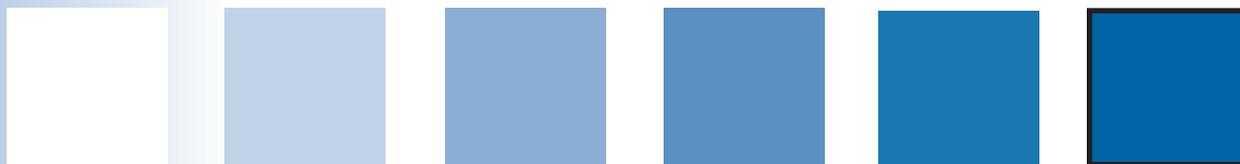


Federal Reserve Bank of St. Louis

REVIEW

NOVEMBER/DECEMBER 2006

VOLUME 88, NUMBER 6



Chinese Growth: A Source of U.S. Export Opportunities

William Poole

Money and Monetary Policy for the Twenty-First Century

Jerry L. Jordan

Rising Natural Gas Prices and Real Economic Activity

Kevin L. Kliesen

**The Transition to Electronic Communications Networks
in the Secondary Treasury Market**

Bruce Mizrach and Christopher J. Neely

**What Are the Odds?
Option-Based Forecasts of FOMC Target Changes**

*William R. Emmons, Aeimit K. Lakdawala,
and Christopher J. Neely*

REVIEW

Director of Research

Robert H. Rasche

Deputy Director of Research

Cletus C. Coughlin

Review Editor

William T. Gavin

Research Economists

Richard G. Anderson

James B. Bullard

Riccardo DiCecio

Michael J. Dueker

Thomas A. Garrett

Massimo Guidolin

Hui Guo

Rubén Hernández-Murillo

Kevin L. Kliesen

Christopher J. Neely

Edward Nelson

Michael T. Owyang

Michael R. Pakko

Rajdeep Sengupta

Daniel L. Thornton

Howard J. Wall

Yi Wen

Christopher H. Wheeler

David C. Wheelock

Managing Editor

George E. Fortier

Assistant Editor

Lydia H. Johnson

Graphic Designer

Donna M. Stiller

The views expressed are those of the individual authors and do not necessarily reflect official positions of the Federal Reserve Bank of St. Louis, the Federal Reserve System, or the Board of Governors.



471 Chinese Growth: A Source of U.S. Export Opportunities

William Poole

485 Money and Monetary Policy for the Twenty-First Century

Jerry L. Jordan

511 Rising Natural Gas Prices and Real Economic Activity

Kevin L. Kliesen

527 The Transition to Electronic Communications Networks in the Secondary Treasury Market

Bruce Mizrach and Christopher J. Neely

543 What Are the Odds? Option-Based Forecasts of FOMC Target Changes

William R. Emmons, Aeimit K. Lakdawala, and Christopher J. Neely

563 Review Index 2006

Review is published six times per year by the Research Division of the Federal Reserve Bank of St. Louis and may be accessed through our web site: research.stlouisfed.org/publications/review. All non-proprietary and nonconfidential data and programs for the articles written by Federal Reserve Bank of St. Louis staff and published in *Review* also are available to our readers on this web site. These data and programs are also available through Inter-university Consortium for Political and Social Research (ICPSR) via their FTP site: www.icpsr.umich.edu/prs/index.html. Or contact the ICPSR at P.O. Box 1248, Ann Arbor, MI 48106-1248; 734-647-5000; netmail@icpsr.umich.edu.

Single-copy subscriptions are available free of charge. Send requests to: Federal Reserve Bank of St. Louis, Public Affairs Department, P.O. Box 442, St. Louis, MO 63166-0442, or call (314) 444-8809.

General data can be obtained through FRED (Federal Reserve Economic Data), a database providing U.S. economic and financial data and regional data for the Eighth Federal Reserve District. You may access FRED through our web site: research.stlouisfed.org/fred.

Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Please send a copy of any reprinted, published, or displayed materials to George Fortier, Research Division, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, MO 63166-0442; george.e.fortier@stls.frb.org. Please note: Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis. Please contact the Research Division at the above address to request permission.

© 2006, Federal Reserve Bank of St. Louis.

ISSN 0014-9187



Chinese Growth: A Source of U.S. Export Opportunities

William Poole

This article was originally presented as a speech to the Fiscal Affairs and Government Operations Committee, Council of State Governments' Southern Legislative Conference (SLC), Louisville, Kentucky, July 31, 2006.

Federal Reserve Bank of St. Louis *Review*, November/December 2006, 88(6), pp. 471-83.

With all the press reports about the enormous growth of China's exports to the United States, I start with a story running in the opposite direction. Kanawha Scales and Systems is a company located in Poca, West Virginia, which has a population of roughly 1,000. Chinese purchases of this company's coal-loading machines have grown to account for about one-third of the company's \$50 million in annual revenues.¹

How many stories are there like the Kanawha Scales story? Well, I'll share another example. A recent report indicates that a group from Kentucky will be involved in the construction of a Thoroughbred racetrack in China, the first in mainland China.² As part of this deal, 1,500 Kentucky Thoroughbreds will be sold and shipped to China and it is also possible that a number of Chinese will come to Kentucky to learn how to be trainers, exercise riders, jockeys, grooms, and hot walkers.

Are these isolated examples? Just how important to the United States are sales of U.S. goods and services to China?

My purpose this morning is to convince you that the answer to this question is clear. Sales of U.S. goods and services to China are large, are growing, and are very important to the United States. In fact, as I'll detail shortly, firms in the 16 member states of the Southern Legislative Conference (SLC) are engaged in substantial exporting activity to China. I'll discuss major features of the economic relationship between the United States and China, but with special emphasis on U.S. exports to China because that critically important part of the relationship is not well understood.

Before proceeding, I want to emphasize that the views I express here are mine and do not necessarily reflect official positions of the Federal Reserve System. I thank my colleagues at the Federal Reserve Bank of St. Louis for their comments, particularly Cletus C. Coughlin, vice president and deputy director of research, who provided special assistance.

TRADE PROSPECTS

Increases in international trade depend on three key factors—income growth, reductions in trade barriers, and declines in transportation costs.

¹ See www.usatoday.com/money/world/2006-04-19-china-exports-usat_x.htm.

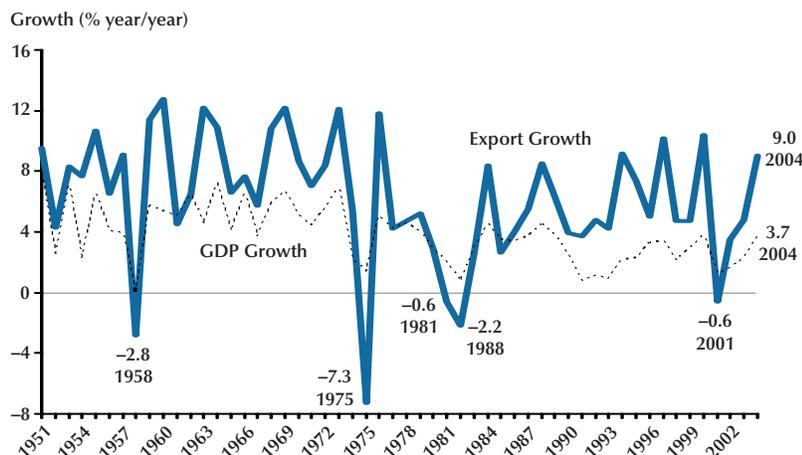
² See <http://charlotte.bizjournals.com/charlotte/stories/2006/03/20/story6.html>.

William Poole is the president of the Federal Reserve Bank of St. Louis. The author appreciates comments provided by colleagues at the Federal Reserve Bank of St. Louis. Cletus C. Coughlin, vice president and deputy director of research, provided special assistance. The views expressed do not necessarily reflect official positions of the Federal Reserve System.

© 2006, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis.

Figure 1

World Merchandise Export Growth and GDP Growth, 1950-2004



SOURCE: World Trade Organization, *International Trade Statistics 2005*.

Income growth has been the most important of these three factors stimulating increased trade worldwide, with reductions in trade barriers a distant second and declines in transportation costs an even more distant third.³ The direct implication of this research finding is that any discussion of trade flows should begin by examining income growth. In fact, almost without exception over the past 55 years, growth in world merchandise exports has exceeded growth in gross domestic product (GDP).⁴ (See Figure 1.)

It is reasonable, therefore, to anticipate a strong relationship between Chinese growth and U.S. exports, and that's exactly what we observe. The transformation of the Chinese economy has been accompanied by a huge increase in international trade and capital flows. U.S. exports to China have also been spurred by reductions in Chinese trade barriers, especially as part of China's

entry into the World Trade Organization in 2001. In addition to a substantial decline since 1982 in import tariffs, in 2005 China eliminated the licenses that were required for the importation of many goods.⁵

CHINESE AND U.S. GROWTH

China, with a population in excess of one billion, has maintained an astonishing rate of economic growth over the past 28 years. Beginning in 1978, China embarked on a series of policy changes that have led to an economy increasingly reliant on markets and price signals for allocating productive resources.⁶

As of July 2006, the Chinese population was 1.3 billion, which is more than four times as large as the U.S. population of 298 million. In terms of total production, measured in dollars at purchasing power parity, the Chinese economy is the

³ See Baier and Bergstrand (2001). Trade barriers and transportation costs are key components of trade costs, which are discussed in detail by Anderson and van Wincoop (2004).

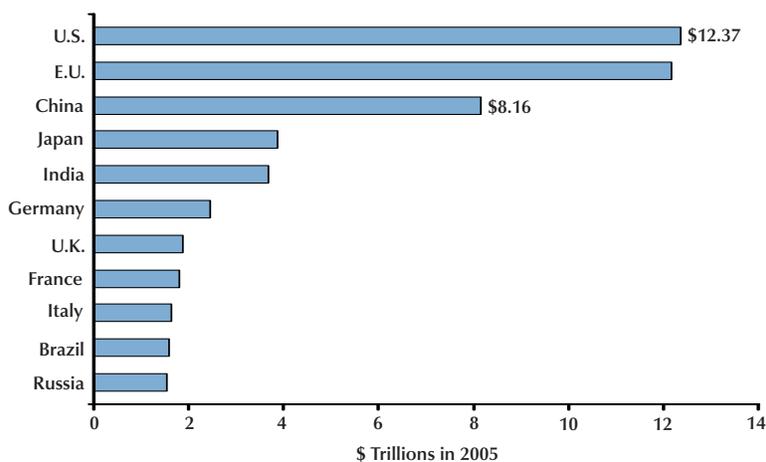
⁴ Using annual data from the World Trade Organization's *International Trade Statistics 2005*, world merchandise export growth exceeded world GDP growth in all but eight years between 1950 and 2004.

⁵ See "Building Explosion in China Pumps Up Exports from USA," a web article at www.usatoday.com/money/world/2006-04-19-china-exports-usat_x.htm in *USA Today*.

⁶ Prasad and Rajan (2006) estimate that between one-half and two-thirds of the Chinese economy is currently market-based.

Figure 2

China: The World's Second-Largest Single Economy in Terms of Purchasing Power Parity



SOURCE: CIA World Factbook.

Figure 3

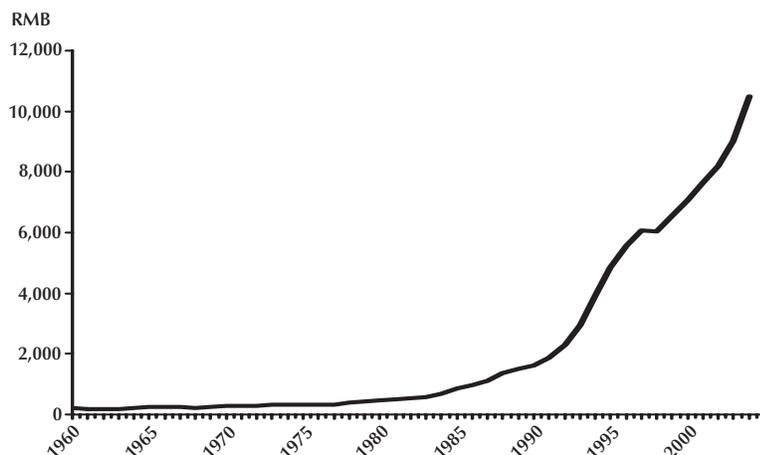
Leading Exporters and Importers in World Merchandise Trade, 2004

Rank	Exporters	Value (\$ billions)	Share (%)	Rank	Importers	Value (\$ billions)	Share (%)
1	Germany	912.3	10.0	1	United States	1,525.5	16.1
2	United States	818.8	8.9	2	Germany	716.9	7.6
3	China	593.3	6.5	3	China	561.2	5.9
4	Japan	565.8	6.2	4	France	465.5	4.9
5	France	448.7	4.9	5	United Kingdom	463.5	4.9
6	Netherlands	358.2	3.9	6	Japan	454.5	4.8
7	Italy	349.2	3.8	7	Italy	351.0	3.7
8	United Kingdom	346.9	3.8	8	Netherlands	319.0	3.4
9	Canada	316.5	3.5	9	Belgium	285.5	3.0
10	Belgium	306.5	3.3	10	Canada	279.8	2.9

SOURCE: World Trade Organization.

Figure 4

China's GDP per Capita



SOURCE: National Bureau of Statistics, China Statistical Yearbook 2004; National Bureau of Statistics Plan Report.

world's second-largest economy, trailing only the United States. In 2005 the Chinese GDP exceeded \$8 trillion, which was roughly two-thirds the U.S. GDP. (See Figure 2.) Not surprisingly, these two countries were two of the three leading exporting and importing countries in the world.⁷ (See Figure 3.)

The most vivid illustration of rapid Chinese growth can be seen by examining the Chinese economy on a per capita basis. Adjusted for inflation, China's per capita GDP in 2004 was 6.6 times its 1980 level. (See Figure 4.) Annual growth rates of real per capita GDP in excess of 5 percent have been the norm in recent years. (See Figure 5.) In the late 1970s, China's real GDP per capita was slightly less than 5 percent of the U.S. level. Today it exceeds 10 percent. (See Figure 6.) Thus, although the overall Chinese economy is large, China is still a country with a relatively low level of per capita income. To provide perspective,

China's real per capita GDP today is about equal to U.S. per capita GDP in 1886.

THEORY OF INTEGRATING A LARGE LABOR-ABUNDANT COUNTRY INTO THE WORLD ECONOMY

Some basic economic theory will provide a foundation for viewing the integration of the Chinese economy into the world economy. The analysis applies not only to the integration of the Chinese economy but also to similar developments that are occurring simultaneously in India and the countries of the former Soviet Union.⁸

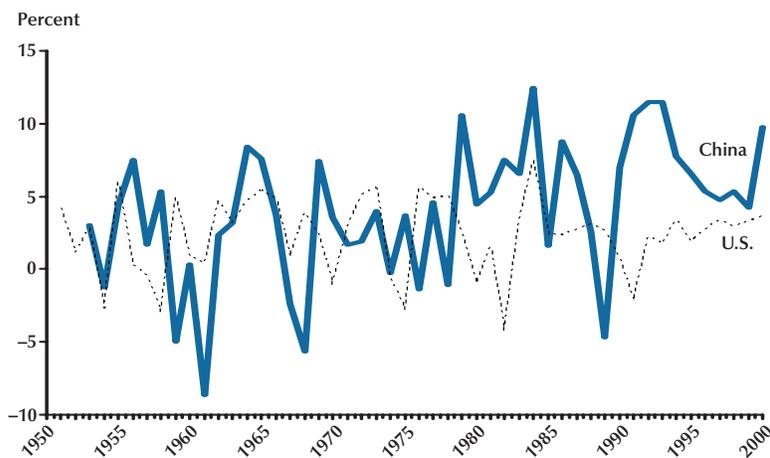
Economists view the integration of these economies into the global economy as a labor "shock." Their integration can be viewed as a very large increase in the world's effective labor supply. To facilitate my discussion, assume that the bulk of this increase in the labor supply in recent years has tended to be low-skilled. Employing this simplifying assumption, two consequences

⁷ For 2004, the leading countries in terms of total world exports were Germany with a 10.0 percent share, the United States with an 8.9 percent share, and China with a 6.5 percent share. In terms of imports, the leading countries were the United States with a 16.1 percent share, Germany with a 7.6 percent share, and China with a 5.9 percent share.

⁸ This idea has been expressed by Wolf (2006).

Figure 5

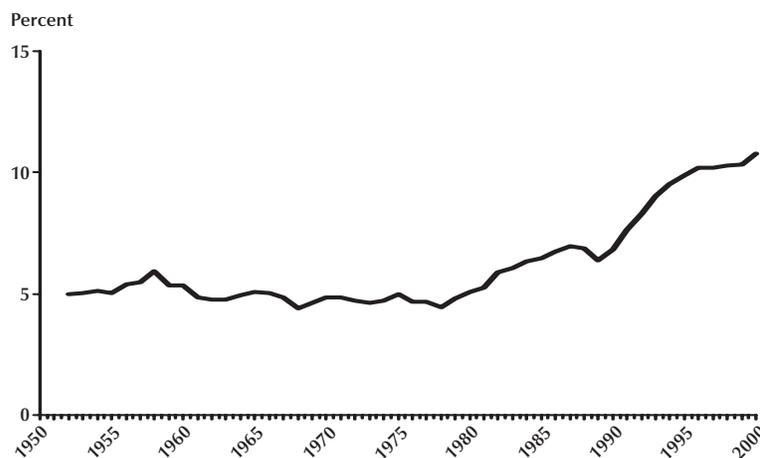
Chinese and U.S. Growth Rates of Real GDP per Capita



SOURCE: Penn World Tables (constant prices: chain series).

Figure 6

China's Real GDP per Capita Relative to the U.S.



SOURCE: Penn World Tables (U.S. = 100 in current prices).

are a direct result of the increased supply of low-skilled labor. One is that wages of low-skilled labor in high-income countries will tend to fall, or to increase more slowly, than before China's

entry into the world trading system. Second, prices of those goods that require relatively large amounts of low-skilled labor should tend to decline relative to the prices of those goods that require relatively

large amounts of high-skilled labor. For convenience of exposition, I'll refer to goods produced with low-skilled labor as "low-tech" goods and goods produced with high-skilled labor as "high-tech" goods. Obviously, there is a continuum of goods from low to high tech, but the simplification will make it easy to understand the basic economic forces at work.

The first effect tends to depress income gains of low-skilled labor in high-income countries. Obviously, the share in total population of high-skilled workers is greater in high-income countries than in low-income countries. Because of the large increase in low-skilled workers worldwide, low-skilled workers in the United States are likely to experience downward pressure on their real wages due to the increased competition associated with Chinese exports.⁹ The adverse income change generates demands for a government response to ameliorate the adverse market change.

The problem is real: Low-skilled workers in the United States have been adversely affected by imports of goods produced by low-skilled workers abroad. However, the nature of the government response is very important. Trade restrictions that hinder the importation of goods from China are unlikely to be a good solution because the United States would simply be forgoing the benefits of Chinese imports. Indeed, those lower-priced goods are important to lower-income, working families in the United States. The only appealing solution for the United States as a whole is to adopt policies that will increase the skill levels of affected workers, so that they can increase their compensation and employment prospects, which will allow them to adjust to the evolving economic environment.

Now consider the effect tending to reduce the prices of goods made with low-skilled labor. This relative price change, in which low-tech goods decline in price relative to high-tech goods, is associated with two other important price changes. The first involves a country's terms of trade, which is the (average) price of a country's exports relative to the (average) price of its imports.

⁹ In fact, declining real compensation for low-skilled workers has been an issue for many years in the United States.

In the case of China, the prices of the goods that China ships to the rest of the world should tend to decline relative to the prices of goods that it buys from the rest of the world.

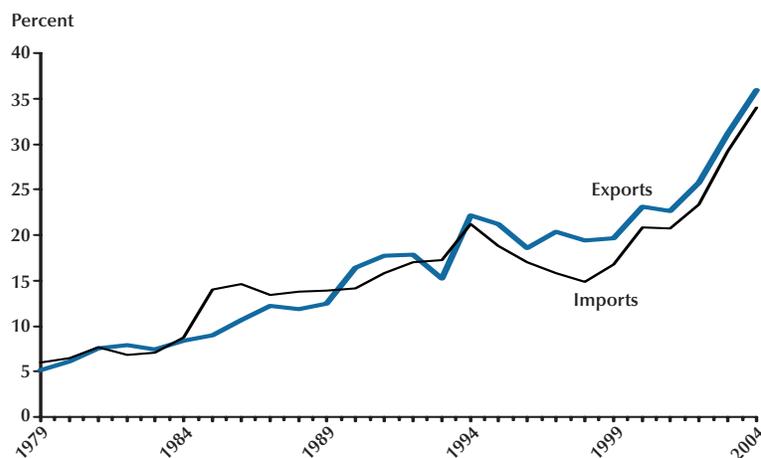
Generally speaking, as the price of Chinese exports declines relative to the price of its imports, countries purchasing Chinese goods should become better off. In theory, the more dissimilar another country's production and consumption is to China's, the more likely the country is to benefit by China's integration into the world economy. Thus, a country such as the United States should tend to benefit from China's integration. Of course, the magnitude of the gains for the United States depends on the impact of Chinese exports on U.S. import prices. Recent research by staff economists at the Board of Governors of the Federal Reserve System found that Chinese exports have caused declines, albeit small, in U.S. import prices.^{10,11} The public-policy challenge is considerable, however, because gains for the United States as a whole are accompanied by downward pressure on wages of U.S. low-skilled workers, as already noted.

There is another change that reduces and possibly negates the net benefits for the United States. Coinciding with China's rapid growth has been substantial increases in China's imports of commodities such as oil. In fact, China has become the world's second largest consumer of oil. Chinese demand for oil has undoubtedly contributed to higher oil prices. Given the scale of U.S. oil imports, higher oil prices have certainly reduced the beneficial effects for the United States of recent developments in China.¹²

¹⁰ See Kamin, Marazzi, and Schindler (2006).

¹¹ Rodrik (2006) argues that China's export bundle is more sophisticated than other countries with similar per capita incomes. While labor-intensive exports, such as toys, clothing, and electronics products that entail simple assembly operations, are important in China's export basket, Rodrik argues that foreign investment has played a major role in the evolution of Chinese exports. Foreign investors dominate Chinese exports. Their contribution of advanced technology, and the resulting transfer of technology, has resulted in Chinese exports that are relatively more sophisticated than those of comparably developed countries.

¹² Not surprisingly, oil is at the center of a contentious political issue. China's desire for increased oil supplies has led to relationships with a number of countries, such as Sudan and Uzbekistan, who many view as unsavory in terms of their records on human rights.

Figure 7**Chinese Exports and Imports as a Percent of GDP**

SOURCE: IMF, *Direction of Trade Statistics*, and official Chinese statistics.

HOW CHINESE GROWTH AFFECTS TRADE

The preceding discussion has focused on the relative-price impacts of China's integration into the world economy. Changes in relative prices, however, are not the only spur to changes in economic activity. China's economy has reached such a size that in recent years it has served as an engine of growth not only in Asia but also worldwide. Put simply, a wealthier China means rising Chinese demand for goods of all sorts, including high-tech goods that China does not produce.

One manifestation of this fact is that Chinese growth has resulted in large effects on overall trade flows. The integration of the Chinese economy into the world economy can be seen very clearly by examining how Chinese exports and imports have changed since the late 1970s. In 1979, Chinese exports as a share of Chinese GDP was 5 percent. Since then the share has risen to 36 percent. (See Figure 7.) The course of Chinese imports has taken a similar path, rising from roughly 6 percent of GDP in 1979 to 34 percent in 2005. These import and export shares may be compared with the shares for the United States:

Imports are 16 percent of U.S. GDP and exports are 10 percent.

As Chinese exports have grown faster than its imports, the Chinese trade balance has increased. A close look at China's trade balance reveals that from 1979 to the mid-1990s, the average yearly balance was roughly zero. (See Figure 8.) Since the mid-1990s, the balance has tended to rise, reaching a level of \$102 billion in 2005, which is 4.4 percent of China's GDP.

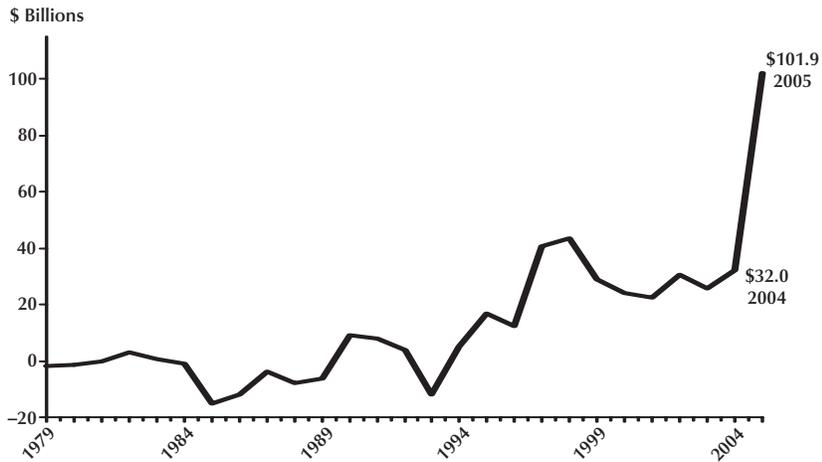
UNITED STATES–CHINA TRADE

The increase of China's trade surplus since the mid-1990s coincides with a substantial increase in the United States–China bilateral trade balance. In 1995 the U.S. bilateral trade deficit with China was approximately \$20 billion. (See Figure 9.) Subsequently, this deficit has increased yearly, reaching \$202 billion for 2005, which was 28 percent of the overall U.S. trade deficit. (See Figure 10.) Surprisingly, in 1995, China's share of the overall U.S. trade deficit was actually *larger*, at 35 percent of the overall U.S. trade deficit.

Obviously, since 1995 the growth of U.S. imports from China has exceeded the growth of

Figure 8

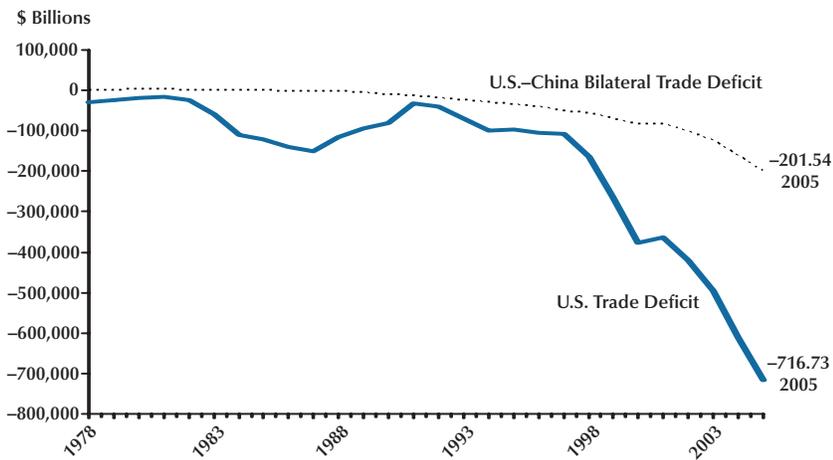
China's Trade Balance, 1979-2005



SOURCE: China Statistical Yearbook.

