FEDERAL RESERVE BANK OF KANSAS CITY

Economic Review

November/December 1990

FEDERAL RESERVE BANK OF KANSAS CITY

Economic Review

November/December 1990

Economic Review

Federal Reserve Bank of Kansas City

The *Economic Review* (ISSN0161-2387) is published bimonthly by the Federal Reserve Bank of Kansas City, 925 Grand Avenue, Kansas City, Missouri 64198-0001. Subscriptions and additional copies are available without charge. Send requests to the Public Affairs Department, Federal Reserve Bank of Kansas City, 925 Grand Avenue, Kansas City, Missouri 64198-0001. Second-class postage paid at Kansas City, Missouri.

POSTMASTER: Send address changes to *Economic Review*, Public Affairs Department, Federal Reserve Bank of Kansas City, 925 Grand Avenue, Kansas City, Missouri 64198-0001.

Contents

November/December 1990

prices have occurred more often and have become larger in recent years.

Some people blame stock index futures for the perceived increase in stock market volatility. To reduce the effect of futures on volatility, regulations aimed at reducing the general level of futures activity have been adopted or proposed. While these regulations may or may not reduce stock market volatility, they certainly will impose costs on participants in the stock index futures market. Because the regulations are costly, it is important to find out whether the stock index futures market actually contributes to volatility.

Becketti and Roberts find that stock index futures have not increased stock market volatility. Thus, futures market regulations intended to reduce the volatility are unlikely to be effective.

A Crossroads for the Cattle Industry 47

By Alan Barkema and Mark Drabenstott

A decade of mergers, buyouts, and declining cattle numbers has brought the nation's cattle industry to a crossroads. One road would continue the path of the past decade—toward a smaller, more concentrated industry. The other road would change direction and allow some expansion in the industry, although most segments might remain highly concentrated. Which road the industry takes will depend on consumers and their willingness to purchase beef instead of other meats.

The future course of the cattle industry will have great impact on the farm economy in the Tenth District. The two roads ahead spell two very different futures: one road leads to economic stagnation or decline, and the other road leads to economic growth.

Barkema and Drabenstott review the cattle industry over the past decade and explore what lies ahead for the industry and the district. They conclude that the future of the cattle industry depends on whether it can lower its costs while satisfying the consumer's demand for leaner, more convenient beef products.

Judging Investment Strength: Taking Account of High Tech

By Jon Faust

Was investment growth strong or weak in the 1980s? This question is important because strong investment has historically promoted higher living standards for U.S. citizens. Surprisingly, however, there is no consensus on the strength of investment in recent years. Some analysts argue the last decade witnessed an investment boom; others insist investment growth was anemic in the 1980s.

Why the controversy? Judging investment strength has always been difficult, but one issue in particular clouds the current debate: the rise of high tech investment. Over the last 15 years, much investment has shifted from heavy equipment toward high tech equipment, such as computers and other information-processing equipment. The unprecedented change in the makeup of investment has confused the interpretation of standard investment measures. Simply put, it is hard to compare the value of today's high tech investment with that of yesterday's investment in tractors and lathes.

At the time this article was written, Jon Faust was an economist at the Federal Reserve Bank of Kansas City. He is currently a visiting lecturer in economics at Princeton University. Robert Hampton, Jr., an assistant economist at the bank, helped prepare the article.

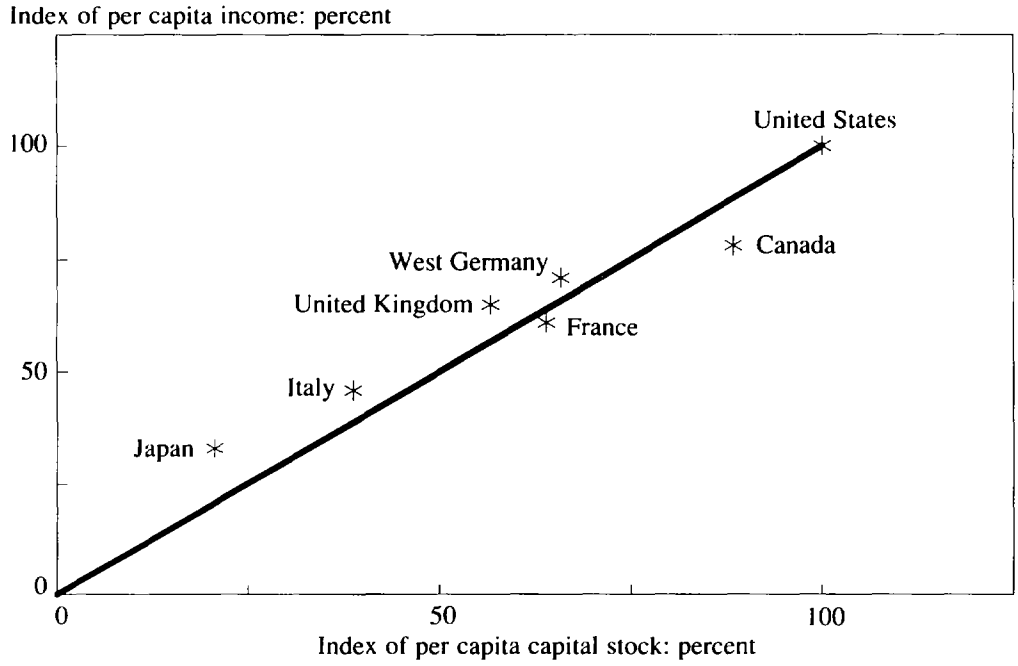
This article evaluates the strength of investment in the 1980s in light of the shift toward high tech investment. The article shows how the rise of high tech investment has distorted traditional investment indicators, and advocates the use of some new, less distorted indicators. The article concludes that, after accounting for the rise of high tech investment, there was no investment boom in the 1980s—nor was there a great bust.

Section I explores the investment controversy. Since the mid-1970s, a rising depreciation rate of the nation's capital stock has caused formerly consistent indicators of investment strength to give conflicting signals. Behind rising depreciation has been a shift toward high tech investment. Section II shows how the shift toward high tech investment has made traditional measures of investment fundamentally unreliable. Section III presents alternative, more reliable measures, which show that investment growth since 1975 has been neither exceptionally strong nor exceptionally weak.

I. The Investment Controversy

Beginning in the mid-1970s, traditional measures of investment strength began to send

Chart 1
Per Capita Income and Per Capita Capital Stock, 1960



Source: Lipsey and Kravis 1987.

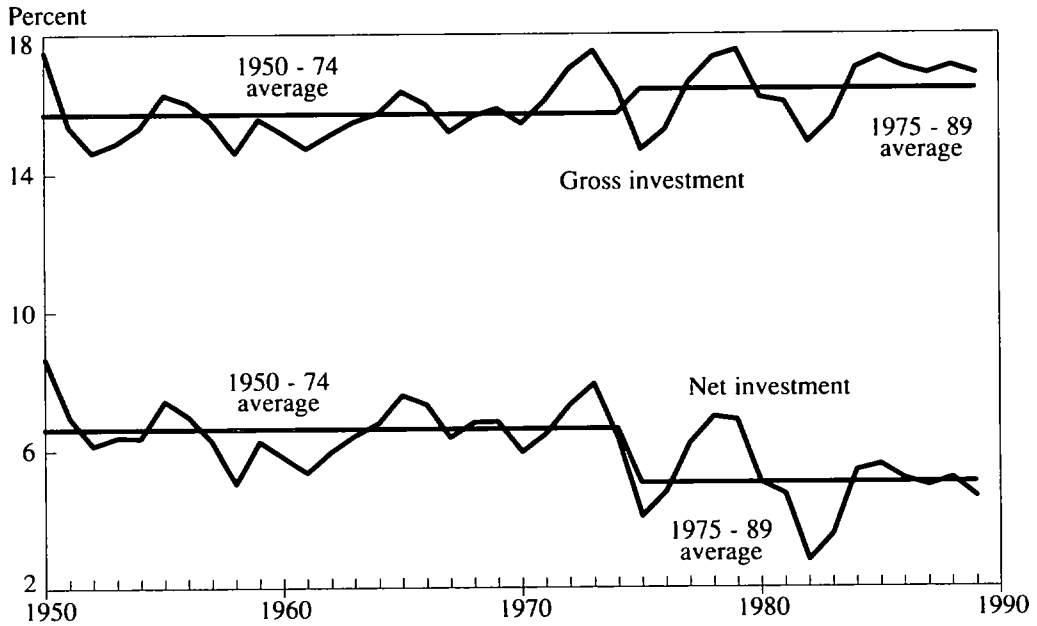
conflicting signals about the strength of investment. Without reliable signals, it has been difficult to gauge the effects of policy initiatives. For example, analysts have been unable to resolve whether the tax reforms and large government budget deficits of the 1980s increased or decreased investment growth.[1] Some analysts contend "the changes in the tax law and regulatory climate inaugurated with Reagan in 1981, and the dramatic decline in the inflation rate thereafter, greatly increased investment demand" (Darby 1989). Other analysts charge that "Reagan's new fiscal policy delivered not more capital formation but less" (B. Friedman 1988).[2] This section shows why such varying views have arisen and how rapidly rising depreciation lies at the heart of the debate.

Diverging investment measures

Analysts monitor investment because it is a key element promoting economic growth. By giving workers more capital to work with, investment allows the average worker to produce more goods than before. For example, using tractors and other modern equipment, a single farmer today can produce about seven times more food than a farmer could produce in 1950.[3] Similar examples of the importance of investment abound throughout the economy.

More generally, data for major industrial countries show a strong relation between investment and economic growth. For example, in 1960 countries with a higher capital stock per capita also enjoyed a higher per capita income (Chart 1).[4] These data for 1960 are typical of the

Chart 2
Gross and Net Investment as a Share of GNP



Source: Department of Commerce, Bureau of Economic Analysis, July issues.

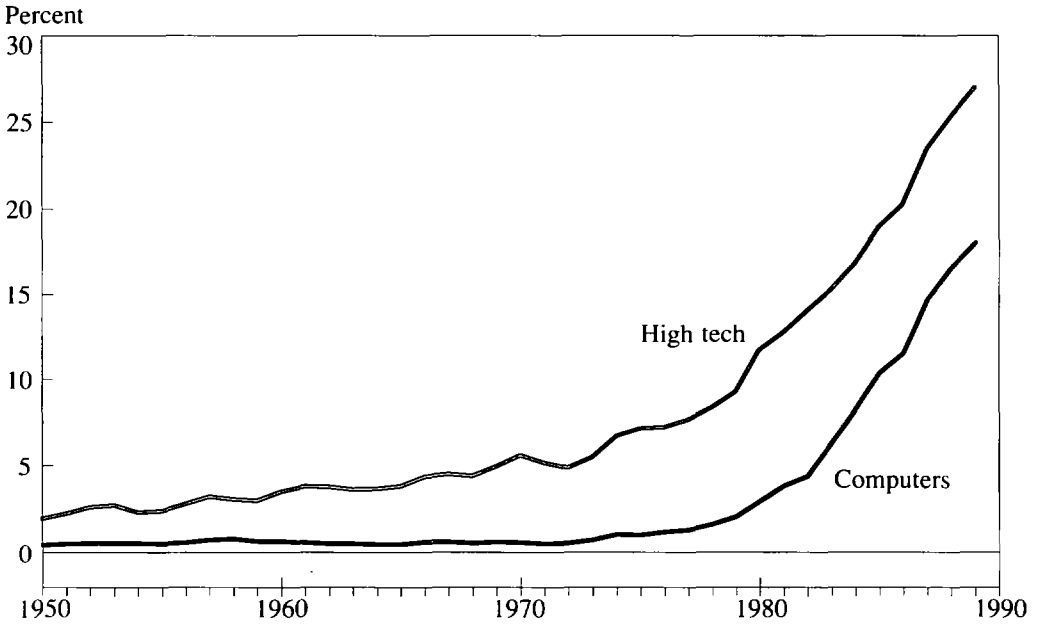
relation between capital and income for these countries since World War II (Lipsey and Kravis 1987).

Because investment is such an important determinant of growth, it is imperative that it be measured accurately. Traditionally, analysts have focused on two measures of investment: *gross investment* as a share of GNP and *net investment* as a share of GNP.[5] While both measures represent the share of GNP set aside to build the nation's capital stock, the measures differ in the way they view investment. Gross investment counts all investment spending, while net investment counts only that portion of investment spending that actually increases the capital stock, leaving out investment going to replace worn-out capital. In other words, net investment equals gross investment minus depreciation. For years analysts have debated the relative merits of the two measures (see box). Until recently, however, the two measures always tended to move together.

The investment controversy has arisen because the gross and net investment indicators have recently been sending conflicting signals. From the late 1940s to the mid-1970s, the two indicators rose and fell together, telling the same story about the health of investment. Since the mid-1970s, however, interpreting the indicators has become much more complicated. The gross investment share has signaled an investment boom, while the net investment share has signaled an investment bust.

The divergence in the behavior of the two investment measures is quite striking (Chart 2). From 1950 to 1974, the shares of national

Chart 3
High Tech and Computer Investment as a Share of Gross Investment



Source: Department of Commerce, Bureau of Economic Analysis, July issues.

income going to gross and net investment remained very close to their average levels of 15.7 and 6.6 percent, respectively. While the investment shares fluctuated, the two series moved up and down in lockstep. Since 1975, however, the two indicators have suggested opposite conclusions about investment strength. The average share of income going to gross investment has risen to 16.4 percent, while the average share of income going to net investment has fallen to 5.0 percent. In particular, this divergent behavior of net and gross investment has continued during the extended economic expansion that began in 1983. From 1983 to 1989, the gross investment share averaged 16.8 percent, while the net share averaged 4.9 percent.

Rising depreciation and high tech investment

It is clear the divergence of the gross and net investment measures is due to rising depreciation. By definition, depreciation is the only difference between the two measures of investment. Indeed, as a share of national income, depreciation rose by two percentage points from 1974 to 1988. And that increase, in turn, is due largely to a shift toward high tech investment.

High tech investment has grown rapidly since the mid-1970s. While there is no high tech category in official investment statistics, the category "information processing and related equipment" is a good measure of high tech investment. This category includes data on three

types of equipment: office computing and accounting; communications; and instruments, photocopiers, and related equipment. These types of equipment encompass many high tech items.[6]

Gross investment in high tech categories jumped to 27 percent of overall gross investment in 1989, up from 7 percent in 1975 (Chart 3).[7] As might be expected, much of this jump was due to increased computer investment. The computer category of high tech investment rose from 1 percent in 1975 to 18 percent in 1989.

Not since World War II has the composition of investment changed so quickly and dramatically. For example, the share of gross investment going to high tech items jumped 18 percentage points during the 14 years ending in 1988. Previously, the largest jump in a single category over a 14-year period was only seven percentage points, which occurred during the commercial building boom following World War II.[8]

The shift toward high tech equipment is the major source of the rise in depreciation. Increased high tech investment has raised the depreciation rate because high tech equipment generally wears out faster than other sorts of

Do Measurement Difficulties Argue for Gross Measures of Investment?

Why cannot analysts simply decide whether gross or net is the more appropriate indicator of investment? If there were good reasons to ignore one measure in favor of the other, the conflicting signals given by the two indicators would not be a problem—analysts would simply use the best indicator. Discussed here are some arguments put forward in favor of gross or net indicators. It is concluded that none of these arguments resolve the conflict, implying that the answer to the investment controversy must be found elsewhere.

Analysts have made both "in principle" and "pragmatic" arguments in favor of one measure or the other. For example, some analysts contend that net investment is, in principle, the more appropriate indicator of investment's contribution to growth. Since investment used to replace worn out capital does not contribute to net growth of the capital stock, the argument goes, net investment should be the better indicator of future growth. On the other hand, other analysts argue that the amount of depreciation is mainly determined by the amount of capital put in place in the past (the more capital put in place in the past, the more capital there is to wear out today). Thus, depreciation is a backward-looking measure. Subtracting depreciation from gross investment, they claim, gives an indicator more of past investment than of future growth (deLeeuw 1990).

Both of these groups have valid points, and analysts have not agreed which measure is better in principle. Ultimately, however, these in principle arguments may not be too important. What analysts are seeking is a reliable simple indicator of investment's contribution to growth. The exact nature of this contribution is complex, and there will be objections to any simple indicator. The important question is, what simple indicator is likely to be most reliable in practice?

On this more pragmatic note, analysts have put forward two arguments about why net investment should be ignored in favor of gross investment. Both arguments stem from the pragmatic issues about how accurately net investment is measured (Scott 1989; and Tatom 1990). Neither argument is convincing.

The first argument is that depreciation is very hard to measure, making net investment measures unreliable. While it is true that

capital. For example, the Bureau of Economic Analysis estimates that the average service life of computers is eight years, nearly the shortest of any type of capital. Metal-working equipment, for example, lasts 16 years, railroad equipment 28 years, and warehouses 40 years (Department of Commerce 1987).

As high tech investment has grown, the expected average service life of new investment in equipment has fallen from 22 years in the first half of the 1970s to 18 years in 1988. For equipment and structures together, the average service life has fallen from 39 years to about 34 years.[9]

The shift to short-lived, high tech investment goods can explain a large portion of the rise in depreciation as a share of GNP. From 1974 to 1988, depreciation on high tech items as a share of GNP increased 1.7 percentage points. In contrast, depreciation on low tech items as a share of GNP increased only 0.3 percentage points. These figures somewhat exaggerate the role of high tech, because investment and hence depreciation in low tech would have been higher if the shift to high tech had not occurred. Nonetheless, the shift to high tech accounts for a substantial portion of the rise in depreciation as a share of GNP.[10]

depreciation is hard to measure, this is not alone an argument in favor of gross investment indicators. If depreciation is important, net investment measures based on shaky depreciation data may well be better than gross investment measures that ignore depreciation entirely.

The second argument in favor of gross investment provides a reason why measured gross investment might be the best indicator of *true* net investment. The argument begins with the fact that investment funds seldom go simply to replace worn out capital. Instead, old machines are usually replaced with better, more efficient, or more useful machines. If this improvement in capital is not accurately measured, then investment going to improve the capital stock might be counted as simply replacing worn out capital. This argument is important because most analysts agree than quality change in capital is very difficult to measure.

For two reasons, however, problems measuring quality change should not lead analysts to ignore depreciation. First, the Department of Commerce has implemented special techniques for dealing with computer investment that are meant to measure the rapid quality change in computers. Thus, the quality issue may not argue for ignoring the rising depreciation on computers.

Second, the appeal of using gross measures due to quality improvement relies on the rough assumption that the mismeasured quality improvement and depreciation nearly cancel out. While this cancellation assumption might be plausible during stable times, it is not plausible when the depreciation rate on capital is changing, as it has recently. For example, when the depreciation rate rises, the cancellation assumption will be valid only in the unlikely event that the pace of mismeasured quality improvement rises with the depreciation rate. If the rate of mismeasured quality improvement does not change in this fortuitous way, the growth of measured net investment will be the best indicator of the true growth in net investment. This is true even in the face of substantial mismeasured quality change. (This conclusion does not imply that net investment is a better measure, only that quality change does not provide a reason to ignore net investment in favor of gross investment.)

Overall, these in principle and pragmatic arguments do not provide a reason to rely exclusively on either gross or net measures.

II. High Tech Distorts the Standard Investment Indicators

The rise in high tech helps explain why the two standard investment measures have diverged. Yet resolving the puzzle over which measure, if either, has been sending an accurate signal requires digging more deeply into the effects of the shift to high tech. This section shows that both measures of investment have been badly distorted by the rise of high tech. The distortions arise from three sources.

Shorter service life implies higher productivity. High tech equipment wears out faster than other capital. In order for it to make good business sense to buy a short-lived piece of equipment, the return on that equipment must be high enough to pay the investment off in a short time. Longer lived equipment can have a lower payoff that stretches over many years. For example, a firm might erect a building that will have a small annual return, knowing that the total payoff over 40 years will justify the initial investment. In contrast, a computer will earn a return for only about eight years and must pay off much more quickly. Thus, to justify an initial investment of $100 in high tech equipment, businesses must expect a return of about $20 per year. In contrast, the building only needs to earn about $8 per year to pay off the same $100 investment.[11]

The higher productivity of high tech investment causes both gross and net investment to paint pictures that tend to be too pessimistic. Both measures ignore the fact that since the mid-1970s investment dollars have shifted into more productive investment than before. Thus, both measures will tend to underestimate investment's contribution to growth.[12]

Short life implies smaller long-run capital stock. While shorter lived capital may be more productive, it contributes for a shorter time. Thus, money spent on short-lived capital will make a smaller long-run contribution to the capital stock than long-lived capital. The long-run increase in the capital stock associated with a given amount of investment in computers, for example, will fall far short of that associated with an equal amount of investment in buildings.

Because the gross investment share takes no account of the more rapid depreciation of high tech items, gross investment measures will currently tend to be too optimistic regarding the long-run investment picture. Depreciation is removed from net investment, on the other hand, implying that it will not be affected by this factor.[13]

Falling high tech prices imply falling high tech productivity. Although high tech investment is more productive than low tech, high tech's relative advantage has undoubtedly fallen throughout the 1980s. This fall in high tech productivity is related to the fall in the price of high tech investment goods.

A typical piece of high tech equipment that cost $100 in 1975 would have cost only $51 in 1989.[14] The price decline has been even more extreme in the computer category of high tech. Computer equipment that cost $100 in 1975 would have cost only $15 in 1989. The decline in high tech prices is even more significant given that the price of other investment goods has risen significantly over this period. For example, a typical piece of low tech capital that cost $100 in 1975 cost $152 in 1989. Thus, while the price of high tech goods fell by almost 50 percent, the price of other capital goods grew by 33 percent.

Falling prices of high tech equipment imply falling productivity of new high tech investment. Productivity declines because businesses apply expensive capital goods only to highly productive tasks, while cheaper capital goods are applied to much less productive tasks. For example, when computer prices were very high, computers were purchased only for extremely productive uses. The biggest firms purchased computers for large jobs that would have been prohibitively expensive without computers.

Today's cheap computers are applied to more mundane tasks, such as keeping electronic address books.

This third effect will tend to make both standard investment measures too optimistic. The standard investment indicators basically assume that a dollar invested in computers today has the same productivity a dollar had in 1982. Why? Because the inflation-adjusted data state values in 1982 dollars, as if 1982 prices still prevailed. But since new computers purchased today are actually applied to less productive tasks than those in 1982, both standard investment measures will tend to give too optimistic a picture of investment.[15]

Thus, the rise of high tech has brought three complications to standard investment indicators. First, high tech equipment is more productive in each year of service than low tech equipment. Second, the equipment is short-lived, and will not contribute to the economy for as long as low tech equipment. Third, new high tech equipment is being applied to less and less productive uses. These complications make one conclusion clear: both gross and net investment measures are currently sending unreliable signals. What is the true picture of investment after adjusting for these distortions?

