy followed by the United States is premised on the belief that open and competitive markets strengthen all market participants and thereby provide both cost and quality benefits to the banking institutions themselves and their customers. Our nation feels strongly that this is the right way to achieve fairness in the financial marketplace for all competitors, and U.S. political leaders recently have raised the issue of reciprocity in the policy of national treatment by others.

Only with price stability can productivity, real income, and living standards achieve their highest possible levels and thereby enable both households and businesses to function as efficiently as possible.

The principle of national treatment in banking was reflected in bilateral treaties and later in major banking legislation enacted in the United States. It was, for example, embodied in the Foreign Bank Supervision Enhancement Act of 1991, which was enacted to align supervision and regulation of foreign banks in the United States with that applied to U.S. institutions. The strengthening of supervision and regulation of foreign banks in 1991 went hand in hand with comparable changes in legislation affecting U.S. institutions. These changes were reflected in the Federal Deposit Insurance Corporation Improvement Act of 1991, as well as in the earlier Financial Institutions Reform, Recovery and Enforcement Act of 1989.

Under the terms of the Foreign Bank Supervision Enhancement Act of 1991, before a foreign bank can establish a branch or agency in the United States, the Federal Reserve Board must determine that the foreign bank is subject to comprehensive consolidated supervision by its home country supervisor. While I recognize that it is not yet the norm worldwide, I am firmly convinced that comprehensive consolidated supervision is in the best interest of all banks if the integrity of our financial markets is to be preserved. Maverick institutions must be precluded from avoiding accountability to an appropriate supervisory authority. The approval by the Basle Committee on Banking Supervision in 1992 of a statement on minimum standards endorsing comprehensive consolidated supervision of banks worldwide provides an impetus for national regulators to move supervisory regimes in this direction.

A recent legislative effort to improve the climate for the banking industry in the United States is the Interstate Banking and Branching Efficiency Act of 1994. This Act substantially removes a number of barriers to full interstate branch banking for foreign as well as domestic banks. Interstate branching will enhance the ability of banks to diversify their balance sheets and thereby lessen credit risk stemming from lending concentrations.

Under the Act, bank holding companies, including foreign banks, will be able to acquire banks in another state beginning one year after passage of the Act, that is, by the end of September 1995. In addition, the Act allows branching by merger across state lines beginning June 1, 1997, provided that a state does not enact legislation prior

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to this date to "opt out" of such branching arrangements. There are also provisions allowing states to "opt in," that is, permit entry by merger or de novo branching before June 1997. I applaud the demise of the outmoded restrictions on banks' ability to do business across state lines and believe it makes sense for all banks and their customers.

Another legislative initiative currently under discussion in the House of Representatives is the repeal of the Glass-Steagall Act. As proposed in the Financial Services Competitiveness Act of 1995, the repeal would, among other things, enable both foreign and domestic banks to expand their securities underwriting and dealing activities through separately capitalized securities affiliates within a "financial services holding company" structure. I not only support the goals of this legislation but also feel its passage is overdue.

Complementing these legislative initiatives are efforts by federal bank supervisors to improve the supervisory environment for foreign banks. These efforts are being directed to streamlining the supervisory process through the implementation of the "Enhanced Framework for Supervising the U.S. Operations of Foreign Banking Organizations," more commonly referred to as the FBO program.

This program, which is now being put into effect, reflects a shift in emphasis in the supervision of foreign bank activities in the United States. Previously, the branches and agencies of foreign banks were reviewed more as stand-alone entities. Now, a more comprehensive approach emphasizes the role of these entities as integral components of the foreign banks as a whole. I am aware of concerns that this approach seems, to some observers, to extend U.S. bank supervision outside of our country. In reality, it does no such thing. Rather, it is an effort to place the U.S. operations of foreign banks in an appropriate context, using a systematic and consistent framework.

Consistent with this approach will be a series of initiatives, including a new examination rating system for U.S. branches and agencies of foreign banks, that several of you may already have seen. Overall, the program focuses more heavily than has been the case in the past on risk management and internal control systems with respect to both lending and capital market activities, similar to what we've been doing increasingly in our examinations of U.S. banking organizations.

In addition to providing U.S. bank supervisors with a more logical approach to the supervision of foreign bank activities, the new program should yield considerable benefits to foreign banks. Most notably, foreign banks should, over time, see a significant reduction in the burden and duplication of supervisory efforts, as well as an improvement in examination efficiency and focus.

Another positive development aimed at enhancing the attractiveness of the United States to foreign banks is the Federal Reserve's program, initiated in March 1993, to streamline the procedures foreign banks must follow when making application to establish a presence in the United States under the Foreign Bank Supervision Enhancement Act of 1991. Under these procedures, the processing of applications has been expedited and the burden on applicants reduced. Some of the key measures adopted, for example, facilitate the process of checking on the backgrounds of shareholders and key personnel, conducting concurrent reviews of applications by staff in Washington and at the Reserve Banks, and jointly identifying deficiencies in the application and promptly communicating these to the foreign bank. I'm well aware that there still is room for further improvement in reducing bottlenecks that have delayed applications. I can assure you that we are committed to continued progress and are working on achieving further efficiencies in an area that has been difficult for all of us.

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Finally, I think it is worthwhile to note that the banking climate in the United States has benefited greatly from extensive communications between the supervisory and legislative authorities. The Federal Reserve attaches great importance to working closely with other bank supervisors and legislators to craft policies and laws that we believe will foster competition and increase flexibility in the provision of financial services. At the same time, we are intent on preserving our unyielding commitment to the safety and soundness of the banking system. Continued cooperation in pursuit of these common goals should help ensure that the United States remains an attractive banking environment for foreign and domestic banks well into the twenty-first century.

There can be no doubt that the better an individual institution's risk management system is, the more efficiently it can deploy its capital.

While there is much cause for satisfaction with many of the measures already put in place, the future is not without considerable challenge. One of the most important challenges banks and supervisors face is to guard against a significant weakening in credit standards. In the aftermath of the 1990-91 stringency in credit, it was not surprising—and even desirable—to see some easing in credit standards. Of late, however, it appears that increased competition among lenders for middle-market and large corporate business has produced a narrowing of margins and additional relaxation in lending terms. Because experience has shown that easing of standards can be and often is overdone, it is incumbent on lenders and supervisors to ensure that future credit quality problems are avoided.

A second challenge banks and supervisors face is to continue their efforts to encourage the development of sound risk management practices in this period of rapid financial innovation. There can be no doubt that the better an individual institution's risk management system is, the more efficiently it can deploy its capital.

We at the Federal Reserve Bank of New York have long encouraged innovation in financial instruments and financial markets. Innovation increases competition, improves market efficiency, and expands the variety of products that can better serve customer needs. But with innovation come increased responsibility and the need for each financial institution, regardless of size, to engage in prudent risk management practices to ensure that its activities remain consistent with its constantly evolving risk profile.

Based on our experience, we believe that a successful risk management system should satisfy—at the least—four basic principles:

- First, it should be subject to active oversight by the board of directors and senior management of the financial institution.
- Second, it should embody well-conceived risk identification measurement and reporting systems.
- Third, it should include comprehensive internal controls emphasizing the clear separation of duties.
- And, fourth, it should incorporate a well-defined structure of limits on risk taking.

A review of some recent, well-publicized problem cases clearly indicates that in each case there was a significant failure in the design or implementation of one or more of these basic principles.

I am pleased to note, however, that there seems to be a consensus building in support of these basic principles among a large group of internationally active banks, securities firms, end users, and their various supervisors. Last year, both the Basle Committee on Banking Supervision and the International Organization of Securities Commissions (IOSCO) issued papers addressing the need for sound practices regarding the risk management of derivatives activities. In March 1995, a private sector group representing the six largest securities firms in the United States issued a paper indicating their voluntary adherence to similar practices. In addition, the Group of Thirty has put forth two surveys and sets of recommendations on this issue. And, from the supervisory side, examiner guidance manuals on this subject have also been issued by the federal banking regulators. But support for these principles, however gratifying, does not mean that our jobs are over. Innovation is an ongoing process and management procedures, as well as supervisory practices, must continually adapt.

A third challenge for banks and supervisors has to do with what I would call internal culture issues. These issues involve the role of senior management and boards of directors in the risk management process. Most of the well-publicized problems of the recent past have also reflected shortcomings in internal management processes.

Experience to date makes it all too clear that the active involvement of a financial institution's board of directors and senior management is absolutely critical to their ability to articulate and promote the requisite risk management culture within their organizations. They must be knowledgeable about the financial products their institution is offering and the risks it is taking if they are to give definition to the organization's tolerance for risk and provide leadership in its implementation.

Innovative financial instruments often are extremely complex and can embody a variety of nontraditional risks. Therefore, no financial institution should be engaging in activities its senior management does not adequately understand and its board of directors cannot oversee. This need for understanding the products and their risk must extend to operating staff, auditors, and controllers.

Furthermore, senior management and boards of directors must foster an environment of open communication at all levels of the organization. Such a dialogue is the foundation of effective management supervision. A well-informed management that encourages this communication will be in a better position to assess the contents of daily internal monitoring reports and respond promptly and appropriately to prevent a problem from emerging.

Honesty is another aspect of this internal culture. The financial services business is traditionally one in which integrity is essential. The most effective managers are explicit about their commitment to fair business practice and arm's-length dealing in rules of conduct for employees, and encourage the prompt communication of problems to higher levels of management. This is more relevant today than ever before. Competition is fierce. Markets can move quickly; huge volumes can be traded in minutes, if not seconds, and end users have a wide choice of alternative institutions with which to do business. In this environment, integrity is indispensable if institutions are to attract clients and retain their loyalty over the long run.

Finally, financial institutions must maintain open lines of communication with their supervisors. Even in the best-managed institutions, something can go awry. The cumulative experience of the industry is that the sooner a problem is addressed, the better the chances of limiting its financial and reputational impact. If a problem occurs, the supervisors must be kept informed—not in order to micromanage the problem, but to be able to play a constructive role in its resolution. The questions supervisors ask will reflect their experience and their awareness of the potential success or pitfalls of different strategies.

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In sum, the environment for the banking industry today is as vibrant as it has ever been. The range of opportunities for financial institutions to prosper and grow has never been greater, as technology continues to shrink the world, integrate markets, and open new avenues of potential profitability. In this environment, the real challenge confronting both banks and their supervisors is to balance the risks with the rewards. To do so requires commitment and vigilance on all our parts—supervisors and supervised—to an ongoing process of dialogue, accountability, and cooperation.

Correlation Products and Risk Management Issues

James M. Mahoney

The large, highly publicized losses incurred by some financial institutions in recent years have caused the press and financial regulators to examine the practice of risk management more closely. In particular, institutional losses have raised concerns about the accuracy of the techniques used to assess the risk of an institution's portfolio. While largely effective when applied to traditional financial portfolios, these techniques are not always successful in capturing the complex configurations of risk inherent in today's highly customized derivative products. This article examines *correlation products*, one such class of derivative instruments, which are challenging the traditional measures of price risk.

"Price risk" is defined as the risk that the value of an institution's entire portfolio will change as a result of shifts in market conditions. Market conditions comprise risk factors (also referred to as "state variables") such as foreign exchange rates, equity prices, interest rates, and commodity prices. In traditional products, or "plain vanilla" instruments, price risk is *separable*. In other words, the sensitivity of the traditional portfolio's value to one risk factor is independent of the level of another risk factor. The price risk of these portfolios can be estimated by measuring their sensitivity to individual risk factors and aggregating these sensitivities to arrive at an overall risk profile.

In correlation products, however, price risk is *nonseparable*—that is, a change in one risk factor will affect the price sensitivity of another risk factor. Thus, the pricing, hedging, and risk management of these instruments depend on the *correlations* between the various risk factors rather than on the analysis and aggregation of the individual variables. Because traditional risk management tools do not account for the interdependency of the risk factors, traditional measures of overall price risk may be inaccurate for portfolios that contain correlation products.

This article defines correlation products and explores the problems they raise for risk management systems in financial institutions. It explains the difficulties of analyzing nonseparable risk in one type of correlation product, the differential (diff) swap, and describes the much simpler measurement of separable risks in a standard constant maturity Treasury swap. The article concludes with some general ways nonseparable risk can be managed.

DEFINING CORRELATION PRODUCTS

Financial instruments can be characterized by the legally binding cash flows that they generate. A correlation product is defined by two characteristics of its cash flow. First, the cash flow must be a function of at least two risk factors. Second, at least two of these risk factors must be combined in a non-additive way.[1] The following expressions compare the cash flows of instruments with separable risks to those with nonseparable risks:

$$\text{(1)} \quad \begin{aligned} \text{separable risk: } & CF(x_1, x_2) = CF(x_1) + CF(x_2) \\ \text{nonseparable risk: } & CF(x_1, x_2) = CF(x_1) \times CF(x_2) \ , \end{aligned}$$

where *CF*(.) represents the cash flow generated by a security as a function of risk factors x_1 and x_2. The risk factors in the separable risk expression are broken into two separate terms that are summed, while the risk factors in the nonseparable risk expression form a single product and cannot be so separated.[2]

Common forms of correlation products include diff swaps and quanto swaps.[3] (Several other types of correlation products are highlighted in Appendix I.) Both swaps are examples of cross-currency basis trades—that is, trades whose cash flows depend on the difference between the levels of two risk factors. In a diff swap, the risk factors are a floating domestic interest rate and a floating foreign interest rate, but unlike standard cross-currency trades, both payments are made in a single currency. Both payments are also based on the same fixed notional principal value with a set maturity and are made according to the term of the interest rate indexes. For instance, if six-month LIBOR is used for the interest rate index, cash flows would be exchanged every six months. Unlike some standard cross-currency swaps, diff swaps do not require principal payments at the origination and termination of the swap, because all cash flows are denominated in a single currency.