Figure 9

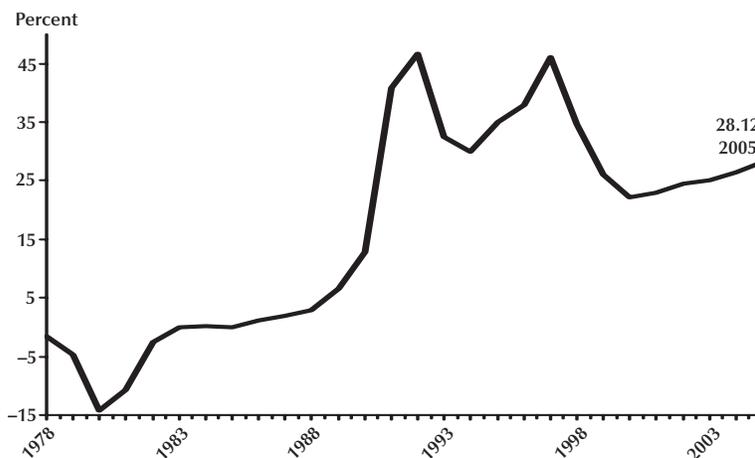
U.S.—China Bilateral Trade Deficit and U.S. Trade Deficit



SOURCE: U.S. Census Bureau, Foreign Trade Statistics.

Figure 10

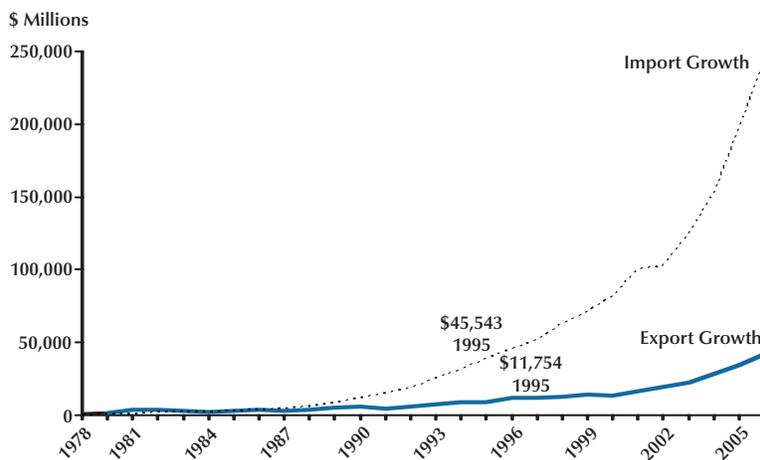
China's Portion of the U.S. Trade Deficit



SOURCE: U.S. Census Bureau, Foreign Trade Statistics.

Figure 11

U.S. Exports to and Imports from China



SOURCE: U.S. Census Bureau, Foreign Trade Statistics.

Table 1**Top 10 U.S. Exports to China—Ranked by 2005 Exports**

HS Industry Codes (\$ millions)

Code	Description	2005	Share of U.S. exports to China (%)
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television recorders and reproducers, parts and accessories	6,851	16.3
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	6,357	15.2
88	Aircraft, spacecraft, and parts thereof	4,381	10.4
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof	2,397	5.7
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruits, industrial or medicinal plants; straw and fodder	2,289	5.5
39	Plastic and articles thereof	2,259	5.4
72	Iron and steel	1,555	3.7
29	Organic chemicals	1,475	3.5
52	Cotton, including yarns and woven fabrics thereof	1,411	3.4
47	Pulp of wood or other fibrous cellulosic material; recovered (waste and scrap) paper and paperboard	992	2.4

U.S. exports to China. Between 1995 and 2005, U.S. imports from China increased more than fivefold, while U.S. exports to China increased by a factor of 3.6. (See Figure 11.) But note this important fact: The growth in U.S. exports to China has been far greater than the growth of U.S. exports overall. Between 1995 and 2005, total U.S. exports increased by a factor of 1.6, which is less than half the rate of increase of U.S. exports to China. In light of the rapid Chinese growth, it is not surprising that U.S. exports to China rose rapidly. It is especially noteworthy that in 1995 China was the 13th leading export market for goods produced in the United States and in 2005 it was the 4th leading export market. Put simply, a wealthier China is a better market for U.S. goods and services, especially for high-tech and agricultural goods, which the United States produces in abundance.

Chinese purchases of U.S. goods took center

stage during President Hu Jintao's visit to the United States last May. During the visit, President Hu agreed that China would buy \$16.2 billion worth of Boeing jets and various other goods, such as networking equipment, medical devices, and beef. A close look at the top 10 exporting industries to China in 2005 reveals that the industry code including aircraft was the third leading export industry and that the industry code including medical devices was the fourth leading export industry. (See Table 1.) The two leading industry codes were (i) electrical machinery and equipment and (ii) nuclear reactors, boilers, machinery, and mechanical appliances. Together, these industries accounted for 31.5 percent of U.S. exports to China.

Large multinational corporations play a major role in U.S. exports to China. However, according to the U.S. Commercial Service, since 1992 the number of small and midsize exporters has increased from 3,143 to 19,201, a gain of 511 percent.¹³ I opened my remarks today with an

¹³ See www.usatoday.com/money/world/2006-04-19-china-exports-usat_x.htm.

Table 2**SLC Top State Exports to China 2005**

State	HS commodity code	Commodity description	Top export 2005 value (\$ millions)	Total 2005 exports value (\$ millions)	Top export as percent of total exports
TX	85	Electric machinery, etc.; sound equipment; TV equipment; parts	1,164.30	4,901.30	23.76
LA	12	Oil seeds, etc.; misc. grain, seed, fruit, plant, etc.	1,193.10	1,896.00	62.93
TN	52	Cotton, including yarn and woven fabric thereof	760.40	1,411.40	53.87
GA	47	Pulp of wood, etc.; waste, etc. of paper and paperboard	139.30	978.70	14.23
NC	84	Nuclear reactors, boilers, machinery, etc.; parts	163.90	774.40	21.17
VA	81	Base metals nesoi; cermets; articles thereof	77.20	721.50	10.70
FL	31	Fertilizers	255.10	690.40	36.95
SC	85	Electric machinery, etc.; sound equipment; TV equipment; parts	88.30	622.20	14.18
MO	84	Nuclear reactors, boilers, machinery, etc.; parts	84.60	499.50	16.94
AL	39	Plastics and articles thereof	153.40	467.00	32.84
KY	72	Iron and steel	103.60	400.90	25.85
MD	84	Nuclear reactors, boilers, machinery, etc.; parts	55.40	284.30	19.49
MS	87	Vehicles, except railway or tramway, and parts, etc.	22.00	164.80	13.38
AR	28	Inorganic chemicals; precious and rare earth metals and radioactive compounds	31.30	144.40	21.66
WV	39	Plastics and articles thereof	53.90	135.40	39.82
OK	84	Nuclear reactors, boilers, machinery, etc.; parts	46.70	94.30	49.55

example of exports sales by Kanawha Scales and Systems. This same phenomenon of small firms selling to the Chinese market is found all over the United States. Consider Sharpe Mixers of Seattle. This firm makes specialized “absorbers mixers” that strip sulfur dioxide from power plant emissions. Chinese power plant construction is proceeding rapidly to meet large increases in power demand. Most of these power plants are coal-fired, and Sharpe has seen its Chinese business increase substantially since receiving its first order in 2004.

This additional business has led to 10 additional employees for a total of 30.

EXPORTS FROM SLC MEMBER STATES

Let’s look more closely at the total exports from the SLC states to China. It turns out that the two leading export sectors are the same as for the United States as a whole. Together, these industries—electrical machinery and equipment and

Poole

nuclear reactors, boilers, machinery, and mechanical appliances—accounted for 25 percent of the SLC states' exports to China during 2005.

Looking at the SLC states individually, we see substantial differences in their exports to China. Electrical machinery and equipment is the leading export category for only two states—Texas and South Carolina—while nuclear reactors, boilers, machinery, and mechanical appliances is the leading export category for four states—North Carolina, Missouri, Maryland, and Oklahoma. (See Table 2.) For the remaining 10 states, various commodity codes appear: plastic products for Alabama and West Virginia, oil seeds for Louisiana, cotton for Tennessee, wood pulp for Georgia, base metals for Virginia, iron and steel products for Kentucky, fertilizers for Florida, vehicles and parts for Mississippi, and inorganic chemicals for Arkansas.

For these states, 2005 exports to China range from \$4.9 billion from Texas to \$0.1 billion from Oklahoma. One fact is that, for SLC states, exports to China relative to gross state product tend to be below the national average for all states together. Using figures for 2005, only 4 of the 16 SLC states had shares in excess of the national average of 0.36 percent. Those states were Louisiana (1.1), Tennessee (0.62), Texas (0.50), and South Carolina (0.45).

What is especially encouraging, however, is that firms in the SLC states have played a key role in the growth of exports to China. Comparing 2002 with 2005, total U.S. exports to China increased by a factor of 1.9. However, 13 of the 16 states represented at this meeting experienced export growth faster than the national average. The leader was Tennessee, whose exports increased by a factor of 4.2. Missouri was the second leading state, with exports to China increasing by a factor of 3.9. The only states lagging the national average were Mississippi (1.2), Florida (1.0), and West Virginia (0.9).

CONCLUSION

My message for you today can be summarized very succinctly: The growth of the Chinese econ-

omy has provided and will almost certainly continue to provide U.S. firms with important export opportunities. This growing demand for U.S. goods and services provides not only more but also better-paying employment opportunities.

This simple message is easy to miss because the continuing integration of China into the world economy presents both political and economic challenges. It is still very easy to identify numerous factors that hinder the sales of goods and services to China by U.S. firms.¹⁴ Without question, Chinese infringement of intellectual property rights remains a problem that limits U.S. exports. In addition, government procurement policies, restrictions involving the wholesale and retail distribution of foreign products in China, and the lack of transparency of many regulations also limit U.S. exports.

As I look to the future, I continue to see much negotiation between the Chinese and U.S. governments as well as many adjustments to the changing economic and political environment by U.S. firms and consumers. Political pressures will continue to be felt by U.S. policymakers. Given the insights from economic theory as well as the lessons of economic history, my hope is that policymakers will resist the calls for isolationist responses. U.S. trade restrictions are highly unlikely to increase employment opportunities at home, but clearly would deprive American consumers of lower-cost goods from China. The best course of action is to continue to encourage China to protect intellectual property rights and to lower barriers on trade.

Taking advantage of the opportunities presented by Chinese growth—rather than simply attempting to negate the competitive pressures—is in the best interest of both countries. Opportunities to increase exports are in fact being seized by U.S. firms, many of which are located in the 16 states served by the Southern Legislative Conference. Recent export growth by nearly all of these states has exceeded the national average.

¹⁴ E. Anthony Wayne, Assistant Secretary for Economic and Business Affairs in the U.S. Department of State, enumerated many of the contentious issues in a speech on May 25, 2005, at the Executive's Club of Chicago.

In light of the continuing strong Chinese growth prospects, prospects for exports to China from the states represented here today are very bright.

I'll finish with a general comment. For over 70 years, since the Reciprocal Trade Agreements Act of 1934, the United States has led the way toward a more open international trading system, and I am hopeful that this historic process will continue. Both economic theory and economic history have provided ample reasons showing that changes in legislation and regulation that tilt toward economic isolation are unwise. Our future prosperity depends on continuing to build on past successes in extending open markets and enjoying the fruits of the productivity advances open markets promote.

REFERENCES

- Anderson, James E. and van Wincoop, Eric. "Trade Costs." *Journal of Economic Literature*, September 2004, 42(3), pp. 691-751.
- Baier, Scott L. and Bergstrand, Jeffrey H. "The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity." *Journal of International Economics*, February 2001, 53(1), pp. 1-27.
- Kamin, Steven B.; Marazzi, Mario and Schindler, John W. "The Impact of Chinese Exports on Global Import Prices." *Review of International Economics*, May 2006, 14(2), pp. 179-201.
- Prasad, Eswar S. and Rajan, Raghuram G. "Modernizing China's Growth Paradigm." *American Economic Review*, May 2006, 96(2), pp. 331-36.
- Rodrik, Dani. "What's So Special about China's Exports." NBER Working Paper 11947, National Bureau of Economic Research, January 2006.
- Wayne, E. Anthony. "China's Emergence as an Economic Superpower and Its Implications for U.S. Businesses." Remarks at The Executives' Club of Chicago, International Leadership Conference, Chicago, IL, May 25, 2005; www.state.gov/e/eb/rls/rm/2005/46950.htm.
- Wolf, Martin. "The Answer to Asia's Rise Is Not To Retreat from the World." *Financial Times*, March 15, 2006, p. 17.



Money and Monetary Policy for the Twenty-First Century

Jerry L. Jordan

This essay challenges the conventional wisdom about money and monetary policy. The role of money in fostering prosperity is a function of the quality, as well as the quantity, of money. Inflation always harms the performance of an economy. Deflations caused by productivity and innovation can be virtuous. A definition of a non-inflationary environment is set forth. Rapid real growth and low unemployment cannot cause inflation. There is no trade-off between inflation and employment. Higher commodity prices or “weak” exchange rates cannot cause inflation. High market interest rates are a symptom of inflationary policies. Low interest rates are a reflection of successful anti-inflationary policies, not “easy money.” (JEL E41, E42, E51, E52)

Federal Reserve Bank of St. Louis *Review*, November/December 2006, 88(6), pp. 485-510.

THE BASICS OF MONEY

Modern market economies would not be possible without financial stability. However, as events around the world in the past decade demonstrated, financial institutions are not sound and payments systems are not efficient when the value of money is not stable. Decades of experience have demonstrated that prosperity is undermined when the value of money fluctuates. Stabilizing the value of money has become the primary, if not the sole, objective of central banks around the world. This is an essay about money—both the meaning of the word and the various ways people have sought over time to stabilize its value. The importance of stable money—and the roles of governments and central banks in providing it—will be presented in a different light than it is in the conventional dialogue.

In a superficial sense, after decades of increase, the number of “monies” circulating in the world began to decline during the final decade

of the past millennium. It is superficial because many of the national currencies did not qualify as “money” in the full sense. There are only a few “standards of value” that do not need to be linked to—or defined in terms of—some other monetary unit. In the same sense that ten “dimes” or four “quarters” are the same as one U.S. dollar, many small-country currencies are defined in terms of the major currency they are tied to.

For the few currencies that do serve as standards of value, the issuing central banks must take actions, which collectively are referred to as “monetary policy.” Such policy actions determine the “quality” of the money over time. A money’s *quality* is inversely related to the *quantity of other real resources* that are used in the economy alongside money to conduct money-type functions. In places in the world plagued with unstable money, people spend much of their time getting paid more frequently, dealing only in cash, making more frequent purchases, or hiring expensive

Jerry L. Jordan was the president of the Federal Reserve Bank of Cleveland from March 1992 to January 2003. Previously, he was director of research at the Federal Reserve Bank of St. Louis. He is a senior fellow at the Fraser Institute and an adjunct scholar at the Cato Institute. This article was presented in part as the Homer Jones Lecture, March 8, 2006, in St. Louis Missouri, after being printed in *Critical Issues Bulletin 2005*, by the Fraser Institute; sections of the article are reprinted here with permission. The author thanks John Chant, Steve Easton, and Anna Schwartz for comments on drafts of this article.

© 2006, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis.

money managers and financial advisers. That is, having money of lower quality means that more time, effort, and resources are employed in gathering information about relative prices and conducting transactions. Those resources could have been used to raise the “potential output” of the economy, which is the social payoff for policies that maintain sound money. The frequently referred to, but little understood, “cost of inflation” is the loss of output over time resulting from deterioration of the quality of money.

The Nature of Money

My very great teachers (Alchian, 1977; Brunner and Meltzer, 1971) taught that a society uses *as* money that entity that economizes best on the use of other real resources to gather information about relative prices and to conduct transactions. This makes clear that the common—but wrong—statement of Gresham’s Law about “bad money” driving out “good money” needs to be restated. What we have observed through the millennia is that high-confidence monies drive out low-confidence monies (Hayek, 1976, p. 29; Mundell, 1998).

Sometimes economists treat money as a factor of production that is separate from, and in addition to, land, labor, or capital. This is not a useful way to think about the role of money in society. It is derived from—and maybe reinforces—the idea that there must be enough money in circulation to “meet the needs of trade.” A more fruitful way to think about the role of money in a market economy is one in which sound money liberates resources, especially resources used to gather information and to conduct private transactions. This view draws attention to the importance of the quality of money. That money facilitates transactions appears to be clear to everyone; its role in enhancing market knowledge about relative prices, however, is less well understood.

Money’s effectiveness depends largely on its quality. The quality of money is high when the value of money is stable. Money prices provide households and businesses with reliable information about the relative costs of goods and services. They can make sound economic decisions and this, in turn, fosters economic prosperity.

The economic efficiency that comes from a stable monetary unit of account is one of the pieces of a Hayekian infrastructure that a market economy requires. That is, a market economy requires a foundation of enforceable property rights, generally accepted accounting principles, sound financial institutions, and a stable currency. Where public contracts are not honored and private contracts are not enforced, markets are impaired. Where title to property is not certain, normal banking is not possible. Where financial statements are not reliable, investment opportunities are obscured. Where the purchasing power of money is not stable, resources are wasted in gathering information or are tied up (hoarded) as stores of value are used in producing and consuming the wrong things.

Money, Prices, and Income

The prices of things people buy and sell and in which they invest are expressed in terms of money units. Changes in the money prices of goods and assets convey information. If an economy’s monetary unit is known to be a stable standard of value, then changes in money prices will accurately reflect changes in the relative values of goods and assets. That is, price fluctuations signal changes in the demand for, and supply of, goods and assets; resources are then shifted toward more valued uses and away from those less valued. This is essential in order for the economy to achieve the most economically efficient aggregate output. In other words, standards of living will be highest when all price changes can be interpreted as relative price changes. Similarly, all changes in interest rates would be changes in real interest rates—a reflection of changes in people’s preferences about time, changes in the pace of innovation, or changes in the economy’s endowment of productive resources.

Unfortunately, in the world of *fiat* money,¹ one can never be absolutely certain that observed changes in the prices of specific things or changes in interest rates reflect real events such as crop

¹ Irredeemable paper currency that does not rest on a specie basis such as gold but derives its purchasing power from the declaratory *fiat* of the government issuing it.

failures, so mistakes are made in the allocation of productive resources. As a consequence, the well-being of the society is less than optimal. A form of monetary static (like a distracting noise) in the pricing of goods and services occurs when the standard of value—money—does not mean the same thing over time. This static means the signals that are coming to decisionmakers from observed price changes cannot be relied upon with certainty when the use of productive resources is shifting.

In economies where changes in money prices are contaminated by the changing purchasing power of money, false signals are being sent to businesses and households. Bad decisions are being made, and resources are being misallocated. Standards of living—real incomes—fail to rise at their potential rate. Nominal interest rates (that is, the kind you see quoted every day) respond to shifting expectations about the future purchasing power of money. Changes in real interest rates are obscured, so resources are misallocated. Since saving and investment decisions are affected, growth is impaired.

The objective of monetary policy is to minimize the misinformation associated with the constantly changing (relative) prices of things. Absence of inflation is the ideal condition in which businesses and households make all decisions based on the assumption that all price changes currently observable or expected in the future are relative price changes; that is, they reflect changes in the underlying demand for, or supply of, everything. Naturally, if all price changes are relative price changes, for every observed or expected rise or decline in some prices there must be corresponding price declines and rises in other prices.² For this condition to prevail, people—while they know that some prices will rise and others will fall—must anticipate that on balance they are safe in assuming the monetary standard—money—will buy the same universal array of goods over time. When innovation occurs and new goods are invented, the average well-being of the society is improved but not because the information content of money has changed.

² Appropriately weighted.

Innovation involves “creative destruction”—the economic value of something old is reduced by the discovery of a new product or more efficient way of producing the old product. Relative prices change; a market system treats such changes as signals that resources are better used by shifting away from the old and toward the new.

A *real* increase in particular prices or wages occurs when there is a shift in demand away from some other good or factor input³ and toward that good or factor. When “improved efficiency” means discovering ways of using the same amount of labor but less of other factor inputs to produce the same output, a real wage gain occurs. In such a circumstance, observed wage increases would be associated with decreases in output prices to the extent that the quantity of the good produced increases as a result of the improved productivity.

An innovation that generally improves productivity in an economy will be associated with higher real returns to productive capital (including human resources such as labor). The resulting increase in observed interest rates—which are themselves relative prices and subject to change—is a part of the mechanism by which resources are bid to their higher-valued uses. As will be discussed later, if governmental (monetary) policies sought to prevent the market from bidding up interest rates, the resulting expansion of the central bank’s balance sheet would cause monetary units to be created at a more rapid rate than people desire to add to their stocks of money balances. The effects would be observed in an acceleration of aggregate spending growth as people seek to exchange the excess balances for things they prefer. The bidding of the excess money units for other things causes the money prices to rise—more money units to acquire the same thing. Price signals are then distorted by the falling purchasing power of the money used in the economy.

The challenges to monetary policymakers in formulating and implementing policy actions to minimize inflation or deflation will be discussed in some detail below. Here, the important point is that frequent changes in the prices of things

³ Economists refer to the materials used to make things—wood, metal, plastics, etc.—as “factor inputs.”

and changes in market interest rates are normal occurrences in a market economy, and an understanding of how and why they are changing is important to both policymakers and the rest of us.

Inflation

It would be hard to get agreement on a definition of inflation and even more difficult to get agreement on an acceptable measure of inflation. We have chosen instead to define the conditions that would prevail when there is an absence of inflation or deflation. Common usage of the term “inflation” is misleading because it confuses cause and effect. Often people think that inflation occurs because “prices are rising.” But, that is too simple. Such a diagnosis often leads naive politicians to think the appropriate prescription is either to put controls in place to prevent prices of things from going up; or they think the task is to ensure that incomes rise at least as rapidly so that standards of living do not erode. Both prescriptions are wrong.

“To inflate” certainly means “to make larger,” but what is increasing is the number of money units required to purchase the same basket of goods over time. The diagnosis should be that money units are being created at a faster rate than people want to add to their holdings of them. “Too much money chasing too few goods” is the familiar cause of inflation. The appropriate prescription is to avoid creating money at a pace that is faster than people want to add to their money balances. How policymakers seek to do this is discussed in the boxed insert.

The obvious political risk of talking as though inflation means that prices of things and people’s wages are rising is that people come to fear that policymakers are out to deny them the well-deserved wage increase or higher price for their products that other people seem willing to pay. Public surveys reveal that people form ideas about inflation based on prices of things they *buy*. They rarely see higher prices of things they *sell* as anything other than just rewards for their labors.

The expressions “price stability” or “stable prices” are not more helpful. Prices of things—both goods for current consumption and investment assets—are constantly changing. All

innovation implies lower (relative) prices for previous goods and technology. The familiar pattern for all newly introduced goods is for their prices to fall as methods of production and distribution are improved and as economies of scale are achieved. Conversely, as wealth rises, people spend a declining share of their income on certain “necessities” and larger shares of their income on goods thought of as luxuries. Such shifts in consumption patterns may be associated with rising prices of the more sought-after goods. These are natural manifestations of a market economy. It would be highly undesirable to have—and to have policies designed to maintain—stable prices.

People know very well that the money prices of some things will rise (cars, concert tickets, impressionist paintings, greens fees, tuition, etc.) even though they cannot be sure by how much. Money prices of other things will fall (refrigerators, telephone calls, computers, televisions, VCRs, carpets, microwave ovens, etc.), even though they cannot be sure by how much. Most of the time for most things (food, gasoline, clothing, prescription drugs, etc.) they cannot be too certain whether the money prices in the future will be higher or lower. Such uncertainties cannot be eliminated from a market economy. As a consequence, people have always chosen to use as money (subject to the effectiveness of criminal prohibitions by governments) the entity that their own experience suggests is more likely to be exchangeable in the future for known quantities of things they desire. Uncertainty about present and future relative values of things is precisely why people hold money balances at all. When alternatives are available, they will choose to use as money the currency they are least uncertain about with respect to future money prices. Because people know they get hurt by inflation, for over 40 years—from the 1930s to the 1970s—the U.S. government made it illegal for American citizens to hold gold as a way of protecting themselves.

Time and other resources are required to shop—to gather information about relative prices of various goods, services, and investment assets. People will naturally prefer to use the monetary units that economize best on the use of their time and productive resources to gather information

MONEY IS NOT INCOME

As noted earlier, even the word “money” cannot be used without ambiguity. It would be hard to find anyone who would admit to having more money than they want. But, their behavior suggests otherwise. Every purchase or investment involves a reduction in money holdings. Acquiring money balances requires selling something or spending at a slower rate relative to cash income. The confusion comes from the unfortunate popular habit of using the word money to mean income or wealth. It is natural for humans to desire more income—ability to consume. Money is the means by which indirect exchange takes place. It is a good that is held for the services it renders. Like any other good, a person can certainly be holding more money balances than desired relative to other things. When one’s money balances are judged to be too large, disposing of excess money in favor of some thing is the least costly adjustment one can make.

In truth though, people do not normally desire to hold something simply because society treats it as money. Rather, they desire to have available claims to consumption—they want to buy things. Naturally, how much they can buy will depend on the prices of things in money units, so the amount of money they hold will depend on how much they expect things to cost. They form their expectations about how much things will cost in the future based on the experiences they have had in the past. If they generally have observed that the money prices of virtually everything they buy are always rising—a condition usually referred to as inflation—they are rational in thinking that will also be the case in the future. Under such circumstances, their current money holdings will be, on average, smaller than if they thought that the money prices of at least some of the things they want to buy will be lower in the future.

about relative prices and to conduct transactions. In recent decades, the world has had ample opportunity to observe ordinary people in Latin America, the former Soviet Republics, and central Europe choose to use U.S. dollars (and, increasingly, euros) rather than the currency supplied by their own governments. Obviously, they do so based on an expectation that the information available to them regarding the relative values of things is more reliable when denominated in dollars than in *rubles*, *pesos*, *dinars*, or *bahts*!

Bad experiences have taught most people that neither inflation nor deflation enhances economic performance. What also occurs, but is not as easy to observe, is that unanticipated inflations and deflations induce redistributions of wealth—especially between debtors and creditors—but they leave the average standard of living lower. According to a former Governor of the Federal Reserve, “a place that tolerates inflation is a place where no one tells the truth.” He meant, of course,

that true changes in the relative values of things cannot be observed from stated prices when the purchasing power of money is not stable.

An appropriate policy with regard to money would be to create the institutional arrangements that minimize the uncertainty that people encounter about the money prices both of goods available for current consumption and of investment assets. Individuals not only want to exchange the proceeds of their current labors for immediate consumption, they want to minimize uncertainty about their future ability to exchange various savings and investment assets for subsequent consumption. The types of money that exhibit the best track records for minimizing these information costs will be the preferred monies.

Money and Interest Rates

A confusion arising from the popular usage of the word “money” is that bankers claim to lend money and bank customers claim to borrow

money. But, people do not increase their indebtedness in order to hold greater idle cash balances! The extension of credit by financial intermediaries does not alter the amount of *money* in the economy. Nevertheless, the unfortunate expressions—“borrowing money” and “lending money”—contribute to an erroneous idea about the relationship between the “amount of money” and observed interest rates. People (and their elected representatives) believe that interest rates would be lower if only there were more money available. This Ptolemaic view of the world persists even in the face of much sad experience that countries “enjoying” rapid money growth have high interest rates.

People hold a variety of financial assets—in addition to money—as stores of value. Often these assets are claims to certain amounts of money units at various times in the future. But, they do not want a certain amount of *money* in the future. They want to buy things. If they think the prices of things they will want to buy in the future will be higher, they know they will have to have more money units. Being able to earn higher interest rates on their assets is one way of having the greater amount of money that will be required by the expected higher prices of things. By the same token, borrowers of money are willing to pay higher interest rates if they expect their investments to generate larger volumes of money units as the money prices of things rise.

There is a common fallacy that “low” interest rates can “cause inflation” and that “high” interest rates are part of the solution. This is completely backward. When people—both businesses and households—start to anticipate that prices will be rising faster in the future, they make adjustments. Sometimes they make purchases sooner than otherwise to “get ahead” of the price rise. They may even go into debt to do so. They also seek to minimize any “idle balances” they hold in the form of cash or low-yielding balances in their checking accounts. But, while one family or one business may reduce its money holdings, the economy cannot do so. Actions by anyone to spend or invest only increases someone else’s money balances. If everyone is trying to do the same thing, prices of goods and assets will get bid up—

the real purchasing power of money falls—and higher interest rates will have to be offered to induce people to hold—rather than spend—the stock of money in circulation.