III. Adjusting for High Tech Distortions: No Investment Boom or Bust

Knowing that the rise of high tech has made both gross and net investment measures unreliable, analysts need some other indicator to judge investment strength. This section discusses the evidence from a relatively new form of investment indicator called *capital input indexes.* These indexes are constructed to be less distorted by rapid changes in the composition of investment. Capital input indexes suggest that the contribution of investment to growth in the 1980s was similar to the contribution in prior decades. Thus, investment measures that account for the shift to high tech support the conclusion there was no investment boom or bust in the 1980s.[16]

Constructing capital input indexes

Capital input indexes are intended to measure the growth in the contribution of capital to economic output. The indexes measure each type of capital separately. Initially, the indexes compute the growth rate of the net stock of each type of capital. The indexes then weight and combine the growth rates into an overall index of capital input growth, using weights that reflect the productivity of each capital type. The weights used in combining the capital growth rates are allowed to change each year to reflect changing productivity of the various types of capital.

Because of the way they are constructed, capital input indexes should not be greatly distorted by the three factors that distort standard investment indicators. The first distortion—the higher productivity of high tech capital—is accounted for in the index by applying a larger weight in the index to high tech capital growth than to low tech growth. The second distortion—the smaller contribution of high tech investment to long-run growth in the capital stock—is directly accounted for in computing the growth rates of the individual capital stocks. The capital stock growth rates are computed using net capital data that reflect the service life of each type of capital. Finally, the third distortion—that falling price implies falling productivity—is accounted for by computing new weights for each year, based on the prices that exist in that year. Thus, while the standard measures use 1982 prices as a base for weighing each year's data, capital input indexes use weights for each year that reflect prices in that year.

If these indexes are so good, why do analysts

rely on the traditional investment measures? The simplicity of traditional measures is, of course, an important virtue. The traditional measures are based directly on data from the national income accounts and have a direct interpretation in terms of the share of income spent on investment. In contrast, creating the weights for the capital input indexes requires complex calculations. While the resulting indexes are indicators of investment strength, they lack the simple, direct interpretation of traditional measures.

Until the mid-1970s, there was no need to abandon the simplicity of the traditional measures. As demonstrated above, however, the recent unprecedented change in the composition of investment has badly distorted traditional measures. In times like these, capital input indexes may be a valuable supplement to simpler measures.

Capital input indexes do not solve all the problems of measuring investment. Important questions remain. For example, should investment include education and military spending?[17] Such questions also plague traditional investment measures. While the capital input indexes do not solve all problems regarding the measurement of investment, they do help solve the problems brought on by rapid change in investment's composition.

What do capital input indexes say about investment?

The impact of the rapid rise in high tech investment can be captured by constructing a simple capital input index that assumes three types of high tech capital—computers, communications, and instruments and photocopiers—and one, generic type of low tech capital. This index, constructed by the author and explained in the appendix, will henceforth be called the HT index. By ignoring changes in the composition of low tech investment, the HT index highlights the shift from low tech to high tech investment. The weights for each capital type in the HT index are assigned in a simple way to reflect the service life and price of the capital.

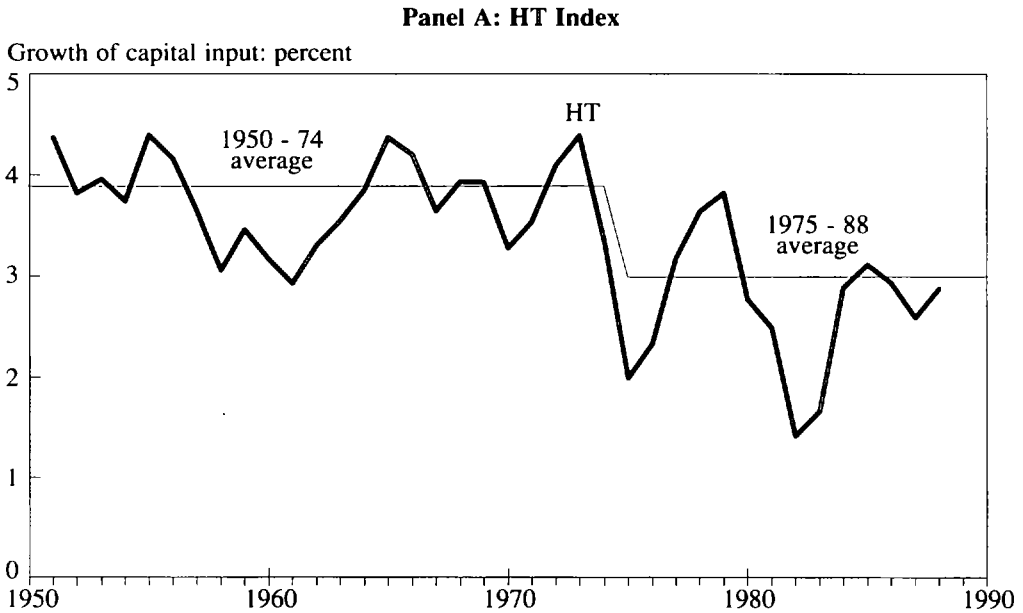
The HT index shows that capital input growth has declined somewhat since the mid-1970s (Chart 4, Panel A). Capital input growth fell from an average 3.9 percent during 1950-74 to an average 3.0 percent during 1975-88.

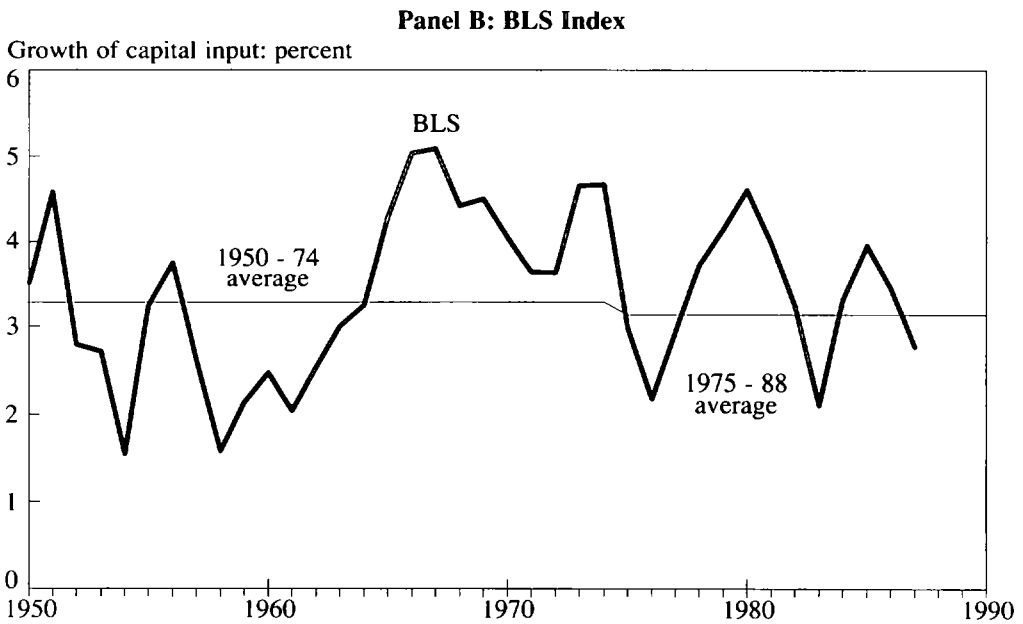
While the HT index emphasizes the shift to high tech, a more comprehensive capital input index, constructed by the Bureau of Labor Statistics, captures all changes in the composition of investment (Chart 4, Panel B). That is, the BLS index takes into account a much broader range of issues than does the HT index.[18] Chart 4 shows that the two capital input indexes have tended to move together closely, except during the 1950s and early 1960s. This agreement since the mid-1960s suggests that the simple HT index, which adjusts only for the shift to high tech, seems to have captured most of the important changes in capital input growth since the mid-1960s. The HT index does not, however, capture some of the adjustments in the capital stock following World War II that are reflected in the BLS index.

By the BLS index, capital input growth averaged 3.4 percent from 1950 to 1974 and only slightly less, 3.3 percent, thereafter. Thus, by this index, which reflects the shift to high tech as well as the earlier adjustments of investment following World War II, capital input growth has shown little change with the rise of high tech.

Overall, then, the capital input indexes provide evidence of neither exceptionally strong nor exceptionally weak investment growth since the mid-1970s.[19] This evidence underscores the unreliability of traditional investment indicators. The changes in the composition of investment have made the gross investment share send too optimistic a signal regarding investment,

Chart 4
Two Capital Input Indexes





Sources: Bureau of Labor Statistics for BLS index; see appendix for HT index.

while the net investment share is sending too weak a signal.

IV. Summary

Was investment growth strong or weak in the 1980s? The unprecedented change in the composition of investment since the mid-1970s has made this seemingly simple question difficult to answer. With the rise of high tech investment, indicators that were traditionally relied upon to answer such questions have become unreliable. Gross investment indicators now send signals that are too optimistic, while net investment indicators send overly pessimistic signals.

During times when investment is shifting, analysts can look to capital input indexes that are less distorted by shifts in the composition of investment. While these capital input indexes do not solve all the problems of measuring investment, they are useful in judging investment strength in a changing investment environment. The picture they paint should lead neither to great optimism nor great pessimism: There was no investment boom in the 1980s—nor was there a great bust.

Appendix

Capital Input Indexes

The capital input indexes discussed in this article measure capital input growth as a weighted average of the growth rates of the net stocks of individual capital types. The weights used are based on the budget share (in rental terms) of each capital type. The weight used in each period is the average of the current and previous periods' budget share.

The precise formulation of the HT index is as follows. Define K_i as the net stock of capital of type i. If the price of purchasing capital of type i is p_i, then the cost of using (renting) capital of type i for one period is defined as: $w_i = A_i p_i$, where $A_i = (r + 1/s_i)/(1 + r)$, s_i is the service life of capital of type i, and r is the real interest rate. This simple user cost formulation assumes that the only factors affecting the user cost are straight line depreciation, a constant real interest rate, and the price of capital. This ignores, for example, taxes.

Using the notation from above, the formulas for the HT index are as follows. The budget share measures are defined by

$$z_{it} = w_{it} K_{it} / \left(\sum_{j-1}^{4} w_{jt} K_{jt} \right); \; Z_{it} = (z_{it} + z_{it-1}) / 2$$

The index is then given by:

$$Capgrowth = \sum_{i-1}^{4} Z_{it} \log (K_{it}/K_{it-1}).$$

In constructing the HT index, the composite low tech service life is assumed to be 40 years. A real interest rate of 4 percent is assumed. Capital prices are based on implicit deflators from the capital stock data for low tech and on fixed weight deflators for the high tech categories. The service lives of the high tech categories, implicit deflators, and capital stock data are from the U.S. Department of Commerce 1987, the fixed weight deflators are from U.S. Department of Commerce, various issues.

Indexes of the form described here are known as Tornqvist indexes and have been widely studied by economists. They exactly reflect growth in the indexed quantity (capital input in this article) under certain restrictive assumptions, and approximately reflect growth under a broad range of assumptions. Accuracy, in practice, relies on the appropriateness of the assumptions as well as on the accuracy of the data used.

Standard investment measures similarly will only be accurate under restrictive assumptions and in the presence of accurate data. A central point of this article is that, when the composition of investment is changing rapidly, the assumptions underlying the Tornqvist indexes are probably more nearly correct than those underlying the standard measures (Diewert 1976).

Endnotes

[1] Actually, any decrease in the growth of investment may have begun in the mid-1970s, well before the Reagan era. Thus, some analysts argue the proper question is whether the policies of the Reagan era reversed any decline that started in the 1970s.

[2] On the strong investment side, see also Tatom 1989 and deLeeuw 1990. On the weak or flat investment side, see Englander and Steindel 1989.

[3] U.S. Department of Agriculture 1988. Part of this increased productivity is due to increased inputs other than capital, such as fertilizer.

[4] While these data perhaps convey too simple a tie between capital and income, analysts generally accept this relation between capital growth and income growth. Many factors complicate the relation, however. For example, education and social and political stability also play an important role in economic growth. Thus, some countries have grown without large increases in capital, and others have increased capital but not grown (Lipsey and Kravis 1987).

[5] Analysts also consider other simple indicators of investment (Englander and Steindel 1989). The two measures considered here are representative, however, and highlight the source of the investment controversy.

[6] Other high tech items such as industrial robots are not included in this measure.

[7] Net investment in high tech categories has shown a similar increase, as the rise in depreciation has shrunk both the numerator and the denominator of the ratio of net high tech investment to total net investment.

[8] Commercial buildings showed this jump for the 14 years that ended in 1961.

[9] These service lives are weighted averages using real investment shares as weights. The reported changes reflect all changes in investment shares, not simply the rise of high tech investment.

[10] Evaluating what the depreciation share would have been in absence of the shift to high tech is difficult in the general equilibrium setting of the real economy. It is difficult both to make clear what counterfactual experiment is being contemplated (what exogenous shock nullified the high tech shift?) and to carry out that experiment. One accounting approach to this question (manifestly a disequilibrium approach) is to simulate what the depreciation share would have been if gross investment were at its historical level, but the high tech share remained at its average 1970-74 level (the extra investment distributed to other categories of business fixed investment based on their shares). This simple experiment suggests the high tech shift accounts for somewhat less than half of the rise in depreciation as a share of GNP. Other similar experiments show a higher role for the high tech shift.

[11] This assumes a real interest rate of 4 percent; service lives of eight years and 40 years for computers and buildings, respectively; straight line depreciation; and a flat return per unit of capital remaining.

[12] In more precise technical terms, the distortion can be stated this way. In equilibrium, firms allocate investment dollars in terms of the rental cost of the capital (often called the *user cost*), investing so that the marginal product of an additional dollar spent *renting* each type of capital is the same. This implies that the marginal product of the last dollar spent *purchasing* high tech must be higher than for low tech. Why? The rental cost includes the cost of replacing worn out capital. Since high tech wears out faster, the rental cost implied by any given purchase price of capital is higher for high tech than for low tech. Thus, if the marginal products are equal in rental cost terms, the marginal product of the last dollar spent *purchasing* high tech must be higher than the marginal product of the last dollar spent purchasing low tech.

[13] There actually may be short-run effects even on net investment. Net investment will be less prone than gross investment to being optimistic due to this factor, however.

[14] The typical piece of high tech equipment used in this example is a composite of the four categories of high tech investment, with the shares based on 1982 investment data. The price index is a weighted average of the fixed-weight indexes for the four categories using these weights. As the next section emphasizes, use of fixed-weight indexes and fixed shares can lead to distortions.

[15] As noted in note 12, firms allocate investment dollars to equalize the marginal product of an extra dollar (in rental cost terms) spent on each type of capital. If the price of high tech capital falls, the rental cost falls. When this happens, the additional dollar now rents more high tech capital than before, say, two units instead of one. The marginal product of a dollar spent on low tech remains about the same when the price of high tech changes. Thus, to equalize marginal products of each type of capital, the marginal product of these two units of high tech must be about the same as the marginal product one unit formerly produced. Thus, the marginal product of each unit must fall.

[16] For a more detailed analysis of the measurement issues that justify looking at capital input indexes, see Oliver 1989.

[17] The issue of the breadth of investment measures was discussed in Faust 1989. The issues regarding measure-

ment of quality change and depreciation discussed in the box also apply to capital input indexes as well as to traditional measures.

[18] This index is for business capital input. The BLS computes two other indexes. Nonfarm business capital input showed a slight decline from 3.7 percent to 3.6 percent. In contrast, manufacturing capital input showed a decline from 3.9 to 2.7 percent. The construction of this index is described in detail in U.S. Department of Labor 1983; the data are reported in U.S. Department of Labor, various issues.

[18] It is important to emphasize that the conclusions of this article about investment strength regard the equilibrioum growth of investment arising from the interaction between the supply of, and demand for, funds. The conclusion of unchanged investment growth remains silent about what offsetting changes in these supply and demand relations may have occurred.

References

Darby, Michael. 1989. "Challenges of Macro Policy in the Open U.S. Economy," *Contemporary Policy Issues*, January.

deLeeuw, Frank. 1990. "Interpreting Investment-to-Output Ratios: Nominal/Real, Net/Gross, Stock/Flow, Narrow/Broad," *Carnegie-Rochester Conference Series on Public Policy*, vol. 32, Spring.

Denison, Edward F. 1989. *Estimates of Productivity Change by Industry*, Washington: Brookings Institution.

Diewert, W.E. 1976. "Exact and Superlative Index Numbers," *Journal of Econometrics*, vol. 4, pp. 115-45.

Englander, A. Steven and Charles Steindel. 1989. "Evaluating Recent Trends in Capital Formation," vol. 14, no. 3, Autumn.

Faust, Jon. 1989. "U.S. Foreign Indebtedness: Are We Investing What We Borrow," *Economic Review*, July/August.

Friedman, Benjamin. 1988. *Day of Reckoning*, New York: Random House, Inc.

Gordon, Robert J. 1990. *The Measurement of Durable Goods Prices*, Chicago: University of Chicago Press.

Lipsey, Robert E., and Irving B. Kravis. 1987. "Is the U.S. a Spendthrift Nation?" N.B.E.R. Working Paper No. 2274, June.

Oliver, Stephen D. 1989. "The Formation of Private Business Capital: Trends, Recent Developments, and Measurement Issues," *Federal Reserve Bulletin*, December.

Scott, Maurice FitzGerald. 1989. *A New View of Economic Growth*, Oxford: Clarendon Press.

Tatom, John A. 1989. "U.S. Investment in the 1980s: The Real Story," *Economic Review*, Federal Reserve Bank of St. Louis, March/April.

Young, Allan H. 1989. "BEA's Measurement of the Output of Computers," *Survey of Current Business*, vol. 69, July, pp. 108-15.

U.S. Department of Agriculture. 1988. "Production and Efficiency Statistics, Economic Indicators of the Farm Sector."

U.S. Department of Commerce, Bureau of Economic Analysis. 1987. "Fixed Reproducible Tangible Wealth in the United States, 1925-85," June.

_____, Various July issues. *Survey of Current Business*.

_____, Various issues. *Survey of Current Business*. Washington: Government Printing Office.

U.S. Department of Labor. 1983. "Trends in Multifactor Productivity, 1948-81," September.

Possible Monetary Policy Responses to the Iraqi Oil Shock

By George A. Kahn and Robert Hampton, Jr.

The oil-price increase resulting from the Iraqi invasion of Kuwait poses a dilemma for monetary policymakers. In the past, sharp increases in oil prices have simultaneously increased inflation and reduced economic growth. If policymakers try to offset the inflation effects of higher oil prices, output suffers. If policymakers try to offset the output effects, inflation rises.

This article uses a small economic model to estimate the effects of higher oil prices under alternative monetary policies. The model provides a relatively simple characterization of these effects. It focuses on the main channels of influence of higher oil prices, ignoring many of the channels that would be incorporated in larger, more complicated models of the economy. Based on the simple model, the article argues the likely effects of the Iraqi oil-price shock will be small, providing monetary policy does not overreact. That is, with a policy that remains roughly constant or "neutral," higher oil prices will cause inflation to increase and real output to decline—but these effects will be small and temporary.

The first section of the article shows why the options available to monetary policymakers cannot completely solve the dilemma. The second section presents estimates of how the various options will affect the economy over the next several years.

I. The Monetary Policy Dilemma of Higher Oil Prices

Monetary policy is ill-equipped to deal with the damage caused by higher oil prices. When oil prices rise sharply, consumers and businesses reduce overall spending, and businesses face higher costs. Monetary policy can, at best, reverse the decline in spending caused by higher oil prices. Monetary policy cannot reverse the increase in costs. As a result, some combination of lower output and higher inflation is the inevitable outcome of higher oil prices.

George A. Kahn is a senior economist and Robert Hampton, Jr., is an assistant economist at the Federal Reserve Bank of Kansas City. Carol Manthey, a research assistant at the bank, assisted in the preparation of the article.

Effects of higher oil prices on inflation and output

Higher oil prices have adverse short-run demand and supply effects. The demand effect results from a decline in spending on U.S.-produced goods and services. Although putting downward pressure on inflation, this effect also causes real output to fall. The supply effect results from increases in production costs. It raises inflation and lowers real output.[1] Because past oil shocks have typically caused inflation to rise, most analysts believe the supply effect dominates the demand effect.

Demand effects. Higher oil prices reduce aggregate demand by reducing spending on U.S.-produced goods and services. This reduced spending stems largely from consumers. Because higher oil prices force consumers to spend more of their income on petroleum products, such as gasoline and home heating oil, consumers must cut back on purchases of other goods and services.[2]

Reduced spending by consumers on other goods and services reduces overall spending in the economy even though spending on energy increases. Overall spending declines because much of the increase in energy spending goes to foreign oil producers. Since the United States imports much of its oil, income is shifted from the United States to oil-exporting countries.[3] The income shifted abroad is no longer available to U.S. consumers for spending at home. Thus, overall spending on U.S. goods and services declines.

Partly offsetting these effects of higher oil prices is the increased income of domestic and foreign energy producers. But these beneficiaries of higher oil prices will spend only part of their higher income on U.S.-produced goods and services. The remainder of their higher income will go to increased spending on foreign goods and services or to increased savings. As a result, on balance, higher oil prices will likely reduce the demand for U.S. products.[4]

With a reduction in demand for U.S. products, other things held constant, real output and inflation will decline. As output falls below the level required to maintain full employment, labor and other resources will be underutilized. As a result, wages and other input prices will moderate, and inflation will fall as production costs moderate and as businesses try to sell excessive inventories. Over time, the moderation of labor and other input costs will increase employment of labor and other resources, causing output to increase. Output will continue to increase and inflation will continue to moderate until full employment has been re-established.

Supply effects. The supply effects of higher oil prices are more pervasive than the demand effects. Oil is not only an input in the production of energy, but also an input in the production of other goods and services. These goods and services include fertilizers, plastics, and indeed any product that must be transported.

Higher oil prices reduce aggregate supply by raising overall costs of production. Oil-price increases have little or no immediate effect on the price of non-energy inputs such as labor, however, because these input prices are often set by long-term contracts. Without offsetting reductions in these other input prices, oil-price increases raise overall production costs. Businesses faced with higher oil prices must raise product prices for any given level of total sales. Alternatively, for any given level of prices, businesses must cut back their production of goods and services. Aggregate output declines, and inflation rises.

These effects are temporary, however, because the decline in real output decreases the employment of inputs, such as labor. As a result, prices of non-energy inputs—the wage rate, for example—moderate as contracts are eventually renegotiated. As these input prices moderate, businesses raise production, and output returns

to its full-employment level. The inflation rate also returns to its original level, providing monetary policymakers have not permanently increased monetary growth in response to higher oil prices. Thus, the short-run supply effects of higher oil prices eventually correct themselves. But before they self-correct, they can do substantial harm.