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The structure of a quanto equity swap is similar to that of a diff swap. The foreign floating interest rate payment, however, is replaced with a payment based on a foreign equity index return such as the Nikkei index.

In both diff swaps and quanto swaps, the dealer commits to paying a floating foreign rate on a fixed U.S. dollar notional principal amount rather than on a fixed amount in the foreign currency. This commitment exposes the dealer on the foreign leg of the correlation product to a variable notional principal amount that changes whenever the exchange rate or the foreign index fluctuates.

THE DEMAND FOR CORRELATION PRODUCTS

The market for correlation products is small compared with the plain vanilla market, estimated to have notional values of trillions of U.S. dollars (Remolona 1992-93). Nevertheless, the market for correlation products represents a growing portion of the overall market for securities that trade over the counter rather than on organized exchanges. End-user demand appears to be the driving force behind this growth. Why are end users drawn to correlation products? To be sure, some investors are in the market purely as speculators. End users and dealers alike, however, cite several nonspeculative reasons for their interest in correlation products.

First, end-user demand for correlation products can stem from the same type of economic analysis that drives other investment decisions. For example, a U.S. dollar investor who believes that a foreign equity market is undervalued because of some underlying weakness in the country's economy may be reluctant to face the foreign exchange exposure involved in buying the foreign equities directly. In this case, a quanto swap—in which the end user pays U.S. dollar LIBOR in U.S. dollars and receives the foreign index return in U.S. dollars—would allow the investor to express confidence in foreign equities at the same time that it protects him or her from unfavorable changes in foreign exchange rates.

Second, investors may desire to gain the benefits of international equity or bond diversification without being subject to the foreign exchange exposure that would occur if the domestic currency appreciates against the currencies whose assets are being held. This currency risk may be unacceptable if the investor faces large future liabilities in the domestic currency (such as retirement expenses). Of course, the investor would have to weigh the potential benefits of diversification against the costs of these swaps.

Because traditional risk management tools do not account for the interdependency of the risk factors, traditional measures of overall price risk may be inaccurate for portfolios that contain correlation products.

Third, some individuals and institutions use derivative securities to circumvent (sometimes self-imposed) restrictions on holdings. For instance, the investment committee of a pension fund or insurance company may require all investments to be denominated in the domestic currency. While this rule would prohibit direct foreign capital market holdings, the managers of these investments could gain exposure to foreign debt or equity markets through correlation products such as diff swaps or quanto swaps.

Fourth, an end user may negotiate a correlation product with a dealer rather than dynamically create a similar exposure because dealers have a competitive advantage over end users in managing the complex exposures of correlation products. Dealers' advantages include their ability to trade at smaller bid-ask spreads in the cash market and their greater experience in negotiating within the legal environments of foreign economies, particularly in the emerging debt and equity markets. In addition, dealers' risk management systems tend to be more advanced than most end users' systems.

One use for which correlation products are generally not appropriate is the hedging of risks arising from traditional products. Most hedgers have little interest in correlation products because the type of exposure found in them is not available in existing cash or derivative securities. Asset managers are more likely to use these products in an effort to outperform an index or other return measure.

An Example of a Correlation Product: The Diff Swap

The Market for Diff Swaps

One of the first reported diff swaps was negotiated in early 1991 between Credit Suisse First Boston and a Japanese insurance company. Since that time, diff swaps have grown rapidly in popularity, reportedly because of the large differential in short-term interest rates across major currencies. Today, diff swaps make up a significant portion of the exotic instruments market. A recent estimate places the notional principal amount of diff swaps outstanding at $40 billion to $50 billion.[4]

The market for correlation products represents a growing portion of the overall market for securities that trade over the counter.

Through the use of diff swaps, investors in currencies with low yields attempt to enhance their returns by swapping into currencies with higher yields. Diff swaps have been transacted in a wide range of currency pairs, including U.S. dollar LIBOR against LIBOR rates of the deutsche mark, British pound, Swiss franc, and Australian dollar, and LIBOR rates of the deutsche mark and Swiss franc against LIBOR rates of the Italian lira, Spanish peseta, and other high-yielding currencies of the European Exchange Rate Mechanism.

Despite the rapid growth of the diff swap market, it is still controlled by only a handful of dealers. The main barrier to entry for other derivatives dealers is the expertise needed to price, hedge, and manage the nonseparable risks present in these instruments. Unlike traditional instruments, correlation products require risk managers to account for nonseparable risks by making assumptions about the future correlations between risk factors.

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ANALYZING THE PRICE RISK OF A DIFF SWAP

The complex procedures for analyzing the price risk of diff swaps are explained below. Readers may wish to compare these procedures with the relatively simple process of analyzing the price risk of a standard derivative instrument, the constant maturity Treasury (CMT) swap, outlined in Appendix II.

Both the diff swap and CMT swap examples rely on the assumption that markets are competitive. Thus, we determine the price of the instrument by estimating the cost to the dealer of hedging the resulting risk exposures. This does not mean that the dealer will (or should) hedge the resulting exposure. Rather, we determine the price of an instrument by ruling out the only other alternatives. If the cost of replicating the exposures is greater than the price that the counterparty offers to the dealer, the dealer will not enter into the trade. At the same time, if the cost of hedging the exposure is less than the price that the dealer offers to the counterparty, the counterparty will take the business to a dealer with more competitive prices. Therefore, the price must be equal to the cost of hedging. Although this approach does not consider market realities such as transaction costs, liquidity considerations, and model risk, it yields a reasonable approximation to the value of a security.

HEDGING AND PRICING A DIFF SWAP

Suppose a dealer has entered into a diff swap in which for a period of one year it receives six-month U.S. dollar LIBOR in U.S. dollars while it pays six-month deutsche mark LIBOR in U.S. dollars to the end user. The semiannual interest payments are based on a $100 million notional principal amount and are settled in arrears (Exhibit 1).[5]

To value the cash flows of the diff swap, the dealer must determine the level of the cash flows that will take place in the future (in this case, in six months' and in one year's time) and discount these flows to the present.[6] Therefore, the present value of the diff swap can be written as

(2) PV of the diff swap =

$$PV_{6\,mo}(\$100\text{m} \times (r^{@\,t\;=\;today}_{US\$\;LIBOR} - r^{@\,t\;=\;today}_{DM\;\;LIBOR}))$$

$$+\ \text{PV}_{12mo}(\$100\text{m} \times (\tilde{r}^{@\,t\;=\;6mo}_{US\$\;LIBOR} - \tilde{r}^{@\,t\;=\;6mo}_{DM\;\;LIBOR}))$$

where $PV_t(CF)$ indicates the present value of a cash flow, CF, occurring at time t, and r^t_x represents the prevailing interest rate in market x at time t.

The value of the cash flow that will occur in six months' time (the first term in equation 2) is easy to calculate. The parties swap the difference between the current value of U.S. dollar LIBOR and deutsche mark LIBOR paid in U.S. dollars on a notional principal amount of $100 million. The cash flow will not change when interest rates or exchange rates fluctuate, and the cash flows can be discounted at the risk-free U.S. dollar six-month interest rate.[7]

However, the value of the cash flow that will occur in twelve months' time (the second term in equation 2) is more difficult to calculate. The dealer cannot convert the deutsche mark liability embedded in the swap into a U.S. dollar liability, because the level of deutsche mark exposure faced at the swap initiation will be determined by the level of deutsche mark LIBOR and the deutsche mark/U.S. dollar exchange rate in six months' time. Thus, while typical hedging instruments protect against exposure by converting a fixed principal amount from one currency to another,[8] the exposure faced by the dealer in a diff swap involves a floating deutsche mark principal. Ultimately, the lack of a static hedge forces the dealer to make assumptions concerning the future correlation between the deutsche mark/U.S. dollar exchange rate and deutsche mark LIBOR and to update the hedging position dynamically.

Estimating the Cost of Hedging the Exposures

Once the cash flows of the diff swap are determined, the dealer estimates the cost of hedging the floating interest rate exposures by observing the costs of entering into two plain vanilla interest rate swaps—one in U.S. dollars and one in deutsche marks. These interest rate swaps, which are based on the notional principal amount of the diff swap in U.S. dollars or its dollar equivalent in deutsche marks, will have the same maturity and payment dates as the diff swap (Exhibit 2). Because the market for interest rate swaps is highly competitive, we can assume that these two hedging swaps will be entered into at a net present value of zero. As a result, the overall value of the diff swap will be the same before and after hedging. However, the combination of the diff swap and the two hedging swaps does not eliminate all price risk. The presence of residual risk suggests that the market prices of existing securities alone are not enough to determine the value of the diff swap.

Accounting for Residual Exposures

To account for residual risk, the dealer must assess the joint probability distribution of the deutsche mark/U.S. dollar exchange rate and the deutsche mark LIBOR rate. For the purposes of this example, assume that the U.S. dollar term structure is flat at 6 percent, the deutsche mark term structure is flat at 8 percent, and the current deutsche mark/U.S. dollar exchange rate is 1.6. Exhibit 3 shows the gross cash flows and the net cash flows to and from the dealer.

To determine the value of the residual exposure that occurs in one year, the dealer converts the net cash flows into U.S. dollars at the exchange rate prevailing at

Exhibit 1
Differential Swap: Generic Cash Flows

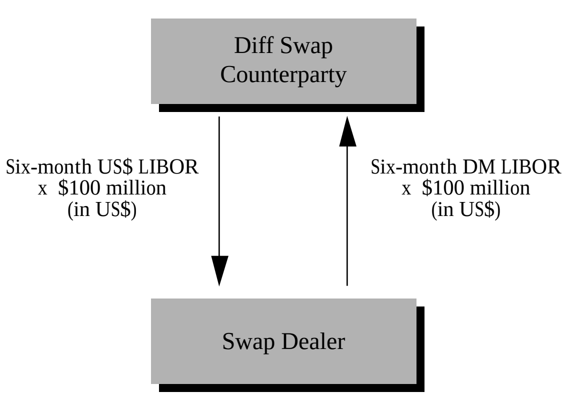
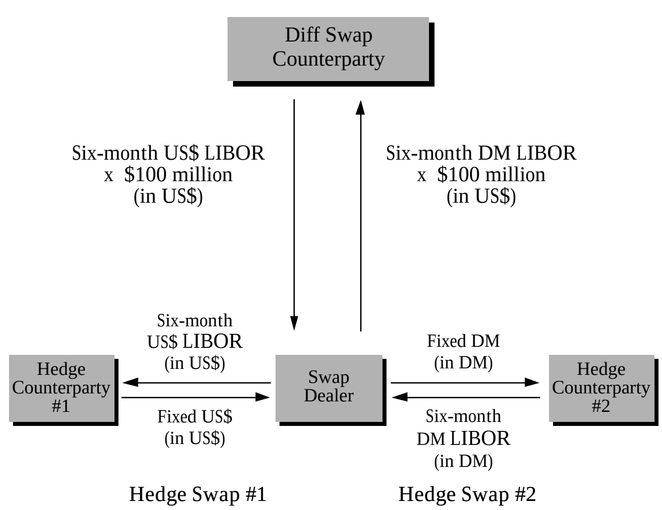


Exhibit 2
Differential Swap: After Dealer Hedges with Interest Rate Swaps



t=6 months, $\tilde{q}_{DM/\$}$:

$$(3) \quad \$100m \times (6\% - \tilde{r}_{DM\ LIBOR}) + DM160m \times (\tilde{r}_{DM\ LIBOR}/\tilde{q}_{DM/\$} - 8\%/\tilde{q}_{DM/\$}),$$

which can be simplified to:

$$(4) \quad (\$100m - DM160m/\tilde{q}_{DM/\$}) \times (8\% - \tilde{r}_{DM\ LIBOR}) - \$100m \times 2\%.$$

As shown in expression 4, the residual cash flow contains a risky component (first term) and a fixed component (second term).[9] The cash flow represented by the second term is easy to value: it represents a fixed cash flow on a fixed date in a single currency and therefore can be discounted at the one-year spot rate at time zero. However, the cash flow represented by the first term is difficult to value because two sources of risk are being combined in a single term. This first term fits the definition of *nonseparable risk*: the two random variables, $\tilde{q}_{\$/DM}$ and $\tilde{r}_{DM\ LIBOR}$, are multiplied rather than summed or differenced and therefore cannot be separated into different terms.

Traditional risk management tools properly measure the risk of correlation products only if risk factors do not fluctuate simultaneously. For example, if the exchange rate remains at 1.6 deutsche marks per U.S. dollar, then the first term of expression 4 will equal zero and the resulting cash flow will be zero, regardless of the level of deutsche mark LIBOR. At the same time, if deutsche mark LIBOR remains at the fixed interest rate of 8 percent, the cash flow will be zero regardless of the level of the deutsche mark/U.S. dollar exchange rate (Exhibit 4). These zero cash flows show that the dealer's position is hedged for movements in either deutsche mark LIBOR or deutsche mark/U.S. dollar exchange rates. However, the dealer is not hedged against simultaneous movements.[10]

Simultaneous movements in the foreign index and the exchange rate will determine the sign—positive or negative—of the cash flow. For example, let us assume that the deutsche mark LIBOR decreases and the deutsche mark/U.S. dollar exchange rate increases (the deutsche mark depreciates relative to the U.S. dollar). Because the movements in the deutsche mark LIBOR and the deutsche mark/U.S. dollar exchange rate are negatively correlated, both terms in expression 4 will be positive, and the dealer will receive a positive cash flow. Conversely, if the deutsche mark LIBOR decreases and the deutsche mark/U.S. dollar exchange rate decreases (the deutsche mark appreciates relative to the U.S. dollar), then the cash flow to the dealer will be negative. Therefore, the *correlation* between the risk factors determines whether the cash flow of the diff swap will be positive or negative. Using the data in Exhibit 4, the chart on page 13 offers a graphic representation of the concept of nonseparability.

In summary, while part of the exposure of the diff swap can be hedged with existing securities, residual risk must be evaluated in order to determine the value of the diff swap. An important, and complex, component of the residual risk is the correlation between the risk factors.