These market dynamics explain why higher interest rates are always and everywhere observed in the places where the value of money is falling fastest, while the lowest interest rates are observed where money is holding its value. There is only one monetary policy that can produce low interest rates: a policy of stable money. Once people start to expect the value of money to erode—the average of money prices to rise—observed interest rates can also be expected to rise. Any attempts to resist these natural market dynamics artificially will only make matters worse.

Even when businesses and households in an economy expect the value of money to be stable over time, there will be fluctuations in interest rates that reflect the changing pace of innovation, agricultural developments, natural disasters, wars, and other real events. Monetary authorities cannot avoid the need to analyze the forces tending to alter interest rates. Those market dynamics emanating from a monetary imbalance must be responded to. Errors in interpreting the forces operating to change interest rates has been the most common source of mistakes in the formulation of monetary policies in the modern world.

Money and Exchange Rates

People in every modern economy buy things from, and sell things to, people in other countries. How much they have to pay when they buy and how much they can get when they sell depends on the exchange rate between the domestic money and the money of the other country. The exchange rate between any two currencies depends on many things, including the inflation rates of each country and “acts of God” in one of the countries.

Wealth gains and losses in one country can result from changes in the exchange rate caused by developments in the other. When international terms of trade are altered by foreign developments—wars, agricultural conditions, etc.—there are redistributive effects in the domestic economy: The effects on import-competing firms is opposite to that on exporting firms, and the prices

of tradable goods change relative to the prices of non-tradable goods. Furthermore, asset prices are influenced differently than goods prices. In all, many prices are affected, in different directions, with some people being positively or negatively affected relative to other people. None of these developments, though, has any certain effect on the stability of the domestic currency.

Even though price indices that include foreign goods—and domestic goods that compete with foreign goods—may increase or decrease as a consequence of international developments, it is not correct to identify such statistical observations as inflation or deflation. A shortfall of the coffee crop will influence coffee prices in importing countries. And, to the extent consumers pay the higher prices, they will experience a real income loss and consequently will purchase less of other things. What is observed is the higher price of coffee in the price statistics. What is not so readily observable is the associated lower demand for, and prices of, other things compared with what otherwise would have occurred. Relative prices have changed, but the average of prices depends on the income and substitution effects and the choices people make.

It is common—but wrong—for someone to say that “higher inflation is caused by higher costs of imports such as oil.” What is true is that misinterpretation of a “price shock” caused by a change in the external exchange rate or by a real event such as a sudden drop in oil production can result in a mistake in monetary policy. Such misinterpretations and policy mistakes have frequently resulted in inflations (and deflations) that could have been avoided.

Money, Growth, and Employment

Contrary to simple intuition, one often sees news reports suggesting that “too much” economic growth will reduce the purchasing power of money—will “cause inflation,” in familiar language. Yet, every person knows that a bumper crop of anything will yield lower prices and a poor harvest will be followed by higher prices. It is simply not logical (or correct) to argue that an increase in production will foster a general rise of prices. Concerns that faster total growth of out-

put in the economy will cause a fall in the purchasing power of money—inflation—are simply wrong.⁴ Similarly, it is false to say that “too many people working” or “too low unemployment” can “cause inflation.”⁵

Market economies have an inherent tendency to grow. How much growth occurs depends on incentives for working, for achieving productive efficiencies, and for introducing new products. In addition to tax laws and regulation, economic policies influence these incentives by fostering a monetary regime that provides reliable information about the relative values of productive resources, both in the present and in the future. That happens only when the monetary unit employed by the economy is of known and stable value. Anything less than stable money gives inaccurate signals about relative values, so resources are not allocated to their most productive uses. Growth, consequently, is less than it would be if money prices could be relied upon to reflect relative underlying supplies of, and demands for, productive resources accurately.

Money and Productivity

Traditionally, economists talk about things being produced using some combinations of land, labor, and capital, where capital is taken to mean tools, machines, buildings, and so on. Productivity—productive efficiency—improves when the same output can be obtained with less of at least one of these inputs. As noted earlier, economists sometimes include “money” in the production function, as a factor of production that is in addition to land, labor, and capital. As such, the quantity of money appears to be an alternative to (or maybe in addition to) lumber, copper, workers, or other factors. This unfortunate way of thinking about the role of money in the economy tends to be derived from—and maybe to reinforce— notions that there is “not enough money” in circulation. Such a false diagnosis is dangerous because it usually is accompanied by a prescription that

⁴ For a discussion of why rapid growth does not cause inflation, see Federal Reserve Bank of Cleveland (2000).

⁵ For further discussion of these issues, see Federal Reserve Bank of Cleveland (1999).

the monetary authorities can make people better off by creating money units at a faster rate. That is certainly wrong.

It is easy to imagine, and probably common, for the lending officer of a bank to respond to a customer's request to borrow more funds by saying, "I would like very much to lend you some (more) money but the central bank is making credit very tight and I have no more to lend...how about golf on Sunday?" The would-be borrower is left with the impression that the currently available stock of money is already being "used" by somebody else and that the central bank is preventing him from expanding his business by failing to increase the total availability of money. A popular (but wrong) conclusion is that the output of the economy is being restrained by the inadequacy of money growth.

The alternative way to think about the role of money is that improving the quality of money reduces the use of other real productive resources employed in the task of gathering information about relative values and conducting transactions and, therefore, increases the productive potential of the economy. That is, instead of being a supplement to other productive resources, money that is more stable liberates such resources from being employed in activities associated with uncertainties that exist when the purchasing power of money is unstable. When the form of money available in the economy is not reliable—that is, its purchasing power over time is not stable—some of other resources will be employed in dealing with the uncertainties. As monetary policies to stabilize the currency start to become effective and credible, other resources can be redeployed in more productive ways. In the end, the productive potential of the economy is greatest when the fewest of other resources are utilized in performing tasks for which money is intended—gathering information about relative values and conducting transactions.

From this analysis it should be clear that a monetary shock—an unanticipated change in the availability of money—would reduce the potential output of the economy. That is because the actions taken by businesses and households to readjust their actual money balances to desired

levels will cause unavoidable changes in relative prices and the average level of all prices and, thus, introduce uncertainty into the economy. Naturally, such increased uncertainty causes resources to be committed to hedging, arbitrage, and speculation. Furthermore, since the quality of price information is diminished, mistakes will be made in interpreting signals about real demands for, and supplies of, goods and services. Overproduction of some things and underproduction of other things will mean that society's well-being is less than it could be.

Resources flow to their highest-valued uses only when the changing prices of things reflect shifts in fundamental real demands for, and supplies of, goods, services, and productive resources. Monetary disturbances introduce price changes that mask these fundamental forces. Consequently, excess production of some things and shortages of other things can occur simultaneously.

In a world with stable population and a given set of goods and services where no new products are invented, one would expect the money prices of final goods to gradually decline at the same pace as the improving productive efficiency of the economy's resources. The gains in wealth to the society from the higher productivity would be distributed to inhabitants in the form of "higher real incomes." That is, their unchanged money incomes would gradually command a larger basket of goods as increased availability of goods and services pressed down on money prices. This "productivity norm" (Selgin, 1990 and 1997) for the average of money prices can be thought of as a static baseline for the purchasing power of money: It would tend to rise in an expanding economy. It neglects population growth, labor force participation rates, introduction of new products, external trade, and distortions arising from tax structures and regulation. Nevertheless, it describes how people in an economy benefit from a stable currency.⁶

⁶ "An increase in the quantity of goods produced...must bring about an improvement in people's conditions. Its consequence is a fall in the money prices of the goods...But such a fall in money prices does not in the least impair the benefits derived from the additional wealth produced...But one must not say that a fall in prices caused by an increase in the production of the goods concerned is the proof of some disequilibrium which cannot be eliminated otherwise than by increasing the quantity of money" (Mises, 1949, p. 431).

It is important to note that a condition of “rising purchasing power of money” is most commonly described by the pejorative “deflation.” This unfortunate custom has caused most observers to believe that a gradually falling “price level” is as bad, or even worse than, a gradually rising “price level.” Our analysis concludes there can be—and historical experience has demonstrated—“virtuous deflations” during periods of rapidly rising productivity.⁷

Money and Innovation

People can readily observe the effects of the introduction of new or better products: The money prices of old goods fall. The phenomenon is most obvious in examples such as computers. The availability of faster machines reduces the demand for, and therefore the prices of, slower models. The new availability of improved software, better fabrics, longer-lasting tires, compact disks with more capacity, and so on is accompanied by lower prices of the products they replace. But, if radial tires are cheaper and last longer than the bias tires they replace, it means people are richer as their incomes will acquire a higher standard of living. That, in turn, means they can consume more of something else. The increased demand for other things that is made possible by the availability of cheaper tires means the money prices of other things will be higher. Thus, while prices are not stable, the role played by money is unchanged. That is, the value of money can be stable even though the money prices of things *must* be changing in an expanding economy.

As is the case with increased efficiency in producing existing products discussed above, the benefits of greater wealth influence prices in two ways: (i) lower prices of less desirable older products and (ii) higher real incomes as a consequence of the lower prices of the goods that are superseded, allowing greater demand for—and higher prices of—other goods. If the pace of innovation is rapid and totally new products as well as improved products are introduced very frequently, the pace of obsolescence of old prod-

ucts must also be rapid. In such a regime, one would expect to see frequent and significant declines of not only the prices of the inferior products but also the capital stock that produces them. That is, “creative destruction” implies falling prices of both goods and productive assets that are superseded by superior products. If such is not observed, it is evidence that the purchasing power of the currency is not stable.

Countries and Monies

There are many currencies in the world today—more than 100. There are only a few standards of value—fewer than a dozen. A hundred years ago there was only one standard of value—gold—but already many national currency units. A dominant trend of the past century was the proliferation of national currencies, especially as new nation-states emerged from the breakup of the colonial empires and the Soviet Union. It seemed that one criterion of nationhood was a national currency. That trend may well have been reversed as the century ended.

The dominant monetary system among colonies was one that relied on currency boards for establishing monetary stability (Schwartz, 1993). The newly formed nations, however, abandoned the currency-board system for a number of reasons. Currency boards lost their standing as valuable institutions for establishing monetary stability after World War II because of the dramatic change in conventional intellectual beliefs, especially the erosion of the legitimacy of imperialism. Perhaps more significant, however, was the prevailing belief that a central bank, with discretion, would outperform a rule-bound currency board.

Aside from national pride, the idea that a nation-state should have its own currency and independent monetary policy was intellectually supported by the idea that some positive rate of inflation was optimal. Even when economists would not defend deliberate debasement of the currency, authorities often rationalized inflation on grounds of political necessity, especially in the face of often large and growing national debts. The political expediency of the “unlegislated tax of inflation” seemed for a while to have had a near universal appeal. Over time, the political benefits

⁷ For more discussion of types of deflations, see Federal Reserve Bank of Cleveland (2002).

Jordan

of deliberate inflation have been counterbalanced by financial innovations in domestic and global markets. In fact, the balance appears now to have shifted such that the costs associated with rising inflation outweigh any residual benefits. First central bankers, then ministers of finance, and finally politicians generally are finding that a reputation for tolerance of inflation is undesirable.

Twenty-five years ago, it was fairly common to hear even prominent, well-respected economists argue the merits of a weak external value of the national currency (devaluation) in order to gain some presumed competitive advantage over trading partners. Such notions now seem increasingly quaint. It is now unimaginable that a politician anywhere would achieve success by arguing that accelerating inflation and a weak currency would benefit local constituents. Much of what has happened in recent years perhaps reflects the rise in so-called “financial market vigilantism,” which imposes a level of discipline not anticipated years ago.

Neither monetary sovereignty nor independent monetary policy is deemed to be worth very much in today’s global financial markets. Moreover, seigniorage is quite small in a noninflationary world. Hence, it is becoming more widely understood that any net benefits associated with maintaining a national central bank and a national currency are quite small. Increasingly, the behavior of businesses and households around the world has included the pragmatic adoption of standards of value that serve their purposes irrespective of national origin. For a couple of decades, the people of the former Yugoslav republics used the Deutsche mark as their preferred monetary standard for the same reason that people in many countries around the world use the U.S. dollar. A reputation for stability of purchasing power means more to the consumer than the local content or national origin of the currency. As we have seen in the case of consumer goods, when the barriers to the free importation and use of products and services of superior quality are removed, people pragmatically choose quality and performance over patriotic gestures.

Reflecting these forces, the importation of monetary policy from another country has been

a growing trend in recent years. Just a few years ago, 11 sovereign countries of Western Europe implemented their plan to shift monetary policy decisionmaking from the autonomous national central banks to a newly created supranational central bank and phased out the 11 national currencies in favor of a single monetary standard to be used by all. Soon other countries started giving up any notions of monetary autonomy and a national currency. Ecuador and El Salvador are examples of countries that have joined others in unilaterally adopting the U.S. dollar as their official standard of value.

GOVERNMENTS AND MONEY

We do not pretend, that a National Bank can establish and maintain a sound and uniform state of currency in the country, in spite of the National Government; but we do say that it has established and maintained such a currency, and can do so again, by the aid of that Government; and we further say, that *no duty is more imperative on that Government, than the duty it owes the people, of furnishing them a sound and uniform currency.*

—Abraham Lincoln (1839)

Abraham Lincoln connected sound banking with political liberty, affirming that government has both the ability and the obligation to provide a stable currency. His belief in the importance of a sound currency has been shared by most thinkers for the past 250 years. Lincoln’s view that government would actually *provide* a stable currency, however, has enjoyed less acceptance. Skepticism about the government’s role with regard to money has been the dominant view since the founding of the republic. These doubts are well summarized by the prominent twentieth-century economist Ludwig von Mises:

Whatever a government does in the pursuit of aims to influence the height of purchasing power depends necessarily upon the ruler’s personal value judgments. It always furthers the interests of some people at the expense of other groups. It never serves what is called the commonweal or the public welfare. (Mises, 1949, p. 422)

Constitutional forms of government usually specified a stable currency, but as James Buchanan observed, such provisions have been inadequate:

This framework role for government also was considered to include the establishment of a monetary standard, and in such fashion as to insure predictability in the value of the designated monetary unit. (It is in the monetary responsibility that almost all constitutions have failed, even those that were allegedly motivated originally by classical liberal precepts. Governments, throughout history, have almost always moved beyond constitutionally authorized limits of their monetary authority.) (Buchanan, 1994, p. 4)

Debates about Money

History is unfortunately replete with examples of governments trying to print money in order to finance their expenditures. Friedrich von Hayek, winner of the 1974 Nobel Prize in Economic Sciences, puts it this way: “History is largely a history of inflation, and usually of inflations engineered by governments and for the gain of governments” (1976, p. 29). In recent times, the hyperinflation of Germany in the 1920s and of Bolivia, Argentina, and Brazil in the 1980s are all examples of governments debasing their currencies and engaging in what Mises called “a fraudulent attempt to cheat the public” (1949, p. 782).

Until the second half of the twentieth century, there was little disagreement that a stable currency was best; the debate centered on how to provide it. Following World War II, the notion that some inflation might be desirable (or at least should be tolerated) entered debates about public policy for a relatively short time. But, after painful inflation experiences in the 1960s and 1970s, the question of *whether* to eliminate inflation is no longer widely debated.

In the closing years of the millennium, the problem of *how* to provide a stable value of money regained prominence. Alternative approaches to stabilizing currencies were pursued around the world, and public-policy debates returned to this issue because people were rethinking the role of government in their societies. The monetary institutions likely to appear during the twenty-first

century will reflect the dynamic economic and political processes currently at work. It remains to be seen whether nations achieve and maintain stable currencies *because of* government, as Abraham Lincoln believed, or *in spite of* government, as thinkers as diverse as James Madison, Mises, and Hayek contended.

The sentiment that government powers should be constrained by constitutional design is certainly not unique to the monetary arena. For example, James Madison set forth principles of government that underscore his views on money. In his elaboration of the “rule of law,” he comments, “To trace the mischievous effects of a mutable government would fill a volume” (Madison, 1977 [1788]). His doubts about elected representatives’ ability to provide a stable currency are reflected clearly in his adherence to a specie (gold or silver) standard. Madison’s defense of an exclusive role of Congress boils down to a distrust of populist sentiments: “A rage for paper money, for an abolition of debts, for an equal division of property, or for any other improper or wicked project, will be less apt to pervade the whole body of the Union than a particular member of it” (Madison, 1977 [1787]).

The history of money over the past two centuries shows the world groping for different institutional structures that limit governments’ temptations to debase money in order to satisfy some short-sighted political objectives. The approaches used in the past have been functions of the nature of money prevailing at the time and of societies’ views about the proper role of government. The approaches used in this century will surely be different from those of the past two if either of these two factors changes materially. In particular, while government will surely have some responsibility in providing a stable currency, government’s exact role should not be taken for granted.

Historical Views of Money. Adam Smith defined the role of money as a medium of exchange, describing it as “the great wheel of circulation” (Smith, 1976 [1776], p. 309). However, money functions in at least two other ways: as a store of value and as a standard of value (unit of account). When we hold money, we trust that it will largely maintain its worth. If the value

of currency is allowed to erode under conditions of inflation, the ability of money to serve as a store of value is seriously hampered. As a unit of account, money serves as a measuring stick, telling us how many units of something exchange for a unit of money.⁸

An often-overlooked consideration is that, while money is an integral part of society because of its service of these three roles, it is not desired for its own sake. Smith pointed out:

No complaint, however, is more common than that of a scarcity of money. Money, like wine, must always be scarce with those who have neither wherewithal to buy it, nor credit to borrow it... It is not for its own sake that men desire money, but for the sake of what they can purchase with it. (1976 [1776], pp. 458-60)

This confusion between more *money* and more *purchasing power* has contributed in large part to the pervading lack of trust in the provision of money by government. As Mises suggests, governments are often tempted to answer the cry for more purchasing power by simply creating more money. But in so doing, the opposite effect is achieved—the purchasing power of money is actually reduced. The result, as Alchian and Allen explain, is inflation: “a rise in the number of dollars required to purchase a given standard of living” (1977, p. 484). If inflation makes individuals uncertain about what to ask or what to give for goods or services, then the quality of money deteriorates, reducing its effectiveness as a medium of exchange. Money is no longer either an efficient store of value or an efficient unit of account, because this “ruler” with which we make our measurements is continually changing.

Three points are clear. First, inflation is highly undesirable. Second, governments have incentives to abuse their power of mintage, which, coupled with historical experience, has slowly created a

consensus among citizens that they cannot trust their governments with unfettered control over money. Third, the mechanisms people have contrived to protect themselves from the seemingly arbitrary debasement of currency have varied over time.

The Gold Standard. For most of recorded history, governments have taken some role in providing money to the economy. In early times, that role was limited to “authentication,” verifying that coins contained the indicated metals. Even in historical monarchies, however, the authorities would occasionally lie to their people about money. People’s dual reliance on, and distrust of, government with regard to the value of money is an age-old phenomenon. The view that, despite all contrary assurances, governments will eventually abuse their powers as counterfeiters led countries to develop institutions aimed at limiting a government’s ability to print additional money. One such method was the gold and silver standards followed (on and off) by most countries from 1821 to 1973.

Specie-backed currency took money out of immediate government control. For example, if the dollar were defined as equal to 1/20 of an ounce of gold, then the number of dollars that the United States could issue would be constrained by its holdings of gold reserves. Moreover, if Britain then defined its currency as to equal 5/20 of an ounce of gold—as it did before World War I—the exchange rate would be fixed at \$5 per pound. If either government issued more currency than prescribed by its gold standard—say, to finance a budget deficit—it would lose gold reserves to the country with the more stable currency. In this way, gold strengthened a government’s covenant with its public not to erode the purchasing power of its money.

The unfortunate problem with a specie standard was that the value of money was only as stable as the value of the specie backing it. This led Benjamin Franklin to note that because “silver itself is of no certain permanent Value, being worth more or less according to its Scarcity or Plenty, therefore it seems requisite to fix upon something else, more proper to be made a *Measure of Values*” (1729; italics in original). Although a specie stan-

⁸ An appreciation of this role was evident in the thinking of Thomas Jefferson, who confided to a friend: “There is, indeed, one evil which awakens me at times, because it jostles me at every turn. It is that we have now no measure of value. I am asked eighteen dollars for a yard of broadcloth, which, when we had dollars, I used to get for eighteen shillings; from this I can only understand that a dollar is now worth two inches of broadcloth, but broadcloth is no standard of value. I do not know, therefore, whereabouts I stand in the scale of property, nor what to ask, or what to give for it” (1819).

dard could clearly result in undesirable swings in the purchasing power of money, the costs of having a *fiat* currency were thought to be even higher. In a letter to a friend, Madison stated:

It cannot be doubted that a paper currency, rigidly limited in its quantity to purposes absolute necessary, may be equal and even superior in value to specie. But experience does not favor reliance on such experiments. Whenever the paper has not been convertible into specie, and its quantity has depended on the policy of the Government, a depreciation has been produced by an undue increase, or an apprehension of it. (Madison, 1820)

Later, commenting on a “Report on a State’s Bank,” Madison wrote, “But I am not yet weaned from the opinion long entertained, that the only adequate *guarantee for the uniform and stable value* of a paper currency is its convertibility into specie” (1831; emphasis added). Repeating his view that a stable paper currency is theoretically possible, doubts remained: “But what is to ensure the inflexible adherence of the Legislative Ensurer to their own principles and purposes?” (1831). Madison left no doubt about what is essential: a money that has stable value. His doubts about the people’s elected representatives providing a stable currency are reflected clearly in his adherence to a specie standard, especially given his recognition that paper money supplied by an honest government is superior to a specie standard.

The quantity theorists of the late nineteenth century, John Stuart Mill and Alfred Marshall, also believed that, although a gold standard provided undesirable swings in currency value, it was the only way for governments to provide a stable paper currency. Mill observed:

After experience had shown that pieces of paper, of no intrinsic value, by merely bearing upon them the written profession of being *equivalent to a certain number of francs, dollars, or pound...* governments began to think that it would be a happy device if they could appropriate to themselves this benefit... The only question is, what determines the value of such a currency... We have seen, however, that even in the case of metallic currency, the immediate agency in determining its value is

its quantity... The value, therefore of such a currency is entirely arbitrary. (Mill, 1907; emphasis added)

Citing the nineteenth-century economist, William Jevons, Mill asserts, “so that the relation of quantity to uses is the only thing which can give value to *fiat* money.” That being the case, Mill thought that convertibility (to metal) was the only thing to prevent temptation to “depreciate the currency without limit” (Mill, 1907).

For the first 195 years following the Declaration of Independence, most government paper currencies were linked to specie. The U.S. dollar was defined in terms of a weight of gold (or occasionally silver). However, this did not completely restrain governments from manipulating the value of their currencies. First, in order to generate revenue, countries would frequently abandon the gold standard during times of war. Second, even without officially abandoning gold, countries could and did periodically redefine the value of their currencies in terms of gold. Instead of allowing gold or foreign reserves to consistently drain from their coffers, they would “be forced” to devalue their currency.

At first glance, it would appear that a gold standard provided no real discipline if countries could devalue their currencies at will. The discipline came from the fact that countries actually could *not* do so without suffering a cost. If there was a threat that a country would devalue its currency, massive speculative attacks would ensue as investors attempted to shed themselves of that currency. The devaluing country would eventually lose massive amounts of foreign reserves (gold and foreign currencies). Over 1966 and 1967, for instance, Britain lost nearly 28 million ounces of its gold reserves defending its currency and, on a single day, November 17, 1967, lost reserves valued at more than \$1 billion.

The common wisdom is that the frequency and destabilizing effects of such attacks caused the Bretton Woods system, and thus the last vestige of a gold standard, to be abandoned in 1973. While this is correct on a superficial level, the underlying cause was that, despite the threat of speculative attacks, governments around the world were unwilling to do what was necessary to maintain

a stable currency—namely, to limit the supply of *fiat* money. Mises was blunt in his condemnation of deliberate, governmentally engineered devaluations of currency, and his criticism of the stated as well as the unstated objectives of a devaluation policy are as relevant today as when he wrote *Human Action* over 50 years ago: “It is impossible to take seriously the arguments advanced in favor of devaluation” (1949, p. 790).

Alternative Monetary Arrangements

Separation of the Central Bank and the Treasury. Another way to keep governments “honest” is to remove the power to inflate from those with the most incentive to inflate. This is achieved by making the central bank—which has the *power* to inflate—highly independent of the Treasury—which has the *incentive* to inflate. This institutional structure is not a panacea but has proven especially useful: Studies have shown that countries where central banks are more independent have lower inflation rates on average (Alesina and Summers, 1993).

The high-inflation era of the 1970s showed us what countries unfettered by fixed exchange rates and a dollar convertible into gold will do left on their own. Addressing this deficiency, the U.S. Congress passed House Concurrent Resolution 133 in 1975, requiring the Federal Reserve to announce annual targets for monetary growth rates. In 1978, the Full Employment and Balanced Growth (Humphrey-Hawkins) Act was passed, requiring the Federal Reserve to explain these objectives and any deviations from them. Most major central banks experimented with this form of “instruments monitoring” in the 1970s and 1980s, establishing growth rates for various money measures in an effort to put boundaries on the rate of inflation.

Despite the relatively low inflation rates realized by most industrial countries around the world since 1983, the call for further institutional constraints on central banks is growing. One example is legislation enacted by New Zealand and other countries that the sole objective of central banks is to provide price stability.

Currency Boards. An institutional constraint that has been adopted by smaller countries that lack an established reputation for low inflation

is the currency board, similar to those initially adopted by former colonies. The central idea behind currency boards is to look more seriously at the discipline provided by fixed exchange rates. For example, in order to maintain a fixed exchange rate between a small country and the United States, the small country’s monetary policy must, in essence, be dictated by the United States. If the United States has the credibility to maintain low inflation, the hope is that the country with the currency board will also achieve credibility over time.

Currency boards are much like a small-scale version of Bretton Woods except that there is no longer a link between the dollar and gold to guarantee that the United States will follow a policy of low inflation. Currency boards are probably best described as small boats anchoring themselves to a large ship. Because the large ship is not firmly anchored, the small countries are left hoping that rough seas will not cause the large ship and, thus, the small boats to drift too far off course.

Private Currencies. Perhaps the most interesting mechanism by which a stable currency might be achieved was proposed by Hayek (1976) in *Denationalisation of Money* (see also Friedman and Schwartz, 1986). Although central banks, currency boards, and the gold standard each attempt to restrain a government’s tendency to inflate, Hayek suggested that governments be removed altogether from the provision of money. He contended that if private currencies are allowed to circulate freely, competition will ensure that the value of these currencies will remain constant. If any issuer attempts to collect too much seigniorage by printing excessive amounts of its currency, consumers will substitute out of that currency into a competing currency with a more stable purchasing power. The offending currency will cease to circulate as money. Thus, currency issuers will have an incentive to remain honest.

Writing almost 30 years ago, Hayek was clearly ahead of his time. His proposal that governments be completely removed from the business of issuing money is not likely to come to fruition in the near future. Nevertheless, his basic propo-

sition that competition will provide the necessary incentive to keep people (or countries) honest is relevant today. International currencies are increasingly competing to become the currency of choice. The rapid “dollarization” or “euroization” in central Europe, the former Soviet Union, and Latin America shows how a foreign currency can become a legitimate substitute for a domestic currency that has failed to maintain its value. Paradoxically, it may be the end of fixed exchange rates and the flawed discipline provided by that system that have allowed internationally competing currencies to flourish.