Supply and demand effects combined. The combination of supply and demand effects implies that higher oil prices lead to higher inflation and lower output in the short run. Demand effects and supply effects reinforce each other in reducing real output. In contrast, demand effects partly offset supply effects on inflation. But because supply effects dominate demand effects, higher oil prices increase inflation in the short run.[5]

Alternative policy responses to higher oil prices

How should monetary policymakers respond to the dilemma of higher oil prices? Even if policymakers knew the exact magnitude of the oil-price shock, understood fully its effects over time on the economy, and could take actions that affected the economy in precisely the right way at precisely the right time, policymakers would face a dilemma. Although policymakers could completely offset the demand effects of higher oil prices, they could not completely offset the supply effects.

Policymakers could ease monetary policy—that is, lower short-term interest rates by increasing the availability of reserves to the banking system—to offset the demand effects of higher oil prices. Such a policy would increase interest-sensitive spending, returning aggregate demand to its pre-oil-shock level. Completely offsetting the demand effect, however, would require quick action by monetary policymakers. Quick action would be necessary because the demand effects of higher oil prices might hit the economy relatively rapidly, while the effects of monetary policy actions take time. And even quick action might not be quick enough if the effects of higher oil prices are immediate. Monetary policymakers would also need to have considerable information about the magnitude and timing of the effects of the oil shock in order to design an offsetting policy response for demand effects.

With an ability to influence only aggregate demand, policymakers cannot offset the supply effects of higher oil prices. But policymakers can influence the mix of higher inflation and lower output resulting from supply effects. Policymakers can do this along a range of possible outcomes. Two types of policy responses span this range. In both cases, policymakers would need to understand fully the effects of the oil-price shock and monetary policy on the economy. And, in both cases, policymakers are assumed to offset completely the demand effects of higher oil prices by easing monetary policy. The two types of responses would differ depending on how policymakers reacted to the supply effects of higher oil prices.

At one end of the range of options is an *accommodative policy*. With an accommodative policy, policymakers would completely offset the output effects of higher oil prices. Policymakers would ease monetary policy not only to offset demand effects but also to keep output equal to its full-employment level. The cost of such a policy would be higher inflation. The increase in inflation would likely be permanent because cost-of-living adjustment clauses in labor-market and other contracts raise input prices and thereby increase inflation expectations.

At the other end of the range is an *extinguishing policy*.[6] With an extinguishing policy, policymakers would completely offset the inflation effects of higher oil prices. Although policymakers would need to ease policy to offset demand effects, policymakers would have to

tighten policy—that is, raise short-term interest rates by reducing the availability of reserves to the banking system—to offset the supply effects. Given that supply effects likely dominate demand effects, policymakers would, on balance, tighten policy to keep inflation constant. The cost of such a policy would be a greater decline in output.

In between the two extremes are any number of other policy options that produce alternative mixes of higher inflation and lower output. One such option would be to maintain constant monetary or nominal GNP growth.[7] Such a response is called a *neutral policy*. With a neutral policy, policymakers would ease or tighten monetary policy as needed in the face of higher oil prices to maintain constant growth of, say, nominal GNP.[8] This article assumes that a neutral policy can be achieved even though, in reality, the Federal Reserve cannot control nominal GNP growth precisely on a quarter-to-quarter basis. The purpose is to broadly characterize the implications of a neutral policy, not to indicate the definitive outcome of attempting to pursue a neutral policy.

With these caveats in mind, such a policy would have effects "in between" the effects of accommodative and extinguishing policies. Because the demand effects of an oil-price shock reduce both inflation and real GNP, they clearly reduce nominal GNP growth. As a result, a neutral policy would offset all of the demand effects of higher oil prices. Because the supply effects of an oil-price shock increase inflation but reduce real GNP, they lead to mostly offsetting effects on nominal GNP growth. By maintaining constant nominal GNP growth, policymakers would "accept" much, if not all, of the supply effects of higher oil prices.[9] As a result, inflation would rise and output would fall under a neutral policy.

A neutral policy has several other distinctive features. First, it might be more feasible to implement than an accommodative or extinguishing policy. Because policymakers have greater short-run influence over nominal GNP growth than they have over real output or inflation, they might be better able to achieve a neutral policy (McCallum 1985). Second, unlike an accommodative policy, a neutral policy would prevent a permanent increase in inflation. Third, while a neutral policy would accept an oil-price-induced decline in output, the decline would be temporary and self-correcting. Finally, regardless of the policy response, the supply effects of higher oil prices hurt the economy—a neutral policy would divide the damage evenly between higher inflation and lower real output.

II. Effects of the Current Oil-Price Shock under Alternative Policies

What are the implications of the current oil-price shock given alternative monetary policy responses? The Iraqi invasion of Kuwait on August 2 caused the refiners' acquisition cost of imported oil—one common measure of oil prices—to rise roughly 50 percent, from $16 per barrel in the second quarter of 1990 to $24 per barrel in the third quarter. Although oil prices rose further early in the fourth quarter of 1990, they have since come down to a level close to their third-quarter average. Despite monthly fluctuations in the price of oil, only that part of the price increase that persists is relevant for the analysis in this article. This article assumes the recent oil-price shock will permanently increase oil prices by $8 per barrel, or 50 percent.

In contrast, past oil-price shocks increased the price of oil by 150 percent or more. Thus, the current oil shock is relatively small by historical standards. This section uses a small economic model to show that the current oil-price shock should have relatively small inflation and output effects provided monetary policy does not overreact.

Estimation results

The small model used to determine the effects of higher oil prices on inflation and output consisted of two equations that are described more fully in the appendix. One equation explained inflation in the implicit GNP deflator, on a quarterly basis, using data from the second quarter of 1954 to the second quarter of 1990.[10] The other equation was an identity relating nominal GNP growth to the sum of inflation and real GNP growth. Assuming a path for nominal GNP, the inflation equation determined the inflation rate, while the nominal GNP identity determined the output effect.

The inflation and output effects of the recent increase in oil prices were projected by combining the estimated inflation equation with assumed paths for future oil prices and nominal GNP growth. Oil prices were assumed to remain permanently at their actual third-quarter level, which was $8 higher than in the second quarter. Nominal GNP growth was allowed to vary depending on the monetary policy response to higher oil prices.

The inflation equation was simulated twice under each of three monetary policy assumptions. Simulations were run first assuming no increase in oil prices, then assuming the actual 50 percent increase in oil prices in the third quarter. Differences in these two sets of simulations were then plotted under alternative assumptions for monetary policy. The three assumptions for monetary policy were the accommodative, extinguishing, and neutral policies described earlier. All other influences on inflation were assumed to be the same in all simulations. Thus, the differences in the simulations show the effect of higher oil prices on inflation and output, given alternative monetary policies and holding constant all other influences on inflation and output.

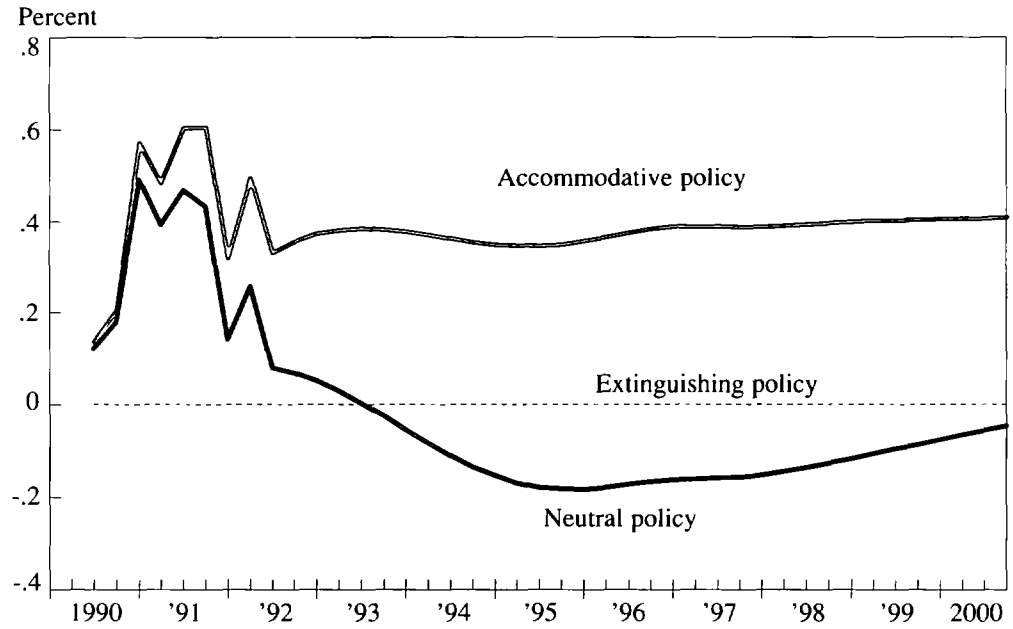
Inflation effects. Except under an extinguishing policy, projected inflation increases slightly in response to the recent 50 percent increase in oil prices (Chart 1). Under a perfectly engineered neutral policy in which monetary policymakers hold nominal GNP growth constant, the effect of the current oil-price shock on inflation is temporary. Inflation increases to a peak of about 0.5 percentage point above what it otherwise would be in the first quarter of 1991. Then inflation falls, eventually reaching levels below what it would have been in the absence of higher oil prices.[11] Finally, over time, inflation returns to its non-oil-shock level, represented in the chart by the zero line.[12] Thus, there is no long-run effect of higher oil prices on inflation under a neutral policy.[13]

Under an accommodative policy—assuming one could be perfectly engineered—inflation rises above the levels implied by a neutral policy in both the short run and the long run. Specifically, inflation increases to a peak of about 0.6 percentage point above what it would have been in the absence of higher oil prices. Moreover, inflation remains permanently higher by about 0.4 percentage point. Higher inflation results because monetary policy offsets the effects of higher oil prices on real output. Because an accommodative policy keeps inputs fully employed, non-energy input prices do not moderate when oil prices rise. The result is higher inflation in both the short and long run.

Under an extinguishing policy—again, assuming one could be perfectly engineered—projected inflation remains unchanged. According to the definition of an extinguishing policy, monetary policymakers offset the inflation effects of higher oil prices so that, during and after the oil-price shock, inflation is the same as it would have been had the oil shock not occurred. As will be seen, the cost of such a policy is a sharper short-run decline in real output than under alternative policies.

Output effects. Except in the case of an accommodative policy, projected output falls temporarily as a result of the current oil-price

Chart 1
Projected Effects of Higher Oil Prices on Inflation



Note: Chart shows the projected effect of the recent increase in oil prices on (a four-quarter moving average of) the annualized quarterly growth rate of the implicit GNP deflator. Projections assume a permanent $8 increase in the real price of imported oil occurring in the third quarter of 1990. The accommodative policy maintains real GNP at its full-employment level. The neutral policy holds nominal GNP growth constant. And the extinguishing policy keeps inflation constant in response to higher oil prices.

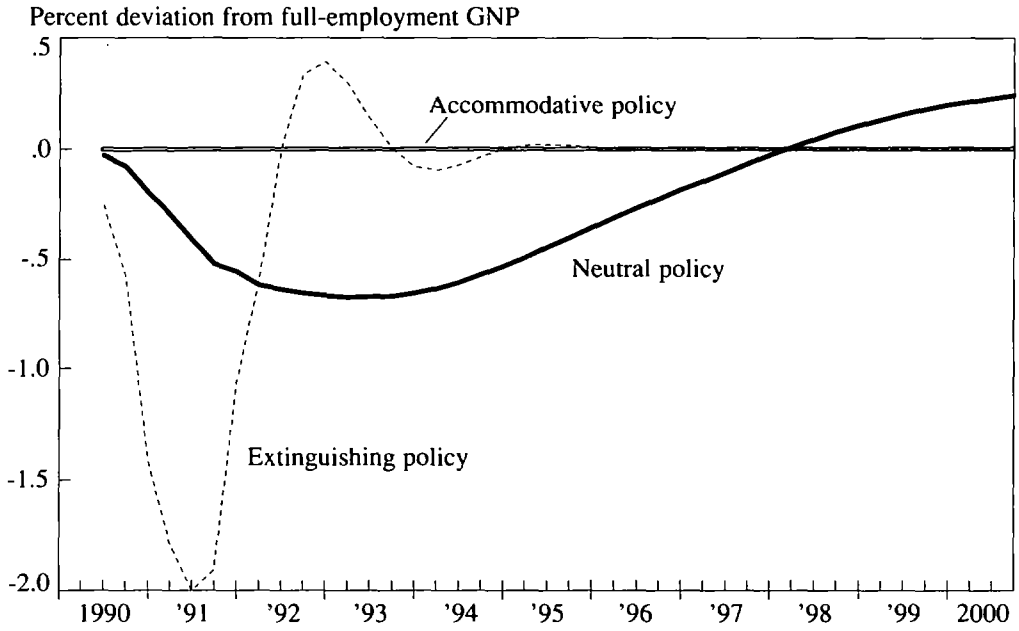
Source: Authors' estimates based on the model described in the appendix.

shock (Chart 2). Under a neutral policy, output declines gradually over several years to a trough of about 0.7 percent below full-employment output. Full-employment output is represented by the zero line in the chart. Points below the line represent less than full-employment real GNP, while points above the line represent more than full-employment real GNP. Under the neutral policy, output eventually "overshoots" full employment. In other words, output increases from below full-employment levels to above full-employment levels. Although output eventually returns to its full-employment level, the process takes considerable time.[14]

Under a perfectly engineered extinguishing policy, output falls further and more sharply than under a neutral policy. Specifically, output falls to a trough of about 2 percent below full-employment output by the third quarter of 1991. Afterward, real output increases sharply, first overshooting its full-employment level, then gradually converging on full employment. More output is lost from an extinguishing policy than from a neutral policy because a tighter monetary policy is necessary to eliminate the inflation effects of higher oil prices. Thus, output must bear the entire adjustment burden of the supply effects of higher oil prices.

Under a perfectly engineered neutral policy, the estimated effect on output of the recent oil-price shock is relatively small while, under an extinguishing policy, the effect is moderate.

Chart 2
Projected Effects of Higher Oil Prices on Real GNP



Note: Chart shows the projected effect of the recent increase in oil prices on (a four-quarter moving average of) the percentage deviation of projected real GNP from the full-employment level of real GNP. See note from Chart 1 for assumption and definitions.

Source: Authors' estimates based on the model described in the appendix.

One way to judge the size of the output effect is to compare it with the size of historical fluctuations of output over the business cycle. From peak to trough, real GNP fell an average of 2.3 percent over all recessions since 1947.[15] As shown earlier for the current oil shock, projected real GNP falls a maximum of 0.7 percent under a neutral policy and 2 percent under an extinguishing policy. Thus, the effect on output of the recent oil-price rise is likely to be less severe than the average recession under a neutral policy and about as severe as the average recession under an extinguishing policy.

Finally, under a perfectly engineered accommodative policy, real output remains at its full-employment level. According to the definition of an accommodative policy, monetary policymakers offset the output effects of higher oil prices so that, during and after the oil-price shock, output remains the same as it would have been had the oil shock not occurred. Given no other influences on output than oil prices and monetary policy, output remains at the full-employment level. As shown earlier, the cost of such a policy is a permanent increase in inflation.

Summary and policy implications. The effects of higher oil prices on inflation and output depend on the monetary policy response. An accommodative policy results in higher inflation in both the short run and the long run but maintains real GNP at its full employment level. Achieving this result would require sub-

stantial quarter-to-quarter swings in nominal GNP growth. Such complicated paths for nominal GNP growth might be difficult to achieve because of uncertainties about the timing and magnitude of the effects of oil-price shocks and policy actions. Because it takes time for policy actions to affect the economy, policymakers would have problems engineering complicated paths for nominal GNP growth. Moreover, determining exactly what policy actions would be required to offset the output effects of oil-price shocks would require knowing precisely how higher oil prices affect the economy. While estimated relationships can give guidance to policymakers, they cannot eliminate uncertainties about the effects of oil-price shocks and monetary policy responses.

An extinguishing policy results in a relatively sharp, temporary decline in real GNP but maintains a constant rate of inflation. Unlike an accommodative policy, an extinguishing policy has no adverse long-run effects. Real output returns to its full-employment level, and inflation remains unchanged by definition. But, like an accommodative policy, achieving an extinguishing policy would require a complicated set of monetary policy actions.

A neutral policy divides the impact of higher oil prices between higher inflation and lower output. Inflation rises in the short run, but by less than with an accommodative policy. Output falls in the short run, but by less than with an extinguishing policy. As with an extinguishing policy, higher oil prices affect neither output nor inflation in the long run. Moreover, a neutral policy might be relatively simple to achieve compared with the complicated paths required for nominal GNP growth under an accommodative or extinguishing policy. Thus, for both short-run and long-run considerations, a neutral policy might be the best policy response to an oil-price shock.

III. Conclusions

The recent increase in the price of oil—if maintained—will hurt the U.S. economy. In the short-run, higher oil prices will increase inflation and lower real GNP. But the relatively small size of the recent oil-price shock compared with past oil-price shocks suggests the size of these effects will likely be small providing monetary policy does not overreact. This conclusion emerges from a simple two-equation model of the economy that attempts to capture the main channels of influence of the higher oil prices.

In such a model, a neutral policy that holds nominal GNP growth constant would prevent a sharp increase in inflation and a sharp decrease in real GNP. A neutral policy would also ensure that the inflation and output effects of higher oil prices were temporary and self-correcting. Although monetary policy cannot offset all of the damage caused by higher oil prices, it can ensure that higher oil prices do not lead to permanently higher inflation. One way to achieve this goal is to adopt a neutral monetary policy that maintains constant nominal GNP growth in the face of higher oil prices.

Appendix

The Triangle Model of Inflation

This appendix describes the model used to project the effects of higher oil prices on inflation and output and discusses its limitations. The model has been used extensively by Robert Gordon to explain the behavior of inflation in the United States and elsewhere. The basic structure is taken from Gordon (1988 and 1990a), but has been used by Gordon in many earlier papers (for example, 1985).

The approach is called the "triangle" model of inflation. This is because it divides factors influencing inflation into three categories—inflation inertia, the output gap, and relative prices. Inertia is the influence of past inflation on current inflation. The output gap is the ratio of real output to the full-employment level of real output. Relative prices are the prices of goods and services measured in relation to the economy's overall price level. Changes in key relative prices, as described in the text for the price of oil, also influence the behavior of inflation.

The model assumes that changes in relative oil prices, though they affect inflation and real output, have no effect on nominal GNP growth. This assumption simplifies the analysis while focusing attention on the short-run supply effects of oil-price shocks. Several rationales can be given for the assumption. First, the demand effects of energy-price shocks—which move inflation and real GNP growth in the same direction and, therefore, affect nominal GNP growth—are relatively unimportant compared with the supply effects. Second, supply effects move inflation and real output growth in opposite directions, with each variable's movement at least partly offsetting the other's effect on nominal GNP growth. Finally, monetary and fiscal policies might possibly hold nominal GNP growth constant in the face of oil-price shocks. Under this rationale, the model can be thought of as estimating what would happen to inflation and real output after an oil-price shock if monetary and fiscal policies held nominal GNP growth constant.

The following two equations summarize the model:

$$(1)\ P_t = A_0(L)\,P_{t-1} + A_1(L)\,GAP_t + A_2(L)\,Z_t + u_t$$

$$(2)\ GAP_t = GAP_{t-1} + Y_t - P_t,$$

where P_t represents inflation in the implicit GNP deflator, GAP_t is the log of the ratio of actual to full-employment real GNP, Z_t is a vector of changes in relative prices, u_t is a zero mean, finite variance error term, Y_t is the growth rate of nominal GNP minus the economy's long-run real growth rate, and the $A_i(L)$ are lag operators.

The point of departure for estimating the model is Gordon (1988, Table 3, column 3). Included in Gordon's specification are variables representing inertia effects, the output gap, and relative price effects. Inertia is represented by a 24-quarter distributed lag on past inflation. The output gap is represented by deviations in actual real GNP from full-employment real GNP. Full-employment real GNP, in turn, is measured as in Gordon (1990b). Two variables measure relative price effects. Relative food and energy prices are measured by the difference between the rates of change of the deflators for personal con-

sumption expenditures and for personal consumption expenditures net of expenditures on food and energy. And relative foreign prices are measured by the change in the price of non-food, non-fuel imports relative to the GNP deflator.[16]

Also included in Gordon's inflation equation are several other variables that help explain inflation but do not fit easily into any of the three categories from the triangle model. First, a variable is included to account for changes in productivity growth relative to trend productivity growth. The inclusion of this variable reflects the potential markup of prices over unit labor costs.[17] This "productivity deviation" variable measures how much of firms' price-setting behavior depends on actual productivity changes versus trend productivity growth. Second, a variable is included to account for changes in the minimum wage. This "effective minimum wage" variable is defined as the statutory nominal minimum wage divided by nominal average hourly earnings. Third, variables are included to account for changes in the payroll, personal, and indirect tax rates. These variables are defined as in Gordon (1985). Finally, the impact of price controls imposed by the Nixon Administration is measured by the inclusion of two dummy variables.[18]

With the exception of the distributed lag on inflation, the lag structure imposed on the inflation equation is the same as Gordon's lag structure. The output gap, food and energy variables, and all tax variables were entered contemporaneously and with four lagged values. The productivity deviation was entered contemporaneously and with one lagged value. All other variables except inflation were entered with four lagged values. Whereas Gordon's basic specification constrained the coefficients on lagged inflation to lie along six constant segments, the specification used in the text constrained the coefficients to lie along a fifth-degree polynomial with no endpoint constraint.

Several other changes were made in Gordon's basic specification to make it more suitable for addressing the effects of higher oil prices. One important change was the definition of the dependent variable. While Gordon used changes in the fixed-weight GNP deflator as the dependent variable, the estimates in the text used changes in the implicit GNP deflator. This switch in the dependent variable was made because the identity relating nominal GNP growth to inflation and changes in the output gap holds exactly when inflation is measured by the implicit GNP deflator, but only approximately when inflation is measured by the fixed-weight deflator.

Another important difference between the approach used in the text and Gordon's approach is the definition of relative oil prices. Gordon's approach lumps changes in energy prices together with changes in food prices, preventing an analysis of the separate effect of oil prices. Moveover, Gordon's variable cannot be interpreted as the effect of an increase in food and energy prices but rather measures the weight of consumption in the overall total fixed-weight GNP deflator.