Exhibit 3
CASH FLOWS OF A DIFF SWAP TO AND FROM DEALER
All cash flows take place at t=12 months based on rates at t=6 months

Diff swap:	
Inflow:	\$100 million x $\tilde{r}_{US\$\ LIBOR}$
Outflow:	\$100 million x $\tilde{r}_{DM\ LIBOR}$
Hedge swap #1:	
Inflow:	\$100 million x 6%
Outflow:	\$100 million x $\tilde{r}_{US\$\ LIBOR}$
Hedge swap #2:	
Inflow:	DM 160 million x $\tilde{r}_{DM\ LIBOR}$
Outflow:	DM 160 million x 8%
Net cash flows:	
Inflow:	\$100 million x 6% + DM 160 million x $\tilde{r}_{DM\ LIBOR}$
Outflow:	\$100 million x $\tilde{r}_{DM\ LIBOR}$ + DM 160 million x 8%

IMPLICATIONS FOR RISK MANAGEMENT AND SUPERVISORY PRACTICES

The most fundamental problem in estimating the price risk of correlation products occurs at the operational level. The feature of nonseparability means that a dealer cannot break up the price sensitivity of diff swaps or other correlation products into component risks and then assign each risk to its corresponding business function. Instead, an institution's trading desks need to coordinate their activities by establishing formal systems of communication among trading units and between trading units and global risk managers. This level of coordination has not been required in managing traditional instruments, and it may entail substantial changes in an institution's management approach and structure.

Of course, the potential for problems at the operational level does not stop there. The portfolios of large institutions can comprise thousands of individual trading positions across multiple trading desks in several geographic locations. To arrive at a comprehensive estimate of risk, most of these institutions rely on summary statistics of each trading position. They then aggregate these summary statistics to arrive at the risk of the entire firm.[11] Because traditional measures of risk do not accurately reflect the risk of a portfolio that contains correlation products, these summary statistics can misguide corporate decisions. For example, an underestimation of price risk, if large enough, could lead a financial institution to hold less than the optimal amount of capital against potential losses.

Inaccurate estimates can also influence the financial decisions of market participants. Transparency of risks and exposures is an important feature of an institution's financial statements (Bank for International Settlements 1994). If the portfolio of an institution contains significant levels of "hidden" correlation risk, then investors may not efficiently allocate capital to that institution. For instance, a lack of transparency of risk can inhibit the flow of capital to a healthy financial institution that is experiencing a temporary liquidity crisis.

Cash Flow Profile of a Diff Swap

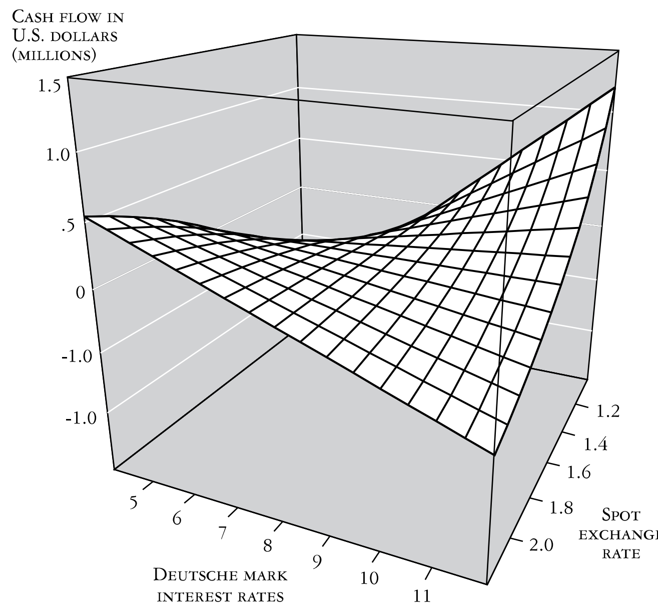


Exhibit 4
CASH FLOW PROFILE FOR DIFF SWAP DEALER

Cash flow occurring in year one for diff swap on $100 million notional principal based on DM LIBOR and DM/U.S. dollar exchange rate in six months:

$$(\$100m - DM\ 160m / \tilde{q}_{DM/\$}) \times (8\% - \tilde{r}_{DM\ LIBOR}).$$

The value of the expression is halved when calculating the cash flows because the diff swap is assumed to have semiannual payments. The following matrix shows the level of cash flow (in millions of dollars) for various possible realizations of the exchange rate and the DM LIBOR rate.

Cash Flow (Millions of Dollars)

		Exchange Rate (DM/U.S. dollar)						
		1	1.2	1.4	1.6	1.8	2	2.2
DM LIBOR (Percent)	12	1,200,000	666,667	285,714	0	(222,222)	(400,000)	(545,455)
	11	900,000	500,000	214,286	0	(166,667)	(300,000)	(409,091)
	10	600,000	333,333	142,857	0	(111,111)	(200,000)	(272,727)
	9	300,000	166,667	71,429	0	(55,556)	(100,000)	(136,364)
	8	0	0	0	0	0	0	0
	7	(300,000)	(166,667)	(71,429)	0	55,556	100,000	136,364
	6	(600,000)	(333,333)	(142,857)	0	111,111	200,000	272,727
	5	(900,000)	(500,000)	(214,286)	0	166,667	300,000	409,091
	4	(1,200,000)	(666,667)	(285,714)	0	222,222	400,000	545,455

Note: The unshaded regions represent the cash flows of a diff swap resulting from changes in individual risk factors.

From a supervisory perspective, the market for correlation products raises several concerns. First, because the development and execution of correlation products are highly concentrated within the banking community, a shift in market conditions could have potentially adverse consequences for a small number of large institutions. Moreover, some correlation products are structured in the risky, illiquid currencies of emerging markets, where large changes in interest rates and exchange rates can occur overnight or, significantly for correlation products, simultaneously. For example, in 1994, the Mexican peso/U.S. dollar exchange rate, the Mexican equity markets, and Mexican interest rates changed dramatically and concurrently over a short period of time. Although nonseparable structures can provide valuable liquidity to otherwise inaccessible markets, risks may be greatly underestimated in these more volatile environments.

The feature of nonseparability means that a dealer cannot break up the price sensitivity of diff swaps or other correlation products into component risks and then assign each risk to its corresponding business function.

Second, nonseparable risk is one of many factors that may affect the implementation of regulatory capital requirements. The Bank for International Settlements (1995) has recently put forth a proposal that would allow individual financial institutions to use their own internal models to assess risk and to assign regulatory capital requirements. Internal models, if properly constructed, should be able to accurately reflect the effects of nonseparable risks on the institution's portfolio.

Finally, liquidity of the market may be at risk because the exposures of a correlation product may be difficult to reverse if the counterparty is not willing to cancel the contract at a fair value. Unlike the investor in traditional instruments, the end user of a correlation product must find a counterparty who is willing to take on the exact exposure of the original contract in order to counteract the existing contract; otherwise, he or she may be compelled to hedge the exposure dynamically. Therefore, if liquidity for correlation products dries up, end users may be forced into dynamically hedging exposures that they would like to eliminate but cannot because of a lack of counterparty interest. The fact that the market for correlation products is predominantly demand-driven adds to future liquidity concerns. If demand diminishes, financial institutions will have little incentive to maintain an active secondary market.

Managing Nonseparable Risk

As shown by the price risk analysis of a diff swap, traditional risk measures can understate the amount of risk present in correlation products. How can institutions enhance risk management tools to address this potential problem? The first step is to identify the presence of nonseparable risks in a portfolio. Two approaches might be taken:

- Each variable to which a portfolio is exposed may be shocked individually and the sum of these changes in market value compared with the changes brought about when the variables are shocked simultaneously. If the change in value stemming from the simultaneous shock differs from the sum of the effects of the individual shocks, then the portfolio contains nonseparable risks.
- Ex post profits and losses and model-predicted profits and losses may be reconciled, taking into account the realized level of the risk factors. A risk manager could investigate the cause of profits or losses in excess of predictions by analyzing discrepancies between model prices and market prices. Such excess returns could arise if nonseparable risk is being measured by traditional risk management tools.

Once nonseparable risks are identified, the risk manager could then use a simulations-based approach to measure price risk. This type of approach requires a number of time-consuming, expensive steps, as outlined below.

A risk manager first identifies the risk factors to which a portfolio is exposed, collects historical data on these factors, and analyzes and models the volatility of the factors and their relationships to each other. Unfortunately, historical data series do not always exist, particularly for newly developed markets or economies. Alternatively, a risk manager may use current market prices (such as options prices), if available, to derive market-implied estimates of future volatilities. A third option is to rely on the data set for a risk factor similar to that under investigation. For example, a risk manager may estimate a current exposure to an emerging economy by using data from a country whose economy has undergone a similar transformation.

Next, the risk manager generates a large number of future paths for the risk factors through one, or a combination, of two methods—a model-based approach or an empirical-based approach. The former assumes a structure for the data, for example, a multivariate normal distribution or generation by a time-varying volatility process such as an ARCH-type process. The latter uses historical data to create a frequency distribution, or histogram, with which the future distribution of the risk factors is assumed to coincide. The model-based approach has the advantage of simulating an unlimited number of future paths, but the model may be misspecified or incorrect (introducing model risk). The empirical-based approach frees the researcher from a potentially incorrect model, but its use is often limited by the lack of reliable historical data on many risk factors.

Once nonseparable risks are identified, the risk manager could then use a simulations-based approach to measure price risk.

After generating future paths for the risk factors, the manager computes the future value of each security under the various scenarios and estimates the present value of the security as the average discounted value of the simulated future values. This averaging procedure assumes that each of the simulated scenarios is equally likely. Finally, the manager calculates estimates of price sensitivities by "perturbing" each path taken by the risk factors and recalculating the value of the portfolio. The change in the value of the portfolio divided by the perturbation is a measure of the delta (the rate of change of the portfolio to a risk factor). Pair-wise perturbations and revaluations yield estimates of price sensitivities to changes in pairs of risk factors.

Because the process is so involved, a simulations-based approach seems appropriate only for firms that place great emphasis on nonseparable products. Such firms will probably find it useful to develop multiple simulation methodologies (using variations of both the empirical-based and model-based approaches) to ensure that their risk estimates are robust to alternative specifications.

CONCLUSIONS

Correlation products, a new class of derivatives instruments, are challenging the effectiveness of existing techniques for measuring price risk. For traditional portfolios, financial institutions evaluate individual risk factors at the trading-unit level and subsequently aggregate the units' estimates to arrive at an accurate risk profile. For correlation products, however, this technique is not effective because the sensitivity of one risk factor is always a function of the level of another risk factor. Thus, because many institutions continue to rely solely on traditional risk management tools, nonseparable risks may go unmeasured.

The potential for understated risk raises several concerns regarding financial institutions' regulatory capital requirements, financial disclosure practices, and supervisory activities. Techniques to capture nonseparable risks—such as the simulations-based approach outlined in the article—can help address these concerns by augmenting traditional risk measures. Given the tremendous rise in financial innovation, new types of risk are likely to prompt an increasing number of financial institutions to reexamine and enhance risk management practices.

APPENDIX I: COMMON FORMS OF CORRELATION PRODUCTS

In addition to diff swaps and quanto swaps, several new types of correlation products have been developed in recent years.

Correlation products include any contract that pays off as a function of the minimum or maximum of two random processes. Specific contracts include the option to trade one asset for another and the outperformance option, which pays some function of the maximum of two indexes, such as stock market indexes. In addition, relative value derivatives, which pay off as a function of the ratio of two variables, appear to be gaining popularity (see, for example, Locke 1995 and Elms 1995).

Correlation effects may also be embedded in more exotic structures. Quanto options—that is, options on a foreign index with the spot and strike prices denominated in a foreign currency but cash flows taking place at a fixed exchange rate in the domestic currency—have become increasingly popular.[12] Also gaining ground are correlation products in the form of a binary option,[13] where the payoff of the option depends on two underlying variables. A hypothetical correlation binary call option would pay a predetermined constant amount, X, if the (constant maturity) three-month U.S. dollar interest rate, r, is above r^* *and* a foreign/U.S. dollar exchange rate, q, is above q^* (that is, the payoff is {X if $r > r^*$ *and* $q > q^*$; 0 otherwise}). This exotic binary option is simultaneously bullish on the U.S. dollar relative to the foreign currency and bearish on U.S. dollar interest rates. Its value will depend on the anticipated correlation between the three-month U.S. dollar interest rate and the foreign currency/U.S. dollar exchange rate.

Certain yield curve trades also involve nonseparable risk. A call option on a short-term interest rate, with the strike determined by a long-term interest rate, is an example of a nonseparable yield curve trade.

In addition, Asian options with geometric means for the spot price or the strike price fit the definition of correlation products. An example is an option on a stock index for the time period [0, T] with strike price K and a payoff that is a function of the geometric mean of the index level taken at T+1 discrete dates:

$$CF_T = \max\,[0, (S_0 \times S_1 \ldots \times S_T)^{1/(T+1)} - K].$$

The cross partial of the value of this option, $\partial^2 V / \partial S_s \partial S_t$, is not zero for $s \neq t$; therefore the value of this option will be a function of the correlation matrix of S, which is effectively the autocorrelation structure of the process for S. If the option payoff were a geometric average across securities instead of across time, the option on the index would be a function of the entire covariance matrix of stock prices.[14]

APPENDIX II: ANALYZING THE PRICE RISK OF A STANDARD INSTRUMENT: THE CONSTANT MATURITY TREASURY SWAP

Suppose a securities dealer has entered into a constant maturity Treasury (CMT) swap with a notional value of $100 million. For a term of one year, the dealer pays the current five-year U.S. Treasury rate on a notional value of $100 million and receives the current ten-year Treasury rate on a notional value of $100 million. The dealer obviously benefits if the yield curve steepens (Exhibit A1).