Recent history teaches us that Hayek was correct when he pointed out that

Gresham’s law will apply *only* to different kinds of money between which a fixed exchange rate is enforced by law. With variable exchange rates, the inferior-quality money would be valued at a lower rate and, particularly if it threatened to fall further in value, people would try to get rid of it as quickly as possible. The selection process would go on towards whatever they regarded as the best sort of money among those issued by the various agencies [or countries], and it would rapidly drive out money found inconvenient or worthless. (Hayek, 1976, p. 31)

Money, Taxes, and Deficits

Governments impose taxes on people in a variety of ways but always on nominal money prices and incomes. Consequently, debasement of the currency always generates greater nominal tax revenue for the taxing authorities. When tax structures are progressive and not indexed, real tax revenue rises when the average of money prices of things rises—the value of a currency erodes. Furthermore, much of the debt of governments is fixed in nominal money units. Thus, debasement of the currency works to the advantage of the governmental taxing and spending authorities. Government’s command over the economy’s output rises while the government’s creditors are repaid with reduced purchasing power. The effect of these institutional arrangements is that the relative share of the economy absorbed by the government increases when the purchasing power of a currency is declining.

Governments usually require that people’s tax liabilities be disposed of by remitting liabilities of the central bank to the account of the Treasury at the central bank. When governments incur deficits and issue debt, they are giving to security holders the promise that they (or their successors) will raise sufficient tax revenue in the future (or issue new bonds) to repay the borrowed sums. At times, the issuance of the debt instruments of the government (increased supply of securities) causes at least temporary downward pressure on security prices (higher interest rates). If the policy of the central bank is to maintain a fixed level of market interest rates and accommodate all demands for credit at that rate, the central bank will passively expand its balance sheet—issue greater quantities of currency and bank balances. Without any corresponding increase in the public’s desire to hold greater balances, the excess creation of liabilities of the central bank will result in a bidding up of the money prices of goods, services, and other financial assets. This dynamic has been common even when the central bank is prohibited from directly purchasing the newly issued debt instruments of the government.

Root Demands for Fiat Monies

As noted above, people throughout the world use U.S. dollar notes in everyday commerce even though their own governments also furnish a currency. They use the U.S. currency even when it is illegal to do so. If asked why they do so, they will say it is simply because the value of the dollar is more stable than other currencies. Two questions arise: Why isn’t the domestic currency stable, and why is the value of the dollar more stable? Both are *fiat* currencies, that is, their value is not defined in terms of something else, such as gold. Both may be legal tender in the home country, but the U.S. dollar is legal tender in only a few countries outside the United States.

So, why do money prices rise more rapidly in terms of one currency than the other? The answer can only be that some monetary authorities create new units of their currency at a rate that is faster, relative to demand to hold it, than other monetary authorities do. Clearly, if the

amount of money people want to be holding is always exactly the amount there is, the purchasing power of the currency can be neither rising nor falling. A disturbance to this happy situation can occur one of three ways: (i) people decide to hold less (more) of the currency and the process of ridding themselves of the excess (or acquiring larger balances) causes money prices to adjust; (ii) monetary authorities create money units at faster (slower) rates than people want to add to their holdings; (iii) favorable or unfavorable surprises in the amount of things available to purchase (natural disasters, crop failures, bumper crops, etc.) cause changes in both relative prices and the average of prices because the society is richer or poorer.

The first possible disturbance—changes in people’s desire to hold some of the currency—raises questions about what goes into a decision to hold *any* of a currency, especially if there is an alternative available. The most fundamental reason that inferior currencies continue to be held even though a superior alternative is available is that taxes must be paid to the domestic governments in units of the national currency. The necessity to remit tax receipts in the form of the liabilities of the national central bank ensures at least some transitory demand for the currency. Since there is a demand, it would be possible to constrain the supply so that there is neither an excess nor a deficient supply relative to the demand. The reason most, if not all, prices of things in terms of that currency rise is that the monetary authorities do not constrain the new supply to match the demand exactly. The usual reason they do not do so is that the government commits to disburse funds to people in amounts that are greater than the sum of tax receipts and proceeds from debt issuance.

Introduction of New Monies

There has never been a “phoenix-like” currency.⁹ Because the central role of money is mini-

⁹ “The acceptance of a new kind of money presupposes that the thing in question already has previous exchange value on account of the services it can render directly to consumption or production. Neither a buyer nor a seller could judge the value of a monetary

mization of information and transaction costs, people will not use an entity as money, a medium of indirect exchange, if they have no prior experience upon which to base their expectations about the prices of things expressed in terms of the proposed money. Historically, then, new *claims to money* (i.e., *money substitutes*) had to circulate for a period of time sufficiently long to establish a “track record” in the minds of people. Warehouse receipts (such as gold certificates) were an early type of paper claims to money that evolved into paper fiat monies.

As described above, U.S. dollars were originally defined to be (and convertible into) specified amounts of gold. For domestic purposes, dollars became a fiat currency in 1933 when the government made it illegal for American residents to own gold. Nevertheless, for official, international payments made by one government to another, dollars continued to represent claims to gold until the early 1970s. For the past three decades, dollars have been simply the liabilities of Federal Reserve Banks.

In the second half of the twentieth century, numerous currencies have been introduced by governments. In every case, the new entity was initially defined in terms of a known medium of exchange. After World War II, the German Deutsche mark was defined to be worth 1/4 of a U.S. dollar and the Japanese yen was introduced as 1/360 of a U.S. dollar at a time the dollar was still defined as 1/35 of an ounce of gold. For over 25 years these currencies were claims to dollars and, indirectly, to gold.

Newly liberated countries in the final decade of the twentieth century introduced new currencies but always defined in terms of, pegged to, and convertible into other familiar national currencies, such as U.S. dollars, Deutsche marks, British pounds, or yen. When the domestic experience with a currency has been favorable for sufficiently long that confidence about future purchasing

unit if he had no information about its exchange value—its purchasing power—in the immediate past...A medium of exchange without a past is unthinkable. Nothing can enter into the function of a medium of exchange which was not already previously an economic good and to which people assigned exchange value already before it was demanded as such a medium” (Mises, 1949. pp. 411, 426).

power is high, governments have chosen to delink (float) their nation's money relative to foreign currencies.

CENTRAL BANKS AND MONEY

The Tools of Monetary Policy

The tools available to central banks to influence the purchasing power of their currency are quite few. Since it is their own liabilities that serve as money, altering the size of the central bank's balance sheet is the essential monetary tool. The assets of the balance sheet usually include loans to banking companies and securities that may be denominated in either the domestic currency or a foreign currency. In either case, the securities are mostly the obligations of the domestic or a foreign government. Central banks can, if they choose, control the size of their balance sheets very precisely. That being the case, they can unilaterally determine the supply of central bank money. The demand for central bank money has several sources: Domestic (and maybe foreign) households and businesses have a demand for the notes issued by the central bank; and commercial banking companies (and maybe others) hold reserve or clearing balances at the central bank, based on their business needs or legal reserve requirements.

Since there is a demand for money from the central bank and the potential to control the supply, monetary policies to stabilize the value of the currency are possible. The difficulty is in estimating the demand by people to hold central bank money. The domestic public's desire to hold notes issued by the central bank tends to grow in proportion to incomes, although changes in the forgone interest from investments can influence currency demands (higher market interest rates mean you hold less cash). Also, the commercial banks' demand for balances at the central bank is a derived demand. The public's demand for checking-type accounts and other reservable deposits at the financial intermediaries determines the amounts of balances held at the central bank. If some liabilities of banks, but not others, are sub-

ject to legal reserve requirements, shifts in the public's preferences between types of deposits will affect the derived demand for balances at the central bank. Similarly, if different sizes or types of financial intermediaries are subject to different legal reserve ratios, shifts in deposit balances among the institutions will affect the derived demand for central bank balances. In other words, institutional arrangements affect the difficulty or ease of estimating the demand for the liabilities of the central bank.

Where it is judged to be difficult to estimate the demand for central bank money, the monetary authorities typically target an overnight interest rate at which they passively accommodate increases and decreases in the demand for their liabilities. While that ensures that there can be neither an excess supply of nor an excess demand for central bank money on an overnight basis, it does not ensure secular¹⁰ stability in the purchasing power of the currency.

The public's desire to hold balances at the depository intermediaries is influenced by several factors—including the opportunity cost of forgone returns on alternative assets,¹¹ domestic as well as foreign. This means changes in investment opportunities as well as consumption plans influence the balances desired by businesses and households. So, the changing yields on alternative savings and investment assets have an indirect effect on the demand for central bank liabilities. Depending on the source of these changing yields, the induced change in the outstanding stock of central bank money may or may not be consistent with maintaining stable purchasing power at the initial overnight bank rate.

Knowing the prevailing operating procedures of central banks is important for understanding the risk of unintended increases or decreases in the purchasing power of money. As mentioned above, it is common for central banks to target an

¹⁰ "Secular" means of, or relating to, a long term of indefinite duration.

¹¹ When the public holds money, they receive either no nominal return on their cash, or very little—less than could be earned on normal investments—on deposits in banks. It is in this sense that we speak of there being an "opportunity cost" of holding money (instead of holding interest-bearing investments).

overnight interbank rate: The operating desk of the central bank buys and sells (in the market) securities previously issued by the government. A purchase of securities by the central bank increases¹² the supply of central bank liabilities while a sale of securities reduces the supply. In effect, the operating desk sets a price at which it is willing to buy (sell) securities from private holders—the central bank’s demand for the debt instruments of the government is unlimited at that price (interest rate). If the market supply of securities to the central bank increases (the demand by private holders for such securities decreases), the quantity of central bank money will increase.

For example, if innovations in the economy raise the perceived returns on real productive capital (which can mean anything from better management to new machines), there will be a tendency for the interest rates offered on financial instruments to rise as well.¹³ There will be both an increase in the demand for loanable funds (money borrowed from a bank) and a decrease in the demand to hold fixed-rate instruments such as government securities. The higher return on financial assets means a higher opportunity cost of holding bank notes or low-yielding balances in banks. This will foster a decline in the quantity demanded as people and businesses seek to reduce the amount of money they hold. Other things being held the same, if the central bank’s operating procedure involves pegging a nominal overnight interest rate, the marketplace forces pressing down on security prices (up on interest rates) will be met by an expansion in the stock of central bank money, even though the amount of money demanded is declining!

Temporarily, the expansion of the supply of central bank money reduces the upward pressure on market interest rates even though an excess supply of money has been created (increased

supply and falling quantity demanded). Under such circumstances, the excess supply of such monies will cause purchasing power to erode as the weighted average of money prices that are rising will exceed the weighted average of prices that are falling. The adjustment process—inflation—will continue (i) until the returns on real productive capital fall to the initial lower level or are brought down to that level by the inflation tax or (ii) until the central bank raises the pegged level of the overnight bank rate to the point where the amount of central bank money demanded is the amount outstanding.

Conversely, if diminished economic prospects are reducing perceived yields on productive capital—or are causing a general preference for more liquidity in the form of secure bank deposits and other low-risk financial instruments—security prices will be bid up (market interest rates will be bid down) and the lower forgone yields will cause people to try to increase their holdings of bank deposits and currency. That means greater demand for central bank money; but the only source is the central bank. If the monetary authorities do not correctly analyze these fundamental economic forces and they fail to lower the nominal overnight intervention rate, the operating desk of the central bank will be selling (or buying fewer) securities and the central bank balance sheet will shrink (supply goes down) or grow too slowly at a time when the amount of central bank money demanded is rising. In time, the weighted average of money prices that are falling will exceed the weighted average of prices that are rising until people want to hold balances that are consistent with the amount of central bank money in circulation. This process, deflation, results in a general rise in the purchasing power of money.

The critical element, then, in the formulation of monetary policy actions is ascertaining the forces at work in the economy that are tending to press upward or downward on the structure of market interest rates, including the perceived yields on real productive capital. Since observed interest rates in a world of *fiat* money include an “inflation premium,” market rates will change because people come to expect the average of money prices to rise at a faster or slower rate while

¹² When the central bank purchases a security from the general public (usually a bank), it pays money for the security. This money is a liability of the central bank, an increase in money held by the public, and, of course, a reduction in the number of securities held by the public.

¹³ Higher expected rewards to real productive capital cause people to buy more of the new productive assets. As they do so, they seek to reduce their holdings of old financial assets. This will cause the price of the old assets to fall, which in turn raises their yield.

the expected yields on real productive capital may be changing simultaneously in the same or opposite direction. Sifting through the variety of forces at work is essential in making judgments about the appropriate level for the overnight bank rate when deciding on the prices at which government securities will be bought or sold.¹⁴

Talking about Monetary Policy

Popular usage by “Fed watchers” of the expression “monetary policy” is quite different from the way it is used in this essay. Even qualifiers such as monetary policy *objectives* and monetary policy *actions* usually require elaboration in order to be clear. At least one dictionary definition of policy is “a high-level overall plan embracing the general goals and acceptable procedures, especially of a government body.” Yet, the most frequent references we see in the daily press about monetary policy include characterizations of policy as “tight” or “easy” or claims that the monetary authorities are going to “tighten” or “loosen” monetary policy. How can a “high-level overall plan” be characterized as tight or easy? Maybe it is fair to characterize the actions to achieve the objectives as being “tighter” or “easier” (than previously?), but it certainly is not appropriate to talk about the objectives as being tight or easy.

Even the most avid “fine tuner” of monetary policy has a long-term objective in mind, and people who share the same objective may differ on the appropriate tactics to be successful. Excessive focus on the short-term actions to implement a policy runs the risk of confusing observers regarding the ultimate objective. If observers do not know the intended destination, or do not agree with the destination, they will naturally second-guess the appropriateness of course corrections.

If the ultimate objective is well understood—and agreed to—it is reasonable to hold policymakers accountable for actual results. Good intentions are not enough if the results are bad. However, the results can be judged as successful

or not relative only to what was intended. Without understanding and agreement about objectives, there is no way for accountability to be tied to performance.

The fact that there are long and variable lags before monetary policies take effect means that objectives must be stated in a multi-year context.¹⁵ If the time horizons of the policymakers and the observers differ, it may be difficult to get agreement on appropriate weights to give to any transition costs when compared with the benefits of progress toward achieving the ultimate objective. As a result, disagreements about the appropriateness of a specific policy action may reflect nothing more than differences in the preferred time path to the destination. All that gets lost in the familiar chatter about whether the policy action represents “tightening” or “loosening.”

The Formulation and Implementation of Monetary Policy

The consumption behavior of households tends to reflect expectations about their longer-term ability to consume. This phenomenon has been called the life-cycle hypothesis, standard or standardized income, and, of course, by Milton Friedman, permanent income (Friedman, 1957). The basic idea is familiar. Transitory changes in measured income or cash flow fluctuate around some longer-term average; household consumption behavior does not fully reflect these transitory changes in the short run. Sharp increases in measured cash-flow income are not fully reflected in corresponding increases in current consumption; nor are sudden rapid declines in measured cash-flow income reflected in corresponding declines in consumption spending.

¹⁴ See the discussion of targeting interest rates in www.clevelandfed.org/Annual01/essay.htm.

¹⁵ The time it takes monetary policy to influence the other macroeconomic variables such as nominal and real output and the rate of change of prices is known as the lag. Sometimes the lag is short and sometimes it is long. It differs as a function of people’s expectations. After a period of no inflation, people tend to interpret an increase in prices as temporary and not necessarily a permanent price increase. After a period of rapid inflation, they interpret an increase in prices as more inflation. How quickly people adjust to changes in policy is related to their experience and their underlying conception of why changes are taking place. It is in the sense that lags depend upon past experience and what people see as causing the changes that we say that policy lags are long and variable—depending on experience.

Changing Productivity. Both the theoretical framework and empirical observations traditionally suggest that permanent income is relatively steady, while transitory changes in measured income are more variable. However, it can also be the case that periods of rising or falling productivity and changes in the pace of technological innovation produce a generalized perception that permanent income is rising or falling relative to measured or cash-flow income. People may come to form these expectations in a variety of ways.

Rising Productivity. Sustained periods of steady employment and growing paychecks may lead people to expect that not only has their real standard of living risen but that it will continue to rise in the future, possibly at a faster rate than previously expected. Or, they may come to expect fewer or shorter periods of unemployment. Or, they may observe that their 401K savings plans or defined-contribution retirement programs now promise a higher future stream of income than previously thought. In a variety of ways, people come to expect that they will be able to consume more in the present, as well as in the future, than they previously thought.

As a result of any (or some combination) of these various forces at work in a “new economy,” households perceive that their long-term ability to consume is higher.¹⁶ The availability of credit means that people can increase their spending in anticipation of the future increase in their incomes. This, in turn, means households will consume a greater share of their current measured income so, consequently, the contemporaneous personal saving rate will fall. Clearly, this analysis suggests that, in such an environment, a low or even negative saving rate is unavoidable and is not a problem to be addressed by economic policies.

In the business or entrepreneurial sector, rising productivity and an enhanced pace of technological innovation mean that the marginal efficiency of capital is higher.¹⁷ Consequently, in return for giving up consumption today, relatively more will

be available for consumption tomorrow. Real interest rates rise as new opportunities bring a higher rate of return on new business investment.

These higher real interest rates are not a matter of policy choice or of anyone’s discretion. Rather they are a manifestation of economic forces that result in better uses for available productive resources. With households and businesses both increasing their claims on current productive resources, real interest rates must rise in competitive markets.

Gold Standard. Higher real interest rates need not imply higher nominal interest rates. Just to exclude complications for the moment, consider the case under a gold standard. Increased productivity growth and technological innovation in an environment of monetary stability implied by a gold standard means that the price level falls. That is, output of goods and services increases because of higher productivity but the quantity of money—gold—remains in relatively fixed supply. Thus, the purchasing power of money rises in the face of greater productivity. The falling price level means that greater permanent real income can be distributed to society with the same level of nominal income. The falling price level also implies that unchanged nominal interest rates, or possibly even lower nominal interest rates, correspond to higher real interest rates. These higher real rates are the essential market mechanism by which competition between consumers and investors rations present consumption against augmented future consumption. But, we’re not on a gold standard.

Fiat Money. The alternative to commodity money, as we have seen, is “managed money,” a discretionary monetary policy regime using a procedure that “pegs” the interest rate. The upward pressure on real interest rates that is a necessary consequence of greater productivity and the faster pace of technological innovation initially will put upward pressure on nominal, i.e., market, interest rates. Greater and greater injections of central bank money will then be necessary to keep the pegged level of the nominal overnight interbank rate unchanged. Rising market interest rates mean that the opportunity cost of holding money balances is rising. That,

¹⁶ In economists’ jargon, they have moved to a higher indifference curve.

¹⁷ Again, in economists’ jargon, the production possibility boundary has both shifted out and changed its shape.

in turn, means the *quantity* of money *demand* declines and the rate at which money changes hands increases as households and businesses seek to rid themselves of undesired money holdings. This combination of excess money holdings and the faster growth of central bank money means that a higher rate of nominal final demand growth would be accommodated by a more expansionary rate of money growth. Again, too much money chasing after too few goods. In such an environment, the increase in nominal interest rates, while initially reflecting upward pressure on real interest rates, would be augmented by a rising inflation premium. The overnight interbank rate would be under persistent upward pressure so long as it continued to lag behind market-determined interest rates.

This dynamic process describes an environment in which acceleration in the pace of technological innovation and productivity growth could inadvertently become an inflationary process. A central bank's actions to maintain an unchanged overnight rate would accommodate nominal price increases by failing to accommodate increases in the real interest rate. As a result, credit markets would be unable to play their role in rationing available real productive resources amongst heightened competing demands that reflect the increased return to real capital. Of course, this analysis is symmetric: A sustained deceleration of the pace of technological innovation and productivity growth would imply a fall in the equilibrium real rate and a necessity to reduce the central bank's intervention rate in order to avoid a procyclical downward thrust of monetary injections.

Policy Neutrality

In the analysis above, "real interest rates" refer to inflation-adjusted nominal interest rates, that is, anticipated yields on an investment after allowing for changes in the purchasing power of money. For example, the rate of inflation that is expected over the life of a bond is subtracted from the nominal yield to obtain the real yield.

Sometimes one hears or reads references to the "real federal funds rate" or "real overnight interbank rate." This makes no sense. Because

there is no meaningful one-day inflation rate, there is no statistical measure of anticipated changes in the purchasing power of money in a single day that can be used to measure a real return for one day.

As an alternative to referencing "real interest rates," economists employ a concept of a "natural rate of interest." While this natural rate cannot be observed, the forces that would tend to cause cyclical or secular increases or decreases would include such factors as the changing productivity trends and pace of technological innovation discussed above. Sometimes the natural rate is associated with the average rate of real output growth over long periods. Demographic patterns, political and economic institutional arrangements, and even geopolitical developments will also influence this "natural" rate.

One thing that does not influence the natural rate is the overnight, interbank rate targeted by central banks. It is simply impossible for central banks to "push up" or "hold down" market interest rates. However, actions by the central bank to target an overnight intervention rate in the face of sometimes strong pressures at work on market interest rates have a major impact on the performance of an economy over time.

As defined above, a world without inflation is one in which people make decisions in the confident expectation that all observed changes in money prices of goods, services, and assets are changes in relative prices, and all observed changes in interest rates are changes in real rates. That is, the "inflation premium" in nominal interest rates is zero, so only those forces that influence the natural rate of interest are causing changes in market interest rates.

A neutral monetary policy would be one in which injections of liquidity by the central bank are faster or slower as necessary to maintain this non-inflationary environment. When forces are at work to raise the natural rate of interest, actions to peg the intervention rate at an unchanged level would require larger and larger injections of central bank money. However, as described above, in that same environment the quantity of money people want to hold idle is declining. Increasing supply and falling demand is not neutral.

To remain neutral, the intervention rate targeted by the central bank must rise in concert with a rising natural rate. Likewise, if the pace of technological advance and productivity growth slows, it is necessary to reduce the intervention target rate in order to maintain the neutral stance. These dynamics show that changes in the targeted intervention rate cannot be taken as indications of the “tightness” or “easiness” of the thrust of policy. The mere observation that the announced target rate has been increased or decreased does not indicate that the stance of policy actions is more “stimulative” or “restrictive.”

On the contrary, failure to change the target rate in concert with forces influencing the natural rate would mean that policy actions have become, *de facto*, more or less expansionary. The paradox, then, is that maintaining neutrality of the thrust of monetary policy actions requires changes in the announced target intervention rate as frequently as policymakers obtain information indicating that the natural rate of interest has risen or fallen.

COMPETING CURRENCIES

The concepts of competitive money, currency boards, and the independence of the central bank were no doubt far from the mind of Abraham Lincoln when he spoke of the government’s obligation to provide a stable currency. However, these are a few of the mechanisms by which governments have tried to achieve this end. It must be remembered, however, that these different options are not independent.

The potential for the forces of competition that have served market economies so well to discipline a country’s ability to print money freely is particularly promising. According to Hayek, “[i]t might prove to be nearly as difficult for a democratic government *not to interfere* with money as to regulate it sensibly” (1976, p. 74; emphasis added). He argues that countries around the world should abolish “any kind of exchange control or regulation of the movement of money between countries” and provide “the full freedom to use any of the currencies for contracts and accounting” (1976, p. 74). Further, there should be “the opportunity for any bank located in these

countries to open branches in any other on the same terms as established banks” (1976, p. 17).

Laws could be changed in various ways in the United States to foster more effective competition. For example, federal law (Title 31, Section 5103) states that “United States coins and currency (including Federal Reserve notes...) are legal tender for all debts, public charges, taxes, and dues. Foreign gold and silver coins are not legal tender for debts.” This law might be altered so that contracts written in terms of foreign or alternative domestic monetary units, including specie, could compete with dollars. Almost 30 years ago, the British House of Lords “ruled that in English courts, foreign creditors could now have their claims recognized in their own currencies” (*The Financial Times*, 1975).

Governments must have a role in the enforcement of contracts. As Mises observed in *Human Action*, the laws and courts of a country

define what the parties to the contract had in mind when speaking of a sum of money...They have to determine what is and what is not legal tender. In attending to this task the laws and the courts do not *create* money [emphasis in original]...In the unhampered market economy the laws and the judges in attributing legal tender quality to a certain thing merely establish what, according to the usages of trade, *was intended by the parties* when they referred in their deal to a definite kind of money” [emphasis added]. (Mises, 1949, p. 780)

Legislation requiring enforcement of “specific performance” by the courts would increase the opportunity for currency competition. Currently, in most countries of the world, when there is a dispute involving a contract that is stated in terms of a currency or unit (such as gold) other than the national currency, courts will not require performance in the stated unit but will require that an “equivalent payment” in the national currency be paid.

Money in the twenty-first century will surely prove to be as different from the money of the past century as that money was from that of the nineteenth century. Just as fiat money replaced specie-backed paper currencies, electronically initiated debits and credits will become the dom-

inant payment modes, creating the potential for private money to compete with government-issued currencies. Such competition between private and governmental monies may help countries around the world to finally live up to Lincoln's challenge of fulfilling "the duty [government] owes the people, of furnishing them a sound and uniform currency."

SUMMARY

Stable money enhances growth. Whenever the purchasing power of money is falling (the impact on the weighted average of all prices from those that are rising exceeds that of those that are falling) productivity improvements are smaller. The faster the average of prices rise, the slower the productivity improvements. This result is unavoidable because the changes in money prices of goods and factors of production do not accurately reflect changes in *relative* values. Consequently, businesses and households make mistakes that they would not have made if they could be confident that all observed price changes are the result of shifts in the supply of, or demand for, some things rather than other things. Furthermore, when the value of money is not stable, changes in interest rates are not necessarily changes in real interest rates. To the extent that changes in interest rates reflect uncertainty about the future purchasing power of money, mistakes in the allocation of resources occur.

The most common forms of money in use in the world today are the liabilities of central banks. The almost universal requirement that taxes be paid to governments in the form of the liabilities of a central bank ensures that there is a demand for such liabilities. However, to some extent the demand for central bank liabilities is a derived demand, dependent on people's usage of the liabilities of financial intermediaries such as banks. Institutional arrangements such as interest prohibitions or ceilings and idle reserve requirements can affect the demand for central bank liabilities, making the amount demanded at any time difficult to estimate.

Central banks control the supply of central bank money by acquiring or disposing of securi-

ties, usually those issued by a sovereign government. In effect, central banks choose levels of nominal interest rates at which they have a horizontal demand for the liabilities of the government. If they guess correctly, the rate at which private holders supply securities to the central bank will generate additional central bank liabilities at the same rate as businesses and households desire to add to their holdings (indirect in the case of "inside money," the deposit liabilities of financial intermediaries). The value of money is stable when there is neither an excess supply of nor an excess demand for the liabilities of the central bank.

When the public's supply of securities to the central bank changes, the growth rate of central bank liabilities also changes. If the public's demand (direct and indirect) for central bank liabilities is not changing in the same direction and by the same amount, the average purchasing power of money (the weighted average of the prices of goods and services) will rise or fall as people seek to dispose of excess, or acquire additional, obligations of the central bank. Such adjustments alter relative prices and induce resource reallocations! Unavoidably, then, output potential is temporarily reduced. Maximum output—and highest standards of living—is achieved only when the purchasing power of money is stable.