In place of Gordon's food and energy price variable, separate variables were included for food and oil prices. Two oil-price series were linked to form the oil-price variable. From the beginning of the sample to the first quarter of 1974, the oil-price variable was the rate of change of the price of Venezuelan crude-oil imports deflated by the growth rate of the implicit GNP deflator.[19] This series was linked in the second quarter of 1974 to the rate of change in the refiners' acquisition cost of imported crude oil deflated by the growth rate

Table A1

Equation for Growth in the Quarterly Implicit GNP Deflator
1954:2–1990:2

Independent variable	Sum of lagged coefficients
Implicit GNP deflator	1.03*
	(36.9)
Output gap	.28*
	(4.7)
Productivity deviation	-.09†
	(1.1)
Food price effect	.42†
	(1.1)
Relative price of imported oil	.02‡
	(2.4)
Effective minimum wage	.03
	(1.3)
Nixon controls "on"	-1.34
	(1.7)
Nixon controls "off"	3.60*
	(3.8)

Summary statistics	
R^2	.798
Sum of squared residuals	209.5
Standard error	1.338

Note: t-statistics are in parentheses.
*Significant at the 1 percent level.
† Contemporaneous effect significant at the 1 percent level.
‡ Significant at the 5 percent level.

Source: Authors' estimates.

of the implicit GNP deflator. Similar to Gordon's food-and-energy-price variable, the food-price variable was the difference in the growth of the total personal consumption expenditures deflator including and excluding food.

Finally, while Gordon's sample period ran from 1954:2 to 1987:3, the sample period used in the text ran from 1954:2 to 1990:2. The extension of the sample past 1987:3 added observations with relatively large oil-price fluctuations.

With these changes, the inflation equation was estimated initially with a complete set of explanatory variables on the right-hand side. The estimation procedure was ordinary least squares. Variables with insignificant sums of lagged coefficients and with lagged coefficients that were individually and jointly insignificant were then excluded from the equation, and the regression was re-run.

The results are reported in Table A.1. Sums of coefficients on the variables used by Gordon are very close to those reported in Gordon 1988. In particular, the sum of coefficients on lagged inflation is close to one, and the sum of coefficients on the output gap is positive and significant.

Limitations of the approach

One potential problem with the estimates reported in the table results from the inclusion of the current output gap on the right-hand side of the inflation equation. Because of the possibility of reverse causality from inflation to the output gap, simultaneous equations bias is a potential problem. See Gordon 1990a for a discussion of the nature of the bias in the context of the triangle model. One way around the problem would be to estimate a separate output gap equation. Another way would be to use a more robust estimation procedure.

To test the sensitivity of the results to simultaneous equations bias, the inflation equation was re-estimated using an instru-

mental variables approach. Instruments included four lags each of the growth rate of the M2 money stock and the growth rate of real federal government expenditures, in addition to all of the right-hand-side variables except the current output gap. The re-estimation had only minor effects on the coefficients of the inflation equation. For example, the sum of the coefficients on the current and lagged output gap rose from 0.28 to 0.29 and the sum of the coefficients on oil prices rose from 0.016 to 0.017. Given the similarity of these results, simultaneous equation bias was considered relatively unimportant and the ordinary least squares results were used in the simulations reported in the text.

Another limitation of the approach is that the model holds relative food prices and relative non-food, non-energy import prices constant in the face of higher oil prices. This simplifying assumption potentially causes an understatement of the adverse short-run inflation and output effects of higher oil prices. Since petroleum products are an input in the production of fertilizers, higher oil prices raise the cost of producing food. Higher oil prices also raise the cost of transporting food to the consumer. Thus, oil-price increases likely contribute to food-price inflation which in turn contributes to higher overall inflation.

The model also ignores the effect of higher oil prices on the price of non-food, non-energy imports. If higher oil prices cause the dollar either to appreciate or depreciate, import prices will change. Thus, oil-price increases possibly contribute to changing import prices which in turn affect overall inflation. Ignoring this effect may lead to an understatement or overstatement of the inflation and output effects of oil-price shocks.

Finally, the model ignores the long-run effects of higher oil prices. If oil-price shocks reduce productivity growth, however, the long-run growth rate of real GNP will decline and future full-employment levels of real GNP will be lower than otherwise. This in turn implies that actual real GNP will not fall as far below the full-employment level of real GNP as in the earlier projections. Thus, inflation will ultimately come under less downward pressure from the output gap. The result will be a permanent increase in the price level and decrease in the level of real output.[20]

Endnotes

1 Sustained increases in oil prices also potentially reduce long-run productivity growth. Oil-price increases reduce the use of energy in the production process and thereby reduce the quantity of goods and services that the existing stock of capital and labor can physically produce. Monetary policy cannot affect this outcome because monetary policy cannot alter the technology firms use to produce output. See Garner 1988 for a discussion of the effect of slower productivity growth on standards of living and for non-monetary policy options to increase long-run productivity growth.

2 Not only are consumers in the United States hurt by higher oil prices but so are consumers in other countries. Like domestic consumers, foreign consumers will cut back their consumption of non-energy goods and services as a result of higher energy bills. To the extent these other goods and services are U.S. products, spending on U.S. goods and services will decline further. Thus the demand for U.S. exports will decline.

3 In 1989, petroleum imports to the United States accounted for 41.3 percent of U.S. petroleum supplies (Bohn 1990).

4 This analysis ignores possible effects of higher oil prices on the foreign exchange value of the dollar. If the dollar depreciates in response to higher oil prices, spending on U.S. exports might increase, and the aggregate demand effects of higher oil prices might be further offset. The dollar might depreciate if foreign central banks raised interest rates relative to U.S. rates in response to higher oil prices. Because oil is priced in dollars, foreign central

banks can potentially offset an increase in the dollar price of oil by raising the foreign exchange value of their currencies relative to the dollar.

In contrast, if the dollar appreciates in response to higher oil prices, spending on U.S. exports might decline and the adverse aggregate demand effects of higher oil prices might be exacerbated. The dollar might appreciate in response to higher oil prices because the United States is less dependent on imported oil than many of its trading partners. For example, Japan imports almost all of its oil supply while the United States imports less than half. As a result, Japan must increase its exports relatively more than the United States to pay for an increase in its imported oil bill. Since Japan exports many of its products to the United States, the Japanese yen would likely fall relative to the dollar.

Given these and other possible effects, it is not certain whether an oil-price increase would cause the dollar to appreciate or depreciate. In any event, these effects are likely to be of secondary importance relative to the more direct effects described in the text.

5 In the long run, after supply effects have run their course, the effect on inflation depends on monetary policy. One monetary policy response would be simply to "accept" the decline in demand. In this case inflation would decline permanently. The reason is that with a decline in demand, output falls below full-employment output and exerts downward pressure on inflation. If monetary policymakers choose not to compensate for this decline in demand, such downward pressure would never be reversed by a period of above-full-employment output. Therefore, inflation would fall even in the long run. The decline would likely be small, however, because demand effects are relatively unimportant and because, in the long run, foreign oil producers would spend a greater and greater share of their increased income on U.S.-produced goods and services. This spending would reverse more and more of the demand effects of higher oil prices.

An alternative policy response would be to compensate for the decline in demand. This is the "neutral" policy described in the next subsection of the text.

6 The term *extinguishing* was coined by Gramlich (1979).

7 Given stable velocity, controlling either money growth or nominal GNP growth amounts to the same thing. See McCallum 1985 (p. 587) for a discussion of the view that policymakers may be better able to control nominal GNP growth than ultimate goal variables such as inflation or real growth.

8 For a discussion of how monetary policy might pursue short-run targets for nominal GNP growth, see Kahn 1988.

9 If the demand effects of oil-price shocks are unimportant and the slope of the demand curve is such that a one-percentage-point increase in inflation leads to a one-percentage-point decline in real GNP growth, then nominal GNP growth will not be affected by oil-price shocks. These assumptions are consistent with most leading intermediate macroeconomic textbooks, which focus on the supply effects of energy-price shocks and ignore the demand effects. It is also consistent with many macroeconomic models. For example, Hickman 1984 (as cited in Tatom 1988) found that aggregate demand effects of oil shocks are minimal in 14 large-scale and small-scale macro models and that, in most of these models, aggregate demand was unitary price-elastic so that "the relative magnitude of the output and price responses to an oil shock is similar across models, with big output reductions accompanying large price increases and vice versa" (Hickman 1984, p. 93, as cited in Tatom 1988, p. 329).

10 The short-run effect of higher oil prices on the implicit GNP deflator is smaller than the effect on other price indexes such as the consumer price index (CPI). This is because the GNP deflator excludes imports, while the CPI does not. One important import, of course, is oil. Thus, the GNP deflator excludes direct effects of higher oil prices on the overall price level that are included in the CPI.

11 The estimated inflation equation may overstate the effects of the current oil-price shock if the economy's vulnerability to higher oil prices has declined because of energy conservation. Evidence supporting a decline in oil-price vulnerability is a sharp decline in petroleum consumption as a share of real GNP since the late 1970s. Estimated effects may also be overstated if people view the current increase in oil prices as temporary rather than permanent.

12 The projected short-run effect on inflation of the current oil-price shock, given constant nominal GNP growth, is similar to that projected by the Data Resources, Inc. (DRI) model. The cumulative effect of the assumed $8 increase in oil prices in the estimated inflation equation was 1.6 percentage points over the four quarters from 1990:3 to 1991:2 (based on the actual estimated increase in inflation in those quarters rather than the four-quarter moving average reported in Chart 1). In the DRI model, with or without the assumption of constant nominal GNP growth imposed, the cumulative increase in inflation over the same period was also 1.6 percentage points. (All DRI estimates are based on simulations of the October 1990 control model assuming no effects of higher oil prices on the exchange rate or consumer confidence.) For another estimate of the inflation effect of the recent oil-price increase, see Feldstein 1990.

13 Because the neutral policy assumes that demand effects

are completely offset, inflation returns to its original level in the long run. One implication of a neutral policy is that output overshoots full-employment output for a period of time. The increase in output above its full-employment level offsets any demand-induced decline in inflation over the long run.

14 The projected short-run effect on output of the current oil-price shock, given constant nominal GNP growth, is similar to that projected by the Data Resources, Inc. (DRI) model. In the DRI model, with the assumption of constant nominal GNP growth imposed, output falls 1.0 percent below full-employment output. (All DRI estimates are based on simulations of the October 1990 control model assuming no effects of higher oil prices on the exchange rate or consumer confidence.) For another estimate of the output effects of the recent oil-price increase, see Feldstein 1990.

15 At the troughs of all recessions since 1947, actual real GNP was on average 4.5 percent below the full-employment level of real GNP. During the same period, the most that actual real GNP fell below full-employment GNP was about 9 percent in the fourth quarter of 1982.

16 Also included in Gordon's basic specification is a variable measuring relative changes in consumer prices. Because the CPI may be important for wage determination through cost-of-living escalators, it may also be important for price determination. The relative change in consumer prices is measured as the difference between the growth rates of the CPI and the GNP deflator.

17 With the inclusion of inertia, output, and relative price effects, Gordon 1988 finds that wage growth contributes insignificantly to the explanation of inflation. Thus, separate wage growth terms do not appear in the inflation equation.

18 The Nixon controls "on" dummy variable is set equal to 0.8 for the five quarters from 1971:3 to 1972:3. The "off" variable is set equal to 0.4 in 1974:2 and 1975:1 and to 1.6 in 1974:3 and 1974:4. Both dummy variables sum to 4.0 rather than 1.0 because the dependent variable is an annualized quarterly rate of change.

19 Before the second quarter of 1961, the Venezuelan crude-oil series was available only on an annual basis. These data were converted to quarterly data by assuming constant growth over the four quarters of each year.

20 Another limitation of the approach is the assumption that oil-price changes do not affect nominal GNP growth. If, contrary to the assumption, oil-price shocks have significant effects on nominal GNP growth, estimated inflation and output effects will be inaccurate. As previously argued, however, oil-price shocks are likely to have only negligible effects on nominal GNP growth. Moreover, monetary and fiscal policy can potentially offset the effects of oil-price changes on nominal GNP growth. In this case, the estimated model would still be useful in projecting what would happen to inflation and output under, say, a neutral monetary policy.

References

Bohn, Aileen A. 1990. "U.S. Petroleum Trade Trends: 1989," *Petroleum Supply Monthly*, January.

Feldstein, Martin. 1990. "The Fed Must Not Accommodate Iraq," *Wall Street Journal*, August 13.

Garner, C. Alan. 1988. "Policy Options to Improve the U.S. Standard of Living," Federal Reserve Bank of Kansas City, *Economic Review*, November.

Gordon, Robert J. 1985. "Understanding Inflation in the 1980s," *Brookings Papers on Economic Activity*, no. 1.

_____. 1988. "U.S. Inflation, Labor's Share, and the Natural Rate of Unemployment," National Bureau of Economic Research Working Paper no. 2585, May.

_____. 1990a. "What is New-Keynesian Economics?" *Journal of Economic Literature*, September.

_____. 1990b. *Macroeconomics*, 5th ed. Boston: Scott, Foresman and Company.

Gramlich, Edward M. 1979. "Macro Policy Responses to Price Shocks," *Brookings Papers on Economic Activity*, no. 1.

Hickman, Bert G. 1984. "Macroeconomic Effects of Energy Shocks and Policy Responses: A Structural Comparison of Fourteen Models," Energy Modeling Forum Working Paper 7.4, Stanford University, September, in Bert G. Hickman, Hill G. Huntington and James C. Sweeney, eds., *Macroeconomic Impacts of Energy Shocks*. New York: North Holland, 1987, pp. 125-98.

Kahn, George A. 1988. "Nominal GNP: An Anchor for Monetary Policy?" Federal Reserve Bank of Kansas City, *Economic Review*, November.

McCallum, Bennett. 1985. "On Consequences and Criticisms of Monetary Targeting," *Journal of Money, Credit, and Banking*, part 2, November.

Tatom, John A. 1988. "Are the Macroeconomic Effects of Oil-Price Changes Symmetric?" Carnegie-Rochester Conference Series on Public Policy, vol. 28, Spring.

Will Increased Regulation of Stock Index Futures Reduce Stock Market Volatility?

By Sean Becketti and Dan J. Roberts

On October 19, 1987, the Dow Jones Industrial Average plunged 508 points, the worst single-day loss ever for U.S. stocks. This episode, along with others, has caused policymakers and the public in general to focus their attention on stock market volatility. Many believe that large swings in stock prices have occurred more often and have become larger in recent years.

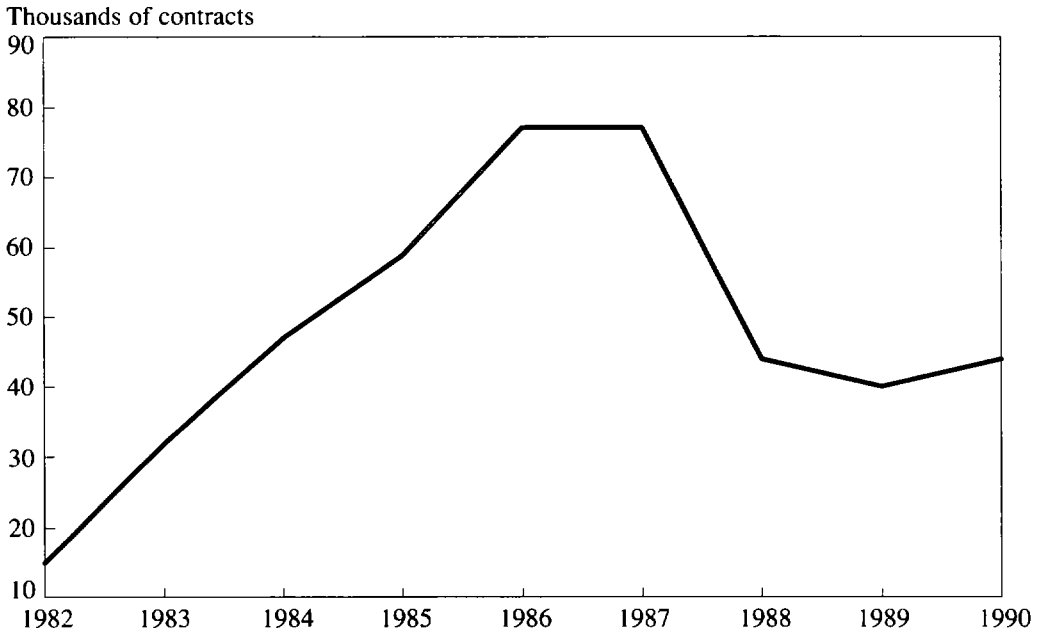
Some people blame stock index futures for the perceived increase in stock market volatility. Stock index futures might contribute to stock market volatility in two ways. First, futures and stock trading might interact to worsen individual stock market disruptions, such as the October 1987 collapse. Second, futures trading might produce a market environment generally more susceptible to stock market disruptions. Many studies have analyzed the interactions between futures and stocks in individual stock market collapses. This article is one of relatively few concerned with the second, more general way in which futures might increase stock market volatility.

To reduce the effect of futures on stock market volatility, regulations aimed at reducing the general level of futures activity have already been adopted or have been proposed. While these regulations may or may not reduce stock market volatility, they certainly will impose costs on participants in the stock index futures market. Because the regulations are costly, it is important to find out whether the stock index futures market actually contributes to stock market volatility.

This article finds that futures market regulations intended to reduce futures trading are

Sean Becketti is a senior economist and Dan J. Roberts is a research associate at the Federal Reserve Bank of Kansas City.

Chart 1
Volume of Stock Index Futures Trading



Note: This chart displays the typical daily stock index futures volume from April 21, 1982 through July 31, 1990. Futures volume is measured by the median daily number of S&P 500 futures contracts traded.

Source: Data Resources Inc., Lexington, Mass.

unlikely to reduce stock market volatility. The first section of this article describes the market for stock index futures and explains why futures are blamed for stock market volatility. The second section discusses the costs of current and proposed futures market regulations. The third section presents evidence that stock index futures have not increased stock market volatility, whether measured by the frequency or the size of large swings in stock prices.

I. Stock Index Futures and Stock Market Volatility

Stock index futures are one of the most successful financial innovations of the 1980s. Two characteristics of stock index futures make them popular with investors. First, the price of these futures is closely related to the value of the stock market as a whole. Second, they are relatively inexpensive to trade. These two characteristics make stock index futures useful in a variety of investment programs. However, these characteristics also lead some observers to blame stock index futures for stock market volatility.

What are stock index futures?

A financial futures contract is an agreement to buy or sell a financial asset, such as a Treasury bond or a specified amount of a foreign currency, at a given time in the future. The price of the future transaction is determined when the

agreement is made. Stock index futures are financial futures contracts in which the underlying financial asset is a basket of stocks. The several different stock index futures contracts are distinguished by the basket of stocks underlying the contract. The most popular of these is the Chicago Mercantile Exchange's contract based on the Standard & Poor's 500 Composite Stock Price Index.

No money is exchanged when a futures contract is traded. A futures contract is simply an agreement to make an exchange in the future. As it turns out, however, assets are not exchanged even in the future. Instead, buyers and sellers of stock index futures contracts are required to settle their positions by taking offsetting positions. For instance, investors who buy S&P 500 contracts must settle their positions by selling contracts by the original contracts' delivery date.[1]

An example may help clarify this process. The price of the S&P 500 futures contract is quoted as an index, in units that are comparable to the actual S&P 500 stock price index. The real price paid for an S&P 500 futures contract is $500 times the value of the index. Thus, if the index value is 300, an investor would pay $150,000 to buy one futures contract ($500 times the index value of 300). Sometime before the expiration date of the contract, the investor must offset this position by selling a contract at whatever the futures index value happens to be. For the purpose of this example, assume the investor sells a contract to offset his initial purchase when the futures index has increased to 303. At this index value, the investor would sell the contract for $151,500 ($500 times 303). Thus, the investor would make a profit of $1,500 ($500 times the three-point change in the futures index value).

Stock index futures were introduced in mid-1982 and were an immediate success (Chart 1). By 1984, the dollar value of S&P 500 contracts traded exceeded the dollar volume of stocks traded on the New York Stock Exchange (Merrick 1987). Trading volume peaked in 1986 and 1987, when the median number of contracts traded each day was 77,000.[2] Volume declined after the stock market collapse in October 1987. In recent years, futures trading volume has averaged around 40,000 contracts a day.

Why are stock index futures popular?

Stock index futures are popular among investors because they are an economical substitute for buying and selling a diversified portfolio of stocks. Futures prices are tied to the values of diversified portfolios rather than to the prices of individual stocks. As a result, investors can buy or sell futures rather than buying or selling many different stocks. Trading futures is more economical than buying or selling many different stocks because the transactions costs of futures are low.

Investors who buy stock index futures contracts receive similar gains and losses as if they bought an equivalent amount of stock. The gains and losses are similar because the price of a futures contract is highly correlated with the price of the basket of stocks in the index that underlies the contract (Cornell and French 1983). In the example above, the 1 percent increase in the futures price, from 300 to 303, reflects a comparable increase in the value of the S&P 500 index. Thus, investors who buy contracts benefit if stock prices rise after they purchase their futures contracts. These investors receive the increase in the value of the index when they offset their position by selling contracts. Similarly, investors who sell contracts benefit if stock prices fall after they sell their futures contracts. To offset their position, these investors purchase contracts at the new, lower price.

Another important feature of stock index futures is their low transactions costs. Trading stock index futures contracts is less expensive

than trading the equivalent basket of stocks because brokers' fees and margin requirements in the futures market are relatively low (Kling 1986). The brokerage cost at a discount broker of establishing and settling a position in an S&P 500 index futures contract is only $32. Since the value of a contract is $500 times the value of the index, this fee represents just over 0.02 percent of the underlying value of the contract when the S&P 500 index is 300. Brokerage fees for an equivalent stock purchase are many times higher.

The initial margin requirement for futures trading is also relatively small. A margin is the minimum amount of money an investor must pay to buy securities.[3] The margin on an S&P 500 index futures contract used for hedging is currently $8,000—less than 5.5 percent of the contract when the S&P 500 index is 300. Investors can earn interest on their initial margin by using U.S. government securities to meet the margin requirement. In contrast, the margin requirement for stock purchases is 50 percent of the value of the purchase, and the margin must be paid in cash.[4]

How are stock index futures used?

The characteristics that make stock index futures popular also make them well suited to a number of different investment uses. Portfolio managers can sell stock index futures to hedge the value of a diversified stock portfolio against changes in the value of the stock market as a whole (Morris 1989). As stock prices change, losses (profits) on the stocks will be largely offset by profits (losses) on the futures contracts because futures prices are closely related to the value of a broad market index. For example, if stock prices fall, the value of the stock portfolio falls. At the same time, the price of the futures contract falls. When portfolio managers buy futures to offset their initial futures contract sales, they make a profit because they pay less than they received when they originally sold the futures. This profit on the futures trades can help offset the loss on the stocks and thus reduce the change in the value of the total portfolio.[5]

Many investment strategies require portfolio managers to adjust the proportion of stocks in the portfolio over time. Portfolio insurance, asset allocation, and market-timing strategies are just a few of the investment approaches that involve frequent changes in stock holdings (Petzel 1989). Portfolio managers frequently choose to make these adjustments by buying or selling futures rather than stocks.