DETERMINING AND VALUING THE CASH FLOWS

Exhibit A2 illustrates the cash flows of this simple portfolio as a function of the five-year Treasury rate and the ten-year Treasury rate. This "five-by-ten CMT swap" shows separable risk in the two risk factors: the sensitivity of the flows to changes in the five-year Treasury rate is independent of the level of the ten-year Treasury rate; the sensitivity of the cash flows to changes in the ten-year Treasury rate is independent of the level of the five-year Treasury rate. To value the CMT swap, the dealer breaks the resulting risks into the five-year and ten-year components, then values these components separately and aggregates them.

Because the risks of the CMT swap are separable, the dealer can break up the risks and assign them to two different trading units—for example, the unit responsible for trading in the five-year Treasury sector and the unit responsible for trading in the ten-year Treasury sector. These two trading units would not need to coordinate their efforts.

ESTIMATING THE COST OF HEDGING THE EXPOSURES

Exhibit A3 shows how the dealer may attempt to hedge (and therefore assign a price to) the exposures of the resulting trade. For the five-year Treasury exposure, the trader uses interest rate forward contracts, which require him or her to pay a fixed rate in exchange for the CMT five-year Treasury rate. For the ten-year Treasury exposure, the trader uses an interest rate swap based on the ten-year Treasury rate, which requires him or her to pay the ten-year CMT rate in exchange for a fixed rate. As a result, exposures to the five-year and ten-year Treasuries are eliminated, and the pricing of the CMT swap amounts to the pricing of two riskless fixed flows in the future (Exhibit A4). We can conclude that the price sensitivity of the CMT swap is similar to the price sensitivities of

Exhibit A1
INTEREST RATE SWAP: GENERIC CASH FLOWS

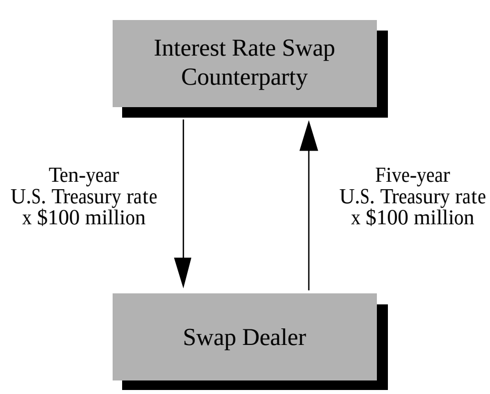


Exhibit A2
CASH FLOWS OF A CMT SWAP TO AND FROM DEALER
All cash flows take place at t=12 months based on rates at t=6 months

Five-by-ten CMT swap:		
	Inflow:	$100 million x $\tilde{r}_{10}$
	Outflow:	$100 million x $\tilde{r}_{5}$
Hedge swap:		
	Inflow:	$100 million x r_{FIXED1}
	Outflow:	$100 million x $\tilde{r}_{10}$
Hedge forwards:		
	Inflow:	$100 million x $\tilde{r}_{5}$
	Outflow:	$100 million x r_{FIXED2}
Net cash flows:		
	Inflow:	$100 million x r_{FIXED1}
	Outflow:	$100 million x r_{FIXED2}

fixed-for-floating swaps on a five-year Treasury rate and a ten-year Treasury rate.[15] Using the data in Exhibit A4, the chart on this page offers a graphic representation of the concept of separability.

REVIEWING THE LACK OF RESIDUAL EXPOSURES

A lack of residual exposures once the two hedging strategies are implemented indicates that two other instruments—interest rate swaps and interest rate forwards—serve the same economic function as a CMT swap. These instruments can be used as alternate hedging vehicles if the market for CMT swaps becomes illiquid. Lack of residual exposure also indicates that the pricing and hedging of a five-by-ten CMT swap is fully determined by markets for the individual five-year and ten-year risks. In summary, because risk is separable, the pricing and hedging of the CMT swap does not require the dealer to estimate the correlation coefficient between the two risk factors.

Exhibit A4

CASH FLOW PROFILE OF A CMT SWAP

The cash flow of a five-by-ten CMT swap is the notional value of the swap times the difference between the most recently issued ten-year Treasury and the most recently issued five-year Treasury:

$$CF = \$100m \times (r_{10} - r_5),$$

where the notional principal is assumed to be \$100 million, and r_5 and r_{10} represent the five-year and ten-year Treasury rates, respectively. The following matrix shows the level of cash flow (in millions of dollars) for various possible realizations of the five-year and ten-year Treasury rates at the next payment date.

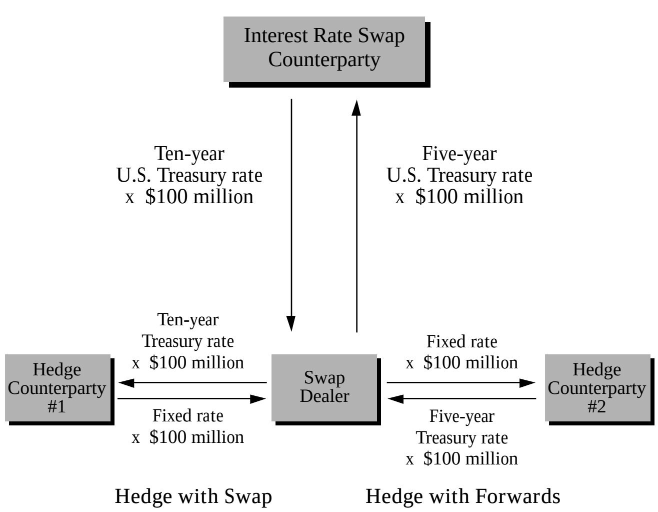
Cash Flow (Millions of Dollars)

		Five-Year Treasury Rate						
	Percent	3	4	5	6	7	8	9
Ten-Year Treasury Rate	9	6.0	5.0	4.0	3.0	2.0	1.0	0.0
	8	5.0	4.0	3.0	2.0	1.0	0.0	-1.0
	7	4.0	3.0	2.0	1.0	0.0	-1.0	-2.0
	6	3.0	2.0	1.0	0.0	-1.0	-2.0	-3.0
	5	2.0	1.0	0.0	-1.0	-2.0	-3.0	-4.0
	4	1.0	0.0	-1.0	-2.0	-3.0	-4.0	-5.0
	3	0.0	-1.0	-2.0	-3.0	-4.0	-5.0	-6.0

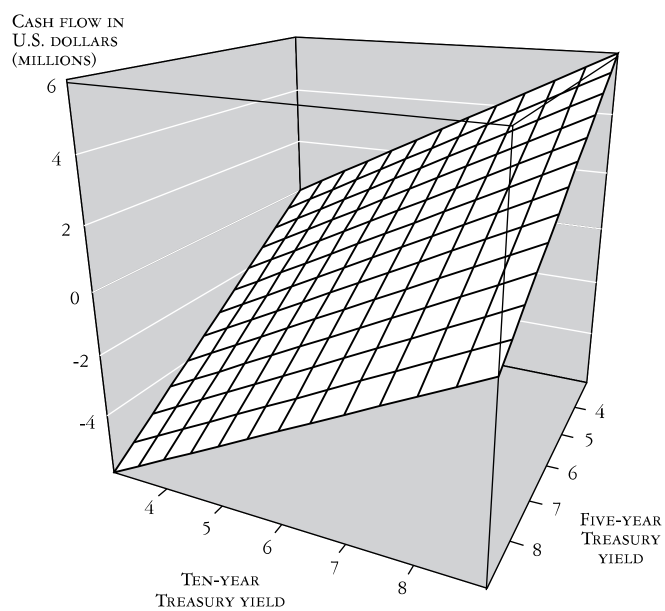
Note: The unshaded regions represent the cash flows of a CMT swap resulting from changes in individual risk factors.

Exhibit A3

INTEREST RATE SWAP: AFTER DEALER HEDGES WITH INTEREST RATE SWAP AND FORWARDS



CASH FLOW PROFILE OF A CMT SWAP



ENDNOTES

1. The term “correlation product” can be misleading because it refers to the structure of the instrument, not to the correlations between the risk factors. If the cash flows of a product cannot be separated into different terms, the instrument is nonseparable and therefore a correlation product.

2. It is not the estimation of the correlations between market risk factors that confounds traditional risk management systems. Indeed, most risk management tools require correlation estimates. Rather, the assumption of separability inherent in most traditional risk management tools leads to the underestimation of risk in correlation products. The nonseparable expression cited in the text shows that the correlation between the risk factors x_1 and x_2, usually denoted $\rho_{x_1 x_2}$, does not enter into the definition of a correlation product.

3. Diff swaps are also referred to in the trade press as quantity-adjusted swaps (quants), guaranteed exchange rate swaps, LIBOR differential swaps, cross index basis (CRIB) swaps, and switch-LIBOR swaps.

4. For a description of the early development of the diff swap market, see Shirreff (1992), Cookson (1992), and Das (1992a, 1992b).

5. Settlement in arrears for a one-year swap with semiannual payments means that the first payment, made in six months’ time, is based on the current values of LIBOR, and the second (and last) payment, made in one year’s time, is based on the values of LIBOR realized in six months’ time.

6. Several authors, including Jamshidian (1993) and Wei (1994), have derived formulas for the present value of a diff swap. These formulas are contingent on the assumed process of the term structure, a complex subject that is not treated in this article.

7. The flows are considered riskless because throughout this paper we assume that there is no counterparty credit risk.

8. For instance, currency futures and forward contracts determine the exchange rate today for a fixed (not a floating) principal exchange from deutsche marks to U.S. dollars in the future.

9. If the market for providing these swaps is competitive, the buyer and seller agree on an additional periodic payment, called “margin,” so that the present value of the swap is zero at swap initiation.

10. When separable risks are present, a dealer hedged against movements in individual risk factors would necessarily be hedged against simultaneous movements in risk factors.

11. Standard summary statistics include the positions’ current market values, deltas (market value sensitivities to underlying risk factors), gammas (sensitivities of the deltas to underlying risk factors), vegas (market value sensitivities to volatility changes), and thetas (market value sensitivities to the passage of time).

12. Quanto Nikkei put warrants, the focus of a study by Dravid, Richardson, and Sun (1993), began trading on the American Stock Exchange in 1992.

13. A plain vanilla binary call option is a derivative security that pays nothing if the underlying asset price or rate, S, finishes at or below the strike price of the option, K, and pays off a predetermined, constant amount, X, if the asset finishes above the strike price (that is, the payoff is $\{X \text{ if } S > K; 0 \text{ if } S \leq K\}$). Binary options are also called all-or-nothing options, bet options, and lottery options.

14. An interesting example of such a contract is the now-defunct Value Line Index Futures contract at the Kansas City Board of Trade (KCBOT) (Thomas 1994). The Value Line Index that was used to determine the delivery price of the contract was a geometric average index, which meant that the appropriate arbitrage model was not the standard cost-of-carry model but rather a dynamic strategy depending on the entire covariance matrix of the stocks in the index. The KCBOT contract failed after other exchanges introduced newer futures contracts based on the arithmetic mean of the components (such as the Standard & Poor’s contracts). The newer futures contracts are much more easily replicated in the cash market because the covariance matrix of their components does not need to be estimated.

15. The reader should note that the important distinctions between diff swaps and swaps with separable risks do not arise because the diff swap involves a foreign currency. The risks of standard cross-currency swaps, for example, can be valued and hedged separately.

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The Commodity–Consumer Price Connection: Fact or Fable?

S. Brock Blomberg and Ethan S. Harris

Interest in commodity prices as indicators of consumer price inflation has ebbed and flowed with the rise and fall in commodity prices themselves. True to form, as commodity prices have surged in the last two years (Chart 1), interest in their predictive power has returned. Inflation hawks point to an outpouring of studies in the late 1980s showing a strong empirical connection between commodity prices and subsequent consumer inflation. Indeed, the concern over commodities has grown to the point where even two previously obscure commodity indexes—the National Association of Purchasing Managers price index (NAPM) and the Federal Reserve Bank of Philadelphia's prices paid index (PHIL)—have begun to capture considerable attention among economists and market analysts.

Is this renewed attention warranted? In this article, we argue that none of the channels through which commodity prices signal more generalized inflation are operating as well as they did in the past: commodities have become less important as an input to production, some of the inflation signals from commodity prices may be sterilized by offsetting monetary policy, and commodities have become less popular as an inflation hedge. We also present evidence that the recent commodity movements are a reaction to swings in dollar exchange rates rather than a signal of generalized inflation pressures.

Our empirical results underscore the diminished signaling power of commodities in the last eight years. Drawing on data for the 1970-94 period, we examine five major U.S. commodity indexes and three subgroups of commodities—gold, oil, and food. We use vector autoregression models (VARs) to test whether commodity prices are useful in predicting subsequent movements in both the finished goods producer price index (PPI) and the core—that is, nonfood and nonenergy—consumer price index (CPI). These VAR methods allow us to isolate the predictive power of commodity prices while controlling for other determinants of inflation. We find that:

- Contrary to conventional theory, there is no long-run link between the level of commodity prices and the level of consumer prices, but there is a link—or cointegrating relationship—between the *level* of commodity prices and the *rate* of consumer price inflation.