REFERENCES

- Alchian, Armen. "Why Money?" *Journal of Money, Credit, and Banking*, February 1977, 9(1, Part 2), pp. 133-40.
- Alchian, Armen and Allen, William R. *Exchange and Production: Competition, Coordination, and Control*, 2nd ed. Belmont, CA: Wadsworth Publishing, 1977.
- Alesina, Alberto and Summers, Lawrence H. "Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence." *Journal of Money, Credit, and Banking*, 1993, 25(2), pp. 151-62.
- Brunner, Karl, and Meltzer, Allan H. "The Uses of Money: Money in the Theory of an Exchange

Jordan

- Economy." *American Economic Review*, December 1971, 61, pp. 784-805.
- Buchanan, James M. "Notes on the Liberal Constitution." *Cato Journal*, Spring-Summer 1994, 14(1), p. 1-9; see p. 4.
- Federal Reserve Bank of Cleveland. "Governments and Money." *1995 Annual Report*, 1995; www.clevelandfed.org/annual/essay.htm.
- Federal Reserve Bank of Cleveland. "Theory Ahead of Rhetoric: Economic Policy for a 'New Economy'." *1999 Annual Report*, 1999; www.clevelandfed.org/Annual99/theory.htm.
- Federal Reserve Bank of Cleveland. "Theory Ahead of Rhetoric: Measurement and the 'New Economy'." *2000 Annual Report*, 2000; www.clevelandfed.org/Annual00/essay.htm.
- Federal Reserve Bank of Cleveland. "Rhetoric Aligned with Theory: Talking Productively about Interest Rates." *2001 Annual Report*, 2001; www.clevelandfed.org/Annual01/essay.htm.
- Federal Reserve Bank of Cleveland. "Deflation." *2002 Annual Report*, 2002; www.clevelandfed.org/Annual02/essay.cfm.
- Financial Times*, November 6, 1975.
- Franklin, Benjamin. *A Modest Enquiry into the Nature and Necessity of a Paper-Currency*. Philadelphia, PA: New Printing Office, 1729.
- Friedman, Milton. *A Theory of the Consumption Function*. Princeton, NJ: Princeton University Press, 1957.
- Friedman, Milton, and Schwartz, Anna J. "Has Government Any Role in Money?" *Journal of Monetary Economics*, January 1986, 17, pp. 37-62.
- Hayek, F.A. *Denationalisation of Money: An Analysis of the Theory and Practice of Concurrent Currencies*. London: Institute of Economic Affairs, 1976, p. 29.
- Jefferson, Thomas. Letter to Nathaniel Macon, Monticello, January 12, 1819.
- Jordan, Jerry L. "Governments and Money." *Cato Journal*, Fall/Winter 1996, 15(2-3), pp. 167-77; www.cato.org/pubs/journal/cj15n2-3-2.html.
- Lincoln, Abraham. "Many Free Countries Have Lost Their Liberty." Speech on the Subtreasury, Springfield, Illinois, December 26, 1839.
- Madison, James. "The Utility of the Union as a Safeguard against Domestic Faction and Insurrection (continued)." *The Federalist*, No. 10. Franklin Center, PA: The Franklin Library, 1977 [1787].
- Madison, James. "Alleged Danger from the Powers of the Union to the State Governments Considered." *The Federalist*, No. 45. Franklin Center, PA: The Franklin Library, 1977 [1788].
- Madison, James. Letter to C.D. Williams, February 1820.
- Madison, James. Letter to Mr. Teachle, March 15, 1831.
- Mill, John S. *Principles of Political Economy*, Laurence Laughlin, ed. New York: D. Appleton, 1907.
- Mises, Ludwig von. *Human Action: A Treatise on Economics*. New Haven, CT: Yale University Press, 1949.
- Mundell, Robert. *Uses and Abuses of Gresham's Law in the History of Money*, 1998; www.columbia.edu/~ram15/grash.html.
- Schwartz, Anna J. "Currency Boards: Their Past, Present, and Possible Future Role." *Carnegie-Rochester Conference Series on Public Policy*, December 1993, 39, pp. 147-85.
- Selgin, George. "Monetary Equilibrium in the 'Productivity Norm' of Price Level Policy." *Cato Journal*, 1990, 10, pp. 265-87.
- Selgin, George. *Less than Zero: The Case for a Falling Price Level in a Growing Economy*. IEA Occasional Paper. London: Institute of Economic Affairs, 1997.
- Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*, Edwin Cannan, ed. Chicago: University of Chicago Press, 1976 [1776].

APPENDIX

The American “Dollar” and Other Monetary Terms

Just what is a “dollar” anyway? Everyone knows what gold is; they know what silver is; or at least there are some guys in the lab who will tell us the gold or silver content of any piece of metal. But a “dollar”? We have pieces of paper saying “one dollar” and other pieces of paper saying more dollars. We have stocks and bonds that are quoted as being traded for so many dollars and everyone keeps getting bills from the electric company, the gas company, and the IRS to send them so many dollars. Fortunately, employers have agreed to give us some dollars every month. Now, if we can just keep a balance between the number of dollars our employer promises to give us each month (assuming we can trust him) and the number of dollars all kinds of people say we must turn over to them—or we’ll hear from their lawyers—we’ll be okay.

Back to the beginning. What is this thing called a “dollar” that some people promise to give us and other people insist that we give to them? Well, it turns out that some valley in the Bohemian part of what we now call the Czech Republic has a lot to do with it. There, coins were made out of metal to help people make indirect exchanges between what they produced and what they wanted. The German word for valley is *thal* and it was common to refer to the metal coins produced in the valley as *taler coins* (the “h” being silent in German). That was often shortened to simply *talers*. In English, *taler coins* or *talers* sounded like dollar coins, or simply dollars, which was how the British referred to some metal coins made in Spain.

After the Spanish staked their claims on large chunks of the “new world,” they started getting boat loads of gold and silver and stamping out a lot of coins. The Spanish monetary unit at the time was the *real*, and an eight-*reales* coin—a “piece of eight”—was referred to by English-speakers as a “dollar.”

The American colonists kept their accounts in British pounds, shillings, and pence but they did not have available to them very many British coins. What they had mostly were Spanish and Portuguese coins, and the most common coin available to them was the Spanish “dollar” coin. Other coins available were the Spanish *doubloon* and *pistole*, the Portuguese *moidore* and *johannes*, and the French *guinea* and *pistole*. (Compared with these alternatives, we are fortunate that the coins the colonists had most of were Spanish dollars.)

Because the proportion of precious metal in all these coins varied and the colonists kept their books in terms of British pounds, it was necessary to define each of the various other metal coins in terms of British pounds. Keeping pounds as the unit of account but using Spanish dollars as the dominant medium of exchange was, of course, a very cumbersome arrangement. As British subjects, however, the colonists did not have a good alternative.

After the Declaration of Independence, it finally became opportune to think about a unique monetary system appropriate to the newly evolving nation. It seems that Thomas Jefferson quite pragmatically concluded that, since the most *familiar* coin in use was the Spanish dollar coin, it would be best to adopt a “dollar” as a standard. That meant a dollar had to be defined in terms of something of known value—other than British pounds. He also concluded that since “every schoolboy” could multiply and divide by ten, it would be best to have money units that were in terms of tenths of a dollar and multiples of ten dollars. Jefferson found the British use of eighths of a money unit to be cumbersome, at best. So, even though the Spanish had minted a “dollar coin” to be a “piece of eight” (consisting of eight *reales*), the colonists ultimately defined a dollar coin to be 24.75 grains of pure gold or 371.25 grains of pure silver. They further decided to mint a ten-dollar gold coin as well as a one-dollar gold piece and a one-dollar silver piece, and to mint silver coins of one-tenth of a dollar and copper coins of one-hundredth of a dollar.

Jordan

Thus, the dollar—like every other thing that has served as money—was initially defined in terms of something of known value. Only gradually during the twentieth century did people come to accept that the word “dollar” stood in its own right as a concept of value. In other words, for almost 200 years a dollar was a *claim to money—gold*—and formally *became money* only in 1973 when the link to gold was severed.

A Dollar as Money Is Distinct from Assets Denominated in Dollars

Currently, there is only one source of dollars: the liabilities of Federal Reserve Banks. Everything else is a substitute for, or claim to, dollars. Actual dollars come in two forms: Federal Reserve notes and balances (deposits) at Reserve Banks that are maintained by depository institutions, such as a commercial bank. All transactions using Federal Reserve notes are final, certain, immediate, and (often) anonymous. That is why people like using them. Although you do not see it directly, all taxes paid by households and businesses to the federal government must be in the form of a transfer of ownership of balances held at a Federal Reserve Bank to the account of the U.S. Treasury at the Federal Reserve Banks.

People commonly exchange promises to pay and receive certain amounts of dollars at definite times in the future (bonds). Ultimately, the payor is giving a promise (which the courts will enforce) to acquire and deliver to the payee a certain number of Federal Reserve Bank notes or bank balances denominated in dollars (that are claims to balances at the Federal Reserve Banks) at a certain date in the future. Consequently, only dollars serve the function of money—indirect exchange—in the United States.

Claims to money—such as balances at financial intermediaries (banks and so on)—are a part of the monetary system. Yet, it is important to distinguish between various stores of wealth (mainly, financial assets) that are *denominated in units of money* and the entity that serves *as money*. The purchasing value of the dollar, for example, is not influenced by the aggregate “dollar value” of equity markets, debt markets, money-market funds, foreign-held “eurodollar” balances, or any other instruments that are specified in legal contracts to pay and receive dollars.

Some Monetary Terms

Coin metal tokens used as media of exchange, either full-bodied (i.e., containing the amount of precious metal indicated by the standard) or merely representational (like paper notes)

Currency (i) name of a unit of account, e.g., “dollar,” “pound,” “yen”; (ii) paper notes used as a medium of exchange

Monetary standard the (legal) (official) definition of the value of a currency in terms of something else, like, e.g., gold, silver, or the discretion of the government (fiat)

Dollar (i) liability of Federal Reserve Banks; (ii) U.S. unit of account and medium of final exchange; (iii) U.S. legal tender—a judicially enforceable right to receive payment or compensation in a certain currency

Indirect exchange interpersonal exchange of goods or services that employs an intermediate entity (money) rather than direct barter of final consumables

Money (i) standard of value; (ii) media of exchange used in indirect exchange; (iii) that entity that economizes best on the use of other real resources in gathering information about relative values and conducting transactions



Rising Natural Gas Prices and Real Economic Activity

Kevin L. Kliesen

In the aftermath of the disruptions caused by hurricanes Katrina and Rita, natural gas prices rose to record-high levels. Because natural gas is an important energy source for the U.S. economy, there was widespread concern that these high prices might cause a significant slowing in the economy—especially among those manufacturing industries that heavily consume natural gas. The analysis presented in this article suggests that output is responsive to natural gas prices in some manufacturing sectors. Although perhaps significant, this result must be balanced against the finding that, when the analysis is extended to the macroeconomy (real gross domestic product growth), increases in crude oil prices significantly predict real gross domestic product growth, but natural gas prices do not. (JEL Q41, Q43)

Federal Reserve Bank of St. Louis *Review*, November/December 2006, 88(6), pp. 511-26.

Beginning in early 2002, prices of crude oil and natural gas began to trend upward. By September 2005, as the damage to the production, refining, and distribution facilities in the Gulf Coast by hurricanes Katrina and Rita became clearer, natural gas prices rose to record-high levels in both nominal and real dollar terms. Although crude oil prices rose to a record-high level in nominal terms, they remained below the record-high levels in real terms seen in early 1981. Previous research has shown that sharply higher oil prices have preceded all but one of the post-World War II recessions. However, less is known about the relationship between rising natural gas prices and macroeconomic activity, despite the fact that many manufacturing industries and, increasingly, electric utilities are heavy consumers of natural gas. Accordingly, one might reasonably assume that record-high levels of natural gas prices might have significant adverse consequences for U.S. macroeconomic activity.

This article examines developments in natural

gas prices and highlights recent trends in natural gas usage at both the industry and national levels. The article concludes with some empirical findings that generally suggest that rising natural gas prices predict growth in only a handful of manufacturing industries. Perhaps surprisingly, higher natural gas prices do not predict slower growth for the three industries where expenditures on natural gas are a relatively large share of total industry shipments: primary metals, nonmetallic mineral products, and chemicals. In terms of the aggregate economy, increases in crude oil prices significantly predict the growth of real gross domestic product (GDP), but increases in natural gas prices do not.

TRENDS IN NATURAL GAS PRICES

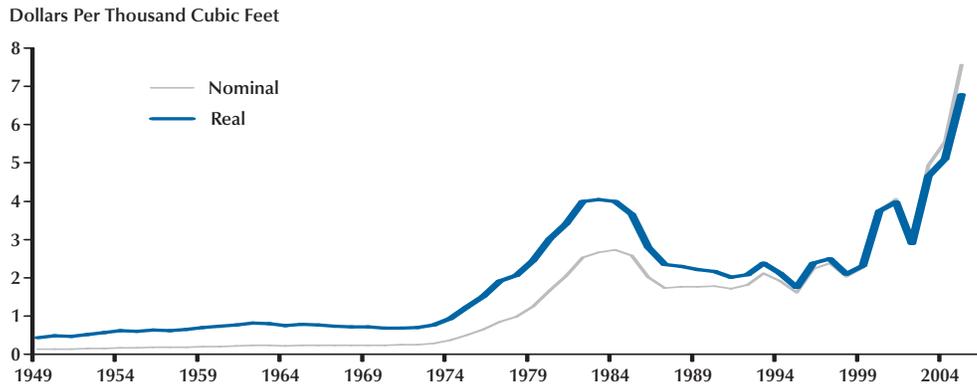
From 1954 to 1978, the price of natural gas transported through the interstate pipeline system was regulated by the Federal Power Commission. Under this system, price-setting was based on pro-

Kevin L. Kliesen is an economist at the Federal Reserve Bank of St. Louis. The author thanks Hui Guo, David Henry, and Crawford Honeycutt for comments and suggestions, and Joshua Byrge, John McAdams, and Joshua Ulrich for research assistance.

© 2006, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis.

Figure 1

Natural Gas Prices at the Wellhead



SOURCE: U.S. Energy Information Administration.

duction costs and applications for rate increases moved slowly through the bureaucratic process.¹ As a result, prices changed very little from year to year. As seen in Figure 1, from 1949 to 1978, wellhead prices averaged \$0.21 per thousand cubic feet (mcf), with an annual standard deviation of \$0.20 per mcf.² Although phased deregulation began with the passage of the Natural Gas Policy Act of 1978, prices began to rise in the mid-1970s, a period of turmoil in international energy markets that saw a sharp increase in crude oil prices. Eventually, natural gas prices peaked in 1984 at \$2.66 per mcf (nominal). Prices subsequently retreated modestly and then remained fairly stable for several years: From 1986 to 1999, natural gas prices averaged \$1.87 per mcf, with a standard

deviation of \$0.24 per year. Following the 2001 recession, natural gas prices began to rise noticeably. By 2004, gas prices in both real and nominal dollars were at record-high levels.

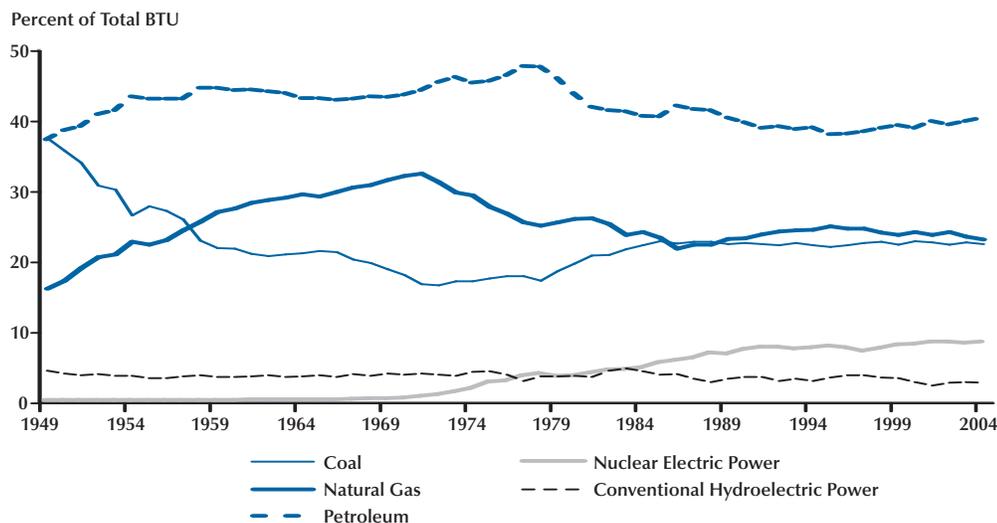
In late August 2005, Hurricane Katrina made landfall near New Orleans, Louisiana, and then about one month later, Hurricane Rita made landfall near the Texas-Louisiana border. These two hurricanes caused significant damage to the Gulf Coast's production, refining, and distribution facilities. In response, natural gas prices surged. Over the first seven months of 2005, natural gas prices at the wellhead averaged \$6.06 per mcf. By August 30, a day after Katrina's landfall, prices in the spot market, which typically include a premium above the wellhead price, had surged past \$12 per million British thermal units (BTU), and by September 22, 2005, the day before Rita's landfall, the spot price had risen to \$15.00 per million BTU.³ Over the final four months of the year, with a significant percentage of natural gas production in the Gulf still shut-in, the wellhead price averaged approximately \$10 per mcf.

Viewed from a slightly longer-term perspec-

¹ Yang (1977) and Ott and Tatom (1982b) discuss the history of natural gas regulation and deregulation.

² The wellhead price is that received at the point of production (when the gas reaches the surface). According to the EIA, this price is calculated by dividing the total reported value at the wellhead by the total quantity produced. The latter is the amount reported by the appropriate agencies of individual producing states and the U.S. Mineral Management Service. The wellhead price includes all costs prior to shipment from the lease, including gathering and compression costs, in addition to state production, severance, and similar charges. See the glossary in the U.S. Energy Information Administration's *Annual Energy Review 2004* (2005); e.g., "mcf" indicates one thousand cubic feet and one cubic foot is equal to 1,031 BTU; www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html#natgascal.

³ In anticipation of Hurricane Rita's landfall, natural gas shipments to the Henry Hub, Louisiana, delivery point were suspended on September 23. Deliveries resumed on October 7. One thousand cubic feet of natural gas is approximately equal to 1 million BTU.

Figure 2**Energy Consumption by Major Source**

SOURCE: U.S. Energy Information Administration.

tive, the hurricanes exacerbated recent trends in higher natural gas prices. In their August 9, 2005, *Short-Term Energy Outlook* (pre-Katrina), the U.S. Energy Information Administration (EIA) noted several factors that were expected to keep natural gas prices at high levels over the near term:

The natural gas market is likely to stay tight over the next couple of months, with prices projected to rise further as the winter heating season increases demand. Although natural gas storage remains above the 5-year average, several factors are expected to continue to support high natural gas prices, including: high world oil prices; continued strength in the economy; the expectation that Pacific Northwest hydroelectric resources will be below normal through the rest of the year; limited prospects for growth in domestic natural gas production; and concerns about the potential effects of hurricanes.

U.S. NATURAL GAS CONSUMPTION

Rising natural gas prices are a concern in the macroeconomy because many industrial and

utility sectors are intensive users of natural gas and most households rely on gas to heat their homes during the winter months. In late 2005, anecdotal reports from the manufacturing sector suggested that high energy prices had indeed raised input costs and precipitated price surcharges among some industries. Examples of this nature were regularly cited in the Institute for Supply Management Report on Business for the manufacturing and nonmanufacturing sectors and in the Federal Reserve's "Beige Book." The purpose of this section is to quantify natural gas usage in the U.S. economy—both in comparison with other sources of energy and usage by sector.

Petroleum products remain the largest source of energy for the U.S. economy. As seen in Figure 2, 40.2 percent of U.S. energy consumption in 2004 (based on BTU) was derived from petroleum products such as oil, gasoline, and diesel fuel. Energy consumption derived from natural gas was the next largest source (23.1 percent), followed closely by coal (22.5 percent). The percentage of energy derived from natural gas consumption has been falling since 1971, when it peaked at nearly 32.4 percent of total BTU. By 1986, the percentage of total energy from

Table 1**Natural Gas Consumption by Sector**

	End-use sectors (% of total)				Total end use	Electrical power [¶]
	Residential [*]	Commercial [†]	Industrial [‡]	Transportation [§]		
1950	20.8	6.7	59.4	2.2	89.1	10.9
1960	25.9	8.5	48.2	2.9	85.6	14.4
1970	22.9	11.3	43.8	3.4	81.4	18.6
1980	23.9	13.1	41.2	3.2	81.5	18.5
1990	22.9	13.7	43.1	3.4	83.1	16.9
2000	21.4	13.6	39.8	2.8	77.7	22.3
2004	21.9	13.4	37.7	3.1	76.0	24.0

NOTE: ^{*}Consumption by private households. [†]Consumption by nonmanufacturing establishments. [‡]Consumption by establishments engaged primarily in processing unfinished materials into another form of product; this includes mining, petroleum refining manufacturing, and (beginning in 1996) agriculture, forestry, and fishing. [§]Natural gas transmission (pipeline) fuel and natural gas delivered for use as vehicle fuel. [¶]Electric utilities and independent power producers.

SOURCE: U.S. Energy Information Administration, *Annual Energy Review, 2004* (2005).

natural gas had fallen to just under 22 percent; however, it has since stabilized. Consumption of nuclear energy and conventional hydroelectric power sources are significantly smaller, both less than 10 percent of the total.

Table 1 details natural gas consumption in the economy by the four major end-use sectors (residential, commercial, industrial, and transportation) and by the electrical power-generating sector. Traditionally, the industrial sector has been a heavy consumer of natural gas.⁴ For instance, in 1950 it accounted for nearly 60 percent of total natural gas consumption.⁵ The next highest end-user was the residential sector (20.8 percent), followed by the commercial (6.7 percent) and transportation (2.2 percent) sectors. (See Table 1 for sector descriptions and definitions.) Over time, there has been a shift in usage shares away from the industrial sector toward the commercial and electrical power generation sectors. In 1950, the

electric power sector accounted for about 11 percent of natural gas consumption, while the commercial sector consumed a little less than 7 percent. Since then the shares of the commercial and electrical-generation sectors have doubled, while there has been relatively little change in the share of natural gas consumed by the residential and transportation sectors. Although industrial usage still accounts for the largest share of *total* consumption in 2004, its share has declined by more than a third.

One of the purposes of this article is to assess whether changes in natural gas prices help to predict changes in the growth of manufacturing and aggregate output and whether changes in gas prices matter more than changes in crude oil prices. This is difficult to accomplish because energy consumption by industry is not available on a timely basis. However, the EIA periodically surveys manufacturers about their energy use. This is known as the Manufacturing Energy Consumption Survey (MECS).

According to the 2002 (latest) MECS, six industries accounted for a little more than 83 percent, or 5,400 trillion BTU, of the roughly 6,500 trillion BTU of natural gas consumed by manufacturers in 2002: chemicals, petroleum and coal products, primary metals, food, paper, and

⁴ Consumption by establishments engaged primarily in processing unfinished materials into another form of product; this includes mining, petroleum refining manufacturing, and, beginning in 1996, agriculture, forestry, and fishing.

⁵ Excluding the electric power sector (the “end-use” sectors), industrial consumption usage was nearly 67 percent of all end-usage in 1950. By 2004, its end-usage share had dropped to 49.5 percent.

Table 2**Percentage of BTU Usage in the Manufacturing Sector Derived from Natural Gas (in trillion BTU)**

NAICS code	Subsector and industry	Total*	Natural gas [†]	Gas BTU as a % of total	Importance in industrial production [‡]
311	Food	1,123	582	51.83	8.32
312	Beverage and tobacco products	105	46	43.81	2.64
313	Textile mills	207	75	36.23	0.62
314	Textile product mills	60	29	48.33	0.52
315	Apparel	30	16	53.33	0.68
316	Leather and allied products	7	4	57.14	0.11
321	Wood products	377	57	15.12	1.58
322	Paper products	2,363	504	21.33	2.77
323	Printing and related support	98	46	46.94	2.09
324	Petroleum and coal products	6,799	878	12.91	2.22
325	Chemicals	6,465	2,307	35.68	10.38
326	Plastics and rubber products	351	128	36.47	3.62
327	Nonmetallic mineral products	1,059	422	39.85	2.27
331	Primary metals	2,120	704	33.21	2.50
332	Fabricated metal products	388	210	54.12	5.76
333	Machinery	177	82	46.33	5.40
334	Computer and electronic products	201	65	32.34	8.25
335	Electrical equipment, appliances, and components	172	53	30.81	2.12
336	Transportation equipment	429	203	47.32	10.91
337	Furniture and related products	64	25	39.06	1.69
339	Miscellaneous manufacturing	71	32	45.07	3.24
	Total	22,666	6,468	28.54	77.71

NOTE: *Total is the sum of all of the listed energy sources, including "miscellaneous manufacturing," minus the shipments of energy sources produced onsite. It is the total amount of first use of energy for all (fuel and nonfuel) purposes. †Natural gas includes natural gas obtained from utilities, local distribution companies, and any other suppliers, such as independent gas producers, gas brokers, marketers, and any marketing subsidiaries of utilities. ‡Relative importance estimates the contribution of the industry to the growth of total industrial production in the following year.

SOURCE: U.S. Energy Information Administration, 2002 Energy Consumption by Manufacturers (Table 1.2) (www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html) and Board of Governors of the Federal Reserve System (industrial production data).

nonmetallic mineral products (see Table 2). The chemical industry consumed the most natural gas (2,307 trillion), accounting for about 36 percent of the total manufacturing BTU usage. The next largest user, petroleum and coal products, used about a third as much natural gas as the chemical industry. In terms of their relative importance,

these industries accounted for about 30 percent of total industrial production in 2005. Table 2 also shows that there are four industries that derive at least 50 percent of their energy demand from natural gas: leather and allied products, fabricated metal products, apparel, and food. However, these four gas-intensive industries combined

Table 3**Natural Gas Expenditures as a Percent of Manufacturing Shipments, 1998 and 2002**

NAICS code	Manufacturing industry	2002 share	1998 share
311	Food	0.55	0.39
312	Beverage and tobacco products	0.19	0.14
313	Textile mills	0.76	0.59
314	Textile product mills	0.40	0.28
315	Apparel	0.19	0.13
316	Leather and allied products	0.30	0.16
321	Wood products	0.31	0.24
322	Paper products	1.36	0.99
323	Printing and related support	0.24	0.17
324	Petroleum and coal products	1.44	1.57
325	Chemicals	1.62	1.37
326	Plastics and rubber products	0.37	0.27
327	Nonmetallic mineral products	1.86	1.39
331	Primary metals	2.06	1.62
332	Fabricated metal products	0.42	0.33
333	Machinery	0.17	0.13
334	Computer and electronic products	0.10	0.05
335	Electrical equipment, appliances, and components	0.25	0.15
336	Transportation equipment	0.13	0.11
337	Furniture and related products	0.17	0.16
339	Miscellaneous manufacturing	0.13	0.15
	Total	0.64	0.49
	Average wellhead price, \$ per thousand cubic feet	2.95	1.96

SOURCE: U.S. Energy Information Administration (energy expenditures data) and the U.S. Department of the Census (manufacturing shipments data).

account for a much smaller share of industrial production, about 15 percent.

Table 3 provides an alternative method of measuring the intensity of natural gas usage. This table shows the dollar value of the industry's total expenditures on natural gas as a percent of its total shipments in the 2002 and 1998 MECS years. Recall from Table 2 that the three most gas-intensive industries were leather and allied products, fabricated metal products, and apparel. Each of these three industries relies on natural gas for more than 50 percent of its total BTU usage. As shown in Table 3, though, the three most gas-

intensive industries in 2002 were primary metals, nonmetallic mineral products, and chemicals. The paper and petroleum and coal products industries were the only other industries where expenditures were more than 1 percent of total industry shipments in 2002. Compared with 1998, expenditures on natural gas as a share of shipments for all industries rose from about 0.5 percent to 0.6 percent, even though the nominal price of natural gas rose by slightly more than 50 percent. Still, as a percent of total shipments, expenditures on natural gas are fairly small for all manufacturing industries.

ENERGY PRICES AND THE MACROECONOMY

Economic theory predicts that a large increase in the relative price of energy will increase the per-unit cost of output, thus increasing the output (supply) price. Hence, in the standard textbook model (for example, see Abel and Bernanke, 2005), a rise in energy prices, in the absence of a fiscal or monetary policy response, reduces aggregate output and employment and raises the price level. One rule of thumb is that a \$10 per barrel rise in oil prices will reduce real GDP by 0.4 percent after four quarters.⁶ As an important energy input in the U.S. economy, increases in natural gas prices would be expected to have virtually the same effect in the textbook model as a rise in crude oil prices. Accordingly, one should expect that the effects of an increase or decrease in natural gas prices on economic activity would be conceptually similar as that for crude oil prices.