Another investment strategy involving stock index futures is index arbitrage. This strategy is a form of program trading in that it involves the purchase or sale of a group of stocks.[6] While the price of stock index futures is highly correlated with the value of the underlying stock index, occasionally the price of the futures contract diverges from its usual relationship to the value of the stocks. These episodes provide arbitragers with opportunities to profit. For example, assume the price of the futures contract rises, while the price of stocks does not change. In this situation, arbitragers can guarantee a profit by selling the relatively expensive futures contract and buying the relatively inexpensive stocks. This arbitrage continues until the usual relationship between futures and stock prices is restored.

Finally, stock index futures are an attractive asset to stock market speculators. The availability of futures makes it possible for speculators to take positions that would not be economical if they had to buy or sell shares directly.

Why are stock index futures blamed for stock market volatility?

Stock market volatility can be divided into two types, normal volatility and jump volatility

(Becketti and Sellon 1989). Normal volatility refers to the ordinary ups and downs in stock prices. Jump volatility, on the other hand, refers to occasional and sudden extreme changes in prices. The leading example of jump volatility is the market collapse in mid-October 1987. However, the market has endured many stock price jumps besides those in October 1987.

The type of stock market volatility that concerns legislators, regulators, and market makers is jump volatility.[7] Jumps in stock prices over a few hours or a day can temporarily disrupt capital markets and strain market mechanisms. In the most extreme example of jump volatility, the October 1987 market collapse, many stocks stopped trading for several hours. The execution of trades of other stocks also was delayed sometimes for hours, leaving investors with little idea of the prices that would prevail when their trades were executed. In addition, losses suffered by many stock market specialists threatened their continued participation in the market (U.S. Presidential Task Force on Market Mechanisms 1988).

Jump volatility also raises concerns about individual investors' access to, and participation in, the market. An increase in jump volatility may make it more important for investors to employ sophisticated strategies to protect the value of their portfolios. While institutional investors possess the expertise in, and the access to, futures and options markets necessary to execute these strategies, some observers fear that individual investors do not have the same expertise and access. As a result, these observers fear that individual investors will simply leave the stock market in reaction to an increase in jump volatility.[8]

The features of stock index futures that make them popular—low transactions costs and a close relationship to the value of the stock market—also explain why futures are blamed for volatility. For example, these features increase speculative activity. To the extent speculative activity tends to increase the volatility of futures prices, this futures market volatility then spills over into the stock market. In addition, low trading costs ensure that the fads and panics that occasionally afflict financial markets find little or no resistance in futures markets. The shifting moods of the financial community are translated immediately into violent oscillations in futures prices and then into stock prices.

Program trading is also believed to increase jump volatility. Some observers fear stock price jumps can set off a cascade effect, that is, a free-fall in stock prices that feeds on itself.[9] According to this view, a sudden drop in stock prices can trigger computer-driven futures trading strategies that drive stock index futures prices down. The drop in futures prices then feeds back to the stock market, and the cycle begins again.

II. Costs of Regulations That Reduce Futures Market Activity

Many people believe stock index futures contribute to jump volatility in the stock market. To reduce the effect of futures on jump volatility, regulations that reduce the general level of futures activity have been adopted or proposed. These regulations reduce futures activity because they make futures trading more costly.

One type of regulation that has already been adopted is circuit breaker rules. Circuit breakers are rules that temporarily suspend trading if price movements exceed certain thresholds. Proponents of circuit breakers believe that suspending trading prevents panics by giving traders time to reevaluate market conditions and to bolster their liquidity and credit (Morris 1990). Thus, one reason for circuit breakers is they halt trading during an incipient panic. Another reason for circuit breakers, however, is to reduce the general level of futures activity.[10]

One cost of circuit breakers is they make

futures trading riskier. Circuit breakers raise the possibility that investors may not be able to trade at some time in the future. Because circuit breakers are triggered by events that cannot be predicted accurately, investors cannot effectively protect themselves against the possibility of these trading halts. From the point of view of investors, this uncertainty makes it riskier to trade in futures.

Another cost of circuit breakers is they can expose clearing houses to increased credit risk by implicitly extending margin credit to some traders (Moser 1990). Traders in futures are required to make additional margin payments when they suffer losses. If trading is halted because of a circuit breaker, the adequacy of margins is evaluated at the price of the last recorded trade. While trading is halted, the true market price, that is, the price that would prevail in the absence of the circuit breaker-imposed trading halt, may change substantially. Thus, some traders have trading losses that are not recognized while trading is halted. When trading resumes, if the losses are so large that these traders cannot fulfill their contracts, the clearing house may be forced to assume the failed traders' obligations.

Circuit breakers also may inadvertently increase stock market volatility. When circuit breakers are close to being triggered, market participants may buy or sell futures frantically to avoid being locked in. This panic trading may increase futures market volatility which, in turn, will increase stock market volatility. In addition, if circuit breakers suspend futures trading but not stock trading, stock market volatility may increase as frustrated futures investors shift their trading to the stock market (Morris 1989).

A regulation that has been proposed to reduce the volume of futures trading is higher margin requirements. Higher margins directly increase the transactions cost of trading futures by increasing the amount of money investors must post to make trades.[11] These increased costs reduce all futures trading, including hedging. The general reduction in trading represents a loss of liquidity to the market. In addition, the reduction in hedging makes investors more vulnerable to swings in the value of stocks than they would be if margins were lower and they hedged more completely.

III. Do Stock Index Futures Cause Stock Market Volatility?

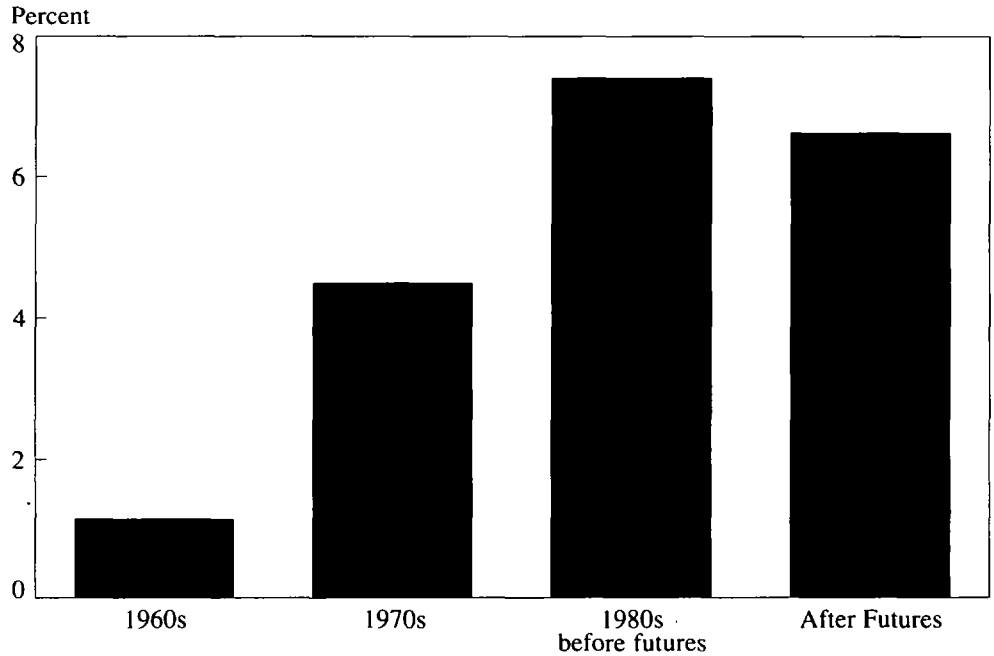
Futures market regulations that reduce the overall level of futures market activity thus impose substantial costs on investors. Imposing these costs is justified by the belief that reducing futures trading reduces jump volatility in the stock market. But without persuasive evidence that futures are responsible for stock market volatility, regulations intended to reduce volatility by reducing the overall level of futures trading are inadvisable.[12]

Have stock index futures increased the frequency of stock price jumps?

One way stock index futures might increase jump volatility is to make stock price jumps more likely. Researchers measure jumps by setting a band within which stock price movements are considered normal or ordinary. Movements outside the band are identified as jumps because they are considered exceptional. For example, some researchers identify jumps in daily data as price changes in excess of 1 or 2 percent, either up or down (Schwert 1990).

Using a statistical technique designed to highlight unusual values, this article defines a daily jump as any day in which the S&P index rises or falls more than approximately 1.75 percent.[13] At current price levels, this represents about a 40-to-50-point or more move in the Dow.[14] From July 1962 through August 1990, 4.5 percent (317 days) of all daily changes in the

Chart 2
Frequency of Jumps in Daily Stock Returns



Note: This chart displays the frequency of stock price jumps in different periods. The frequency of jumps is measured by the number of daily jumps in the S&P 500 index divided by the number of trading days in the period. The bar labeled "1960s" includes data from July 3, 1962, through the end of the 1960s. The bar labeled "1970s" covers the entire 1970s. The bar labeled "1980s before futures" includes data from the beginning of 1980 through April 20, 1982. The bar labeled "After Futures" includes data from April 21, 1982 - the first day of trading for the S&P 500 futures contract - through August 10, 1990.

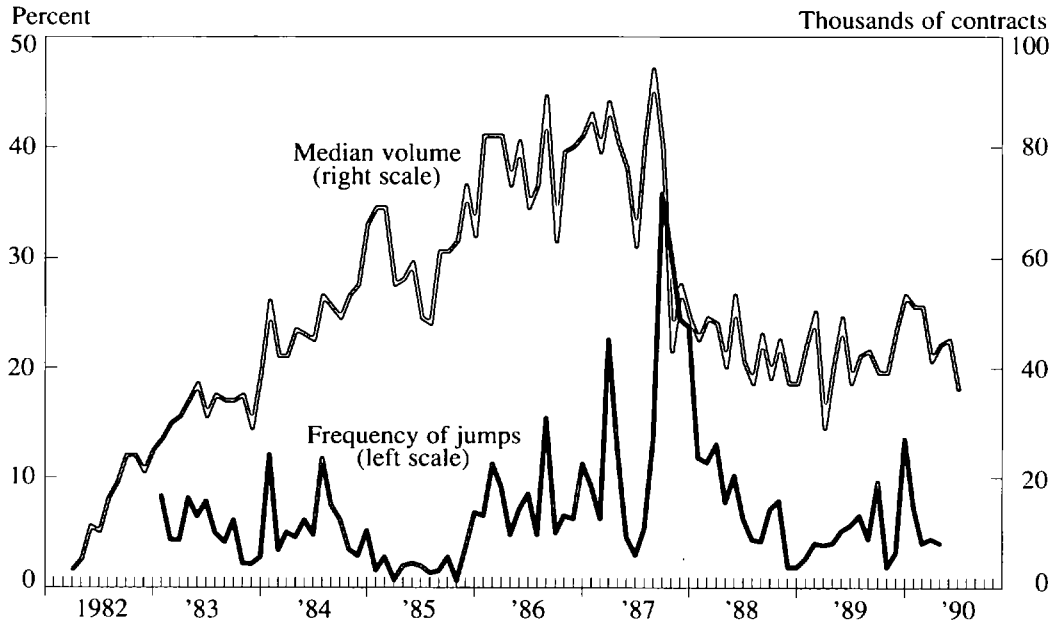
Source: Standard and Poor's Corporation.

S&P 500 stock index were jumps. Forty-six percent of these jumps represented declines in the stock index. The median jump involved a change of slightly more than 2 percent, either up or down, in the S&P 500 index.

At first glance, the futures market appears to have made stock price jumps more likely because jumps in stock prices have been more frequent since stock index futures began trading. Trading in S&P 500 stock index futures began on April 21, 1982. From 1962 through April 20, 1982, 3.6 percent of daily returns were jumps. From April 21, 1982, through August 1990, 6.6 percent of daily returns were jumps. In other words, stock price jumps have been almost twice as frequent since the introduction of futures as in the preceding 20 years.

Closer examination, however, shows the increase in the frequency of jumps cannot be attributed to stock index futures because the frequency of jumps began increasing well before futures began trading (Chart 2). In the 1960s, only 1.1 percent of daily returns were jumps. By the early 1980s, jumps represented 7.4 percent of daily returns. In fact, compared with the early 1980s, stock price jumps have become slightly less frequent since the advent of stock index futures trading. Thus, it is not plausible to attribute the slow, steady increase in the frèquency of jumps since the early 1960s

Chart 3
Futures Volume and the Frequency of Stock Price Jumps



Note: This chart displays monthly measurements of stock index futures volume and the frequency of stock price jumps. Futures volume is measured by the median daily number of S&P 500 futures contracts traded. The frequency of stock price jumps is measured by the number of hourly jumps in the S&P 500 index divided by the number of trading hours in the month.

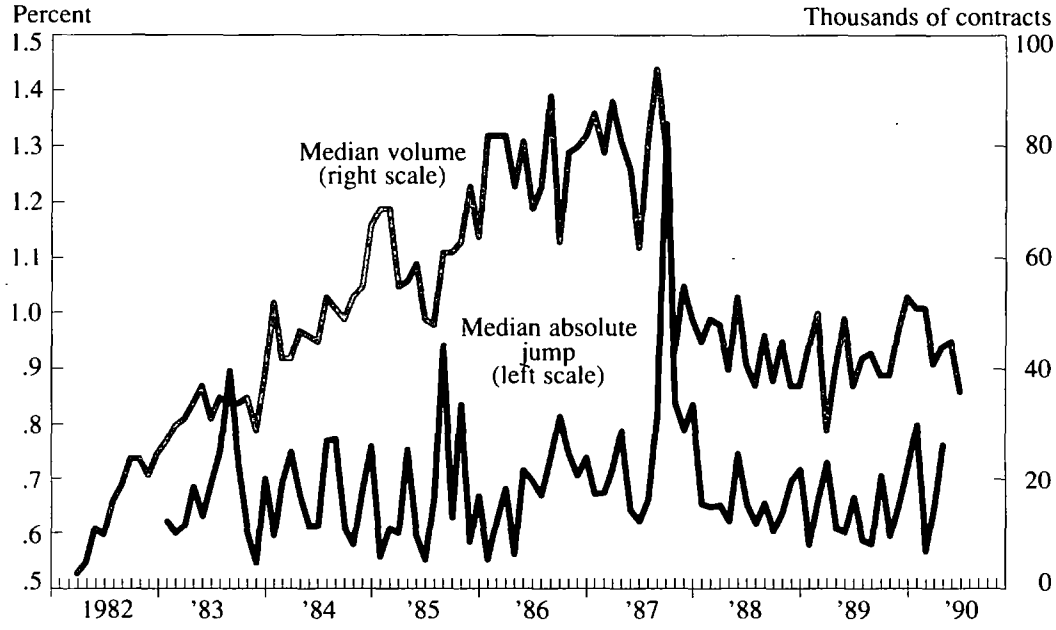
Source: Data Resources Inc., Lexington, Mass. (for futures volume) and Tick Data Inc. , Lakewood, Colo. (for S&P 500 index).

solely, or even mainly, to the futures market.

Even though the frequency of jumps has decreased compared with the early 1980s, jump volatility might be even lower if stock index futures were not available. One way to test whether the futures market contributes to jump volatility is to see if jumps are more frequent when futures activity is high. If stock index futures are a source of additional jump volatility, then volatility should be high when futures activity is generally high and low when futures activity is generally low.

As it turns out, trading volume—the most common measure of futures activity—appears to be unrelated to the frequency of jumps. Chart 3 displays monthly observations of futures trading volume and hourly stock price jumps.[15] For this comparison, hourly jumps are a more appropriate measure of volatility than daily jumps.[16] The volume of futures trading grew steadily from 1982 then peaked in 1986-87 at around 77,000 contracts a day. In contrast, the frequency of hourly jumps showed no upward trend. In October 1987, the frequency of jumps rose sharply without a corresponding rise in futures volume. Both volatility and volume fell sharply after October 1987. Since the stock market collapse, there has been no upward or downward trend in either volatility or volume. Thus, the only period over which a close relationship appeared to exist is the several months of decline in volume and volatility just

Chart 4
Futures Volume and the Size of Stock Price Jumps



Note: This chart displays monthly measurements of stock index futures volume and the size of stock price jumps. Futures volume is measured by the median daily number of S&P 500 futures contracts traded. The size of stock price jumps is measured by the median hourly absolute percentage change in the S&P 500 index within each month.

Source: Data Resources Inc., Lexington, Mass. (for futures volume) and Tick Data Inc., Lakewood, Colo. (for S&P 500 index).

following the October 1987 collapse.

The lack of relationship between futures volume and the frequency of jumps apparent in Chart 3 is confirmed by statistical analysis. One statistic that measures the relationship between two variables is the correlation coefficient. The correlations between daily and hourly stock price jumps and futures trading volume are small, indicating little or no association between futures trading volume and the frequency of stock price jumps.[17] The correlation between daily stock price jumps and futures volume is only 0.14 and is not significantly different from zero at the 5 percent level. The correlation between hourly stock price jumps and futures volume is also small, 0.17. However, this correlation is significantly different from zero at the 5 percent level.

The statistical significance of the relationship between futures volume and hourly stock price jumps disappears, however, when other factors that might affect volatility are taken into account. One problem with correlation coefficients is they ignore the impact of other variables that may be important. For example, stock market volatility may exhibit seasonal variation reflecting end-of-year tax-related trading strategies or the time pattern of dividend payments. In addition, stock market volatility today may be influenced by recent episodes of volatility. In other words, once volatility is high, it may stay high for a while. To test for these

possibilities, the frequency of jumps was regressed on its own recent past and seasonal factors along with the volume of futures trading. When these other factors were taken into account, the relationship between jumps and futures volume was no longer statistically significant.[18]

Have stock index futures increased the size of stock price jumps?

Another way that stock index futures might increase jump volatility is to increase the size of stock price jumps when they do occur. However, the size of the typical stock price jump has not increased markedly since futures began trading. From the beginning of 1962 through April 20, 1982, the median daily jump involved a 2.1 percent change in stock prices, either up or down. Since April 20, 1982, the typical jump has increased only 0.2 percent to 2.3 percent.

Even though the typical jump has not grown larger since stock index futures trading began, jumps might be even smaller if futures were not available. If stock index futures are responsible for this type of increase in jump volatility, then jumps should be larger when futures activity is generally high and smaller when futures activity is generally low.

As it turns out, however, the size of the typical hourly jump in stock prices appears to be unrelated to the volume of futures trading. Chart 4 shows that the median absolute hourly stock price jump essentially has been flat except for the October 1987 market collapse. In contrast, the volume of trading grew until October 1987, dropped sharply just after the market collapse, and has been flat ever since.

A correlation analysis confirms the impression given by the chart. The correlation between the size of daily stock price jumps and futures volume is only 0.03. The correlation between the size of hourly stock price jumps and futures volume is 0.11. Neither of these correlations is significantly different from zero.[19]

IV. Conclusion

The high correlation between stock index futures prices and stock prices, combined with the low cost of futures trading, has led some observers to blame high levels of stock index futures activity for recent bouts of volatility in the stock market. Circuit breakers were adopted partly to reduce futures activity in order to reduce stock market volatility. Higher margins also have been proposed to reduce futures activity. However, circuit breakers and higher margins impose costs on investors and may have adverse effects on the functioning of financial markets. Thus, reducing futures market activity to reduce stock market volatility makes sense only if futures trading is responsible for volatility.

This article finds little or no relationship between stock market volatility and either the existence of, or the level of activity in, the stock index futures market. As a result, while circuit breakers and higher margins may be useful for other reasons, their depressing influence on the volume of futures trading is unlikely to reduce stock market volatility.

Appendix

This article uses a statistical method designed to highlight potential outliers—abnormally small or large values—to identify stock price jumps. The method consists of constructing a band based on a robust measure of the dispersion of the observations in the sample. Observations that fall outside this band are identified as jumps.

The upper and lower ends of the band are calculated as follows:

$$\text{upper end of band} = 75\text{th percentile} + 1.5\left(\text{interquartile range}\right)$$

$$\text{lower end of band} = 25\text{th percentile} - 1.5\left(\text{interquartile range}\right)$$

The interquartile range is the difference between the 75th and 25th percentile of the distribution of stock returns. These percentiles are calculated for the entire sample of returns. The frequency of jumps is calculated as the number of jumps divided by the number of observations.

A similar measure of jumps is used and described in Becketti and Sellon 1989. This measure is particularly well suited to analyzing data that are approximately normally distributed except in the tails of the distribution. Stock returns fit this description exactly. The value *1.5* in the formulas above controls the frequency of jumps. For a normally distributed variable, this measure identifies less than 1 percent of a large sample as jumps.

This measure has the advantage of being able to identify multiple jumps when the maximum number of jumps is not known in advance. Because jumps are restricted to lie outside the interquartile range, up to half the observations could, in theory, be identified as jumps. Since the quartiles are the only order statistics used in constructing the cutoffs, the breakdown point of this measure is 25 percent; that is, up to a quarter of the observations could be replaced by arbitrary values without affecting the measure. This is a high breakdown point for a measure of dispersion. A detailed study of this measure and its statistical properties can be found in Hoaglin, Iglewicz, and Tukey 1987.

Endnotes

[1] Physical delivery rarely occurs in most futures contracts, whether financial or commodity. In the case of stock index futures contracts, delivery is prohibited and cash settlement required because of the difficulty of assembling the precise basket of stocks that underlies the contract.

[2] The median volume is the 50th percentile of the observed volumes; that is, half the observed volumes are less than the median and half are greater. As a measure of the central tendency or average value, the median is less sensitive to a few unusual observations than is the arithmetic mean.

[3] For stock purchases, the margin is the down payment on a loan used to buy the stock. For futures purchases and sales, the margin is essentially a performance bond the investor posts to guarantee he will fulfill his side of the contract.

[4] There are some exceptions and qualifications to the requirement that margins for stock purchases are paid in cash. Sofianos 1988 provides a thorough description of margin requirements.

[5] An additional reason that stock index futures contracts are particularly useful for hedging is that short sales of stocks are often difficult and costly. Investors sell stocks short by borrowing shares and then selling the borrowed shares. Thus, to sell stocks short, investors must find current shareholders willing to lend their shares. This requirement limits the volume of short sales to the amount

of existing shares. In addition, it can be difficult and time-consuming to find the desired number of shares to borrow.

In contrast, it is easy and economical to take the equivalent position by selling futures contracts. When a futures contract is sold, the seller is simply agreeing to sell the underlying asset at some future date. Since futures contracts are settled in cash rather than shares of stock, sellers never have to obtain the shares of stock. Thus, the amount of futures contracts that can be sold is limited only by the availability of buyers.