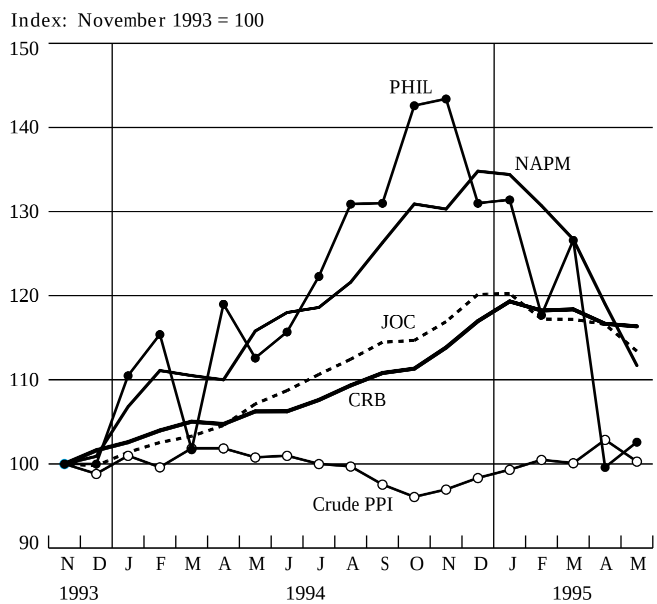
- During the full 1970-94 sample period, all of the traditional commodity indexes have some ability to predict short-run changes in core CPI inflation. However, this relationship weakens considerably starting in the mid-1980s. The breakdown extends beyond commodity prices: even the finished goods PPI cannot help predict changes in core CPI inflation in the recent period.

- Adding monetary variables and the dollar exchange rate to the models helps eliminate some perverse findings, suggesting that some inflation signals from commodities are being obscured by offsetting changes in exchange rates and monetary policy.

- Commodities that are particularly sensitive to major supply disruptions (such as food and oil) appear to have retained more explanatory power than those influenced primarily by input demands (industrial materials) or those used for inflation hedging (gold).

Chart 1

Recent Commodity Price Movements



Sources: Authors' calculations, based on data from Bureau of Labor Statistics, Commodity Research Bureau, *Journal of Commerce*, National Association of Purchasing Managers, Federal Reserve Bank of Philadelphia.

Note: Chart shows the price movements tracked by five major commodity indexes. PHIL is the Federal Reserve Bank of Philadelphia's prices paid index; NAPM, the National Association of Purchasing Managers price index; JOC, the *Journal of Commerce* index; CRB, the Commodity Research Bureau index; crude PPI, the crude producer price index.

Our examination of the signaling power of commodities begins with a review of the theoretical linkages between commodity prices and subsequent consumer price inflation.

The Tortoise and the Hare and Other Commodity Fables

Most arguments for a signaling role for commodities rest on the fact that commodity prices are set in auction or flexi-price markets and therefore can sprint ahead quickly in response to actual or expected changes in supply or demand. By contrast, prices of most final goods and services, restrained by contractual arrangements and other frictions, respond slowly and steadily to supply and demand pressures, only gradually gaining ground on commodity prices. Like the hare in Aesop's famous fable, commodity prices tend to take a quick, early lead in inflation cycles, but ultimately lose the race, falling in real terms.

Formal theoretical models, such as Boughton and Branson (1991) and Fuhrer and Moore (1992), are based on this notion of commodity behavior, building on Dornbusch's (1976) classic exchange rate model. In these models, commodities are assets whose price "jumps" to equilibrate the money and goods markets. Thus, a surge in aggregate demand (for example, an unexpected increase in the money supply) causes commodity prices to shoot upward while final goods prices respond only with a lag.[1]

The empirical literature on commodities expands on this simple theoretical framework and presents three different accounts of the linkages between commodity prices and broad inflation. These accounts—or commodity "fables"—explain why commodity prices could be a useful leading indicator of inflation.

First, as illustrated by the tortoise-and-hare fable, commodity prices may give early warning signals of an inflationary surge in aggregate demand. Higher demand for final goods increases the demand for commodity inputs and, even though the inflation impetus may start in final goods markets, the first visible increase in prices may be in the flexi-price commodity markets.[2] Because commodities are widely traded internationally, this aggregate demand signal would most likely occur when strong domestic demand is not offset by weak foreign demand. Indeed, in empirical models, commodity prices are often modeled as a function of global economic activity. These demand-induced commodity price run-ups presumably will be concentrated in industrial materials.

Second, commodity prices and broad inflation may be directly linked because commodities are an important input into production, representing about one-tenth of the value of output in the United States. Thus, all else being equal, an increase in commodity prices should eventually be passed through to final goods prices. Historically, large direct input price effects have tended to be concentrated in food and energy commodities.

The third linkage between commodity prices and future inflation stems from the first two. Because commodity prices respond quickly to general inflation pressures, investors may see them as a useful inflation hedge. This perception tends to be self-fulfilling: the more that commodities are seen as an effective hedge, the more likely investors are to turn to them in anticipation of inflation. Traditionally, precious metals have been singled out as the most convenient commodities for hedging inflation.

Like the hare in Aesop's famous fable, commodity prices tend to take a quick, early lead in inflation cycles, but ultimately lose the race, falling in real terms.

VAR Literature

These three fables motivate empirical studies of the commodity–consumer price connection. Most studies, however, avoid the complications of a formal structural model and instead use VAR models to test for a positive correlation between commodity prices and subsequent consumer price inflation. The VAR methodology assumes that each variable can be best explained by using past values of both itself and all other relevant variables. Using this approach, a very active literature in the late 1980s established the following:[3]

- Although commodity prices and consumer prices tend to diverge over time, commodity price *levels* and consumer price *inflation* tend to move together over time—that is, they are cointegrated (Boughton and Branson 1991; Cody and Mills 1991).
- Commodities have significant predictive power in explaining short-run movements in CPI inflation, even when researchers control for information contained in monetary aggregates, real output, interest rates, and exchange rates (Horrigan 1986; Webb 1988; Durand and Blondal 1991; Cody and Mills 1991; Garner 1989).
- The economic magnitude of these signals, however, may be small (Horrigan 1986; Furlong 1989; Garner 1989).
- There is some evidence that these relationships have shifted over time, with stronger linkages in the late 1970s and early 1980s than in the earlier period (Whitt 1988; Furlong 1989).

Despite the empirical consensus, there are reasons to believe that the commodity-CPI connection may have weakened since the mid-1980s. First, with commodities playing a smaller role in U.S. production, and in the absence of major food and oil price shocks, recent commodity price fluctuations may not have been big enough to be passed through to consumer prices. Second, the theoretical literature on commodity prices suggests that the recent attention of monetary authorities to commodity prices may have diminished commodities' signaling role.[4] This would occur if monetary authorities eased or tightened policy in response to the inflationary signals of commodity prices and thereby mitigated the actual inflation outcome. Third, because commodity investments have yielded a poor return in recent years, they have lost some appeal as inflation hedges, making them less sensitive to inflation expectations. Finally, recent commodity movements may have little to do with underlying inflation pressures and instead may reflect a rebound in very depressed markets and the impact of movements in dollar exchange rates.

Testing Commodities' Signaling Power

Eight Commodity Price Indicators

For our empirical tests, rather than focus on a single commodity index, we consider five popular alternative indexes and three key subgroups of commodities. Each of the indexes has advantages and disadvantages relating to the properties of its construction and its correspondence to the various commodity fables.

The most popular indicators in past empirical research have been the Commodity Research Bureau (CRB) spot index, the *Journal of Commerce* (JOC) index, and the crude PPI:

- The CRB index is a simple, equally weighted average of twenty-three commodities, including foodstuffs and industrial materials. It is updated instantly on computer screens and is the most closely watched commodity index.
- The JOC focuses just on industrial commodities and is therefore presumably well suited to capture the tortoise-and-hare fable discussed above. It also has the advantage of being specifically weighted according to the inflation sensitivity of each of its components.
- The crude PPI is divided about evenly into three parts: food, energy, and other. It is weighted according to the actual value of commodity shipments and therefore presumably is the best index for exploring how commodity price increases are passed through to final goods prices.

In addition to these three traditional indexes, two survey-based measures of commodity prices have recently garnered attention—the NAPM and PHIL price indexes. Both of these indexes measure the diffusion of price increases across firms:

- The NAPM index measures the percentage of manufacturing firms reporting higher material prices, plus half the percentage of those firms reporting no change in prices. It therefore has a value of roughly 50 percent when aggregate prices are unchanged.
- The PHIL index, calculated a bit differently, is the percentage of firms in the Philadelphia region reporting higher prices, minus the percentage reporting lower prices; hence, it should have a value of roughly zero when aggregate prices are unchanged.

Historically, both of these diffusion indexes have proved to be quite sensitive to conditions in commodity markets.

Three subgroups of commodities are also potentially useful inflation predictors:

- Gold traditionally has been the commodity most associated with inflation hedging.
- Food and oil have both been subject to major supply disruptions and can be used to pinpoint the price pass-through scenario.

Impressionistic Evidence: Turning Points and Trends

The simplest, least technical test of the inflation-signaling power of commodity prices is to look at turning points in the inflation cycle. The top panel of Chart 2 plots core CPI inflation, with shading to indicate periods of falling inflation; the bottom panel plots inflation in the JOC index and superimposes the shaded regions from the core CPI chart. The chart illustrates why commodity prices gained popularity as inflation indicators in the 1970s: from the late 1960s to the early 1980s, JOC inflation peaks and troughs regularly predated peaks and troughs in core CPI inflation. There were no missing signals over this period and there was only one false signal: in 1976, JOC inflation peaked and then declined, but CPI inflation continued to trend up.

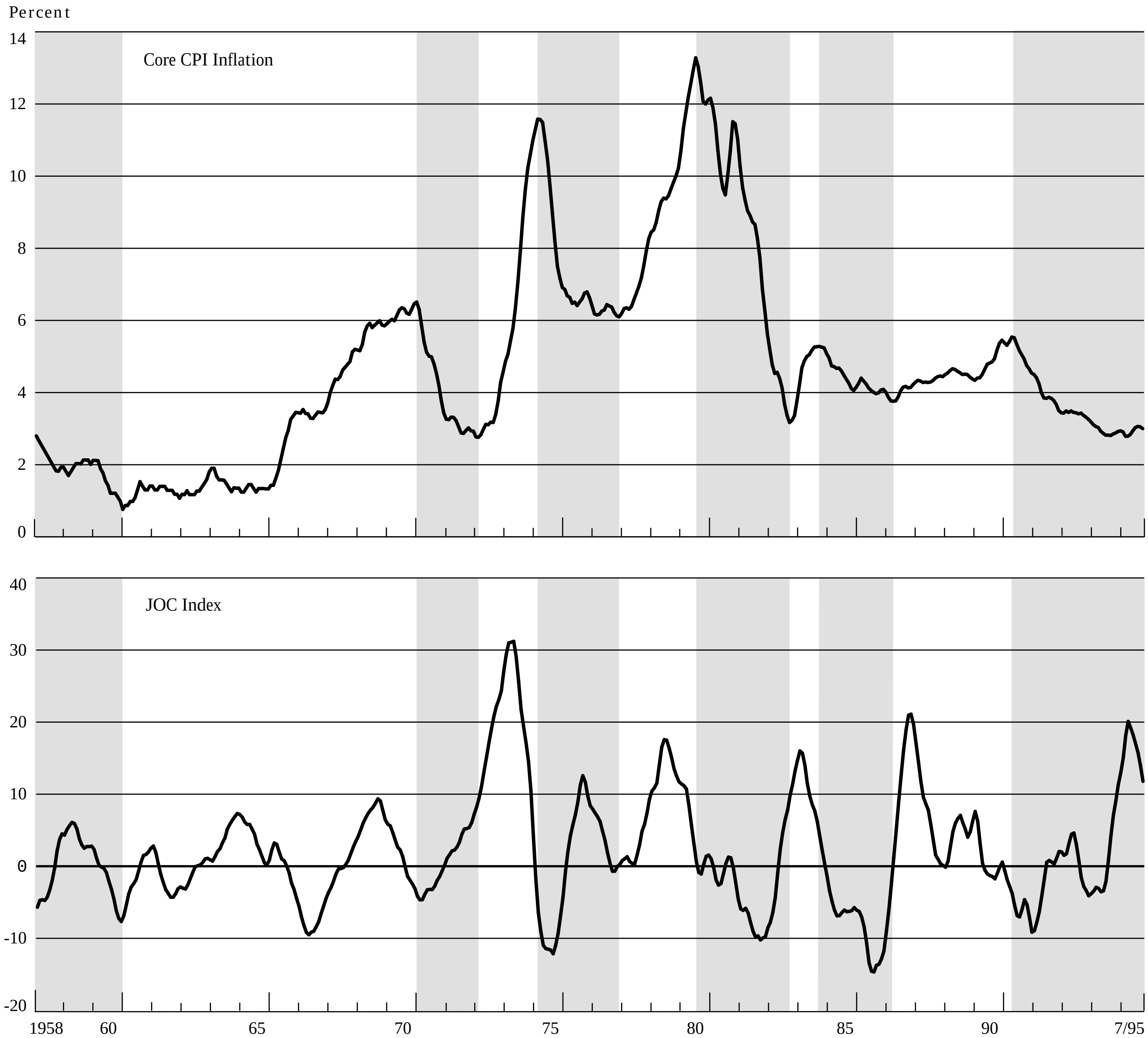
During the 1960s and over the last decade, the JOC index has been a poor leading indicator of turning points in inflation, sending more false signals than correct signals.

Chart 2 also underscores why we suspect that commodity prices have not always been reliable indicators of future inflation. During the 1960s and over the last decade, the JOC index has been a poor leading indicator of turning points in inflation, sending more false signals than correct signals. For the most recent period, strong false signals have occurred in 1987 and 1992. Even the correct signals have been somewhat misleading, with very sharp commodity price surges preceding relatively mild inflation accelerations. Similar results hold for the other major commodity indexes. Thus, on a stand-alone basis, commodity price indexes appear to be relatively unreliable indicators of inflation in the recent period.