Oil Price Effects

There is much research that explores the relationship between energy prices and economic activity, and a reading of this literature suggests that oil prices matter. This should probably not be surprising given that petroleum still accounts for 40 percent of U.S. energy usage. The prevailing view is that increases in oil prices reduce real GDP growth for several quarters. The size of the effect varies, but earlier studies seem to suggest larger effects than later studies. This could reflect the fact that the U.S. economy has become more energy efficient over time.⁷

For a recent survey, see Jones, Leiby, and Paik (2004). Hamilton (1983), among many others, has documented a negative and significant relation between oil price changes and future GDP growth. Early research efforts by the Energy Modeling Forum at Stanford University (1987), which employed several well-known macroeconomic forecasting models in use at the time, were consistent with Hamilton's findings. Conversely,

recent research by Barsky and Kilian (2004) suggest that the causality runs in the other direction. That is, stronger (weaker) macroeconomic growth increases (decreases) the demand for oil and thus the price of oil.

Hooker (1996) found that Hamilton's result breaks down after 1986, a year in which, perhaps not coincidentally, there was a sharp, unexpected drop in oil prices. The unstable oil-macro economy relation possibly reflected the fact that Hamilton had implicitly assumed a symmetric effect of oil shocks in his linear specification: An increase (decrease) in oil prices reduces (raises) future GDP growth. This specification is consistent with the view of some transmission channels—for example, Rasche and Tatom (1977a,b), Baily (1981), Energy Modeling Forum (1987), and Wei (2003).⁸

However, the effect can be also *asymmetric*. In particular, a sharp oil price change—either increase or decrease—affects the macroeconomy adversely for at least two reasons. First, it raises uncertainty about future oil prices and thus causes delays in business investment (e.g., Bernanke, 1983, and Pindyck, 1991). Similarly, Guo and Kliesen (2005) found that oil price volatility—a measure of uncertainty—reduced real GDP growth and other measures of macroeconomic activity over the period 1984-2004. Second, it induces costly resource reallocations (e.g., Lilien, 1982, and Hamilton, 1988). Overall, whereas an oil price increase has a negative effect on future GDP growth, the effect of an oil price decrease is ambiguous. Subsequent work by Hamilton (1996 and 2003) revealed asymmetries with respect to oil price changes and real GDP growth.

Natural Gas Price Effects

The literature examining the relationship between natural gas prices and macroeconomic activity appears to be considerably more sparse. However, because natural gas consumption in the aggregate economy is about half as much as petroleum (in terms of BTU), it might be reasonable to conclude that rising natural gas prices might have smaller aggregate effects than do oil prices. Early

⁶ See Council of Economic Advisers (2005, p. 32).

⁷ Energy consumption per unit of GDP (thousands of BTU per one dollar of real GDP) declined by 41 percent from 1979 to 2004.

⁸ Also see Jones, Leiby, and Paik (2004) for discussion on various transmission channels of oil shocks.

work in this area appeared in a special issue of the October 1982 *Contemporary Policy Issues*. There were three papers in this issue that studied the effects of lifting natural gas price controls (i) on regional economic activity (Leone, 1982), (ii) on the distribution of income between households and suppliers (Stockfish, 1982), and (iii) on inflation (Ott and Tatom, 1982a). The general conclusion of the papers was that the presumed effects of natural gas decontrol (higher prices, higher inflation, and falling real incomes) were not expected to be significant. According to the Energy Modeling Forum (1987), a 10 percent increase in natural gas prices was found to have roughly the same effect on real GDP growth (two years after the shock) as a 20 percent increase in oil prices. According to the median result of 11 models, a 50 percent oil shock reduced real gross national product by about 1.5 percent after one year and by a little less than 3 percent by the end of two years.⁹ At the disaggregated level, Cullen, Friedberg, and Wolfram (2005) studied the effects of anticipated and unanticipated shocks to household disposable income arising from increased energy expenditures on household consumption. They found that increases in energy prices reduce consumption among lower-income households, but only when the increase is unanticipated.

More recently, the Energy Modeling Forum at Stanford University hosted a conference in December 2005: “World Natural Gas Markets and Trade.” According to an Economics and Statistics Administration (2005) study prepared for the U.S. Congress, a permanent \$1 increase in natural gas prices (wellhead price) over the period 2000-04 reduced real GDP growth by 0.1 percentage points per year.¹⁰ Studies by Global Insight and Oxford Economics Forecasting were cited as showing similar results.

However, because some manufacturing industries are more natural gas-intensive than others, it

is possible that the disaggregated effects are more significant. The next section examines this issue.

EMPIRICAL ANALYSIS

This analysis will test whether higher natural gas prices predict the growth of U.S. manufacturing output and real GDP: Aggregate manufacturing output will be measured using the manufacturing component of the industrial production (IP) index; the disaggregated measures are IP output at the three-digit NAICS level for all manufacturing industries.¹¹ The IP indices are published monthly by the Federal Reserve Board of Governors. The natural gas price data series used in the empirical analysis is the producer price index (PPI) for natural gas, which is a commodity index published monthly by the Bureau of Labor Statistics. One potential shortcoming of this approach is that natural gas prices paid can vary significantly across industries. For example, the 2002 MECS found that the average price paid by three-digit NAICS industries varied between \$3.37 and \$5.47 per million BTU; the standard deviation was \$0.57 per million BTU. Although the use of price-hedging arrangements such as fixed-price or futures markets contracts may allow some firms to pay less on average than other firms, it seems reasonable to conclude that, eventually, all firms must bear price increases or decreases based on market trends.

The empirical analysis will follow the general form of a simple least-squares regression:

$$(1) \quad \Delta \ln(X_t) = a_t + \sum_{i=1}^n [b_i \Delta \ln(X_{t-i}) + c_i \Delta \ln(P_{t-i})] + \varepsilon_t,$$

where a_t is a constant, X_t is output, and P_t is the PPI measure of natural gas prices. The maximum lag length is set to 12 for the monthly analysis and 4 for the quarterly analysis, and the optimum lag length is determined by using the Akaike information criterion (AIC) statistic. The sample period begins in January 1979, which immediately fol-

⁹ Using a general-equilibrium framework, Guerrieri (2005) found that a 50 percent permanent increase in the price of oil reduced U.S. real GDP growth by 0.6 percent after one year and 1.9 percent after two years (relative to the baseline forecast).

¹⁰ The study used an interindustry model of the U.S. economy developed at the University of Maryland (INFORUM LIFT); www.stanford.edu/group/EMF/projects/emf23/Henry.pdf.

¹¹ Total industrial production also includes output produced by mines and utilities. Thus, the analysis presented in this paper excludes the effects of higher natural gas prices on these sectors.

Table 4**Do Changes in Natural Gas Prices Affect the Industrial Sector?**

IP sector	Lags (AIC)	Sum of c_i coefficient	p -Value
Manufacturing	3	0.0033	0.862
Food	1	0.0013	0.709
Beverages and tobacco products	2	0.0232	0.419
Textile mills	12	-0.0499	0.416
Textile product mills	9	-0.0381	0.844
Apparel	4	0.0276	0.284
Leather and allied products	4	0.0379	0.255
Wood products	1	-0.0031	0.791
Paper products	3	-0.0091	0.791
Printing and related support activities	4	0.0062	0.920
Petroleum and coal products	2	-0.0063	0.256
Chemicals	1	-0.0033	0.519
Plastics and rubber products	1	-0.0030	0.612
Nonmetallic mineral products	3	0.0186	0.192
Primary metals	2	-0.0170	0.614
Fabricated metal products	3	-0.0007	0.800
Machinery	6	-0.0254	0.148
Computers and electrical products	6	-0.0158	0.371
Electrical equipment, appliances, and components	12	-0.0372	0.841
Transportation equipment	1	-0.0063	0.61
Furniture and related products	2	-0.0155*	0.077
Miscellaneous manufacturing	3	-0.0031	0.742

NOTE: The table reports the general form of the model that was run over the period January 1979 to February 2006:

$$\Delta \ln(IP_Sector_t) = a_t + \sum_{i=1}^n [b_i \Delta \ln(IP_Sector_{t-i}) + c_i \Delta \ln(PPI_NatGas_{t-i})] + e_t.$$

IP is industrial production (total and individual industry), and PPI_NatGas is the producer price index for gas fuels. The p -values are from the test of the null that all of the lags of PPI_NatGas are equal to zero. The optimum lag length chosen by the AIC statistic. For the reported p -values, ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

lows the commencement of U.S. natural gas deregulation, and extends through February 2006.

The results are reported in Table 4.¹² Each row reports the results of separate regressions for total manufacturing output and industry output at the three-digit NAICS level. Following Hamilton

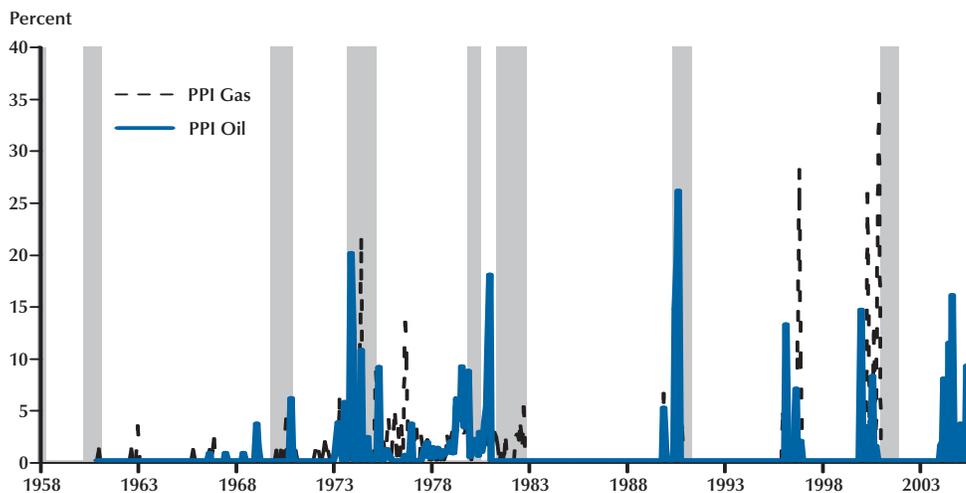
(2003), the table regresses contemporaneous output growth (log change) on an equal number of its lags and lags in the log change in natural gas prices. As Hamilton showed, even though the individual coefficients of the lagged energy prices may not be significantly different from zero, collectively they may be significantly different from

¹² In results not reported here, the growth of U.S. manufacturing output (log change) was regressed on a constant, the growth (log change) in natural gas prices, and its coefficient was positive and not significantly different from zero. In fact, the adjusted R^2 of the equation was negative. This regression was subsequently augmented (i) with last period's output growth and (ii) by cyclical changes in

economic activity, as measured by the unemployment rate. The adjusted R^2 of the final specification was only about 20 percent. For brevity, the results are not published here, but are available from the author.

Figure 3

Hamilton Transformations of Petroleum and Natural Gas Prices (36 months)



NOTE: Shaded bars indicate recessions.

zero.¹³ As indicated by the p -value, a simple F-test is used to determine whether the sum of the coefficients on the natural gas prices is significantly different from zero.

The results in Table 4 are revealing. First, changes in natural gas prices do not significantly predict total manufacturing output. Although the sum of the coefficients in the aggregate regression is positive, it is not significantly different from zero. Second, regressions at the three-digit NAICS level reveal that the furniture and related products sector is the only industry where changes in natural gas prices help to predict output growth. In this case, the sum of the coefficients is negative, as expected, and significant at the 10 percent level. The other regressions in Table 4 suggest that changes in natural gas prices do not help to predict output growth for the remaining industries. In fact, the sum of the coefficients for 6 of the 21 industries is positive, with 12 of the industries reporting p -values greater than 0.5.

¹³ This amounts to running a constrained and unconstrained regression (with and without the lags on natural gas prices).

Using An Alternative Measure of Natural Gas Prices

Hamilton (2003) showed that an asymmetric measure of oil prices helps explain real GDP growth. To test whether there are similar asymmetries with respect to natural gas prices, this article constructs two transformations of monthly natural gas prices that are consistent with his findings. The first is the percentage difference in the maximum price (log) over the most recent 12 months. The second uses a 36-month interval. If the percentage difference is negative, that month's observation is arbitrarily set to zero. Thus, in the Hamilton framework, only energy price increases matter; energy price decreases do not matter. Figure 3 plots the transformation for crude oil and natural gas prices for the 36-month interval. The figure shows that price increases for crude oil tend to be larger before 1990, while natural gas price increases tend to be larger after 1990.

Tables 5 and 6 attempt to assess whether Hamilton's transformations for natural gas and crude oil prices help to explain growth of manufacturing output at the aggregate and disaggregated level. Table 5 uses Hamilton's price changes over

Table 5**Do Increases in Crude Petroleum and Natural Gas Prices Affect Manufacturing Activity?
A Test Using Hamilton's 12-Month Specification**

IP sector	Crude petroleum			Natural gas		
	Lags (AIC) [†]	Sum of c_i coefficient	p -Value	Lags (AIC) [†]	Sum of c_i coefficient	p -Value
Manufacturing	3	-0.0206	0.535	4	-0.0099	0.555
Food	1	0.0150	0.190	1	0.0027	0.707
Beverages and tobacco products	7	0.0348	0.113	2	0.0070	0.803
Textile mills	12	-0.1079	0.176	12	-0.0592**	0.035
Textile product mills	4	-0.1498*	0.057	9	-0.0583	0.336
Apparel	4	0.0000	0.656	5	-0.0427	0.149
Leather and allied products	6	-0.0017	0.114	7	-0.0849	0.172
Wood products	10	-0.2520**	0.040	7	-0.0319	0.945
Paper products	3	-0.0147	0.554	6	-0.0787**	0.027
Printing and related activities	4	-0.0312	0.276	4	-0.0263	0.631
Petroleum and coal products	2	-0.0946***	0.010	2	-0.0103	0.261
Chemicals	1	-0.0109	0.501	1	0.0002	0.987
Plastics and rubber products	1	-0.0281	0.133	1	-0.0146	0.217
Nonmetallic mineral products	5	-0.1034***	0.008	3	0.0171	0.252
Primary metals	2	-0.0522	0.601	2	-0.0283	0.514
Fabricated metal products	3	-0.0249*	0.051	3	-0.0137	0.656
Machinery	3	-0.009	0.772	3	-0.0256	0.324
Computer and electrical products	6	-0.0077	0.958	6	-0.0358	0.167
Electrical equipment, appliances, and components	12	-0.0499	0.877	12	-0.0639	0.490
Transportation equipment	1	-0.0698*	0.080	1	-0.0307	0.222
Furniture and related products	3	-0.0574	0.121	2	-0.0231	0.228
Miscellaneous manufacturing	3	-0.0132	0.716	3	-0.0188	0.182

NOTE: The table reports the general form of the two regressions (for the separate energy price series) that were run over the period January 1979 to February 2006:

$$\Delta \ln(IP_Sector_t) = a_t + \sum_{i=1}^n [b_i \Delta \ln(IP_Sector_{t-i}) + c_i \Delta \ln(H1.PPI_Energy_{t-i})] + e_t.$$

IP is industrial production (total and individual industry), and $H1.PPI_Energy$ is the producer price index for natural gas and domestic crude petroleum production transformed according to Hamilton (2003); the transformation period is 12 months. The p -values are from the test of the null that all of the lags of $H1.PPI_NatGas$ are equal to zero. For the reported p -values, ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. [†]The optimum lag length was chosen by the AIC statistic.

Table 6
**Do Increases in Crude Petroleum and Natural Gas Prices Affect Manufacturing Activity?
A Test Using Hamilton's 36-Month Specification**

IP sector	Crude petroleum			Natural gas		
	Lags (AIC) [†]	Sum of c_j coefficient	p -Value	Lags (AIC) [†]	Sum of c_j coefficient	p -Value
Manufacturing	4	-0.0444	0.125	4	-0.0186	0.365
Food	1	0.0086	0.509	1	0.0000	0.996
Beverages and tobacco products	6	-0.0470	0.151	4	-0.0802**	0.033
Textile mills	2	-0.0532	0.151	12	-0.0426**	0.033
Textile product mills	4	-0.1869**	0.016	9	-0.1159	0.434
Apparel	4	0.0088	0.403	4	-0.020	0.651
Leather and allied products	6	-0.0070	0.120	7	-0.1143**	0.013
Wood products	10	-0.3299**	0.021	7	-0.0639	0.631
Paper and products	3	-0.0115	0.659	10	-0.0623*	0.097
Printing and related support	8	-0.0452	0.358	4	-0.0172	0.610
Petroleum and coal products	2	-0.1157***	0.004	2	-0.002	0.342
Chemicals	1	-0.0157	0.395	1	0.0049	0.713
Plastics and rubber products	1	-0.0343	0.105	1	-0.0144	0.342
Nonmetallic mineral products	5	-0.1478***	0.002	3	0.0091	0.674
Primary metals	2	-0.0534	0.678	2	-0.0438	0.481
Fabricated metal products	5	-0.0681***	0.003	3	-0.0157	0.608
Machinery	6	-0.0637	0.365	6	-0.0944**	0.022
Computers and electrical products	6	-0.0360	0.725	6	-0.0773**	0.016
Electrical equipment, appliances, and components	12	-0.0883	0.412	12	-0.1101	0.309
Transportation equipment	1	-0.0892**	0.048	1	-0.0181	0.573
Furniture and related products	9	-0.1564***	0.003	2	-0.0296	0.263
Miscellaneous manufacturing	3	-0.0294	0.328	3	-0.0292**	0.049

NOTE: The table reports the general form of the two regressions (for the separate energy price series) that were run over the period January 1979 to February 2006:

$$\Delta \ln(IP_Sector_t) = a_t + \sum_{i=1}^n [b_i \Delta \ln(IP_Sector_{t-i}) + c_i \Delta \ln(H3.PPI_Energy_{t-i})] + e_t.$$

IP is industrial production (total and individual industry) and $H3.PPI_Energy$ is the producer price index for natural gas and domestic crude petroleum production transformed according to Hamilton (2003); the transformation period is 36 months. The p -values are from the test of the null that all of the lags of $H3.PPI_NatGas$ are equal to zero. For the reported p -values, ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. [†]The optimum lag length was chosen by the AIC statistic.

a 12-month period, and Table 6 uses price changes over a 36-month period. The latter corresponds with the 3-year period that Hamilton used in his 2003 article. As in Table 4, Tables 5 and 6 report the number of significant lags of the natural gas variable based on the AIC criteria, as well as the sum of the coefficients of the lags. The tables also report the p -values for the lags at the conventional 1, 5, and 10 percent levels of significance.

Switching to the Hamilton transformation for natural gas prices produces results that are broadly consistent with the theory noted above. Table 5 shows that, for total manufacturing output, the sum of the lagged coefficients on gas prices is negative (first line); however, they are still not significantly different from zero (p -value of 0.56). This result is essentially the same for crude oil prices. Table 5 also shows that when Hamilton's 12-month specification is used, the number of industries where increases in gas prices significantly predict industry output growth increases from one to two: textile mills and paper products. In both cases, the effects of higher gas prices linger from 6 to 12 months. Perhaps of greater interest, Table 5 also shows that there are six manufacturing industries that are significantly affected by changes in crude oil prices—three times the number that are affected by increases in natural gas prices. The sum of the coefficients on each of these industries is the expected sign.

Table 6 is an extension of Table 5. In this case, results are reported using the 36-month specification. In this specification, changes in natural gas prices have a negative effect on the growth of manufacturing output (line 1), but the p -value is still insignificant (0.37). Unlike Table 5, which showed comparable results for increases in oil and gas prices on total manufacturing output, the first line of Table 6 shows that the sum of the coefficients on crude oil prices (−0.044) is more than twice as large as that for natural gas prices (−0.019), but the p -value for crude oil is not significant. Another interesting difference between the results in Tables 5 and 6 is that the number of industries that are significantly affected by changes in natural gas prices increases from two to seven. As before, the sum of the coefficients is still nega-

tive. Combined, these seven industries comprise about a quarter of manufacturing's total weight in IP (reported in Table 2). Also of interest, higher gas prices do not significantly help predict output growth in the three industries where expenditures on natural gas were the largest percentage of total industry shipments: primary metals, nonmetallic mineral products, and chemicals (see Table 3). This might explain why the aggregate effect (line 1) is not significant. As an aside, the finding for the chemical industry is particularly interesting, since it is by far the largest user of natural gas (see Table 2).

Finally, Table 6 shows that increases in crude oil prices have similar predictive effects on output when the Hamilton specification is extended to 36 months. In this case, the number of industries where increases in crude oil prices significantly predict output increases from six to seven. Again, the sum of the coefficients in each case has the expected negative sign. As with the seven industries in the previous paragraph, these seven industries also combine to comprise about a quarter of manufacturing's weight in IP.

Extending the Analysis to the Aggregate Level

The basic conclusion of the results presented in Tables 5 and 6 is that crude oil prices seem to have a more significant predictive effect for manufacturing industry output growth using Hamilton's 12-month specification, but essentially comparable effects when the specification is extended to 36 months. Table 7 reports an extended version of Hamilton's findings to assess whether this finding holds for real GDP. Hamilton (2003) found that the explanatory power of his 3-year specification for oil price increases was much more significant than the 1-year specification in explaining real GDP growth.¹⁴ Using data from the first quarter of 1979 through the fourth quarter of 2005, Table 7 shows that this is still the case: The p -value using Hamilton's 12-quarter specification is significant,

¹⁴ Hamilton's results are based on data that begin in 1948, a much longer time series than reported here. As in Hamilton's work, Table 7 uses four lags and it adopts Hamilton's convention of using the log change in quarterly real GDP (not annualized).

Table 7**Do Changes in Natural Gas Prices Matter for Real GDP Growth?**

Hamilton regressions: energy prices	F-Statistic	p-Value
4-Quarter transformation		
Crude oil prices	1.349	0.258
Natural gas prices	0.549	0.701
12-Quarter transformation		
Crude oil prices	3.550***	0.0096
Natural gas prices	1.613	0.177

NOTE: The regressions present statistics from the following specification:

$$\Delta \ln(\text{real_GDP}_t) = a_t + \sum_{i=1}^n [b_i \Delta \ln(\text{real_GDP}_{t-i}) + c_i \Delta \ln(\text{PPI_Energy}_{t-i})] + e_t,$$

where $n = 4$. *PPI_Energy* is the producer price index for gas fuels and domestic crude petroleum production transformed according to Hamilton (2003). The model is estimated over the period 1979:Q1-2005:Q4. For the reported p -values, ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

but it is not significant for the 4-quarter transformation.

Table 7 also reports tests of whether changes in natural gas prices predict real GDP growth. The evidence presented in the table suggests that that is not the case. Unlike increases in crude oil prices, increases in natural gas prices do not significantly predict real GDP growth using either of Hamilton's specifications. These results are generally consistent with the total manufacturing results reported earlier.

CONCLUSION

In the aftermath of the disruptions caused by hurricanes Katrina and Rita, natural gas prices faced by consumers and producers rose to record-high levels. Because natural gas is the second most important energy source for the economy, there was widespread concern that these high prices might cause a significant slowing in the economy and among those manufacturing industries that depend heavily on natural gas as a source of energy. The analysis presented in this article offers some support for the latter contention, but only when prices are transformed according to the specification suggested by Hamilton. However, the results using Hamilton's specifications indi-

cate that changes in natural gas prices do not cause significant output effects for the two manufacturers that are the most-intensive users of natural gas (primary metals and nonmetallic mineral products), although they do cause significant output effects for other, less-intensive manufacturers (such as machinery and computers and electrical products). While perhaps significant, this result must be balanced against the finding that, when the analysis is extended to the macroeconomy (real GDP), increases in crude oil prices significantly predict real GDP growth, but natural gas prices do not.

REFERENCES

- Abel, Andrew B. and Bernanke, Ben S. *Macroeconomics*. Fifth Edition. Boston: Pearson Addison Wesley, 2005.
- Baily, Martin Neal. "Productivity and the Service of Capital and Labor." *Brookings Papers on Economic Activity*, 1981, 1, pp. 1-50.
- Barsky, Robert B. and Kilian, Lutz. "Oil and the Macroeconomy Since the 1970s." *Journal of Economic Perspectives*, Fall 2004, 18(4), pp. 115-34.

- Bernanke, Ben S. "Irreversibility, Uncertainty, and Cyclical Investment." *Quarterly Journal of Economics*, February 1983, 98(1), pp. 85-106.
- Council of Economic Advisers. *Economic Report of the President*. Washington, DC: U.S. Government Printing Office, February 2005.
- Cullen, Julie B.; Friedberg, Leora and Wolfram, Catherine. "Do Households Smooth Small Consumption Shocks? Evidence from Anticipated and Unanticipated Variation in Home Energy Costs." CSEM Working Paper 141, Center for the Study of Energy Markets, University of California Energy Institute, 2005.
- Economics and Statistics Administration. "Impacts of Rising Natural Gas Prices on the U.S. Economy and Industries: Report to Congress." U.S. Department of Commerce, June 29, 2005; www.esa.doc.gov.
- Energy Modeling Forum. "Macroeconomic Impacts of Energy Shocks: A Summary of the Key Results," in B.G. Hickman, H.G. Huntington, and J.L. Sweeney, eds., *Energy Modeling Forum Report 7*. Volume 1. Stanford University/North Holland, 1987.
- Guerrieri, Luca. "The Effects of Oil Shocks on the Global Economy." Unpublished manuscript, Federal Reserve Board, 2005.
- Guo, Hui, and Kliesen, Kevin L. "Oil Price Volatility and U.S. Macroeconomic Activity." *Federal Reserve Bank of St. Louis Review*, November/December 2005, 87(6), pp. 669-83.
- Hamilton, James D. "Oil and the Macroeconomy since World War II." *Journal of Political Economy*, April 1983, 91(2), pp. 228-48.
- Hamilton, James D. "A Neoclassical Model of Unemployment and the Business Cycle," *Journal of Political Economy*, 1988, 96(3), pp. 593-617.
- Hamilton, James D. "This Is What Happened to the Oil Price-Macroeconomy Relationship." *Journal of Monetary Economics*, 1996, 38(2), pp. 215-20.
- Hamilton, James D. "What Is an Oil Shock." *Journal of Econometrics*, 2003, 113(2), pp. 363-98.
- Hooker, Mark A. "What Happened to the Oil Price-Macroeconomy Relationship?" *Journal of Monetary Economics*, 1996, 38(2), pp. 195-213.
- Jones, Donald W.; Leiby, Paul N. and Paik, Inja K. "Oil Price Shocks and the Macroeconomy: What Has Been Learned Since 1996?" *Energy Journal*, 2004, 25(2), pp. 1-32.
- Leone, Robert A. "Impact of Higher Natural Gas Prices on the Northeast Regional Economy." *Contemporary Policy Issues*, October 1982, 1(1), pp. 1-8.
- Lilien, David M. "Sectoral Shifts and Cyclical Unemployment." *Journal of Political Economy*, August 1982, 90(4), pp. 777-93.
- Ott, Mack and Tatom, John A. "Are There Adverse Inflation Effects Associated with Natural Gas Decontrol?" *Contemporary Policy Issues*, October 1982a, (1), pp. 27-46.
- Ott, Mack and Tatom, John A. "A Perspective on the Economics of Natural Gas Decontrol." *Federal Reserve Bank of St. Louis Review*, November 1982b, 64(9), pp. 19-31.
- Pindyck, Robert. "Irreversibility, Uncertainty, and Investment." *Journal of Economic Literature*, September 1991, 29(3), pp. 110-48.
- Rasche, Robert H. and Tatom, John A. "The Effects of the New Energy Regime on Economic Capacity, Production, and Prices." *Federal Reserve Bank of St. Louis Review*, May 1977a, 59(5), pp. 2-12.
- Rasche, Robert H. and Tatom, John A. "Energy Resources and Potential GNP." *Federal Reserve Bank of St. Louis Review*, June 1977b, 59(6), pp. 10-24.
- Stockfish, J.A. "The Income Distribution Effects of a Natural Gas Price Increase." *Contemporary Economic Policy Issues*, October 1982, 1(1), pp. 9-26.
- United States Energy Information Administration. *Annual Energy Review 2004*, U.S. Department of Energy, August 2005.