[6] The New York Stock Exchange defines a program trade as the simultaneous purchase or sale of at least 15 stocks with a total trade value greater than $1 million. See Duffee, Kupiec, and White 1990 for an examination of program trading.

[7] Most researchers have found that normal volatility in U.S. stock markets has, with the exception of the Great Depression, been stable since the mid-19th century (Schwert 1990; Shiller 1989).

[8] Former Treasury Secretary Donald Regan expressed this viewpoint forcefully in testimony at a U.S. Senate hearing (1988). He said, "The public has every reason to believe that the present game is rigged. It is. Many would be better off in a casino since there people expect to lose but have a good meal and a good time while they're doing it."

[9] Following the October 1987 market collapse, the Brady Commission (U.S. Presidential Task Force on Market Mechanisms 1988) identified some types of program trading as a contributing factor to the collapse. The Brady Commission also concluded that links forged by program trading between the futures and stock market have made the stock market vulnerable to disruptions emanating from the futures market. In the *Interim Report of the Working Group on Financial Markets*, another study of October 1987, then-chairman of the SEC David Ruder concurred that "certain futures-related trading strategies [i.e., program trading] have resulted in a dramatic increase in the size and velocity of institutional trading which, in turn, has resulted in substantially increased price volatility."

[10] The Brady Commission (U.S. Presidential Task Force on Market Mechanisms 1988) emphasized this role of circuit breakers. Their report points out that circuit breaker mechanisms counter the illusion of liquidity by formalizing the economic fact of life...that markets have a limited capacity to absorb massive one-sided volume.... This makes it less likely in the future that flawed trading strategies will be pursued to the point of disrupting markets and threatening the financial system." (U.S. Presidential Task Force on Market Mechanisms 1988, p.66)

In other words, circuit breakers force investors to realize there will be times in the future when they will not be able to carry out some futures-related trading strategies. As a result, these investors will be less aggressive in pursuing these strategies in the present. Thus, the portion of futures trading due to these strategies will decline as a result of circuit breakers.

[11] Noting that margins in the futures market are low compared with margins in the stock market, the Brady Commission proposed that margins be "harmonized" across markets. The Commission reasoned that the apparent disparity in margin requirements encourages excessive futures trading. David Ruder, in the *Interim Report of the Working Group on Financial Markets*, also called for higher margins on futures, in part to "decrease derivative market speculative activity."

[12] Circuit breakers and higher margins might be ineffective even if stock index futures contribute to stock market volatility (Edwards 1988). In this case, of course, the regulations are inadvisable. This article, however, argues against regulations intended to reduce futures trading on the grounds the evidence does not support the notion that stock index futures are linked to stock market volatility. Of course, statistical evidence on the general relationship between futures activity and stock market volatility cannot determine whether futures trading was related to a specific historical event, such as the October 1987 market collapse.

[13] The precise cutoffs for jumps are daily S&P 500 returns greater than 1.7865 percent or less than -1.7367 percent. The statistical technique used to determine these cutoffs is described in the appendix.

[14] The New York Stock Exchange places restrictions on index arbitrage whenever the Dow Jones Industrial Average moves 50 points or more from its closing value on the previous trading day. While the exchange did not use the statistical method employed in this article in designing its restrictions, this exchange rule indicates that this statistical method highlights stock movements that the exchange also recognizes as potentially destabilizing.

[15] Chart 3 displays monthly observations of the median daily volume of trading of S&P 500 index futures contracts and the frequency of hourly jumps in the S&P 500 index. Monthly observations are used because the hypothesis under examination relates the frequency of price jumps to changes in the general level of activity in the futures market. The median daily volume for the month is an indicator of the general level of activity in the futures market. Thus, the data displayed in Chart 3 show whether months with higher-than-average futures trading activity are also months with a higher-than-average frequency of jumps.

A related question, not considered in this article, is

whether stock price jumps and high futures volume occur at precisely the same time. This question is concerned not with volatility, but with the ways new information is incorporated in securities prices. This latter question is addressed more appropriately with daily or hourly, rather than monthly, observations. Karpoff (1987) surveys studies that test whether increases in trading volume are related to price changes and discusses the significance of these studies.

[16] It is difficult to appraise the relationship between daily stock price jumps and futures trading from a chart of monthly observations because there are many months with no daily jumps. The data on hourly stock prices cover the period from February 1983 through May 1990. Thus, the hourly data are available only after stock index futures began trading. For this reason, only daily stock price jumps could be used to assess whether stock price jumps increased after futures were introduced. In these data, hourly returns greater than 0.5386 percent or less than -0.5151 percent are considered jumps.

[17] Correlations were calculated between monthly observations of the median daily volume of S&P 500 stock index futures trading and the frequency of daily and hourly jumps in the S&P 500 index. The correlation coefficient is Kendall's tau, a nonparametric statistic that takes on values between minus one and one. Values near minus one or one indicate pairs of variables with a strong association. Values near zero indicate pairs of variables with little or no association.

[18] This result is obtained by regressing the log of the monthly frequency of hourly stock price jumps against 12 lagged values of stock price jumps, monthly dummy variables, and the log of the median monthly volume of daily futures trading. The regression is estimated using data from February 1984 through May 1990. The coefficient on the trading volume variable is 0.57 indicating that a 1 percent increase in trading volume is associated with a 0.57 percent increase in the frequency of jumps. This regression has an R-square of 0.55 and an F-statistic of 2.61 with 24 numerator and 51 denominator degrees of freedom.

This regression is representative of an extensive regression analysis performed to see if any relationship between futures trading activity and jump volatility could be discovered. A second measure of futures activity—the open interest in S&P 500 stock index futures contracts—was included. This analysis confirmed the lack of association between futures trading and jump volatility reported in this article. Details of this analysis are available on request.

[19] Correlations were calculated between monthly observations of the median daily volume of S&P 500 stock index futures trading and the median absolute daily and hourly jumps in the S&P 500 index. As before, the correlation coefficient is Kendall's tau.

References

Becketti, Sean, and Gordon H. Sellon, Jr. 1989. "Has Financial Market Volatility Increased?" Federal Reserve Bank of Kansas City, *Economic Review*, June.

Cornell, Bradford, and Kenneth R. French. 1983. "The Pricing of Stock Index Futures," *The Journal of Futures Markets*, Spring.

Duffee, Gregory, Paul Kupiec, and Patricia White. 1990. "A Primer on Program Trading and Stock Price Volatility: A Survey of the Issues and the Evidence," Finance and Economics Discussion Series no. 109, Board of Governors of the Federal Reserve System, January.

Edwards, Franklin R. 1988. "Studies of the 1987 Stock Market Crash: Review and Appraisal," *Journal of Financial Services Research*, June.

Hoaglin, David C., Boris Iglewicz, and John W. Tukey. 1986. "Performance of Some Resistant Rules for Outlier Labeling," *Journal of the American Statistical Association*, December.

Karpoff, Johnathan, M. 1987. "The Relation between Price Changes and Trading Volume: A Survey." *Journal of Financial and Quantitative Analysis*, March.

Kling, Arnold. 1986. "Futures Markets and Transactions Costs," in Myron L. Kwast, ed., *Financial Futures and Options in the U.S. Economy: A Study by the Staff of the Federal Reserve System*. Washington: Board of Governors of the Federal Reserve System.

Merrick, John J. 1987. "Price Discovery in the Stock Market." Working paper no. 416, Salomon Brothers Center for the Study of Financial Institutions, Graduate School of Business Administration, New York University, April.

Morris, Charles S. 1989. "Managing Stock Market Risk with Stock Index Futures," Federal Reserve Bank of Kansas City, *Economic Review*, June.

Morris, Charles S. 1990. "Coordinating Circuit Breakers in Stock and Futures Markets," Federal Reserve Bank of Kansas City, *Economic Review*, March/April.

Moser, James T. 1990. "Circuit Breakers," Federal Reserve Bank of Chicago, *Economic Perspectives*, September/October.

Petzel, Todd E. 1989. *Financial Futures and Options: A Guide to Markets, Applications, and Strategies*. New York: Quorum Books.

Regan, Donald. 1988. Testimony, U.S. Senate Hearing, Committee on Banking, Housing, and Urban Affairs, May 24.

Roll, Richard. 1988. "The International Crash of October 1987," *Financial Analysts Journal*, September/October.

Schwert, G. William. 1990. "Stock Market Volatility," *Financial Analysts Journal*, May/June.

Shiller, Robert J. 1989. "Causes of Changing Financial Market Volatility," in *Financial Market Volatility*, Federal Reserve Bank of Kansas City.

Sofianos, George. 1988. "Margin Requirements on Equity Instruments," Federal Reserve Bank of New York, *Quarterly Review*, Summer.

U.S. Presidential Task Force on Market Mechanisms. 1988. *Report of the Presidential Task Force on Market Mechanisms*, Washington, January.

Working Group on Financial Markets. 1988. *Interim Report of the Working Group on Financial Markets*, Washington, May.

A Crossroads for the Cattle Industry

By Alan D. Barkema and Mark Drabenstott

A decade of mergers, buyouts, and declining cattle numbers has brought the nation's cattle industry to a crossroads as it enters the 1990s. One road would continue the path of the past decade—toward a smaller, more concentrated industry. The other road would change direction and allow some expansion in the industry, although most segments might remain highly concentrated. Which road the industry takes will depend on consumers and their willingness to purchase beef instead of other meats.

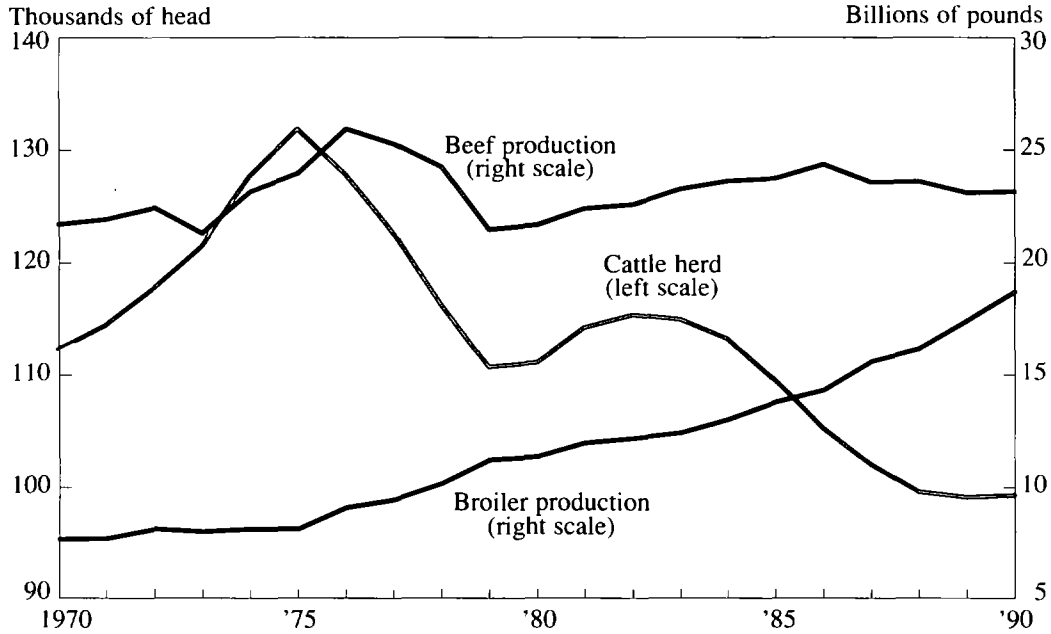
The future course of the cattle industry will have great impact on the farm economy in the region. At the farm level alone, cattle account for nearly $15 billion of annual farm income in the seven states of the Tenth Federal Reserve District—Colorado, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, and Wyoming. The economic activity associated with beef processing is even greater. District states are home to some of the nation's largest beef feedlots and beef packing plants, a critical economic base for many rural communities in the region. For these communities, the two roads ahead spell two very different futures: one road leads to economic stagnation or decline and the other road leads to economic growth.

The future of the cattle industry depends on whether it can lower its costs while satisfying the consumer's demand for leaner, more convenient beef products. The industry has little prospect for cutting costs further through traditional methods. But a new industry effort to deliver beef products better suited to today's consumers could also unlock significant cost savings. If successful, the new strategy would push the district's cattle industry toward expansion.

The first section of this article reviews the downsizing and increased concentration that occurred in the cattle industry over the past

Alan D. Barkema is a senior economist at the Federal Reserve Bank of Kansas City and Mark Drabenstott is an assistant vice president and economist. Julie Stanley, an assistant economist at the bank, assisted in preparing the article.

Chart 1
Cattle Herd Size and Meat Production



Source: U.S. Department of Agriculture, "*Agricultural Outlook*"; U.S. Department of Agriculture, "*Cattle*."

decade. The second section examines the cost and marketing problems that led to a sharp decline in beef consumption, the economic force that set in motion the downsizing and drive to concentration in the industry. The third section explores the cost-cutting and marketing alternatives available to the industry in the 1990s, and considers how each alternative may affect the regional economy.

I. A Decade of Concentration for the Cattle Industry

The cattle industry has just finished a decade of remarkable structural change. Cattle numbers fell to the lowest level in 30 years. And while most observers expected the industry to become more concentrated in the 1980s, the industry's move toward concentration was faster than expected. In addition, the cattle feeding and beef packing segments of the industry became more integrated throughout the decade.

Industry size

By simple measures, the cattle industry shrank in the 1980s. One overall indicator of the industry's size is the number of cattle in the United States. The nation's cattle herd peaked at 132 million head in 1975, fell to 111 million in 1980, and fell further to 99 million in 1990 (Chart 1). Today's herd is the smallest since 1960.

But while cattle numbers fell throughout the decade, the amount of beef produced has stayed relatively constant. During the 1980s, U.S. beef production stayed within a fairly narrow range of 21.6 to 24.4 million pounds. The anomaly of

falling numbers of cattle and relatively steady beef production is explained by a change in the *type* of cattle slaughtered. Beef packers increasingly slaughter larger, heavier cattle.

Although beef production held fairly steady in the 1980s, beef fared poorly compared with other meats. Chicken production increased nearly two-thirds during the past decade and turkey production increased 88 percent. Pork production, like beef, was essentially constant. Thus, while beef output was relatively steady in the decade, beef was an ever smaller share of a growing overall meat market.

Industry concentration

The beef industry became much more concentrated in the 1980s. In addition, the tendency toward larger firms was not equally shared across the entire industry. Of the industry's three main segments—processing, feeding, and ranching—concentration was most pronounced in packing and feeding.

The most important change in the cattle industry in the 1980s was the dramatic concentration that occurred in beef processing. Following a flurry of buyouts and plant closings, beef processing in the United States moved into the control of fewer and larger companies. At the beginning of the 1980s, the largest four firms controlled slightly more than a third of the cattle slaughtered. By the end of the decade, their market share had more than doubled to 70 percent.

The cattle feeding segment of the industry followed a strong, if somewhat slower, trend toward concentration. Farm feedlots controlled a quarter of the nation's cattle on feed in 1980, but just 16 percent in 1988—the last year for which data are available (Table 1). Commercial feedlots, on the other hand, increased their overall share from 43 percent in 1980 to 50 percent in 1988. The largest commercial feedlots now control nearly a third of the cattle slaughtered.

Table 1

Structure of the Cattle-Feeding Industry
Share of Feedlot Cattle Sold
(Percent)

	1980	1988
Farm feedlots (less than 1,000 head)	25.0	16.3
Medium-sized feedlots (1,000 to 16,000 head)	32.3	33.5
Commercial feedlots		
Medium (16,000 to 32,000 head)	20.4	18.7
Large (more than 32,000 head)	22.3	31.6

Source: U.S. Department of Agriculture, Statistical Reporting Service, *Cattle*.

Ranching was the only segment of the cattle industry that stayed relatively unchanged in the decade of the 1980s. Ranching has always been less concentrated than cattle feeding because calf production uses more land, labor, and management per unit of output. Thus, it is less amenable to economies of size than cattle feeding or processing. The smallest ranches still control about 15 percent of the nation's beef cows, while large ranches control about 30 percent.

Industry integration

As cattle feeding and beef processing became more concentrated, these two key segments of the industry also became more integrated. Processors want to keep their large plants operating at or near capacity since average operating costs rise very rapidly if a plant is not operated at its optimum rate. For example, operating costs rise nearly $8 per head

if a modern slaughtering and fabrication plant is operated at only 80 percent of its optimal rate. An $8 rise in costs cuts in half a large plant's cost advantage over a smaller plant (Ward 1988).

To ensure their large plants work near capacity, beef processors have promoted new market mechanisms to "capture" their future supply of slaughter cattle. The term captive supply has been given to cattle that packers arrange to be delivered far in advance of slaughter to guarantee a major part of their future slaughter needs. Captive supplies are now a significant part of the market; an estimated 19 percent of cattle slaughtered in 1988—the only year for which data exist—were captive supplies (Purcell 1990).

Processors have used three market innovations to capture supplies: feeding their own cattle, forward contracting with feedlot operators, and purchasing agreements with livestock feeders. While some processors own feedlots, the practice of a processor feeding its own cattle is still uncommon. Under a forward contract, a processor signs a contract to purchase a certain number of cattle at a specified price on a particular date. This practice is becoming quite common. Under a purchasing agreement, a feedlot agrees to market a certain number of cattle to the processor on a predetermined schedule with the price set in a specified manner. This practice is also gaining wider acceptance.

A key to the future of the cattle industry will be whether more steps are taken to integrate cattle feeding and processing. Further integration might significantly cut the cost of producing beef, a critical determinant of beef's competitiveness in the retail market. But greater integration will also affect which firms survive in the future. Smaller feedlots that are unable to meet the volume or quality specifications of large processing firms may have limited opportunities to market their cattle.

II. What Drove the Cattle Industry Toward Concentration?

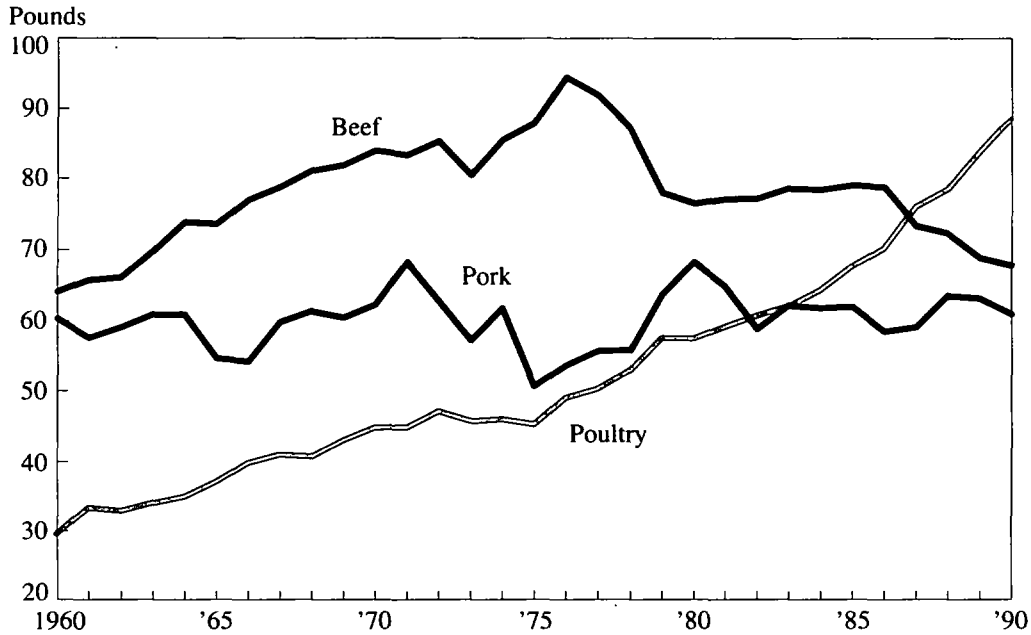
What caused the cattle industry to change so fundamentally in the 1980s? The answer, in a word, is consumers. A striking decline in per capita demand for beef appears to be the force behind the drive to concentration. Throughout the past decade and a half, consumers bought more poultry and less beef. The slump in beef demand squeezed profit margins throughout the beef industry, triggering a scramble for cost reductions that ultimately resulted in a more concentrated industry.

While industry observers agree that consumers were the driving force behind the industry's concentration, they disagree sharply on *why* consumers cut back on beef purchases. Consumers may have changed their diets because lifestyles changed or because of health concerns related to consuming red meat. On the other hand, consumers may have cut beef purchases simply because retail beef prices remained higher than other meats, especially poultry. Which explanation is more telling not only explains demand developments during the past decade but will also have a dramatic effect on the future of the cattle industry.

What happened to beef consumption?

Beef consumption began falling in the mid-1970s, and the decline persisted throughout the 1980s. Per capita beef consumption peaked at 95 pounds in 1976, a year after the nation's cattle herd reached its crest (Chart 2).[1] Consumption then began to plummet, eventually falling to an estimated 67.8 pounds in 1990—only modestly higher than in 1960. While beef consumption was falling, growth in poultry consumption accelerated. Per capita poultry consumption is expected to be nearly 91 pounds in 1990, about 75 percent more than in 1976 when the slide in beef consumption began. And while U.S. con-

Chart 2
Per Capita Meat Consumption



Source: U.S. Department of Agriculture, *"Agricultural Outlook."*

sumers have cut back on beef, the rise in poultry consumption has been big enough to push consumption of all meats and poultry to an all-time high of 221.8 pounds in 1990. In short, beef's share of a growing meat market has fallen from nearly half in 1976 to less than a third in 1990.

The cause of the striking shift in meat consumption from beef to poultry is vitally important to the future of the cattle industry, but the cause is sharply disputed. Two possible explanations are at the center of an ongoing debate in the cattle industry. The *lifestyles explanation* suggests consumers chose to eat less beef due to health concerns and changes in lifestyles. The *relative-prices explanation* suggests consumers switched from beef to poultry because beef became relatively more expensive than poultry.

The lifestyles explanation

The lifestyles explanation attributes the decline in beef consumption to two key elements of today's consumer lifestyles. The first element is the consumer's elevated concern for maintaining a healthful diet by reducing saturated fat and cholesterol in the diet. For example, consumers may be paying more attention to the health recommendations of groups like the American Heart Association (AHA). The AHA recommends consumers limit total intake of meat, seafood, and poultry to no more than 6 ounces per day, use chicken or turkey (without the skin) or fish in most main meals, and substitute meatless main dishes for regular entrees (American Heart Association 1985).