Another reason to suspect a breakdown in the commodity-CPI connection is the steady drifting apart of price levels. Chart 3 plots three stages of producer prices—the crude, intermediate, and finished goods PPIs—along with the core CPI since 1967. Note that each stage seems to be relatively tightly linked until 1980. After that, each index seems to drift apart, with the magnitude of the drift increasing at each stage of fabrication. Although this drift does not necessarily compromise the short-run commodity-

Chart 2

The JOC Index and Turning Points in Inflation

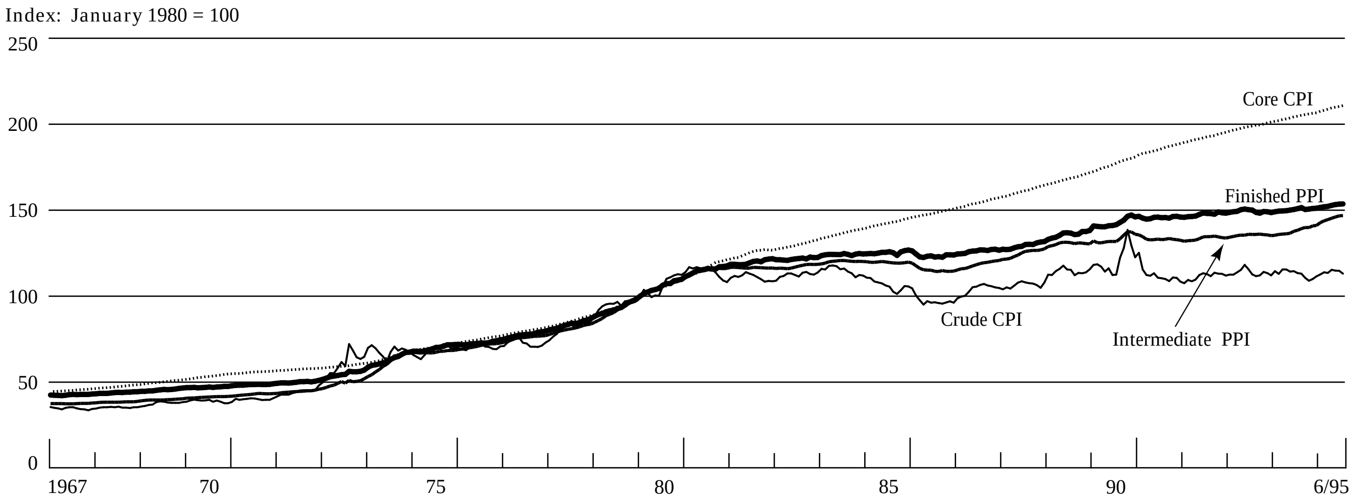


Sources: Bureau of Labor Statistics; *Journal of Commerce*.

Notes: Each series is a three-month moving average of twelve-month percentage changes. The shaded areas denote periods of declining core CPI inflation.

Chart 3

Prices by Stage of Fabrication



Source: Bureau of Labor Statistics.

CPI relationship, it does make the arguments for a long-run price pass-through more tenuous.

Formal Tests: VARs

The impressionistic evidence suggests that the linkage may have broken down; we now present more rigorous evidence of a structural shift. We assess the overall performance of the commodity indicators using conventional VARs, which provide simple tests of the short-run causal relationship between these variables. In addition to using conventional VARs, we present in the appendix the results obtained by using two alternative VAR models: error correction models, which test for long-run as well as short-run linkages; and time-varying parameter models, which can be used to explore shifts in the relationships among the variables without having to divide the sample. These alternative models generally confirm the findings for the conventional VARs.

For our VAR tests, we regress core CPI on lags of itself and lags of a commodity index. Each equation also includes a constant, a time trend, and the prime-age male unemployment rate to control for business cycle impacts on inflation. All variables included in the models are appropriately differenced to ensure that the data are "stationary"; we also include twelve lags on each explanatory variable.[5] In addition to estimating our core CPI equations, we test for a two-stage link between commodity prices and core CPI inflation by first estimating the relationship between the commodity indexes and the finished goods PPI and then testing the impact of the finished goods PPI on core CPI inflation. This two-stage approach enables us to explore the commodity-CPI connection in more detail.

The results for the full sample[6]—January 1970 to April 1994—confirm some findings in the literature. The top panel of Table 1 shows tests of the joint statistical significance of twelve lags of the commodity indicators in predicting the change in core CPI inflation, as well as the sign of the sum of the coefficients. The bottom panel of the table shows the results when finished goods PPI inflation is the dependent variable. If the commodity indexes are useful predictors of final goods inflation, we would expect the sum of the coefficients to be positive and statistically significant (generally with p-values of less than .05). As in past studies, the CRB and JOC indexes are significant and have the correct sign in explaining both the core CPI and the finished goods PPI. Thus, they seem to provide information beyond that contained in the model's other variables.

Some of the full sample results, however, are surprising. The crude PPI is insignificant not only in the core CPI equation, but in the finished goods PPI equation as well. This result is particularly troubling for the price pass-through view of the inflation process because the crude PPI—more than any other commodity index—is weighted to reflect the use of commodities in production. Our finding also contradicts studies such as Horrigan's (1986), which found that the crude PPI was significant in explaining the first difference of CPI inflation for the 1959-84 period. The finished goods PPI does help explain core CPI inflation, so there is only one weak link in the chain running from crude producer goods to finished producer goods to consumer prices.

The results for the diffusion indexes—NAPM and PHIL—also warrant some discussion since these indexes have garnered considerable attention among business economists and financial market analysts but have been largely ignored in the academic literature. These indexes have advantages and disadvantages relative to the JOC and CRB indexes. On the plus side, they reflect the actual prices companies pay for inputs—through long-term contracts and auction markets—whereas the CRB and JOC indexes include only auction prices. On the minus side, they are based on qualitative surveys and are not released to the public until weeks after the data are collected (by contrast, the JOC and CRB indexes are immediately available).[7] Thus, it is an empirical question whether the release of these diffusion indexes each month adds any information beyond that already reported in the market-based indexes. The full-sample findings in Table 1 suggest that the academics have been right to ignore the diffusion indexes: neither is useful in predicting either core CPI inflation or finished goods PPI. Indeed, in "horse races"—when the diffusion indexes enter in the same regression as either the JOC or CRB index—they are never significant.

SPLIT SAMPLE RESULTS: A BREAK IN THE COMMODITY-CPI CONNECTION

Table 1 also shows the results when we split the sample into two parts: an early period (January 1970 to December 1986), which roughly covers the period tested in many previous studies, and the more recent period (January 1987 to April 1994). Preliminary tests showed a significant structural break in these models in the mid-1980s, with the qualitative results insensitive to the particular date chosen.[8] The results for the earlier sample continue to support previous research: the sum of the coefficients for the commodity variables always has the correct sign and is highly statistically significant. In contrast to the full sample results and in conformity with Horrigan (1986), the crude PPI is also significant.

For the more recent period, the good news is that all of the commodity indexes except CRB have a significant positive relationship to the finished goods PPI. Indeed, in contrast to the full sample, the two diffusion indexes—NAPM and PHIL—have a significantly positive relationship with the finished goods PPI. The bad news, and perhaps this article's key finding, is that except for the JOC index, all of the commodity indexes have a perverse *negative* relationship to core CPI inflation. Even the finished goods PPI has developed a negative link, suggesting a breakdown in the relationship between the inflation process in the

Table 1
VAR TESTS OF COMMODITIES AS INFLATION PREDICTORS

Dependent Variable: Change in Core CPI Inflation

	1970-94		1970-86		1987-94	
Commodity Indicator	Sign	P-Value	Sign	P-Value	Sign	P-Value
JOC	(+)	.01	(+)	.01	(+)	.06
CRB	(+)	.01	(+)	.00	(-)	.02
PPI crude	(+)	.32	(+)	.06	(-)	.04
NAPM	(+)	.20	(+)	.00	(-)	.03
PHIL	(+)	.52	(+)	.04	(-)	.01
PPI finished	(+)	.00	(+)	.00	(-)	.01

Dependent Variable: Finished Goods PPI Inflation

	1970-94		1970-86		1987-94	
Commodity Indicator	Sign	P-Value	Sign	P-Value	Sign	P-Value
JOC	(+)	.00	(+)	.00	(+)	.00
CRB	(+)	.01	(+)	.00	(+)	.57
PPI crude	(+)	.61	(+)	.00	(+)	.07
NAPM	(+)	.24	(+)	.00	(+)	.00
PHIL	(+)	.23	(+)	.03	(+)	.00

Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau, National Association of Purchasing Managers, Federal Reserve Bank of Philadelphia.

Notes: Table reports the sign and joint statistical significance of the coefficients for each commodity index. The explanatory variables in the regression include a constant, a linear time trend, and one to twelve lags of: the prime-age male unemployment rate, the dependent variable, and a commodity index. NAPM and the unemployment rate enter as levels; PHIL enters as a difference; and the CRB, JOC, crude PPI, and finished PPI enter as log differences.

manufacturing sector and the overall economy. In other words, for many indexes, an increase in commodity inflation has become associated with a future slowing in core CPI inflation.[9]

OUT-OF-SAMPLE FORECASTS

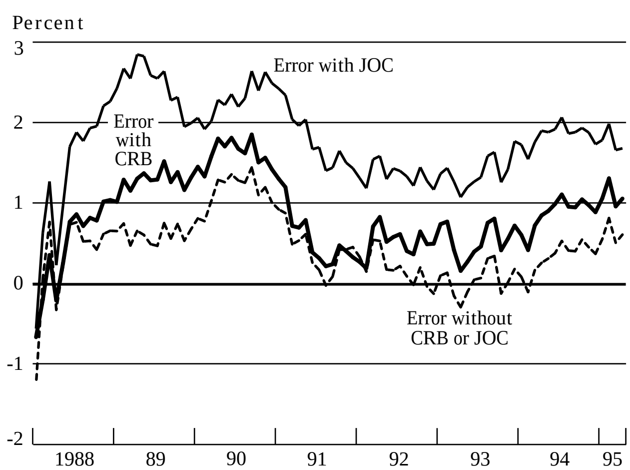
Although Table 1 suggests that commodity indexes have failed to correctly signal movements in core CPI inflation in the recent period, it tells us nothing about the magnitude of this signaling error. To get a sense of the size of this error, we take the parameter estimates for the 1970-86 period for the CRB and JOC models and simulate the models dynamically over the 1987-94 period (Chart 4). The out-of-sample errors from this forecasting exercise could reflect either shifts in the coefficients for the commodity variables or shifts in other relationships in the model. To pinpoint the impact of the weakened commodity connection, therefore, the chart presents three simulations: one excluding the commodity indexes, a second including the CRB index, and a third including the JOC index. The difference between the simulations with and without the commodity indexes is used to measure the additional error (or improvement) in the forecast due to the commodity variable.

The simulations confirm that these models have a chronic tendency to overestimate the change in inflation in the recent period. This overprediction is due in part to misleading signals from the commodity indexes and in part to a shift in other relationships in the model. Chart 4 plots a twelve-month moving sum of the monthly forecast errors. It shows that the model without a commodity index predicted an earlier and more virulent acceleration in inflation in the 1987-89 period than in fact occurred; the model also suggested an uptick in inflation in 1994 rather than the actual downtrend. When the CRB index is included in the model, the overpredictions are even larger, particularly for 1989 and 1994, and the average annual error is about 1 percentage point over the entire 1987-94 period.

The bad news, and perhaps this article's key finding, is that except for the JOC index, all of the commodity indexes have a perverse negative relationship to core CPI inflation.

Chart 4

Model Prediction Errors Attributable to Commodity Indexes



Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau.

Notes: The model for the acceleration in core CPI inflation is estimated through December 1986 and then dynamically simulated forward. The forecast prediction errors are reported as a twelve-month moving sum. The sums for the first twelve months include both in-sample and out-of-sample errors.

The results are more dramatic for the JOC index: the model significantly overpredicts over the entire period, with annual errors of more than 2 percentage points in the late 1980s and about 1 1/2 percentage points in 1994. This poor performance is particularly troubling because this index was designed specifically as an indicator of broad inflation. Moreover, similar results are obtained when the other commodity indexes are used, with an average annual overprediction of about 1 percentage point.

ARE THE PARTS WORTH MORE THAN THE WHOLE?

By lumping together a diverse group of commodities, the indexes could obscure their components' predictive power. This would be the case if some commodities were not good inflation predictors or if the timing of the inflation signals varied among different kinds of commodities.

To investigate these possibilities, we subject three narrowly defined commodities—gold, food, and oil—to the same tests as the broader indexes (Table 2). Despite its reputation as an inflation hedge, gold shows the weakest results, sending unreliable signals for the full sample period and both subsamples. Indeed, in the earlier period, the sum of the coefficients on gold is negative and statistically significant, suggesting that rising gold prices are a signal of falling consumer price inflation.

By contrast, both oil and food—with positive, significant coefficients—appear to be good predictors of core CPI inflation in the earlier period. This is consistent with the idea that major supply disruptions in these markets fed through to general inflation in the 1970s and early 1980s. In the more recent period, both continue to have the correct sign. In the case of oil, this probably reflects the impact of the 1990 supply shock to oil prices. As we will explain later, one reason for this positive response may be that monetary policymakers are more reluctant to tighten when the commodity price rise is due to a supply shock rather than a demand shock. Supply shocks pose a dilemma for policymakers because inflation pressures increase at the same time that real economic activity weakens. Hence, supply-induced increases in commodity prices are more likely to be allowed to show through to increases in final goods prices.

Table 2
THE PREDICTIVE POWER OF THREE COMMODITY SUBGROUPS

	1970-94		1970-86		1987-94	
Commodity Indicator	Sign	P-Value	Sign	P-Value	Sign	P-Value
Gold	(-)	.31	(-)	.05	(-)	.18
Food	(+)	.01	(+)	.00	(+)	.00
Oil	(+)	.05	(+)	.01	(+)	.02

Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau.

Notes: The dependent variable is the second difference of log core CPI. The table reports the sign and joint statistical significance of the coefficients for each commodity index. The explanatory variables in the regression include a constant, a linear time trend, and one to twelve lags of: the prime-age male unemployment rate; the dependent variable; and the price index for either gold, food (a subcomponent of the CRB), or oil (West Texas Intermediate posted price before 1982 and spot price thereafter). The unemployment rate enters as a level, gold enters as a log difference, and oil and food enter as second log differences.