Kliesen

Wei, Chao. "Energy, the Stock Market, and the Putty-Clay Investment Model." *American Economic Review*, March 2003, 93(1), pp. 311-23.

Yang, Jai-Hoon. "The Nature and Origins of the U.S. Energy Crisis." Federal Reserve Bank of St. Louis *Review*, July 1977, 59(7), pp. 2-12.



The Transition to Electronic Communications Networks in the Secondary Treasury Market

Bruce Mizrach and Christopher J. Neely

This article reviews the history of the recent shift to electronic trading in equity, foreign exchange, and fixed-income markets. The authors analyze a new data set: the eSpeed electronic Treasury network. They contrast the market microstructure of the eSpeed trading platform with the traditional voice-assisted networks that report through GovPX. The electronic market (eSpeed) has greater volume, smaller spreads, and a lower estimated trade impact than the voice market (GovPX). (JEL G14, G12, D4, C32)

Federal Reserve Bank of St. Louis *Review*, November/December 2006, 88(6), pp. 527-41.

In the past 15 years, advances in information technology have revolutionized electronic trading—posting quotes, transacting, and confirming orders electronically. Electronic methods have grown to dominate trading in major asset markets, such as equities, foreign exchange, and most recently U.S. Treasuries.

The Securities and Exchange Commission (SEC) (2000) defines electronic communications networks (ECNs) as “electronic trading systems that automatically match buy and sell orders at specified prices.”¹ ECNs have several advantages over other systems, such as open-outcry trading floors or telephone trading. First, ECNs permit users all over the world to trade, without regard to physical location. Second, ECNs permit the number of traders, the size of trades, or the asset to vary costlessly. Third, ECNs automate the processing and clearing of trading, reducing the risk of clearing errors and facilitating risk management (Bank for International Settlements [BIS], 2001).

¹ One should not confuse ECNs, which offer firm prices and immediate execution, with other forms of trading that use electronic technology.

The advantages of ECNs are most evident in the markets for more liquid and homogenous assets. In contrast, assets whose trading requires more customization—that is, negotiation over quantities and settlement details—will benefit from human brokers. Barclay, Hendershott, and Kotz (2006) discuss the conditions under which voice brokers outperform ECNs in conveying complex information (“market color”) during trading for less-liquid assets or nonstandard instruments.

By dramatically reducing the cost of trading for relatively liquid and homogeneous assets, electronic trading has facilitated portfolio management for institutional investors and banks. Rising volume has mirrored the fall in the cost of trading, enabling customers to rebalance portfolios more quickly, making them less risky.

This article scrutinizes a previously unexamined data set, the U.S. Treasury bond market data from the eSpeed ECN, founded by Cantor Fitzgerald and Co. We have a complete record of trades and quotes from eSpeed for 2004, and we contrast the ECN market with similar 1999 data from GovPX, a joint venture among voice brokers. Compared with GovPX, eSpeed exhibits much

Bruce Mizrach is an associate professor of economics at Rutgers University, and Christopher J. Neely is a research officer at the Federal Reserve Bank of St. Louis. The authors thank Bill Emmons, Michael Fleming, Ken Garbade, Laura Lipscomb, and Dan Thornton for helpful comments on preliminary drafts and Justin Hauke for outstanding research assistance.

© 2006, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis.

lower spreads and a smaller impact on prices from order flow. A detailed understanding of market microstructure can contribute to better regulation and improvements to market architecture.

STAGES OF THE TREASURY BOND MARKET

The sale of Treasuries undergoes three distinct phases: primary, on-the-run, and off-the-run. Each of these three stages has a distinct market structure.

The Primary Market

In the first or *primary* stage, the U.S. Treasury auctions off debt to the public. Garbade and Ingber (2005) describe this process in detail.² The Treasury provides a predictable flow of auction information to “promote competitiveness by enhancing market transparencies” and to improve the size of offerings. Since August 8, 2002, the Treasury has made auction announcements (for all new securities) at 11:00 a.m. eastern time. There is also a stable schedule³ for auctions. For example, 3- and 6-month bills are auctioned weekly; 2- and 5-year notes are auctioned monthly; 30-year bonds were reintroduced on February 9, 2006, after a 5-year hiatus, and are auctioned in February and August each year.

A few days prior to the auction, the specific dollar amount (*par value*) of the securities to be auctioned is announced and the *when-issued* security market begins. The when-issued market continues until settlement of auction purchases. Nyborg and Sundaresan (1996) document that when-issued trading provides important information about auction prices prior to the auction and also permits market participants to reduce the risk they take in bidding.⁴

² See the glossary for definitions of terms.

³ The Treasury auction schedule can be found at: www.treasury.gov/offices/domestic-finance/debt-management/auctions/.

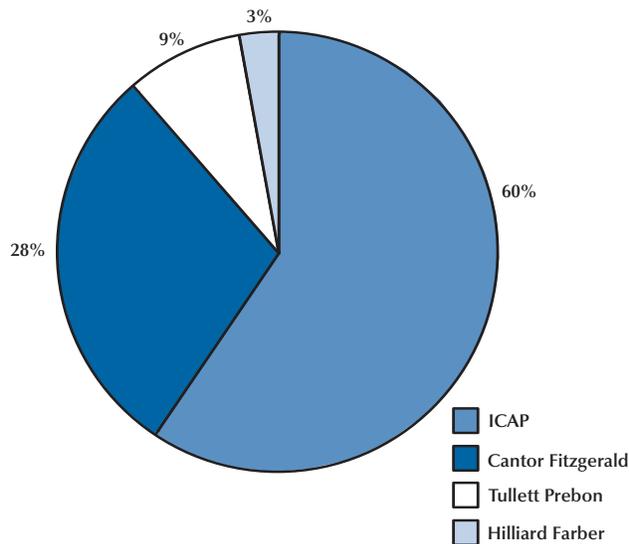
⁴ On August 20, 1998, the Treasury shortened the when-issued period for 13- and 26-week bill auctions. Similarly, the Treasury shortened the when-issued period by two days for 2-year notes, beginning with the August 2, 2002, auction. Fleming (2002) and Garbade and Ingber (2005) discuss the results of such changes in when-issued periods.

Bids for Treasury auctions can either be competitive bids by primary dealers or noncompetitive bids by firms and individuals. Firms and individuals can also competitively bid through brokers and primary dealers. Competitive bids specify a price to be bid and a quantity sought. In the recent past, there have been two types of auctions: multiple-price and single-price.

Garbade and Ingber (2005) discuss the transition from multiple-price auctions to single-price auctions. Historically (prior to 1992) multiple-price auctions were used to sell Treasury securities. In multiple-price auctions, the competitive bids were ranked to determine the highest yield that will sell all the Treasuries. The average yield for all accepted competitive bids is called the *stop-out yield*. First, all noncompetitive bids are satisfied at the stop-out yield and then the remainder of the auctioned securities are allocated to competitive bidders with the lowest bid yield (highest bid price). Competitive bids above the stop-out yield are not filled, whereas those at the stop-out yield may be only partially filled.

The Treasury began to experiment with single-price auctions in 1992 for the 2- and 5-year notes (Garbade and Ingber, 2005). In this auction design, all securities are allocated to bidders at the price implied by the highest accepted yield. In October 1998, the Treasury adopted this procedure for all maturities, safeguarded by quantity restrictions on the amount a single bidder can purchase.

Upon completion of the auction, the most recently issued bill, note, or bond becomes *on-the-run* and the previous on-the-run issue goes *off-the-run*. Both on-the-run and off-the-run trading occurs in the *secondary* Treasury market. Secondary market participants are often divided into two parts: the sell side and the buy side. The primary securities dealers constitute the sell side, while the diverse group of final users of Treasury bonds constitutes the buy side. The buy side includes commercial and investment banks, insurance companies, financial firms, investors, and pension funds—those who use Treasuries for speculation, as well as for hedging real and financial risk.

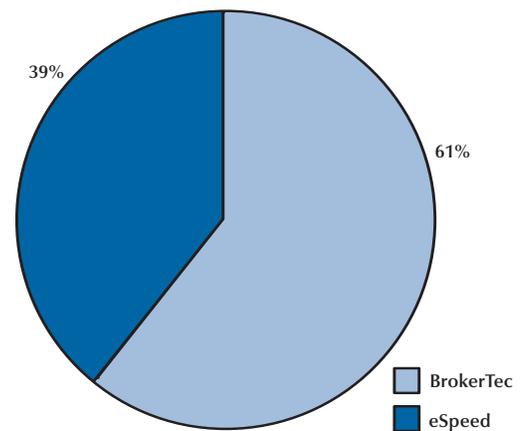
Figure 1**Secondary Government Bond Market, 2005 Market Share**

SOURCE: Federal Reserve Bank of New York primary dealer data, ICAP 2005 Annual Report, eSpeed Quarterly Report, and market estimates from www.espeed.com and www.cstplc.com (Tullett Prebon).

The Overall Secondary Market

It is difficult to get primary source data for all secondary market transactions, therefore we will use market-share⁵ estimates made by the Federal Reserve and industry participants. Figure 1 shows that, in 2005, two large *interdealer brokerage* (IDB) firms dominate the overall secondary market: ICAP PLC, with a 60 percent market share, and Cantor Fitzgerald, with 28 percent. Both of these firms trade a large array of fixed-income financial instruments, including *swaps*, and *mortgage-backed* and *agency securities*, using both electronic and voice-brokered systems. We describe these two firms and their purely electronic Treasury platforms in greater detail in the next sec-

⁵ Mizrach and Neely (2005) explore a related concept known as *information share*. This is a statistical measure of where (in which market) price discovery takes place. From 1995 to 1999, we found the spot and futures markets played nearly equal roles, with futures dominating after 1999.

Figure 2**ECN Trading of On-the-Run Treasury Securities, 2005:Q3 Market Share**

SOURCE: Federal Reserve Bank of New York primary dealer data, eSpeed and ICAP 2005 financials, and author's estimates.

tion. Tullett Prebon,⁶ with 9 percent, and Hilliard Farber & Co., with 3 percent, complete the secondary Treasury market.

On- and off-the-run markets differ by volume and trading methods. We turn first to the more liquid on-the-run market.

On-the-Run. There is much more secondary volume in on-the-run securities than off-the-run securities, with the former representing 70 percent of all trading volume (Fabozzi and Fleming, 2005). Because of this liquidity difference, off-the-run securities trade at a higher yield (lower price) than on-the-run securities of similar maturity. The amount by which the off-the-run yield exceeds the on-the-run yield is known as the

⁶ Collins Stewart Tullett PLC is an agglomeration of a number of prior firms: (i) Collins Stewart Ltd. was a London-based financial services firm founded in 1991; (ii) Tullett & Riley was founded in 1971, originally focusing on foreign exchange; (iii) Tokyo Forex took a stake in Tullett in 1986, creating Tullett & Tokyo; (iv) in 2000, Tullett & Tokyo merged with Liberty Brokerage to create Tullett & Tokyo Liberty; (v) Prebon was formed in 1990 following the merger of three leading London-based money broking businesses, Babcock & Brown, Kirkland-Whittaker, and Fulton Prebon; (vi) Prebon's close business alliance with the Tokyo-based Yamane Tanshi provided its current title of Prebon Yamane. Collins Stewart acquired Tullett in March 2003 and Prebon in October 2004. The firm's IDB business uses the name Tullett Prebon.

liquidity premium. Trading of benchmark (on-the-run) issues is *commoditized*, and nearly all of it has migrated to the electronic networks.⁷

Figure 2 shows market share estimates for the ECN portion of the on-the-run market in the third quarter of 2005.⁸ We estimate that on-the-run trading for this quarter was \$21.19 trillion.⁹ In their financial filings, eSpeed reports transactions volumes of \$8.014 trillion during the quarter. We then estimate BrokerTec ECN volume of \$12.29 trillion.¹⁰ These figures imply on-the-run ECN market shares, 61 percent for BrokerTec and 39 percent for eSpeed, as reported in Figure 2, which are consistent with industry estimates for that time (Kutler, 2006). eSpeed reports that it has gained market share since the third quarter of 2005, however.¹¹

We now turn to the more numerous but less actively traded off-the-run issues.

Off-the-Run. Off-the-run securities require more customization—that is, negotiation over quantities and settlement details—and thus benefit from human brokers. Although assets themselves don't change when they go off-the-run, they do become more heterogeneous with respect to *depth*, the quantity the dealer is willing to sell at the bid or offer. Therefore they require more negotiation in trading. Barclay, Hendershott, and Kotz (2006) report that transaction volume falls by more than 90 percent, on average, once a bond goes off-the-run. There is a large number of issues—99 notes and 43 bonds as of February 2006—but, with each being relatively illiquid, most off-the-run trading occurs in traditional voice networks.

⁷ Commoditized securities are those that are undifferentiated and liquid and trade only on price. See the glossary for further definitions.

⁸ Electronic trading in fixed income refers to both electronically brokered, voice-assisted transactions and pure ECN trades. We focus only on the latter here.

⁹ Total Treasury market trading volume averaged \$473 billion per day or \$30.27 trillion for the whole quarter. Assuming 70 percent was on-the-run, we arrive at the \$21.19 trillion estimate.

¹⁰ ICAP's BrokerTec reports a 58 percent overall secondary market share in their filings, and we assume the same market share in the on-the-run portion.

¹¹ Cantor Fitzgerald reported a market share gain since 2005:Q3 in a personal communication.

eSpeed does not compete with BrokerTec in off-the-run trading, but the voice-assisted part of Cantor Fitzgerald does compete with ICAP. Because neither firm breaks out their off-the-run voice-assisted trading from their overall figures, we cannot estimate a market share for off-the-run trading.

THE GROWTH OF ELECTRONIC TRADING

Compared with equity or foreign exchange markets, bond markets were slower to adopt electronic trading. The bond market is large and decentralized, such as the NASDAQ equity market or foreign exchange market, but has more varied assets—many types of bonds, maturities, coupons, *strips*, etc. Two boxed inserts in this article describe the growth of electronic trading in equity and foreign exchange markets. The greater complexity of trading in sundry instruments, each of which has less liquidity than large capitalization stocks or the major currencies, retarded the transition to electronic trading.

Electronic communications can play different roles in the trading process. For more than a decade, bond trading screens have displayed quotes from dealers that helped to initiate voice transactions. This section focuses on the completely electronic trading through ECNs. These ECNs permit dealers to post transactable prices and quantities and execute trades electronically.

Cantor Fitzgerald introduced the first ECN in bond markets, eSpeed, in 1999. A consortium of Wall Street firms, including Morgan Stanley and Goldman Sachs, launched a competitor, BrokerTec, the same year. BrokerTec began commercial operations in 2000. ICAP PLC, a global, London-based IDB, acquired BrokerTec in April 2003. On-the-run trading is now almost completely electronic, with the market split roughly 60-40 between the two ECNs, as Figure 2 illustrates. While these ECNs (eSpeed and BrokerTec) have captured most bond market trading activity, voice brokerage systems are used for trading in less liquid assets or more complex deals.

History of Cantor Fitzgerald

Bernie Cantor and John Fitzgerald founded the firm of Cantor Fitzgerald in 1945 to provide investment advice to wealthy individuals. Cantor Fitzgerald rose to prominence as a Wall Street bond market *broker*. Cantor's fortunes rose in 1972, when it bought a controlling interest in Telerate and began to post bond prices for its bond dealer clients through the Telerate computer network. Customers purchased the data streams and naturally directed business toward its source, Cantor. The strategy was so successful in generating trading volume that Cantor gained a "nearly monopolistic" bond market share (Zuckerman, Davis, and McGee, 2001).¹² Rising federal government budget deficits in the 1980s aided Cantor's fortunes by greatly expanding the bond market. By the early 1990s, Cantor Fitzgerald had 20 to 25 percent of the IDB market (SEC, 1992).

In 1991, demands by the SEC and bond market dealers for greater transparency led to the formation of GovPX, a joint venture among five IDBs.¹³ Cantor was the only IDB that did not participate in GovPX. GovPX was established to provide real-time interdealer trade prices and volume for U.S. Treasury bonds. The information is made publicly available, distributed through the Internet and data vendors.

As electronic trading became commonplace in the equity and foreign exchange markets, Cantor followed suit by starting the first electronic brokerage system for bonds, eSpeed, in March 1999. Cantor subsequently spun off eSpeed in a December 1999 public offering, but retains a controlling interest. ESPEED Inc. is listed on the NASDAQ and trades under the symbol ESPD.

¹² Rust and Hall (2003) present a model to explain the differences in microstructure between markets. They motivate their paper by observing that Cantor Fitzgerald has been a successful market maker in the U.S. Treasury bond market, but such an outcome—a single market maker—has not emerged in the market for steel.

¹³ The original IDBs reporting to GovPX were Garvin Guy Butler, Liberty Brokerage, Hilliard Farber, RMJ, and Tullet & Tokyo Securities. As the structure of the market changed, so did the brokers reporting to GovPX. Fleming (2003), which examines the period 1997-2000, listed GovPX coverage as including Garban-Intercapital, Hilliard Farber, and Tullett & Tokyo Liberty. After ICAP's purchase of GovPX in January 2005, ICAP PLC was the only broker reporting through GovPX.

The terrorist attacks of September 11, 2001, struck Cantor particularly hard, destroying its offices in the World Trade Center and killing 658 employees. Despite this tragedy, eSpeed became one of the two dominant trading platforms in the IDB market for U.S. Treasuries.

ICAP and BrokerTec

Cantor was not alone in seeing the potential of an electronic IDB bond-trading system. In 1999, several other Wall Street firms, including Morgan Stanley Dean Witter & Co. and Goldman Sachs Inc., founded BrokerTec Global LLC. ICAP is the product of a merger between Garban PLC and Intercapital PLC in September 1999; originally called Garban-Intercapital, the name was changed to ICAP in July 2001. ICAP is currently the world's largest IDB with revenues of £794 million, and operating profits of £122.7 million. The company trades publicly on the London Stock Exchange under the symbol IAP.

In February 2000, Garban-Intercapital launched the Electronic Trading Community (ETC), a hybrid voice/electronic brokering system for the Treasury market. They eventually struck alliances with Tullett & Tokyo Liberty in November 2000 and SunGard in September 2001.

ICAP realized that it needed to grow its ECN business and bought BrokerTec's Treasury platform in April 2003 for \$185.9 million. The U.S. Department of Justice approved the purchase after restructuring commission agreements between the pre-merger entities (Department of Justice, 2003). ICAP has used the BrokerTec platform to form partnerships similar to the one with MarketAxess in March 2004 (*Wall Street & Technology*, 2004). ICAP also acquired the data provider GovPX Inc., in January 2005.

Recent Competition

eSpeed briefly had a dominant 70 percent share in on-the-run trading, but BrokerTec gained market share with lower transactions costs. Cantor Fitzgerald filed a lawsuit alleging patent infringement on eSpeed's trading systems. The case, filed in January 2003, was dismissed in February 2005 by a Delaware court.

ELECTRONIC TRADING IN EQUITY MARKETS

The equity markets were the first to embrace electronic trading. Over-the-counter stocks have traded electronically at least since the creation of the National Association of Security Dealers (NASD) automated quote (NASDAQ) system in 1971. NASDAQ was a dealer market without a central trading floor. It was a distant second competitor to the floor-based New York Stock Exchange (NYSE).

The Philadelphia Stock Exchange was one of the first floor exchanges in the United States to introduce electronic trading with the PACE (Philadelphia Automated Communication and Execution) System in 1975. PACE permitted two-party trading from anywhere in the world but allowed for only limited information flow. Purely electronic limit order books began with Instinet in 1979. Instinet provided interdealer equity trading in both NYSE and NASDAQ securities.¹

Despite the early adoption of this technology, U.S. equity markets tended to lag behind foreign markets in establishing electronic markets. ECNs were created in Toronto in 1977, Tokyo in 1982, Paris in 1986, Australia in 1990, Germany in 1991, Israel in 1991, Mexico in 1993, and Switzerland in 1995 (Economides and Schwartz, 1995).

The Chicago Board of Trade (CBOT) moved the equity futures and options markets significantly toward electronic trading with the successful introduction of GLOBEX, in 1994. The CBOT followed this effort with GLOBEX2, in 1998, which permitted round-the-clock trading.

Christie and Schultz (1994) triggered a watershed in electronic trading by finding NASDAQ market makers to be colluding over spreads. Following this discovery, in 1997, the SEC allowed electronic communication networks (ECNs) or alternative trading systems (ATS) to compete with NASDAQ dealers on an equal footing. This legal deregulation sparked a surge in electronic trading in U.S. equity markets. However, in moving to electronic trading through independent ECNs, the U.S. equity markets have differed from those in the rest of the world, where existing exchanges have largely developed electronic trading.

By 2004, ECNs had grabbed a dominant market share of equity trading. In 2005, both NASDAQ and the NYSE initiated mergers with their major electronic competitors. NASDAQ completed its merger with Instinet in 2005 and the NYSE with Archipelago in March 2006. Even with major changes and new electronic competition, the market has reorganized as a duopoly.

Although NASDAQ dealers held only a 35 percent market share in October 2005, this figure understates the market power of the for-profit NASDAQ. The combined market share of NASDAQ's own anonymous trading facility SIZE, and the Brut and Instinet ECNs that NASDAQ has acquired, gives this ECN more than three-quarters of the market (Mizrach, 2005).

Going forward, it appears that a hybrid market model with floor-based, open-outcry trading will co-exist with electronic trading both through limit order books and the NASDAQ dealer structure. Both NASDAQ and NYSE are now able to trade securities listed on the rival exchange. In August 2006, NASDAQ handled 12.5 percent of the volume in NYSE-listed securities, while the NYSE processed 21.3 percent of the trading in NASDAQ listings.

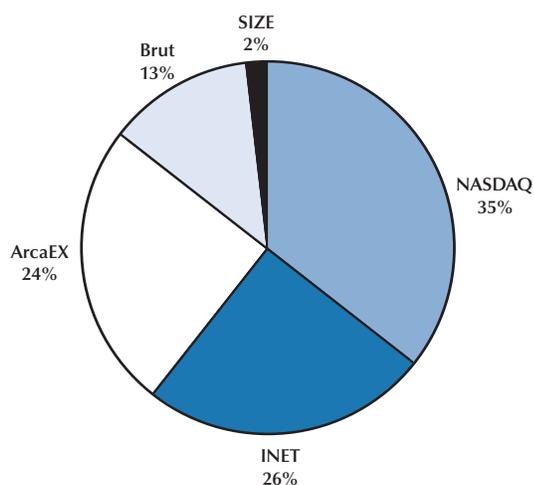
¹ A limit order is a request to buy or sell a security at a specific price. Market orders are buy/sell orders that are to be executed immediately, at current market prices.

ELECTRONIC TRADING IN EQUITY MARKETS, cont'd

Figure B1

ECN Share in Over-the-Counter Equities

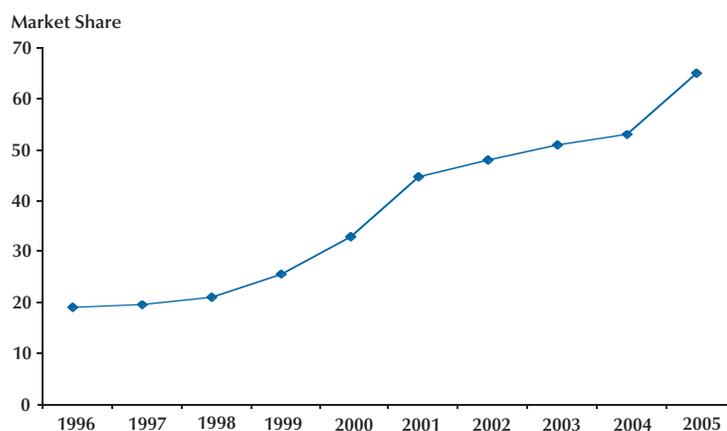
A. Trading Volume of NASDAQ-Listed Shares



NOTE: Brut is the Brass Utility ECN, ArcaEX is the Archipelago ECN, INET is Instinet, and SIZE is the NASDAQ anonymous trading facility. All other NASDAQ market makers are grouped into the NASDAQ 35 percent share. NASDAQ acquired BRUT in September 2004 and Instinet in December 2005.

SOURCE: Securities Industry News, Bloomberg, Instinet, Archipelago, and NASDAQ.

B. ECN's Share of Trading Volume in NASDAQ-Listed Shares



NOTE: The figure shows the growth of ECN trading since they entered the NASDAQ quote display in 1996.

SOURCE: Smith (2002), Merrill Lynch, Bloomberg, Instinet, Archipelago, and NASDAQ.

ELECTRONIC TRADING IN FOREIGN EXCHANGE MARKETS

The foreign exchange market is made up of customers, dealers, and IDBs. Customers are firms or individuals who buy or sell foreign exchange to hedge risk associated with business activities or balance sheet exposure, to manage investment portfolios, or to import/export goods and services. Hedge funds and pension funds, for example, frequently use the foreign exchange market to improve their investment performance. Corporations might buy foreign exchange to purchase needed intermediate goods from foreign suppliers. Dealers, who typically work for banks, stand ready to “make a market”—that is, to quote prices at which they are ready to buy or sell foreign exchange. Dealers wish to profit from the spread between the prices at which they buy and sell, as well as to take calculated intraday positions in currencies to profit from short-term expected changes in exchange rates. Dealers carefully manage their currency positions—especially overnight—to reduce their exposure to adverse exchange rate movements. Therefore, most trading in the foreign exchange market is between dealers who are seeking to manage their currency exposure. Interdealer brokers exist to facilitate this trading by matching buyers and sellers of foreign exchange. They do not take positions of their own.

Until the early 1990s, all foreign exchange trading was conducted via telephone. Reuters introduced the Reuters Market Data Service (RMDS) in February 1981, which permitted the exchange of information over computer screens, but did not allow actual trading. Reuters Dealing 2000-1 replaced RMDS in 1989. The new system facilitated direct trading that used to take place over the telephone (Rime, 2003).

Reuters continued to lead electronic trading in foreign exchange when it launched Dealing 2000-2 (D2000-2) in 1992. This network brokered trades between ex ante anonymous parties. Competitors soon followed, however. Minex launched an automated trading system in April 1993 and a consortium of large banks—ABN-AMRO, Bank of America, Barclays, Chemical, Citibank, Citicorp, Commerzbank, Credit Suisse, Lehman Brothers, Midland, J.P. Morgan, NatWest, Swiss Bankcorp, and Union Bank of Switzerland—followed suit by creating Electronic Broking Service (EBS) in April 1993, which later bought out Minex in 1996 (Chaboud and Weinberg, 2002).

For the first few years of their existence, the electronic trading systems’ (ETS) share of foreign exchange trading grew slowly. But the figure shows that electronic trading was clearly the dominant method of operation in the interdealer market by the late 1990s. Chaboud and Weinberg (2002) estimate the share of interdealer trading volume executed through electronic platforms to be over 60 percent by 2001. Voice trading remained important for customers and for less-liquid currencies. This is consistent with the general observation that electronic trading has its greatest advantages in the most liquid markets for homogenous assets.

Reuters and EBS remain the principal ETSs in the interdealer foreign exchange market as of early 2006. The latest incarnation of the Reuters network is called D3000. EBS has the foremost market share in trading in the two largest currency pairs, the euro-dollar and dollar-yen, while Reuters has a leading share in British pound currency pairs and the major market shares in a broader selection of exchange rates, including emerging market rates.