The second key element of consumer life-

styles that may have affected beef consumption is the reduced time consumers are willing to devote to meal preparation. For example, the number of single-individual and dual-income households has risen sharply in recent years, and both types of households are believed to spend less time preparing meals than traditional families.[2] In brief, meals-on-the-run has become a national norm. The poultry industry's leadership—and the beef industry's delay—in developing a wide menu of conveniently prepared food products may have boosted poultry consumption at the expense of beef consumption.

Changes in consumer lifestyles and their links to consumer behavior in the market are difficult if not impossible to measure directly. As a result, empirical evidence supporting the lifestyles explanation is generally gained only indirectly. That is, changes in meat consumption that cannot first be attributed to changes in meat price relationships or consumer incomes are often attributed to changing lifestyles.[3]

Notwithstanding the data difficulties, some empirical evidence does show a direct link between changes in consumer lifestyles and changes in beef consumption. One recent study suggests the proliferation of fast-food restaurants in recent years led to increased poultry consumption at the expense of beef (Wohlgenant 1989). That conclusion is based on two facts. First, the proportion of beef consumed as hamburger rather than higher priced retail cuts has increased sharply in recent years, presumably due to the increased popularity of fast-food restaurants. Second, meat market data indicate consumption of hamburger declines more than consumption of higher priced cuts of beef when poultry prices fall. Consumers, apparently, are more willing to substitute poultry products for hamburger than for sirloin. In brief, head-to-head competition between beef and poultry may have increased as consumers grew willing to substitute poultry products for their fast-food hamburgers.[4] Thus, consumers' increased demand for mealtime convenience—as reflected in the increased number of fast-food restaurants—may have promoted the substitution of poultry for beef.

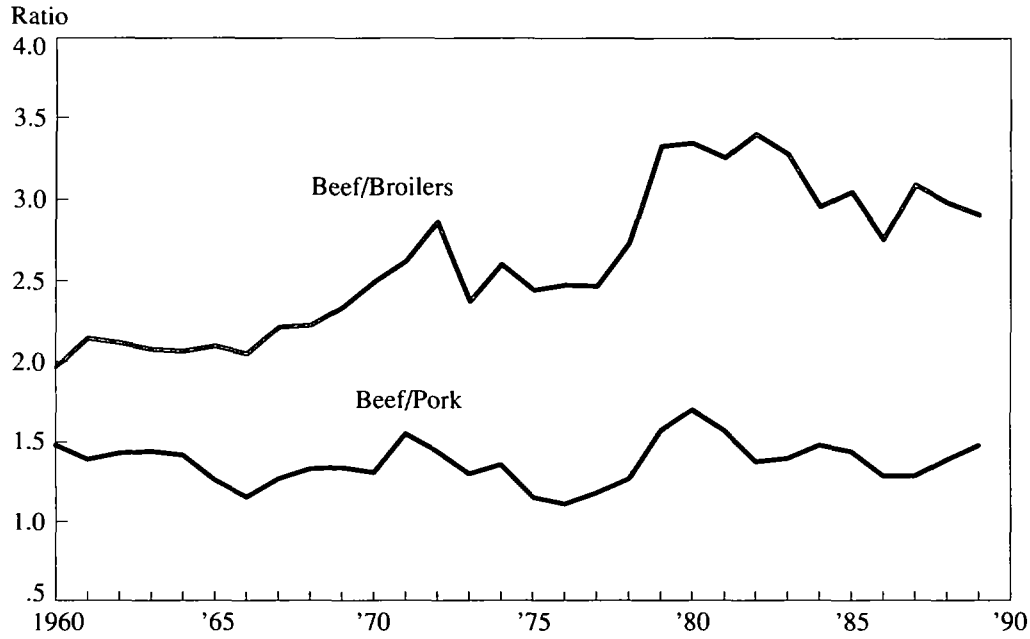
The relative-prices explanation

The relative-prices explanation suggests beef consumption fell because beef became more expensive than other meats. The sharp decline in beef consumption since the mid-1970s occurred as consumer incomes rose and retail beef prices fell, changes that would generally be expected to boost beef consumption. From 1976—when beef consumption peaked—to 1989, real per capita income increased more than a fourth. At the same time, real beef prices fell. Real beef prices at retail in 1989 were nearly a third below the peak that occurred in 1979 and about a fifth lower than in 1960. Thus, rising incomes and falling beef prices should have given consumers the means to purchase more beef.

But beef consumption fell because other meat prices fell even more. Retail broiler prices, in particular, fell faster than retail beef prices. From 1976 to 1982, when the sharpest decline in beef consumption occurred, the ratio of retail beef prices to retail broiler prices rose from about 2.5 to a peak of 3.4 (Chart 3). Since then, beef prices have fallen faster than broiler prices, pushing the beef-broiler price ratio down to 2.9 in 1989. Still, the beef-broiler price ratio remains more than a fifth higher than in the mid-1970s, providing some strong evidence to support the relative-prices explanation for declining beef consumption. Retail pork prices, on the other hand, fell at roughly the same rate as beef prices from 1976 to 1989. As a result, the ratio of retail beef prices to retail pork prices has remained about 1.5 for the past three decades.

The relative-prices explanation is much

Chart 3
Retail Price Ratios



Source: U.S. Department of Agriculture, *"Agricultural Outlook."*

easier to test than the lifestyles explanation because changes in meat prices are relatively easy to measure. One recent study examined the relationship between food consumption and food prices for 40 food groups from 1954 to 1983 (Huang and Haidacher 1989). The results indicated that, other things equal, a 10 percent increase in beef prices was associated with a 6.2 percent decline in beef consumption, a 1.9 percent increase in pork consumption, and a 2.9 percent increase in chicken consumption. Overall, the study claimed that 95 percent of the variation in per capita consumption of beef, pork, and poultry during the 30-year span could be explained by changes in relative meat prices and consumer incomes. A more recent study extended the analysis through 1987 with similar results (D. Johnson and others 1989). Both studies agree that less than 5 percent of the decline in beef consumption since 1976 has been caused by changes in consumer lifestyles.

Which explanation is correct?

Neither explanation for the decline in beef consumption can be easily dismissed as incorrect. Nevertheless, empirical evidence lends somewhat greater support to the relative-prices explanation than the lifestyles explanation. The evidence shows that beef, pork, and poultry can substitute for one another in the consumer's diet. In addition, consumption of all three meats increases as consumer incomes rise. When poultry prices decline relative to beef prices, as happened in the late 1970s and early 1980s, consumers are encouraged to buy more poultry and less beef.

Empirical evidence supporting the lifestyles

explanation is generally not as strong as that supporting the relative prices explanation. Frequently, studies that provide support for the lifestyles explanation are subject to the criticism that a causal link between meat price relationships and consumption has been overlooked (S. Johnson 1989). But lack of direct support for the lifestyles explanation does not necessarily prove the explanation false. Instead, the lack of support may simply reflect the inadequacy of current economic theory, empirical techniques, and data sources to capture the effects of changes in consumer lifestyles.[5]

Some evidence does suggest consumers have become more willing to accept poultry as a substitute for red meat in recent years. But the evidence does not support a strong conclusion on *why* consumers have adjusted their meat consumption. Health concerns and an increased demand for mealtime convenience may have both played a role in the consumer's switch from beef to poultry.

The link between slumping demand and industry concentration

How did the slump in demand push the cattle industry toward consolidation over the past decade? The link depends on two factors: the effect of retail demand on cattle prices and producer profits and the ability of the industry to cut costs through consolidation (see appendix).

Reduced beef consumption drove down real beef prices at retail and at the feedlot. From their peak in 1979 to 1989, inflation-adjusted prices for retail beef fell 30 percent. The soft retail market led to an even steeper fall in prices for fed cattle. Inflation-adjusted prices for fed cattle fell 40 percent from their peak in 1979 to 1989 (Chart 4). The fall in producer prices created big losses for many producers. The resulting squeeze on profit margins triggered a scramble for cost efficiencies throughout the cattle industry. The result was a wave of consolidations aimed at cutting costs.

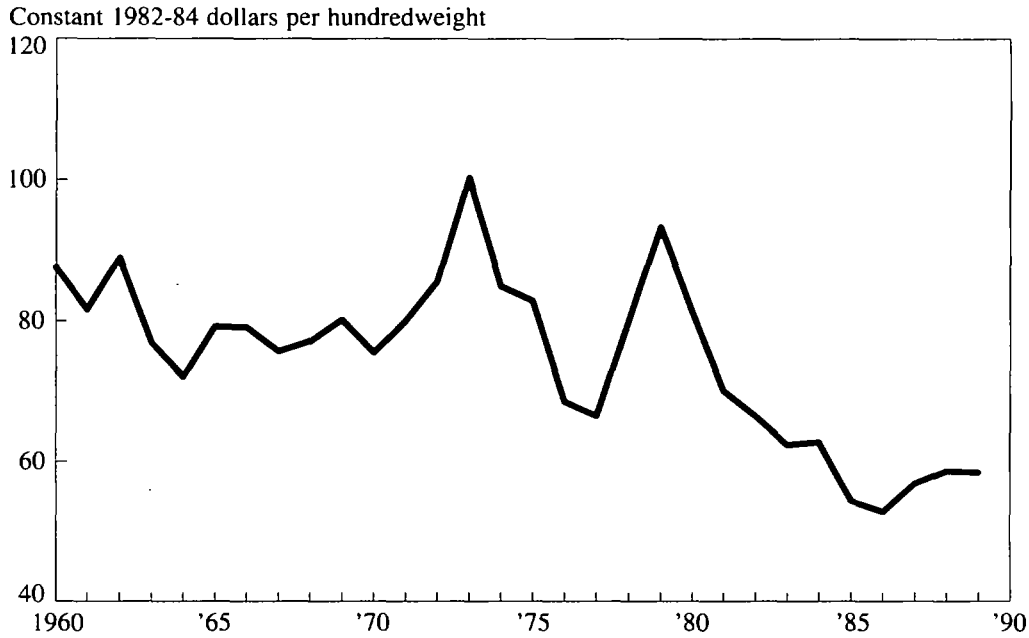
An effective way to reduce costs and bolster sagging profit margins is to combine operations into larger units, thereby capturing economies of size.[6] Economies of size have been found throughout two key segments of the cattle industry, cattle feeding and beef processing. One study of Texas feedlots found total feeding costs in 50,000-head feedlots were nearly 20 percent lower than in 2,000-head feedlots.[7] Similarly, large-scale cattle slaughter and fabrication plants operate more cheaply than smaller plants. For example, combined slaughtering and fabrication costs are about $17 per head (about 25 percent) lower in a 700,000-head-per-year plant than in a 300,000-head-per-year plant.[8]

The lower costs of operating larger feedlots and processing plants provided a strong incentive for increased concentration. As shown in the previous section, the consolidation in cattle feeding and beef packing has proceeded apace in the 1980s. What remains unknown is whether the industry will be forced to undergo further consolidation in the 1990s.

III. The Road Ahead for the Cattle Industry

Beef prices and consumer lifestyles figure prominently in explaining changes in the cattle industry over the past decade. They also promise to be central to the future of the industry. The outlook for the cattle industry over the coming decade might be summed up by two questions: First, can the industry cut costs to make the price of beef more competitive? And second, can the industry deliver new products that respond to consumer demands for nutrition and convenience? Given the dominant role of cattle in the farm and rural economies of the Tenth District, the answers to these questions will be important to the regional economy.

Chart 4
Fed Cattle Prices



Source: U.S. Department of Agriculture, *"Agricultural Outlook."*

The industry's two-pronged challenge

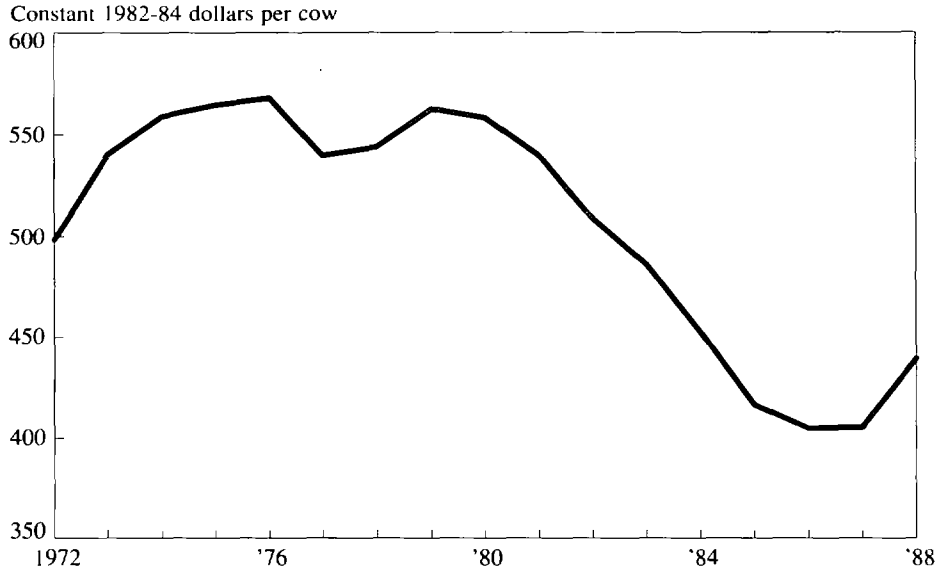
The cattle industry's outlook in the coming decade may ultimately rest on the industry's ability to link efforts to cut costs with efforts to deliver new products. Further consolidation and emerging technology appear to offer only incremental cost savings. Meanwhile, the industry appears to have few new products on the shelf. But a new industry initiative to produce leaner cattle could help cut costs and provide a more attractive consumer product.

After spending a decade on consolidating and lowering production costs, the cattle industry may have more difficulty making the next generation of costs cuts. Still, some additional cost savings will likely be found in all three segments of the industry. With beef prices still relatively high compared with chicken prices, market pressures will encourage the search for greater efficiency.

The industry has a strong track record in cutting costs. Adjusted for inflation, beef production costs have been cut across all segments of the industry. From the late 1970s to the mid-1980s, cattle ranching costs fell more than a fourth and cattle feeding costs more than a third before higher feed costs in the last half of the 1980s pushed up beef costs (Charts 5 and 6). Processing costs, reflected in the difference between beef prices at retail and the farm, fell more than a fifth during the 1980s (Chart 7). These sweeping cost reductions enabled the industry to keep beef production essentially constant in the 1980s in the face of a 30 percent decline in retail beef prices.[9]

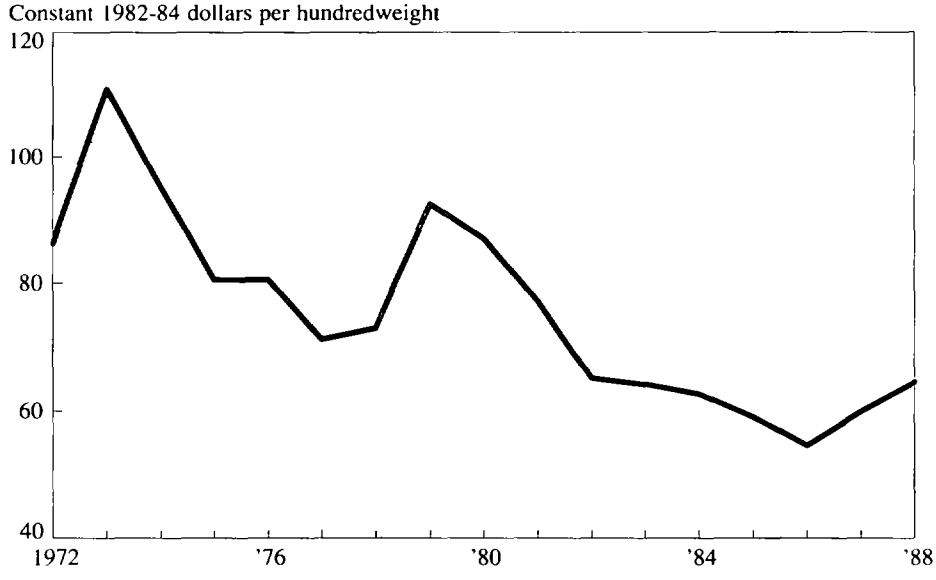
Where the cattle industry will find cost reductions in the 1990s is not clear. Further

Chart 5
Cow-Calf Production Costs



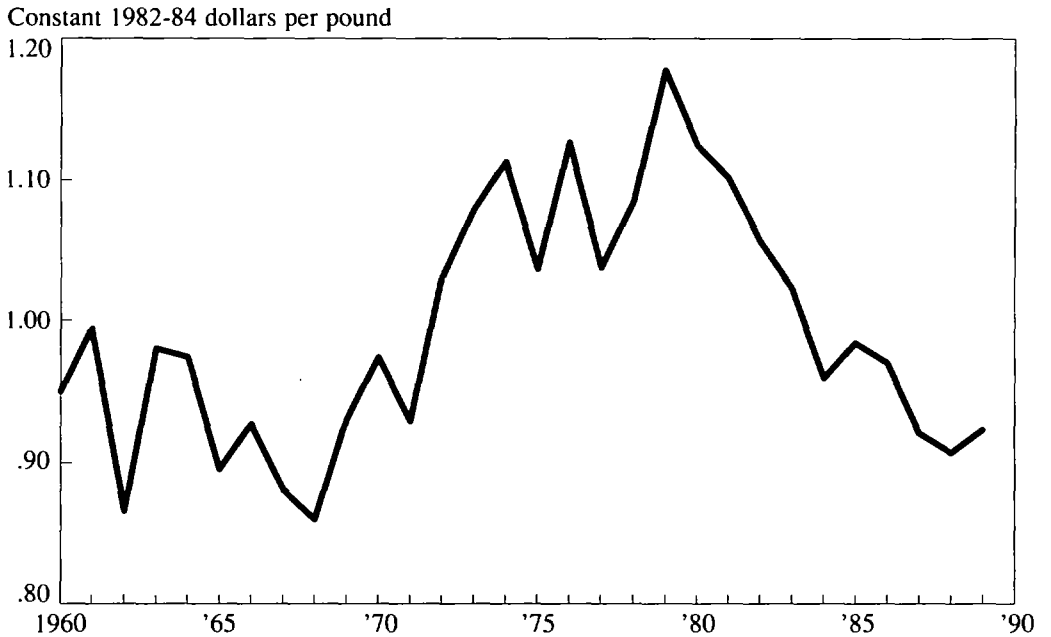
Source: U.S. Department of Agriculture, *"Economic Indicators of the Farm Sector: Costs of Production."*

Chart 6
Feedlot Production Costs



Source: U.S. Department of Agriculture, *"Economic Indicators of the Farm Sector: Costs of Production."*

Chart 7
Beef Farm-Retail Price Spread



Source: U.S. Department of Agriculture, *"Agricultural Outlook."*

consolidation promises some cost savings for feedlots and slight gains for processing plants. With half of the nation's cattle in farm or medium-sized feedlots, consolidation is likely to proceed in the 1990s, thereby reducing overall feeding costs for the industry. But most beef processing plants have already grown to a size that captures most available cost economies.[10] Thus, the industry will have to look elsewhere to achieve substantial cost reductions.

Ranchers and feedlot operators may be able to lower costs through new developments in biotechnology. For example, potential breakthroughs in genetic engineering could boost reproductive efficiency and growth rates. Such advances would reduce the two biggest cost items in cattle ranching and feeding: feed and feeder cattle. Feed is now about a quarter of both ranching and feedlot costs (Tables 2 and 3). And feeder cattle are the biggest single cost item for feedlots, more than three-fifths of total costs. Thus, technologies targeting these two major cost items are likely to be among the most effective in reducing costs in these two industry segments.

One comprehensive study of agriculture's emerging technologies suggests efficiency gains in ranching will outstrip gains in the feedlot in the next decade (U.S. Congress, Office of Technology Assessment 1986). By the year 2000, gains in reproductive efficiency could boost the average number of calves a cow produces each year 14 to 18 percent. Meanwhile, projected gains in feed efficiency, as measured by pounds of beef produced per pound of feed consumed, would be a more modest 3 to 4 percent.

Despite these advances, beef may gain little if any ground on other meats in the technological

race. Projected gains in reproductive efficiency of poultry and swine are expected to equal or slightly exceed those of cattle. But gains in feed efficiency for both poultry and swine are expected to exceed by a wide margin the modest gains expected for cattle. In sum, new technologies appear likely to offer some cost reductions for the cattle industry, but reductions will probably be matched or surpassed by its competitors.

The beef industry could discover some sizable cost savings through a new marketing initiative that would encourage producers to market cattle with less fat (National Cattlemen's Association 1990). Current beef grading standards encourage producers to market cattle with high fat content. But consumers no longer want retail cuts with excess fat. Thus, cattle go to market carrying fat that is later trimmed away by processors and retailers. Industry observers estimate that the cost of producing and then trimming the excess fat is at least $2 billion a year. The industry's new marketing initiative hopes to reduce this loss by reducing excess fat 20 percent and increasing lean meat production 6 percent by 1995.

The new marketing initiative also targets the processing and retailing steps that on average account for more than 40 percent of the retail cost of beef. In addition to encouraging ranchers and cattle feeders to produce leaner cattle, the initiative urges processors and retailers to develop conveniently prepared beef products. The costs of producing several of these new products are likely to be lower than the cost of producing conventional boxed beef.[11] For example, the industry is already experimenting with shipping retail cuts of beef in vacuum-sealed, retail-ready packages rather than as conventional boxed beef, which is subsequently cut and packaged at the grocery store. By centralizing the packaging step, labor costs are cut, and retail beef prices could be reduced by approximately 10 cents a pound. Although costs are lower, consumers may resist these new products, which may have a darker color than usual (Farris and others 1990).

Overall, the cattle industry appears likely to reduce beef production costs incrementally in the 1990s. Most of the gains from consolidation have already occurred. Advances in biotechnology promise unknown gains in efficiency. But in the end, the cost of producing beef appears likely to remain relatively high simply because cattle are relatively inefficient in producing offspring and processing feed. Technology appears unlikely to unlock these two biological puzzles and put a sizable dent in the current cost advantage held by poultry.

Eliminating the production of excess fat may be one of the industry's best opportunities for reducing costs. A new marketing initiative launched by the National Cattlemen's Association targets the production of excess fat but would also answer the consumer's call for leaner, more convenient beef products. The outcome of the new initiative remains uncertain, however, given the industry's relatively weak record of translating consumer needs into production decisions.

The importance of the marketing initiative is underscored by the fact that the industry has almost no new products on the shelf. New forms of packaging may bring a new look to beef products on retail counters. But the beef industry has not displayed the product innovation found in the poultry industry. To the contrary, the beef industry has a long history of taking beef's niche in the meat market for granted.