EXPLAINING THE DIMINISHED SIGNALING POWER OF COMMODITIES

Commodity prices have clearly become a much less reliable indicator in the recent period. In this section, we combine impressionistic evidence, results from other research, and our own empirical findings to support three explanations for the shift:

- the diminished use of commodities as inflation hedges,
- monetary policy reactions to commodity prices, and
- the shift away from commodity-intensive production.

In recent years, commodities have lost much of their reputation as an effective tool for hedging inflation. Over the postwar period, all three major commodity indexes have failed to keep up with inflation and have been particularly poor performers during the last twenty years (Table 3). Some individual commodities have fared better but have still fallen well short of safer investments, such as Treasury bonds. For example, although gold prices have matched the CPI for the 1975-94 period as a whole, they have been a very volatile investment, skyrocketing in the late 1970s, then dropping sharply, and finally hovering around $400 per ounce for more than a decade. It is therefore not surprising that investors have generally rejected commodities as an inflation hedge and instead are using financial futures on interest rates or exchange rates. For

Table 3
THE ANNUAL REAL RETURN TO COMMODITIES

Commodity Indicator	Postwar	1975-94
JOC	-2.4	-3.1
CRB	-1.4	-3.0
PPI crude	-1.2	-1.8
Gold	1.4	0.1
Nonferrous metals	0.0	-1.0
Food and feed	-1.8	-2.8
Oil	1.1	-2.2
Memo: Ten-year Treasury bonds	2.6	3.5

Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau, Board of Governors of the Federal Reserve System.

Notes: Each variable is deflated by the CPI. The postwar sample starts in 1947, except for JOC and CRB, which start in 1948 and 1967, respectively. Nonferrous metals and food and feed are components of the crude producer price index, and oil is the West Texas Intermediate posted price before 1982 and spot price thereafter.

instance, in 1993, trading in Treasury bond futures outnumbered trading in gold futures more than ten to one (Einhorn 1994). If gold and other commodities are not seen as reliable inflation hedges, then less of their movement will be due to changes in inflation expectations (and a larger portion will be due to factors specific to commodity markets).

A second explanation for the weaker predictive power of commodities is that they may be an example of Goodhart's law. Goodhart argued that "any statistical regularity will tend to collapse once pressure is placed on it for control purposes." Therefore, if investors believe that monetary authorities are reacting to the inflation signals from commodity prices, then the commodity price movements will begin to reflect market expectations of monetary policy rather than independent information on the economy. As an extreme example, Fuhrer and Moore (1992) show that if the monetary authorities include commodities in their "reaction function," even "mild targeting pressure" on commodity prices can lead to perverse results, with increases in commodity prices predicting a decline in final goods prices. In this case, the signal of *incipient* inflation pressures from commodities may be correct, but little *actual* inflation occurs because of offsetting monetary policy. To continue our tortoise-and-hare analogy: the hare sprints ahead, but the authorities cancel the race before it heats up.

Table 4
COMMODITY COEFFICIENTS WHEN MONEY AND THE DOLLAR ARE ADDED TO THE 1987-94 MODEL

	Core CPI Model		Finished PPI Model	
Commodity Indicator	Sign	P-Value	Sign	P-Value
JOC	(+)	.00	(+)	.00
CRB	(+)	.00	(+)	.00
PPI crude	(+)	.00	(+)	.00
NAPM	(-)	.00	(+)	.00
PHIL	(-)	.03	(-)	.00
PPI finished	(+)	.00	NA	NA

Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau, National Association of Purchasing Managers, Federal Reserve Bank of Philadelphia, Board of Governors of the Federal Reserve System.

Notes: Table reports the sign and joint statistical significance of the coefficients for each commodity index. The explanatory variables in the regression include a constant, a linear time trend, and one to twelve lags of: M2, the trade-weighted dollar (Board of Governors of the Federal Reserve System measure), the prime-age male unemployment rate, the dependent variable, and a commodity index. NAPM and the unemployment rate enter as levels; PHIL enters as a difference; and M2, the dollar, CRB, JOC, crude PPI, and finished PPI enter as log differences.

To test whether monetary policy may have offset some inflation signals from commodity prices, we added a variety of monetary policy measures to our VAR model for the 1987-94 period. Table 4 shows the typical results when M2 and the dollar are added: controlling for monetary policy in this way causes the coefficients to switch signs from negative to positive for several commodity variables.[10] This finding suggests that some of the weakening in the commodity-inflation connection stems from policy reaction.

As Chart 5 shows, however, adding M2 and the dollar only partly solves the tendency of these models to overpredict the acceleration in inflation in the recent period. In particular, we repeat the out-of-sample exercise reported earlier, estimating the JOC and CRB models over the 1970-86 period and then simulating them over the recent period. Adding M2 and the dollar to each model does reduce the twelve-month sum of these out-of-sample forecast errors by an average of about 0.2 percentage points, but large overpredictions remain.[11]

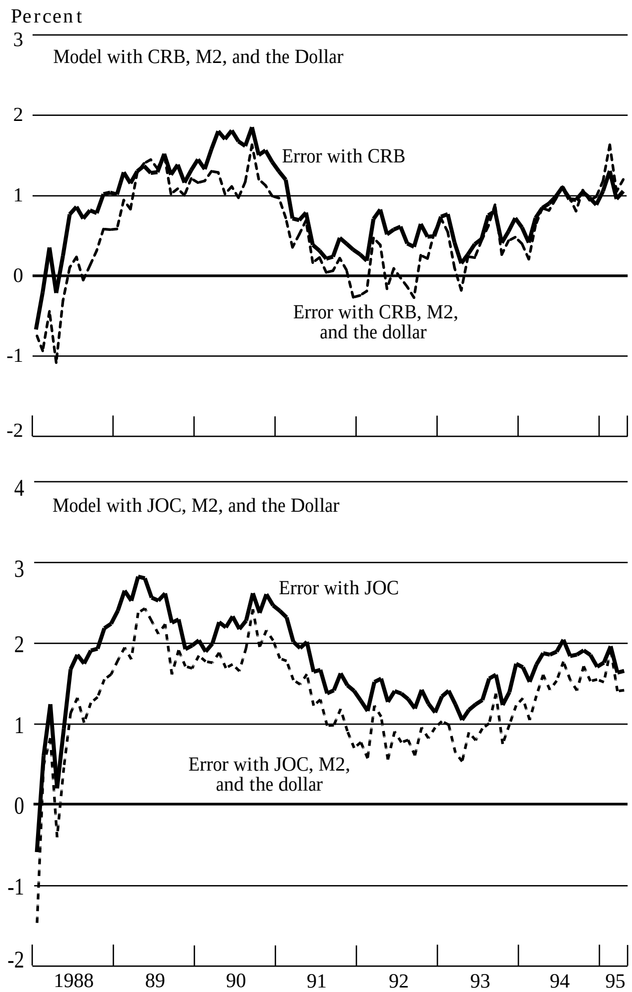
These results complement the literature on the "price puzzle." Christiano, Eichenbaum, and Evans (1994) and others have pointed out that in a simple VAR framework, money tends to have a perverse relationship to aggregate prices—a tightening of policy raises the price level. They also note that if a commodity indicator is added to the model, the price puzzle tends to go away. Here we have turned this puzzle around and have shown that in the recent period, commodities have had a perverse link to aggregate prices—higher commodity prices predict a decline in final goods prices—but the puzzle is partially solved by including money in the model.

The final—and probably most important—factor in the diminished commodity-CPI connection is the sharp decline in the commodity composition of U.S. output. According to Rosine (1987), consumption of spot commodities as a share of nominal GDP ranged from 8 percent to 10 percent from 1973 to 1981, but fell to just 4 percent by 1986.[12] With the ongoing technological revolution, this decline has presumably continued into the 1990s.

This diminished role seems to reflect a sharp downward shift in demand for commodities that has lowered both the relative price of commodities and the growth in quantity consumed. Final demand has moved steadily away from goods with high commodity content (such as food, textiles, and furniture) toward sectors with low commodity content (such as engineering products, electronics, plastics, and services). For example, from 1948 to 1994,

Chart 5

Prediction Errors in a Model That Controls for Monetary Policy



Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau.

Notes: The model for the acceleration in core CPI inflation is estimated through December 1986 and then dynamically simulated forward. The forecast prediction errors are reported as a twelve-month moving sum. The average for the first twelve months includes both in-sample and out-of-sample errors.

the share of services in consumer spending almost doubled, from 32 percent to 57 percent. Furthermore, although commodity price inflation has exceeded CPI inflation for brief periods, for the 1970-94 period as a whole, commodities have lost more than half their value relative to consumer prices (Chart 6). This reduced role for commodities means that they are a less reliable inflation signal, not only

The final—and probably most important—factor in the diminished commodity-CPI connection is the sharp decline in the commodity composition of U.S. output.

because price pass-through effects are weakened, but because as increasing parts of the economy become independent of commodity markets, a rise in commodity prices is more likely to reflect an increase in a narrow part of final demand than an increase in economy-wide demand.

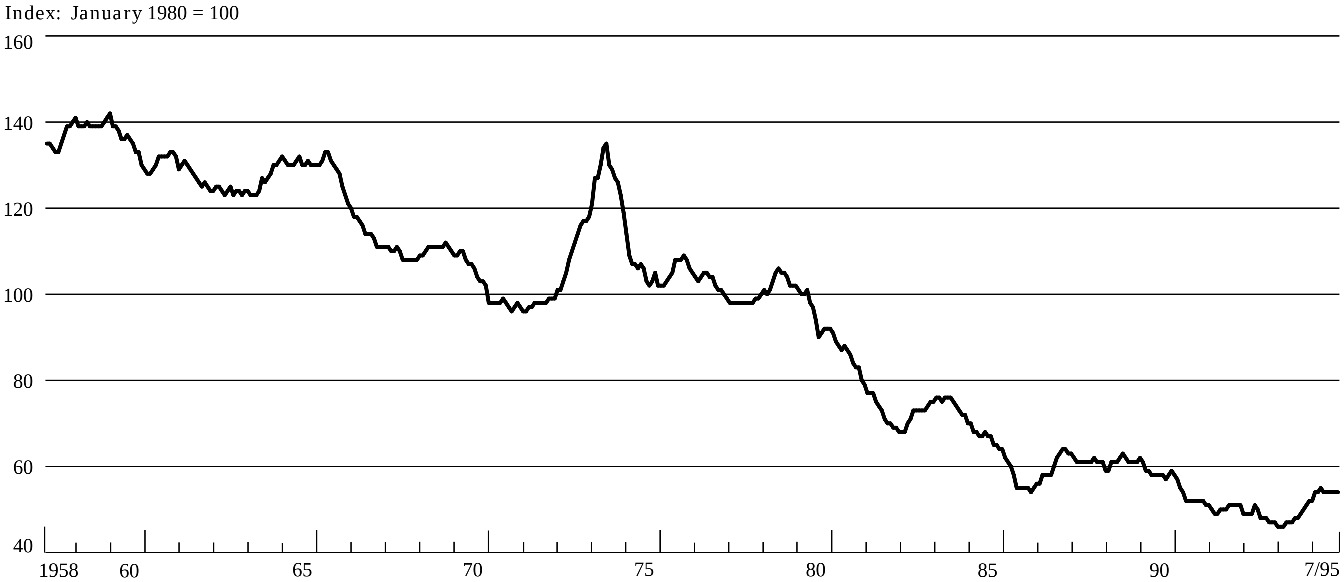
WHY HAVE COMMODITY PRICES RISEN?

If commodities are not signaling major inflation pressures, why have they risen so sharply? In large part, two factors seem to be at work. First, in many cases, prices have rebounded from unusually depressed levels. As in most cycles, the initial rebound in commodity prices may represent a catching-up process or a return to more normal input demands rather than a signal of economy-wide capacity pressures. As Chart 6 shows, even with their recent rebound, commodity prices remain well below their late 1980s peaks in real, CPI-adjusted terms.

Second, commodity prices may also have risen in response to the weak dollar. We would expect commodities—which are homogenous goods and are heavily traded in international markets—to be subject to the law of one price, that is, to have similar prices in each country's home currency. Thus, if the dollar weakens relative to other currencies, all else being equal, commodity consumers outside the United States should be willing to pay more dollars for

Chart 6

"Real" JOC Index

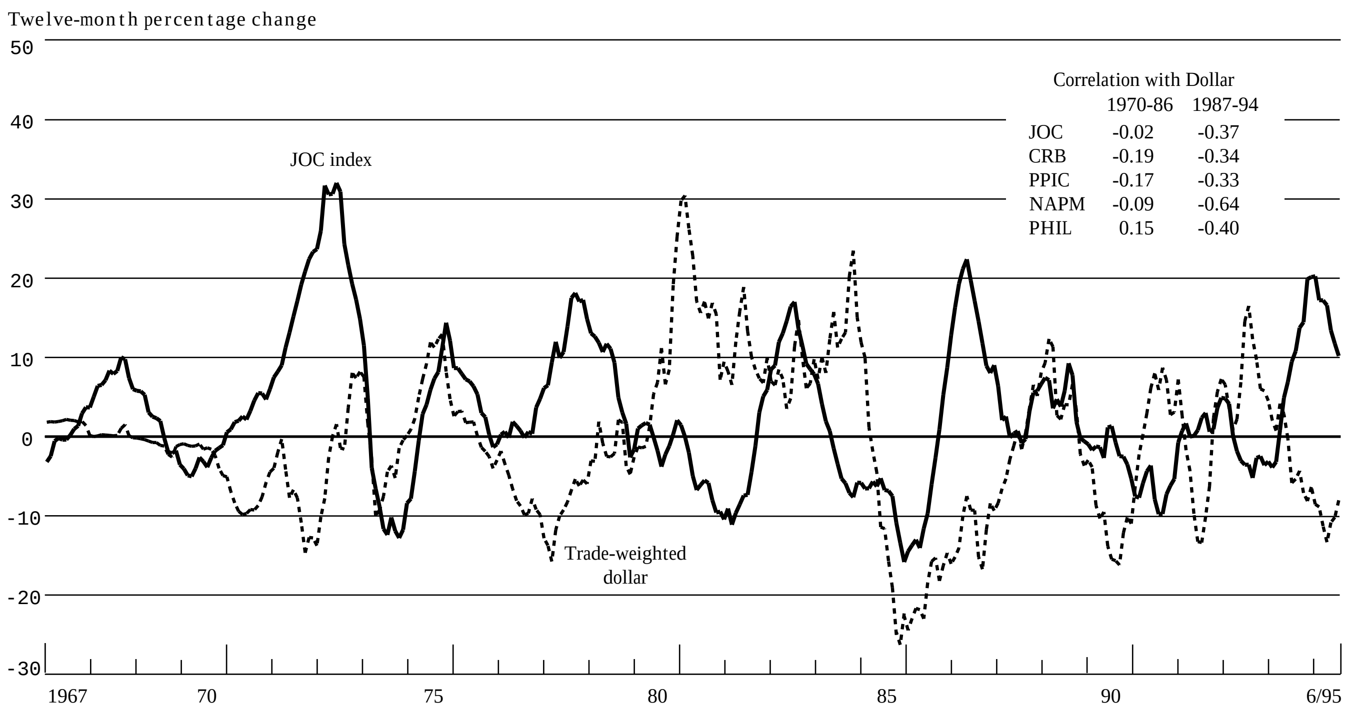


Sources: Bureau of Labor Statistics; *Journal of Commerce*.