The future for the cattle industry in the region

The road the cattle industry takes in the 1990s will have a great effect on the farm and rural economy of the Tenth Federal Reserve District. Cattle account for about 60 percent of the cash receipts in the seven states of the dis-

Table 2

Distribution of Cow-Calf Production Costs
(Percent)

	1972-75	1976-79	1980-84	1985-88
Feed	31.4	25.2	23.6	22.6
Other variable expenses	12.5	12.0	13.6	13.5
Overhead, taxes, insurance	6.7	8.3	8.7	12.6
Capital replacement	11.6	10.9	12.7	13.8
Imputed returns to land, labor, and capital	37.9	43.6	41.4	37.5
Total costs	100.0	100.0	100.0	100.0

Source: U.S. Department of Agriculture, Economic Research Service, *Economic Indicators of the Farm Sector: Costs of Production*, various issues.

Table 3

Distribution of Feedlot Production Costs
(Percent)

	1972-75	1976-79	1980-84	1985-88
Feeder cattle	51.5	56.8	61.4	61.8
Feed	36.7	30.0	26.3	22.0
Other variable expenses	3.9	4.8	5.1	5.8
Overhead, taxes, insurance	1.5	1.7	1.9	4.0
Capital replacement	2.4	2.6	1.7	2.5
Imputed returns to land, labor, and capital	3.9	4.1	3.5	3.8
Total costs	100.0	100.0	100.0	100.0

Source: U.S. Department of Agriculture, Economic Research Service, *Economic Indicators of the Farm Sector: Costs of Production*, various issues.

trict, and meat packing employs nearly 45,000 workers in the region. What does the outlook for the industry suggest for the district farm and rural economies in the decade ahead?

In simple terms, the industry's outlook depends on its success or failure in meeting the twin challenges of cutting costs and improving marketing. Lower costs and better marketing would make beef both more economical and attractive to consumers, leading to a stabilization or possible expansion of beef's share of meat purchases. While such growth will preserve some market niches for small producers, there would still be market pressures for all available economies of size to be realized. Failure to meet the challenges, on the other hand, would simply extend the industry trends of the past decade. Consumer demand would probably fall further, pushing real beef and cattle prices down. The resulting squeeze on profits would force the industry to cut costs aggressively. Only large, efficient producers would likely survive.

The region clearly stands to benefit from successful efforts to reduce costs and enhance marketing. Regional gains would likely take the form of expanded cattle numbers and higher value beef products leaving the region.

Expansion in cattle production will be concentrated in the Tenth District. District states contain 27 percent of all cattle in the nation and an even higher percentage of beef cattle. From ranching to processing, the district cattle industry is both big and efficient, suggesting that a significant portion of the industry's expansion will occur here. Such expansion would boost the already large portion of district farm income tied to cattle production.

Successful introduction of new value-added beef products would significantly boost the region's economy. When and if developed, the next generation of beef products will be designed to enhance both nutrition and convenience. To achieve that objective, products will receive more processing before being shipped to retail markets. In short, greater economic value will be created where the beef is processed, and that would benefit communities now dependent on large processing plants.

Meat packing plants in the district already account for more than a quarter of shipments from the nation's meat packing plants. Most district plants produce boxed beef, an intermediate product that requires additional processing at retail centers. Increased processing would add value to the production of district plants and, correspondingly, boost employment and income in communities where packing plants are located. Depending on the success of the new beef products, this boost could be substantial.

If the cattle industry fails to meet its challenges, market pressures will lead to failure of some firms. Compared with other parts of the nation, however, the region will fare well overall. Most cattle ranches in the district are relatively large, although Missouri, an important calf producing state, has predominantly small producers. District feedlots and processing plants are among the nation's largest and operate at low per-unit cost. Thus, further decline in the cattle industry will probably squeeze out cattle producers and processors in other regions first.

Cattle ranching in the district will be well positioned if cattle numbers shrink further in the 1990s, but some ranches may be forced from business. District states produce more than a fifth of the nation's calf crop, and four district states rank among the top eight producing states. Although Missouri ranks second in feeder calf production, a downturn in the industry appears likely to have the biggest effect there.

Missouri cattle ranches are small, pointing to significant consolidation ahead if profits worsen. The average ranch in the state has only 21 cows compared with an average of 115 cows in Wyoming. While most Missouri ranchers sub-

sidize ranching with off-farm income, declining profit margins would almost certainly bring a sorting out of small, inefficient producers.

On the other hand, relatively large ranches and low land costs elsewhere in the district suggest that district ranches will compete well against other important cow-calf production areas, such as the Southeast. Across wide stretches of the district, ranchland has little if any alternative use and thus is likely to remain in ranching under almost any future scenario.

District cattle feeders will be in a strong position to compete in the future even if the feeding industry shrinks. The district is the heart of the cattle feeding industry and now accounts for 43 percent of the nation's cattle on feed, up from 34 percent when cattle numbers peaked in 1976. Large and efficient, the district feedlots concentrated in Colorado, Kansas, and Nebraska appear likely to operate near capacity even if cattle prices are weak. In short, many farm feedlots in the Corn Belt and elsewhere may be squeezed out of production before the commercial feedlots of the High Plains.

Similarly, the big beef processing plants concentrated in Colorado, Kansas, and Nebraska appear likely to be survivors even if industry profits are squeezed. The plants are modern and relatively new; most were built since 1975. Labor costs are much lower than in older plants in the Great Lakes region. The plants are far from major consumer markets, but the advent of boxed beef, which is cheaper to ship than whole carcasses, has diminished that location disadvantage.

IV. Conclusions

The cattle industry is at a crossroads entering the 1990s. After a decade of dramatic restructuring, the industry faces two futures. One road would continue the trends of the past decade to a smaller industry with fewer, larger firms. These firms would remain profitable due to their efficiency and low cost. Because the Tenth District is home to many of the nation's large ranches, feedlots, and processing plants, the region would likely maintain its cattle activity even if the industry shrinks overall. The other road would stem a decline in beef demand and perhaps lead to some growth in per capita consumption. Any expansion in beef output would be based in Tenth District states. Moreover, development of new beef products might expand processing in the region, boosting employment and incomes in areas where processing plants are located.

The road taken depends on the ability of the industry to meet twin challenges of lower costs and improved marketing. Further consolidation appears to hold little promise to lower the costs of producing beef. Advances in biotechnology offer unknown gains in efficiency, but gains in other meats probably will be equal or greater. The best chance to cut costs may be found in an industry marketing initiative to discourage the production of excess fat. If successful, this initiative could begin the process of tying production decisions more closely to consumer preferences. With few new consumer products now on the shelf, integrating production and marketing decisions appears to be an essential first step for the industry.

Appendix

How Changing Beef Demand Affects the Cattle Industry

The decline in per capita beef consumption and the subsequent structural changes in the beef industry are illustrated in the three panels of Figure 1. The effect of a structural decline in beef consumption on beef prices and per capita beef consumption is shown in Panel A. The beef demand curve *(D_b)* shows the quantities of beef consumers are willing to purchase at various beef prices, and the beef supply curve *(D_s)* shows the quantity of beef producers are willing to produce at various prices. At the initial equilibrium price *(P_b)*, determined at the intersection of the beef demand and supply curves, the quantity consumers are willing to buy *(q_b)* is equal to the quantity producers are willing to produce. A decline in the amount of beef consumers are willing to buy at any price is shown by the leftward shift of the beef demand curve to D_b*. As the demand curve shifts, the quantity of beef sold to consumers falls to q_b* and the equilibrium price of beef is pushed down to P_b*.

The effect of the decline in beef consumption on the structure of the beef industry is shown in Panels B and C. Curve C_1 in Panel B, the short-run average cost curve for older beef processing plants, shows per-unit costs for various beef processing volumes. At the initial price of beef P_b, all plants of this type are processing beef at a rate of Q_1 and covering all costs equal to P_b per pound. With the decline in beef prices to P_b*, however, older processing plants can no longer cover their costs and are eventually forced to close.

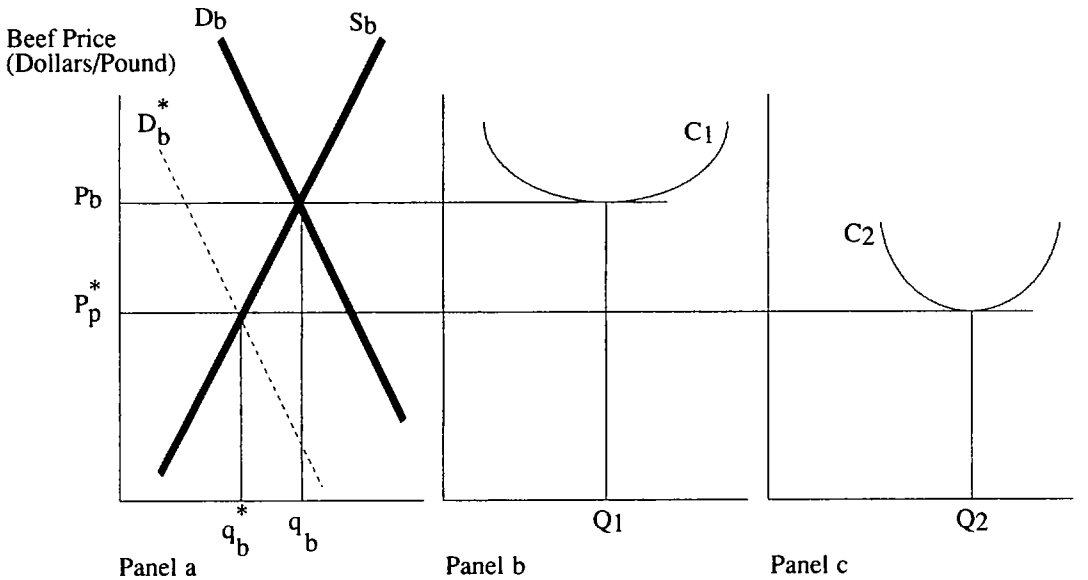
As processing technology evolves, more modern processing plants that operate at lower cost are developed (Panel C). Even at the lower price P_b*, these newer, more efficient plants can cover all costs. The newer plants, however, operate at a much larger processing volume *(Q_2)* than the smaller plants they replaced. As a result, the industry's processing activity becomes more concentrated in fewer, larger plants.

Although the modern plants have lower operating costs than the older plants, costs rise quickly in the new plants if they are not operated at the optimal rate. As a result, the average cost curve in Panel C slopes up sharply as the plant's output changes from the optimal level Q_2. For example, if a temporary shortage of fed cattle forces a modern, high-capacity beef processing facility to operate at less than its optimal rate, average operating costs rise sharply. This characteristic of high-capacity beef processing plants encourages plant managers to enter marketing arrangements with large-scale cattle feeders that can ensure timely supplies of cattle for the processing facility. These marketing arrangements, a loose form of vertical integration, can limit marketing opportunities for smaller scale cattle feeders.

The cause of the initial leftward shift of the beef demand curve in Figure 1, Panel A, is the topic of considerable debate in the beef industry. One explanation is a change in consumer health concerns and lifestyles that resulted in less consumption of beef regardless of its price.

An alternative explanation for the decline in beef consumption is a decline in the price of other meats that made them more attractive to budget-minded consumers. This alternative explanation for reduced beef consumption is

Figure 1
Structural Changes in the Beef Industry

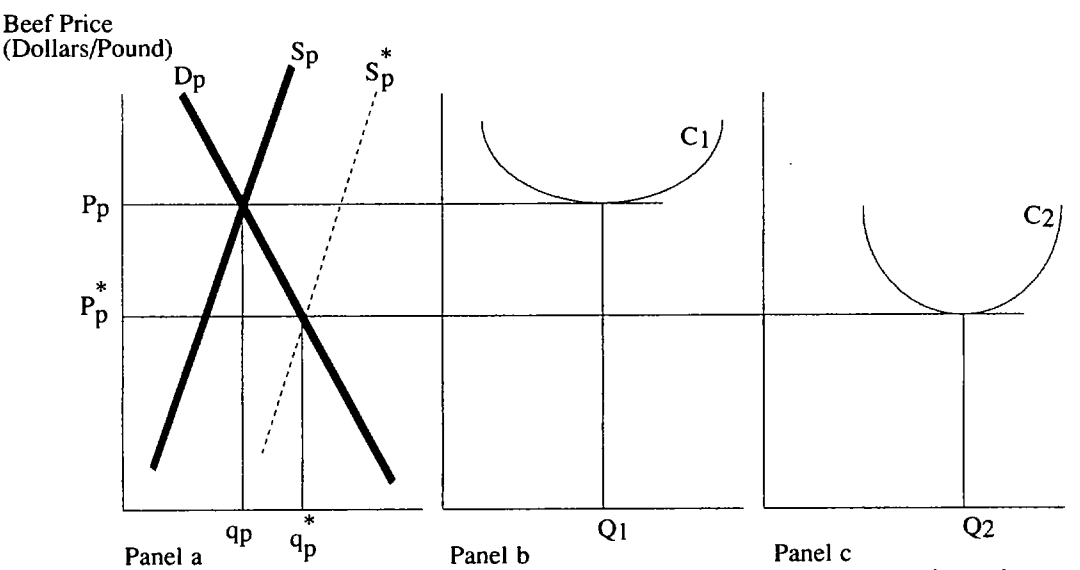


Panel a
Per capita beef supply and demand

Panel b
Average costs in old beef plants

Panel c
Average costs in modern beef plants

Figure 2
Structural Changes in the Poultry Industry



Panel a
Per capita poultry supply and demand

Panel b
Average costs in old poultry facilities

Panel c
Average costs in modern poultry facilities

diagrammed in Figure 2. The three panels of Figure 2 are nearly identical to the corresponding panels of Figure 1, with the exception that Figure 2 is drawn for the poultry industry. Figure 2 shows how concentration in the poultry industry has resulted in an expansion of poultry supplies at lower cost. Consolidation of poultry production in fewer, larger, more efficient plants has reduced unit costs of poultry production (Panels B and C). The result is a rightward shift of the poultry supply curve from S_p to S_p*, a decrease in poultry prices from P_p to P_p*, and an increase in per capita poultry consumption from q_p to q_p* (Panel A). As consumers buy more poultry, beef consumption is curtailed, resulting in the leftward shift of the beef demand curve in Figure 1, Panel A. Most evidence suggests that a rapid expansion in poultry supplies and the attendant reduction in poultry prices shown in Figure 2 played a major role in the decline in beef consumption shown in Figure 1.

Endnotes

[1] Changes in per capita meat consumption reflect shifts in market share among the various kinds of meat. Recent shifts in meat consumption are less pronounced when viewed in terms of total (rather than per capita) consumption, because population growth masks the decline in market share held by beef. While per capita beef consumption has declined sharply in recent years, total beef consumption has been relatively stable due to population growth. After growing rapidly during the 1960s and early 1970s, total beef consumption crested at more than 27.5 million pounds in 1976. Beef consumption edged down in the late 1970s and stagnated at an annual average of about 24.6 million pounds in the 1980s. While beef consumption remained flat in the 1980s, broiler and turkey consumption surged and pork consumption made modest gains. As a result, total consumption of all red meats and poultry climbed to nearly 63 million pounds in 1989, a record that is expected to be broken in 1990.

[2] Nearly a fourth of all U.S. households were single-person households in 1989, up from 21 percent in 1976. Both spouses of about half of U.S. married-couple families worked in 1990, up from 37 percent in 1976.

[3] Thurman, for example, states, "It seems impossible to conclusively attribute meat expenditure trends to any particular cause. In this case, it is particularly difficult to document changes in consumers' perceptions. I will only remark here on the plausible coincidence of the observed expenditure trends and increased health concerns in the 1970s" (Thurman 1989).

[4] The share of U.S. beef consumption eaten as nonfed beef averaged 43.8 percent from 1967 to 1973 and 56.6 percent from 1974 to 1981. Hamburger is typically ground from nonfed beef while higher priced cuts are typically cut from fed beef. Wohlgenant estimated the elasticities of demand for nonfed and fed beef with respect to prices of several kinds of meat. The elasticity of demand for nonfed beef with respect to retail poultry prices increased from 0.26 in 1958 to 0.61 in 1982. The elasticity of demand for fed beef with respect to retail poultry prices remained much lower, -0.07 in 1958 and -0.08 in 1982 (Wohlgenant 1989).

[5] In assessing the current search for the cause of the decline in beef consumption, Chavas states, "Also, traditional economic theory does not provide much insight into the effects on consumers of factors other than prices and incomes. As a result, little empirical evidence on such effects has been found by economists. However, it seems hard to believe that, among other factors, the recommendations of the American Medical Association concerning meat consumption have not had at least some influence on consumer behavior." (Chavas 1989)

[6] Economies of size are generally attributed to a larger firm's ability to divide tasks among specialized workers, to use the most advanced technology, and to spread fixed production costs across a larger volume of output. Diseconomies of size, an increase in average costs as the volume of output increases, may eventually occur if the firm's size exceeds technological constraints or if the firm becomes too large to manage effectively.

[7] Most savings in cattle feeding were realized by feedlots of 20,000-head capacity, with only modest additional cost savings accruing to feedlots of larger capacity. Most of the reduction in total feeding costs was gained by spreading the cost of fixed investments—feed mills, pens, and other equipment—across a much larger number of cattle in the larger feedlots (Dietrich and others 1985).

[8] Most cost savings are realized in plants with capacity of about 700,000 head per year, with only modest additional savings gained by larger plants with capacity of up to one million head per year. These cost savings would add about $1.50 per hundredweight to the price of fed cattle if passed along to cattle feeders (Ward 1988 and Purcell 1990).

[9] These cost reductions occurred while total beef production remained nearly constant, expanding only 7 percent during the decade.

[10] See endnotes 7 and 8.

[11] Historically, beef packing plants slaughtered cattle and shipped beef carcasses to meat retailers for further processing. To reduce transportation and labor costs, packers began to process the carcasses further and ship smaller cuts directly. The cuts were shipped under refrigeration in boxes, hence the term boxed beef. Boxed beef still requires additional cutting, trimming, and packaging at the retail market. The new marketing scheme would increase further the amount of processing done before beef is shipped to retail centers.

References

American Heart Association. 1985. "The American Heart Association Diet, An Eating Plan for Healthy Americans." Dallas, Texas.

Chavas, Jean-Paul. 1989. "On the Structure of Demand for Meat," in Reuben C. Buse, ed., *The Economics of Meat Demand*, Department of Agricultural Economics, University of Wisconsin, Madison, Wisc.

Dietrich, R. A., P. J. Thomas, and D. E. Farris. 1985. "The Texas Cattle Feeding Industry—Operations, Management, and Costs," Experiment Station Bulletin B-1495, The Texas Agricultural Experiment Station, College Station, Texas.

Farris, D. E., J. B. Ward, R. A. Dietrich, and D. W. Holloway. 1990. "Reducing the Cost of Marketing Beef Through Central Retail Packaging." Poster paper presented at the joint American and Canadian Agricultural Economics Associations meeting, Vancouver, British Columbia.

Huang, Kuo S., and Richard C. Haidacher. 1989. "An Assessment of Price and Income Effects on Changes in Meat Consumption, in Reuben C. Buse, ed., *The Economics of Meat Demand*, Department of Agricultural Economics, University of Wisconsin, Madison, Wisc.

Johnson, D. Gale, John M. Connor, Timothy Josling, Andrew Schmitz, and G. Edward Schuh. 1989. *Competitive Issues in the Beef Sector: Can Beef Compete in the 1990s?* Humphrey Institute Report No. 1, Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, Minneapolis, Minn.

Johnson, Stanley A. 1989. "Discussion: Structural Change in Meat Demand: The End of the 'Chicken Little' Era," in Reuben C. Buse, ed., *The Economics of Meat Demand*, Department of Agricultural Economics, University of Wisconsin, Madison, Wisc.

National Cattlemen's Association. 1990. "The War on Fat." Report of the value-based marketing task force. Denver, Colo.

Purcell, Wayne, ed. 1990. *Structural Change in Livestock: Causes, Implications, Alternatives*, Research Institute on Livestock Pricing.

Thurman, Walter N. 1989. "Have Meat Price and Income Elasticities Changed? Their Connection with Changes in Marketing Channels," in Reuben C. Buse, ed., *The Economics of Meat Demand*, Department of Agricultural Economics, University of Wisconsin, Madison, Wisc.

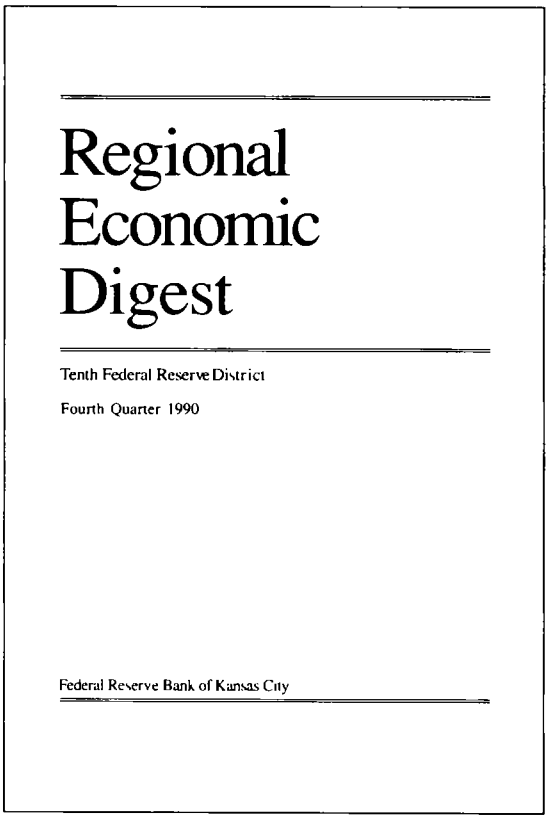
U.S. Congress, Office of Technology Assessment. 1986. "Technology, Public Policy, and the Changing Structure of American Agriculture," OTA-F-285, U.S. Government Printing Office, Washington D.C.

Ward, Clement E. 1988. *Meatpacking Competition and Pricing*, Research Institute on Livestock Pricing, Blacksburg, Va.

Wohlgenant, Michael K. 1989. "Effects of Changing Composition of Beef Consumption on the Elasticities for Beef and Poultry." in Reuben C. Buse, ed., *The Economics of Meat Demand*, Department of Agricultural Economics, University of Wisconsin, Madison, Wisc.

1990 Index
Economic Review

Regional Economic Digest



The *Regional Economic Digest* is a new publication of the Federal Reserve Bank of Kansas City. Issued quarterly, the *Digest* reviews economic conditions in the Tenth Federal Reserve District. It includes articles of regional interest, statistics on the regional economy and District commercial banks, and results of the quarterly survey of agricultural credit conditions.

Free subscriptions to the Regional Economic Digest are available by contacting:

Public Affairs Department
Federal Reserve Bank of Kansas City
925 Grand Avenue
Kansas City, Missouri 64198-0001

Economic Review
Federal Reserve Bank of Kansas City
Kansas City, Missouri 64198-0001
November/December 1990, Vol. 75, No. 6