Note: The values are calculated by dividing the JOC index by the CPI and then rescaling the data to equal 100 in January 1980.

Chart 7

Commodity Inflation and Dollar Appreciation



Sources: *Journal of Commerce*; Board of Governors of the Federal Reserve System.

commodity inputs, bidding up their dollar price.[13] Chart 7 shows that commodity prices have been particularly sensitive to dollar movements in recent years. For example, over the 1971-86 period, the simple correlation between twelve-month changes in the dollar and the JOC index was only -0.02, but grew to -0.34 in the 1987-94 period.

Conclusion

This article has analyzed the short- and long-run relationships between commodity prices and consumer prices. Using several VAR specifications, we find that most commodity indexes did have predictive power in explaining consumer inflation in the 1970s and early 1980s. However, we also present evidence that commodities have either lost that power or, in some cases, are sending perversely negative signals.

What accounts for this poor performance? Commodities have declined in importance, both as a share of final output and as a source of exogenous shocks to the economy. Some commodity price signals may also have been offset by countervailing changes in monetary policy. Furthermore, much of the recent commodity price run-up should be seen as both a reaction to the dollar's weakness and a normal catch-up from very depressed levels.

These findings clearly pour some cold water on the use of commodities as inflation signals in the recent period. But could commodities regain their predictive power in the future? There is little reason to expect a change in the trend away from commodity-intensive production; commodities should continue to diminish in importance as a measure of input prices and as an indicator of broad-based strength in the economy. In other respects, however, their signaling power may partially revive. Commodities should remain an indicator of global excess demand. Thus, even if they do poorly in predicting inflation in individual countries, they should retain some role as global inflation predictors. There are also signs of a partial revival in commodity investments as inflation hedges: several new commodity funds cropped up in the last year.

Nonetheless, in the absence of a major supply shock, commodity prices should remain a secondary indicator of future inflation. Inflation hawks might more profitably focus on the unemployment rate and other indicators for signs of future inflation.

The conventional VAR methods reported in this article are the most popular, but not the only, econometric methodology used in the commodity literature. This appendix briefly reviews the results for two alternatives: (1) error correction VARs, which help us regain information on the long-run relationships among the variables, and (2) time-varying parameter VARs, which provide a more flexible test for shifts in the model relationships.

ERROR CORRECTION VARS

If two or more series have a cointegrating relationship—an equilibrium relationship to which they gravitate over time—then conventional VAR specifications ignore useful information. Error correction VAR models can help us regain information on these long-run relationships. In this two-stage procedure, we first estimate a cointegrating vector and we then add the lagged errors from this cointegrating regression—the error correction term—to the conventional VAR model to explain the acceleration in CPI inflation.

The stationarity tests reported in this article limit the scope for cointegration. Two series can only be cointegrated at one degree of differencing less than the differencing needed to achieve stationarity. As a result:

- NAPM, which is stationary in levels, cannot be cointegrated with the core CPI, and
- the other four commodity indexes and the core CPI cannot be cointegrated at the same degree of differencing because the commodity indexes are stationary in first differences, while the core CPI is stationary in second differences.

Nonetheless, cointegration tests were run and revealed that the *levels* of the JOC, CRB, and crude PPI indexes were cointegrated with core CPI *inflation*, but only if the finished goods PPI was also included in the cointegrating vector.[14]

These cointegration results present a dilemma for the literature on the commodity–consumer price connection. Although the statistical results show a long-run linkage between the *level* of commodity prices and the rate of core CPI inflation, this relationship is difficult to reconcile with economic theory. For example, in a price pass-through model, why would a onetime increase in the price of a commodity input cause a permanent increase in the rate of growth in output prices? The puzzling nature of our findings prompted us to focus on the conventional VAR tests of a short-run commodity-CPI linkage in this article.

With this important caveat in mind, we present in the appendix table the error correction results for the three

DUMMY VARIABLE TESTS IN AN ERROR CORRECTION VAR MODEL

	Full Sample		Dummy Variable	
	Sign	P-Value	Sign	P-Value
CRB model				
Error correction	(-)	.01	(+)	.72
CPI	(+)	.00	(-)	.00
Finished PPI	(+)	.01	(-)	.00
CRB	(+)	.59	(-)	.00
JOC model				
Error correction	(-)	.01	(-)	.48
CPI	(-)	.00	(-)	.00
Finished PPI	(+)	.17	(-)	.10
JOC	(+)	.34	(-)	.33
Crude PPI model				
Error correction	(-)	.00	(+)	.09
CPI	(-)	.00	(-)	.00
Finished PPI	(+)	.00	(-)	.00
Crude PPI	(-)	.00	(+)	.00

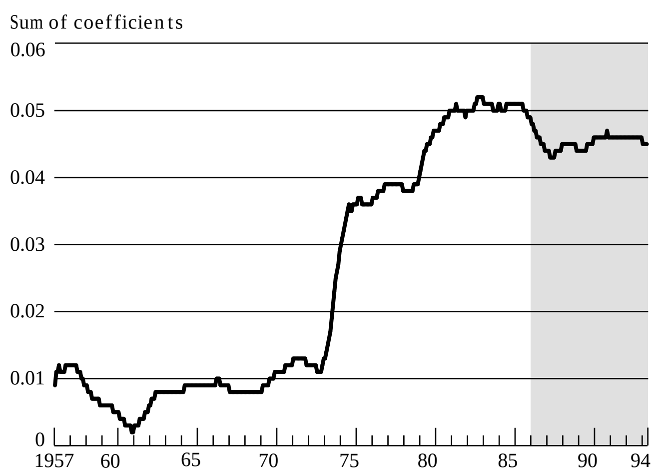
Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*, Commodity Research Bureau, National Association of Purchasing Managers, Federal Reserve Bank of Philadelphia.

Notes: Table reports the sign and joint statistical significance of the coefficients for the principal explanatory variables and the corresponding dummy variables. The dummy variables are set equal to the explanatory variables for the 1987-94 period, and are zero otherwise. The regression equation includes a constant, a linear time trend, the lagged errors from the cointegrating regression, and one to twelve lags of: the prime-age male unemployment rate, the dependent variable, the finished PPI, and a commodity index. NAPM and the unemployment rate enter as levels; the CRB, JOC, crude PPI, and finished PPI enter as log differences.

commodity models. The explanatory variables, including the error correction term, are listed at the left. The first two columns show the sign and the joint statistical significance of the sum of the lagged coefficients associated with each variable. The last two columns continue our tests for a structural shift in these relationships, showing the sign and statistical significance of dummy variables. These variables take on a value equal to the explanatory variable for the 1987-94 period and are zero otherwise. The coefficients for the dummy variables show whether the relationship has shifted in the more recent period, becoming either stronger (positive coefficient) or weaker. The formulation also allows for a formal Chow test of whether the dummy variables are jointly statistically different from zero.

The results from this more complicated model generally support the VAR findings. In particular, the coefficients for the commodity price dummy variables provide further evidence of a diminished short-run linkage between commodities and core CPI inflation in the recent period. The coefficients on both the CRB and JOC dummy variables are negative; for the CRB index, the shift is highly statistically significant. Chow tests are highly significant in all three cases, confirming a shift in the overall relationships in the model.

The Changing Link between the JOC and the CPI



Sources: Authors' calculations, based on data from Bureau of Labor Statistics, *Journal of Commerce*.

Notes: The chart is based on a regression of the second difference in the log of core CPI on a constant, a linear time trend, the prime-age male unemployment rate, and one to twelve lags of the dependent variable and the log change of the JOC index. All parameters are estimated assuming they follow a random-walk process. The sum of the coefficients on the JOC index is plotted as a twelve-month moving average to smooth out month-to-month variations. The shaded area denotes the 1987-94 period.

TIME-VARYING PARAMETER ESTIMATION

Using dummy variables or splitting the sample does not allow us to examine the evolution of the coefficient estimates. In this section of the appendix, we allow the coefficients associated with commodity prices to vary over time. This methodology is useful because it enables us to examine when the relationship between commodity prices and inflation appears strongest and when it appears weakest. The time-varying technique uses initial conditions to estimate coefficients and updates the coefficients under the assumption that the parameters are persistent, that is, follow a random-walk process. The econometrics involved closely resemble those used in Doan, Litterman, and Sims (1984) and are briefly reviewed in Blomberg and Harris (1995).

We estimate the time-varying model for all commodity indexes and obtain qualitatively similar results for all indexes. Therefore, we report only those results for the JOC because it has the longest history of our commodity series. The appendix chart plots the twelve-month moving average of the sum of coefficients associated with the JOC index. The results are generally consistent with our earlier findings: the commodity coefficients tend to increase in the 1970s but decline in the more recent period. The decline appears modest because the estimation methodology only gradually captures a structural shift; if the recent weaker linkages continue, the time-varying coefficients will continue to fall as well.

ENDNOTES

1. Indeed, these models predict that commodity prices will tend to overshoot the mark in response to a money supply increase, rising above their long-run equilibrium initially and then falling back to equilibrium.

2. Even if commodity prices rise simultaneously with final goods prices, the increase will first be *observed* in commodity indexes because they are updated almost immediately, while consumer price indexes are reported with a lag of several weeks.

3. For an excellent review of the literature, see Hilton (1990).

4. Starting in the late 1980s, several Federal Reserve Governors pointed to a role for commodity prices in the conduct of policy. See, for example, Angell (1987), Greenspan (1987), and Johnson (1988). Studies of the Federal Reserve's "reaction function" have found mixed evidence of a role for commodity prices. Hakkio and Sellon (1994), for example, find that commodity indexes are individually statistically significant in explaining movements in the federal funds rate but do not add to the model's overall ability to predict the funds rate over the 1983-93 period.

5. If the data are not stationary—that is, if the underlying process that generated the series changes over time—then classical tests are invalid. Dickey-Fuller tests showed NAPM and the prime-age unemployment rate to be stationary in levels; finished PPI, crude PPI, CRB, JOC, and PHIL to be stationary in first differences; and the core CPI to be stationary in second differences. We experimented with alternative lag lengths. Akaike information criteria suggested that nine or twelve lags were optimal for all our equations, with very little difference in the test statistics. In keeping with the literature and to ensure that seasonal effects were captured, we settled on twelve lags for all our tests. See Blomberg and Harris (1995) for details of these tests.

6. Earlier data are available for some of our commodity indexes, but we choose a uniform sample to make our tests comparable.

7. An additional disadvantage of the PHIL index as an indicator of national inflation pressures is that it covers only a relatively narrow geographic region.

8. In experimenting with alternative dates for splitting the sample, we found a progressive deterioration in the commodity variable coefficients as we moved through the 1980s. For example, although all of the commodity price variables had the correct sign for the full sample, only four of five were correct for the 1979-94 sample, only three were correct for 1983-94, only two for 1985-94, only one for 1987-94, and none for 1989-94. We settled on the 1987 split not only to make comparisons with previous research, but also to ensure an adequate number of observations in each subsample.

9. In contrast to commodity prices, the prime-age male unemployment rate remains a significant inflation predictor in all our equations, regardless of the sample period.

10. Similar results were obtained using the federal funds rate as the monetary indicator. For these equations, we also deleted the trade-weighted dollar, but this change did not materially affect the results for the monetary variables.

11. The simulation results are sensitive to how the unemployment rate enters the model. Although it is logical to assume that the unemployment rate is stationary, the Dickey-Fuller tests suggest that we may want to enter it in first differences rather than in levels. In this case, although the commodity models still tend to strongly overpredict the change in CPI inflation during periods of high commodity inflation, the forecast errors for the 1987-94 period as a whole have less of an upward bias. In addition, by including the change in the unemployment rate, we reverse our finding for M2: it no longer appears to improve the out-of-sample forecast performance.

12. These figures understate total commodity consumption somewhat because they include only purchases on spot markets.

13. A key assumption here is that the dollar movement is exogenous and is causing the commodity price change. Alternatively, both the dollar depreciation and the commodity price surge could reflect worsening inflation expectations. It is hard to believe, however, that the relatively modest inflation cycles of recent years could play much of a role in the period's dramatic exchange rate movements. It seems more plausible to argue that swings in investor sentiment are driving the dollar, which in turn is influencing commodity prices.

14. See Blomberg and Harris (1995) for formal test results.

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