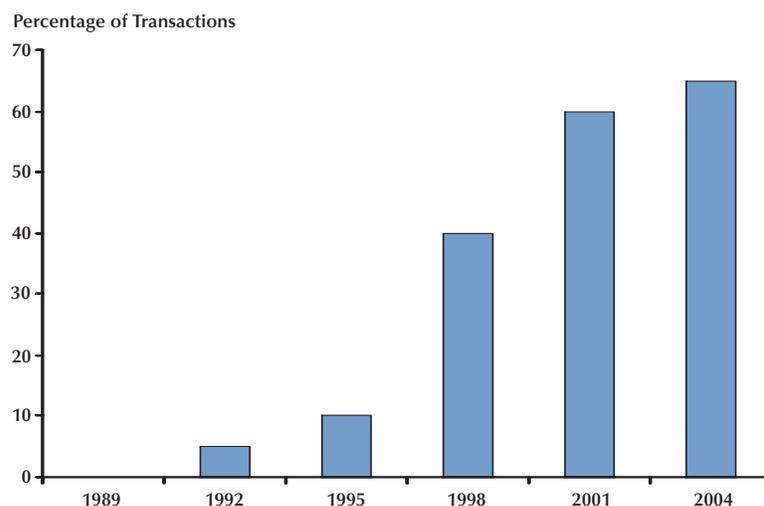
ELECTRONIC TRADING IN FOREIGN EXCHANGE MARKETS, cont'd

In recent years, the already large foreign exchange market has continued to grow. The Bank for International Settlements reports that foreign exchange trading volume grew by 36 percent, from 2001 to 2004 (BIS, 2005). Some of this growth has occurred on exchanges such as the Chicago Mercantile Exchange, which currently handles only a very small proportion of the foreign exchange market. In the midst of this expansion, the dealer market has consolidated; more trading is done by fewer and larger banks.

These large banks have their own (bank-specific) electronic trading platforms that allow direct bank-customer trading. The three banks with the highest volumes are Deutsche Bank, UBS, and Barclays, according to Kimbell, Newby, and Skalinder (2005). But there are now a number of smaller electronic networks that facilitate transactions between customers and dealers (e.g., FX All, FX Connect, and Currenex) and between customers without dealers (e.g., OANDA, HotSpot FX, IG Markets, FXDealerDirect, DealStation, ChoiceFX, Deal4Free Forex, GFT's DealbookFX, GCI, IFX Markets, and Grain Capital). These ECNs enable non-bank actors—such as hedge funds—to trade at prices that are very close to those enjoyed by the largest banks.

Figure B2

Electronic Trading in Foreign Exchange Markets Market Share of ECNs in Foreign Exchange Market Transactions



NOTE: Precise estimates of electronic foreign exchange broking systems' market share are difficult to come by because of the foreign exchange market's decentralized nature. The BIS (2004) estimates the 2004 number and states that the share increased slightly in that year by an unspecified amount.

SOURCE: Estimates for 1989-2001 are from Chaboud and Weinberg (2002). The BIS provides the 2004 number.

Transactions costs have fallen dramatically over the past decade. Fleming (1997) reports fees paid by the trade initiator of \$39 per \$1 million of bonds in the voice-brokered GovPX markets. By 2005, these fees had fallen by more than 90 percent to \$2.50 on eSpeed and \$2.00 on BrokerTec for the best customers (Kruger, 2005).

eSpeed's price improvement facility, a tool that allowed traders to offer prices between the quotes, reportedly also hurt them in the marketplace (*Computer Business Review*, 2005). The price improvement system proved complex and unpopular with customers. Quantity, rather than price negotiation, had been standard in the industry in the days of voice brokerage, and eSpeed eliminated the price-improvement tool in January 2005. These changes seem to have stabilized a duopoly in ECN on-the-run trading with the market split 60-40 between BrokerTec and eSpeed, respectively.

DATA SOURCES AND ANALYSIS

To study trading activity, spreads, and price impact, we rely on two publicly available historical transactions databases. The first is GovPX, which consolidated voice-brokered interdealer quotes and trades from Garban-Intercapital, Hilliard Farber, and Tullett & Tokyo Liberty during our sample period of 1999. Fleming (2003) describes the characteristics of liquidity in this market in the period from 1997 to 2000. Our second source is the eSpeed ECN, which recently began to offer a transactions database.

Both the GovPX and eSpeed data sets have their limitations. GovPX does not provide a reliable indicator of transactions after March 2001. The market share of voice-brokered trading has also substantially diminished since 1999. The eSpeed data set is from 2004, contains only on-the-run securities, and includes transactions but no quotes.

Trading Activity

Trading volume continues to grow in the government bond market much faster than the supply of Treasuries. The marketable federal debt

held by the public grew from \$3.64 trillion in fiscal year 1999 to \$4.31 trillion in fiscal year 2004.¹⁴ Figure 3 shows the average daily trading volume in Treasuries from 1994 to 2005. Since its 1999 nadir of under \$200 billion per day, the average volume of such transactions by primary dealers has almost tripled to nearly \$575 billion.

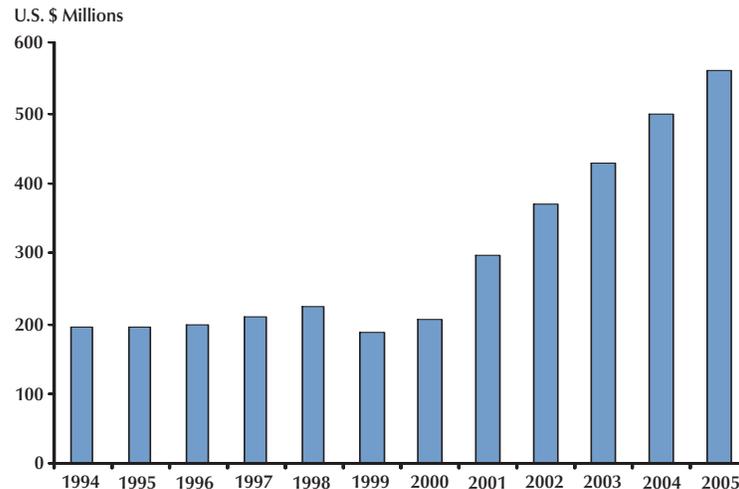
GovPX trading volume declined markedly after 1999 as ECNs, such as eSpeed and BrokerTec, began to attract business. Because the GovPX trade volume data become very thin after 1999, this paper will contrast GovPX data from 1999—the last year in which voice-brokered trading predominated—with eSpeed data from 2004.

While we omit the exact figures to protect confidentiality, the data show a dramatic increase in trading volume between 1999 and 2004, which dwarfs the tripling of the government bond market over the same period. It seems likely that the lower cost of trading through ECNs has facilitated much higher turnover, attracting new participants to the Treasury market. More than 50 percent of bids and offers on BrokerTec are now from *algorithmic trading* firms (Safarik, 2005) rather than the primary dealers.

Spreads

A standard measure of liquidity is the bid/ask spread. Dealers in the Treasury market post quotes, along with depth, to both buy and sell Treasuries. A combination of inventory and *adverse selection* costs explains the existence of spreads in the interdealer market. The inventory component is the cost of keeping a ready supply of securities for sale. The adverse selection component is due to the risk that the dealer's counterparty has private information about future price changes, which could lead to losses for the dealer. Adverse selection is less of a problem in the Treasury market (which is driven by publicly available information) than in equity markets (in which private

¹⁴ The debt figures are available at www.publicdebt.treas.gov/opd/opdpdodt.htm. Ironically, market participants and the Federal Reserve were concerned about running out of Treasuries just a few years ago when federal budget surpluses were growing. Alan Greenspan (2001) testified in January 2001: "At zero debt, the continuing unified budget surpluses currently projected imply a major accumulation of private assets by the federal government."

Figure 3**Average Daily Treasury Volume**

NOTE: The figure displays average daily volume of U.S. Treasury securities primary dealer transactions, by year.

SOURCE: Federal Reserve Bank of New York primary dealer data.

information is more important). We measure this markup for the GovPX data in 1999 and the eSpeed data in 2004.

The most basic measure of the bid/ask spread is the *quoted spread*. The quoted spread is the gap between lowest ask price, p_t^a , and the highest bid, p_t^b .¹⁵ It is computed in percentage terms to compare spreads across securities and over time:

$$(1) \quad s_t^q = 100 \times \frac{(p_t^a - p_t^b)}{p_t^a}.$$

Unfortunately, the eSpeed database does not include posted bid and ask prices, and we must compute an alternative measure based on transactions.

A commonly used procedure, first proposed by Thompson and Waller (1988), is to measure the spread for day t with the mean absolute change in the transactions prices:

$$(2) \quad S_t^{TW} = \sum_{i=i}^T |p_i - p_{i-1}|^+ / T^+,$$

where T^+ is the number of transactions in which the price changes on day t . The correlation between quoted spreads and the transactions measure is 0.99 in the GovPX data.

Table 1 summarizes the differences in Thompson and Waller (1988) bid-ask spreads as on-the-run trading moved to ECNs.

The GovPX voice market spreads average 0.8344 basis points for the 2-year note in 1999, compared with 0.2053 for the eSpeed ECN quotes in 2004, a reduction of 75 percent. The reduction is similar for other maturities: 0.8834 basis points in the 5-year, or 76 percent; 1.7167 basis points in the 10-year, or 82 percent; and, finally, 4.2622 basis points in the 30-year, or 78 percent. These substantial declines are statistically and economically significant.

MARKET IMPACT

A purchase or a sale of an asset might influence prices either through inventory effects or by

¹⁵ Many transactions take place within the quoted spread, though. GovPX provides a *workup facility* to increase the transaction size but not change the price. Until January 2005, the eSpeed network provided an explicit mechanism for trading between the bid and ask, a process known as *price improvement*.

Table 1
Spreads in the Voice and ECN Markets

	GovPX	eSpeed	Δ Spread	Percent change
2-year	0.8344	0.2053	-0.6291	-75
5-year	1.1572	0.2738	-0.8834	-76
10-year	2.0986	0.3819	-1.7167	-82
30-year	5.4484	1.1862	-4.2622	-78

NOTE: The GovPX estimates are from 1999, and the eSpeed estimates are from 2004. The spread units are in basis points (hundredths of a percent).

Table 2
Market Impact Estimates for the Voice and ECN Markets

	GovPX	eSpeed
2-year	0.4235	0.2321
5-year	0.9368	0.1709
10-year	0.9066	0.1850
30-year	2.2936	0.2749

NOTE: These are the 15-minute cumulative market impact effects for the January 1999 GovPX database and for the January 2004 eSpeed transactions based on the VAR analysis shown by equations (3) and (4). The units are in basis points (hundredths of a percent).

revealing private information about fundamentals to other market participants. One would like to know how much trades impact prices. Price impact increases the cost of large trades, and such costs are often larger than brokerage commissions and spreads. This section examines the interaction between trades and quotes using the vector autoregressive (VAR) system methods that Hasbrouck (1991) introduced.

Hasbrouck proposed to study intraday price formation with a standard bivariate VAR model. Time t here is measured in 1-minute intervals. Let r_t be the percentage change in the transaction price. x_t^0 is the sum of signed trade indicators (+1 for buyer initiated, -1 for seller initiated) over minute t . Fortunately, both data sets directly indicate trade initiation as a “hit” -1 or a “take” +1.¹⁶

The bivariate VAR assumes that causality flows from trade initiation to returns by permitting r_t to depend on the contemporaneous value for x_t^0 , but not allowing x_t^0 to depend on contemporaneous r_t . The quote revision model is specified as follows:

$$(3) \quad r_t = a_{r,0} + \sum_{i=1}^5 a_{r,i} r_{t-i} + \sum_{i=0}^{15} b_{r,i} x_{t-i}^0 + \varepsilon_{r,t},$$

$$(4) \quad x_t^0 = a_{x,0} + \sum_{i=1}^5 a_{x,i} r_{t-i} + \sum_{i=1}^{15} b_{x,i} x_{t-i}^0 + \varepsilon_{x,t}.$$

We estimate two versions of the VAR model for each instrument: One version uses GovPX data from 8:20 to 15:00 each day in January 1999, and the other version uses similar eSpeed data from January 2004. The original number of observations varied from instrument to instrument before aggregating to one-minute frequency. For example there were 17,127, 62,175, 75,791, and 19,706 observations for the 2-, 5-, 10-, and 30-year bonds for the Cantor data. After aggregating to one-minute returns there were 8,000 observations for the 20 trading days in the Cantor data and 7,600 observations for the 19 trading days in the GovPX data. To allow comparison with other more-recent market impact studies, such as Cohen and Shin (2003), we include 15 lags of the signed trades.¹⁷

¹⁶ In microstructure databases, this inference is usually determined by distance from the quote midpoint.

¹⁷ Given the potentially unusual distribution of the order flow variable, x_t^0 , we considered nonlinear specifications—products of leads and lags—but they do not enter the VAR significantly or change substantially the market impact estimates. There does not appear to be any significant nonlinearity in the dependent variable.

Our estimates show that trade indicators are positively autocorrelated and highly predictable. In other words, buyer- (seller-) initiated trades reliably tend to follow buyer- (seller-) initiated trades. As one might expect from simple versions of the efficient markets hypothesis, returns are not very predictable, except through contemporaneous orders. That is, net buyer- (seller-) initiated trades are associated with contemporaneous price increases (decreases).

The market impact of the trade can be measured by the dynamic effect on subsequent trade prices. The impact grows over time, generally stabilizing after about 15 minutes. We report 15-minute impact estimates in Table 2 for the 2-, 5-, 10-, and 30-year bonds. GovPX estimates for January 1999 are reported in the first column, and eSpeed estimates for January 2004 are reported in the second column. The coefficients are in basis points (hundredths of a percent).

The smallest GovPX market impact is for the 2-year note. Nonetheless, a one-unit (\$1 million) buy order still moves trade prices by 0.4235 basis points, nearly double the eSpeed impact for the same issue. The relative market impact is inversely related to the relative volumes of the two markets. For the other issues, the GovPX market impact is five to eight times as large, with the latter figure for the illiquid 30-year Treasury. On average, the eSpeed market impact is 73.6 percent lower than that of GovPX.

We believe that market impact is the most comprehensive measure of market quality, reflecting spreads, depths, and trading volume. The eSpeed ECN seems to illustrate that electronic trading in the secondary Treasury market benefits market participants by reducing spreads and transactions costs.

CONCLUSION

This article has reviewed the growth of ECNs in equity, foreign exchange, and the U.S. Treasury markets. The growth of such ECNs has enabled firms and individuals to trade and rebalance their portfolios at much lower cost, thereby enabling them to reduce the risk to which they are exposed.

In particular, this article has examined the growth of electronic competition in the secondary market for U.S. Treasury bonds. The eSpeed and BrokerTec ECNs have captured virtually the entire market for the on-the-run Treasuries. This paper has studied transactions from eSpeed for 2004, a data set that has not yet been explored in the literature, and documented improvements over the earlier voice-assisted technology. The eSpeed ECN has greater volume, smaller spreads, and a lower estimated impact of a trade. Lower spreads can benefit smaller traders by lowering their costs of portfolio rebalancing. A smaller market impact ensures that institutional investors get similar benefits.

REFERENCES

- Bank for International Settlements, Committee on the Global Financial System. *The Implications of Electronic Trading in Financial Markets*. 2001.
- Bank for International Settlements, Committee on the Global Financial System. *Triennial Central Bank Survey: Foreign Exchange and Derivatives Market Activity in 2004*. March 2005.
- Barclay, Michael J.; Hendershott, Terrence and Kotz, Kenneth. "Automation Versus Intermediation: Evidence from Treasuries Going Off the Run." Forthcoming in the *Journal of Finance*, October 2006.
- Chaboud, Alain and Weinberg, Steven. "Foreign Exchange Markets in the 1990s: Intraday Market Volatility and the Growth of Electronic Trading." *Bank of International Settlements Papers*, 2002, 12(Part 8), pp. 138-47.
- Christie, William and Schultz, Paul. "Why Do NASDAQ Market Makers Avoid Odd-Eighth Quotes?" *Journal of Finance*, December 1994, 49(5), pp. 1813-40.
- Cohen, Benjamin H. and Shin, Hyun Song. "Positive Feedback Trading Under Stress: Evidence From the U.S. Treasury Securities Market." BIS Working Paper No. 122, Bank for International Settlements, January 2003.

Mizrach and Neely

- Computer Business Review*. "eSpeed to Remove Price Improvement Feature." January 7, 2005.
- Department of Justice. "ICAP PLC and BrokerTec LLC Restructure Deal after Justice Department Raises Antitrust Objections." Department of Justice Press Release, April 22, 2003.
- Economides, Nicholas and Robert A. Schwartz. "Electronic Call Market Trading." *Journal of Portfolio Management*, Spring 1995, 21(3), pp. 10-18.
- Fabozzi, Frank J. and Michael J. Fleming. "U.S. Treasury and Agency Securities," in Frank J. Fabozzi, ed., *The Handbook of Fixed Income Securities*, 7th Edition. New York: McGraw Hill, 2005.
- Fleming, Michael J. "The Round-the-Clock Market for U.S. Treasury Securities." Federal Reserve Bank of New York *Economic Policy Review*, July 1997, 3(2), pp. 9-32.
- Fleming, Michael J. "Are Larger Treasury Issues More Liquid? Evidence from Bill Reopenings," *Journal of Money, Credit, and Banking*, August 2002, 34(3), pp. 707-35.
- Fleming, Michael J. "Measuring Treasury Market Liquidity." Federal Reserve Bank of New York *Economic Policy Review*, September 2003, 9(3), pp. 83-108.
- Garbade, Kenneth D. and Ingber, Jeffrey F. "The Treasury Auction Process: Objectives, Structure, and Recent Adaptations." Federal Reserve Bank of New York *Current Issues in Economics and Finance*, February 2005, 11(2), pp. 1-11.
- Greenspan, Alan. "Outlook for the Federal Budget and Implications for Fiscal Policy." Testimony before the Committee on the Budget, U.S. Senate, January 25, 2001.
- Hasbrouck, Joel. "Measuring the Information Content of Stock Trades." *Journal of Finance*, March 1991, 46(1), pp. 179-207.
- Kimbell, Deborah; Newby, Andrew, and Skalinder, David. "The Big Get Bigger—But Is It for the Best?" *Euromoney*, May 2005, 36(433), pp. 74-85.
- Kruger, Daniel. "On the Run." *Forbes*, August 15, 2005.
- Kutler, Jeffrey. "Cantor Spin-Offs Prepare Integrated Platform for Repos." *Securities Industry News*, January 16, 2006, p. 11.
- Mizrach, Bruce. "Does SIZE Matter: Liquidity Provision By The Nasdaq Anonymous Trading Facility." Rutgers University Working Paper, December 2005.
- Mizrach, Bruce and Neely, Christopher J. "The Microstructure of Bond Market Tatonnement." Federal Reserve Bank of St. Louis Working Paper No. 2005-70, November 2005.
- Nyborg, Kjell G. and Sundaresan, Suresh. "Discriminatory versus Uniform Treasury Auctions: Evidence from When-Issued Transactions." *Journal of Financial Economics*, September 1996, 42(1), pp. 63-104.
- Rime, Dagfinn. "New Electronic Trading Systems in Foreign Exchange Markets," in Derek C. Jones, ed., *New Economy Handbook*. Chapter 21. New York: Elsevier, 2003, pp. 469-504.
- Rust, John and Hall, George. "Middlemen versus Market Makers: A Theory of Competitive Exchange." *Journal of Political Economy*, April 2003, 111(2), pp. 353-403.
- Safarik, Daniel. "Fixed Income Meets the Black Box." *Wall Street & Technology*, October 24, 2005, pp. A7.
- Securities and Exchange Commission, Department of the Treasury, Board of Governors Federal of the Reserve System. *Joint Report on the Government Securities Market*. 1992.
- Securities and Exchange Commission and Department of the Treasury. *Special Study: Electronic Communication Networks and After-Hours Trading*. 2000.
- Smith, G.W. "ECN Market Share Analysis: Fourth Quarter 2001." Equity Research, J.P. Morgan Securities Inc., January 30, 2002.
- Thompson, Sarahelen. R., and Waller, Mark L. "The

Intraday Variability Of Soybean Futures Prices: Information and Trading Effects.” *Review of Futures Markets*, 1988, 7(1), pp. 110-126.

Zuckerman, G.; Davis, A. and McGee, S. “Before and After: Why Cantor Fitzgerald Can Never Re-create What It Once Was.” *Wall Street Journal*, October 26, 2001, p. A1.

Wall Street & Technology. Electronic-Trading Newsflashes, March 29, 2004.

GLOSSARY

Agency securities are issued by institutions established by the U.S. government, such as the Student Loan Marketing Association (Sallie Mae). Such institutions were created to lower borrowing costs in favored sectors of the economy.

Algorithmic trading is the practice of automatically transacting based on a quantitative model.

A *broker* is a firm that matches buyers and sellers in financial transactions. Brokerage firms in bond markets do not trade for their own account. An *interdealer broker* (IDB) is an intermediary providing trading services to hedge funds, institutions, and other dealers. IDBs handle the majority of Treasury securities transactions in the secondary market.

A *commoditized security* has been altered to increase its liquidity, making it an undifferentiated product traded solely on price.

Depth is the quantity the dealer is willing to sell at the bid or offer.

Electronic communications networks (ECNs) are electronic trading systems that automatically match buy and sell orders at specified prices.

A *limit order* is a request to buy or sell a security at a specific price. Market orders are buy/sell orders that are to be executed immediately, at current market prices.

A *mortgage-backed security* is a bond whose payoff is backed by the payments on a pool of mortgages, such as those issued by Freddie Mac.

On-the-run refers to the most recently auctioned Treasury security of a particular maturity. After the next auction, the other bonds go off-the-run.

The *quoted spread* is the gap between lowest ask price and the highest bid.

Trading in on-the-run and off-the-run securities makes up the *secondary* Treasury market.

Strips are portions of securities that have been separated into different assets. U.S. Treasury bonds, for example, are often split into principal and interest components and each can be separately owned. Such division permits the construction of zero-coupon bonds. STRIPS stands for “Separate Trading of Registered Interest and Principal Securities.”

Parties to an *interest rate swap* exchange interest payments on a notional principal amount. Typically, one party pays a fixed interest rate, while the other party pays a floating rate.

When-issued bonds are those Treasuries whose auctions have been announced but that have not yet been delivered.



What Are the Odds? Option-Based Forecasts of FOMC Target Changes

William R. Emmons, Aeimit K. Lakdawala, and Christopher J. Neely

This article uses probability forecasts derived from options to assess evolving market uncertainty about Federal Reserve monetary policy actions in a variety of recent events and episodes. Options on federal funds futures contracts reveal a complete probability density function over possible Federal Reserve target rates, thus augmenting the expectations provided by federal funds futures contracts. Option-based forecasts are most useful when more than two federal funds target outcomes are plausible at an upcoming policy meeting. (JEL E47, E52, G13)

Federal Reserve Bank of St. Louis *Review*, November/December 2006, 88(6), pp. 543-61.

Options on federal funds futures contracts provide information about market expectations of Federal Open Market Committee (FOMC) monetary policy actions above and beyond that provided by federal funds futures contracts alone. In particular, options provide important information about the dispersion and skewness of market expectations. Under some assumptions, option prices imply a complete probability density function (PDF) over possible FOMC target-rate choices.

This article uses the method of Carlson, Craig, and Melick (2005) to extract an implied risk-neutral probability density function over possible future federal funds target rates from daily option prices. Option-based forecasts are most useful when more than two federal funds target outcomes are plausible at an upcoming FOMC meeting. If only one or two meeting outcomes are plausible, a futures-based forecast is simpler and more appropriate.

FEDERAL FUNDS FUTURES OPTIONS

The Chicago Board of Trade has offered futures contracts written on the federal funds rate since 1988. For more than a decade, trading volumes in these contracts remained miniscule in comparison with other interest rate futures contracts, such as 3-month eurodollar and long-term Treasury securities. Researchers nonetheless have found that federal funds futures contracts provide useful information about market expectations of short-term interest rate movements (Poole, Rasche, and Thornton, 2002; Sack, 2004; and Piazzesi and Swanson, 2005).

For reasons that are not well understood, trading volumes in the federal funds futures contracts increased dramatically after 2000.¹ This led to the introduction, in 2003, of exchange-traded

¹ See Carlson, Craig, and Melick (2005) for a more extensive discussion of federal funds futures options contracts and market conventions. The Chicago Board of Trade provides contract specifications and current market prices for both federal funds futures and futures options at www.cbot.com/cbot/pub/cont_detail/0,3206,1525+14453,00.html.

William R. Emmons is a senior economist, Aeimit K. Lakdawala was a research associate at the time this article was written, and Christopher J. Neely is a research officer at the Federal Reserve Bank of St. Louis.

© 2006, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if copyright notice, author name(s), and full citation are included. Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis.

THE FEDERAL FUNDS FUTURES AND OPTIONS-ON-FUTURES MARKETS

The 30-day federal fund futures contract is an interest rate derivative, which has been traded on the Chicago Board of Trade since October 3, 1988. The volume of trading on federal funds has grown dramatically since the market's inception, reaching almost 6.3 million contracts traded in 2002. Prices on the federal funds futures markets are quoted as 100 minus the average daily federal funds overnight rate for the delivery month. That is, a price quote of 96.1 implies an average daily interest rate of $(100 - 96.1 =) 3.9$ percent for the delivery month.

Contracts are settled in cash, at 2:00 p.m. central time, on the last trading day of the month. The final settlement price for the contract is the average daily federal funds overnight rate for the delivery month, as reported by the Federal Reserve Bank of New York. The average is calculated over calendar days. The notional contract size is \$5 million, which means that a rise in the contract price of 1 basis point nets (costs) a holder of a long (short) position \$41.67. The \$41.67 is the increase in the interest earned from a 1-basis-point rise in interest rates on a deposit held for 30 days, using a day count of 360 days per year ($41.67 = 5,000,000 * 0.0001 * 30/360$). The minimum quote size is one-half of 1 basis point.

The Chicago Board of Trade has sponsored trading American options on federal funds futures contracts since March 14, 2003.¹ Strike prices are created every 6.25 basis points. The asset underlying the options contract is one federal funds futures contract. Option premia are quoted in basis points and the minimum tick size is one-quarter of 1 basis point or \$10.4175. Options contracts trade until the last business day of the delivery month.

Because other short-term interest rates closely track the federal funds rate, federal funds futures can be used to hedge general short-term interest rate risk and/or speculate on future short-term interest rates. And the design of the options on federal funds futures permits speculators to invest based on detailed views on the likely path of the future funds rate. Therefore a variety of users find federal funds futures and options on federal funds futures to be useful. Users of options on federal funds futures include issuers of commercial paper, portfolio managers, dealers in government securities, hedge fund managers, and even foreign exchange dealers.

¹ American options can be exercised any time until expiry; European options can be exercised only at expiry.

options contracts written on federal funds futures contracts. A federal funds futures call option, for example, gives the buyer the right, but not the obligation, to obtain a long position in the referenced federal funds futures contract at a pre-specified price. The options are American-style (i.e., they can be exercised at any time up to or at maturity) and are settled in cash rather than by actual delivery of the futures contract. Trading volume in federal funds futures options has varied considerably over time, but substantial amounts of open interest have been observed in some contracts. The first boxed insert, on the federal funds

futures and options-on-futures markets, reviews the specifications of those derivative contracts.

Finance theory long has recognized that a rich set of option contracts written on any underlying financial instrument or economic variable, such as an interest rate (or interest rate futures contract), can provide a great deal of information beyond simple expectations of a future price. In particular, option prices reveal how much investors are willing to pay for a chance to profit from an "extreme" future movement in the spot price of the reference instrument, either up or down. Therefore, option prices can potentially tell

us about investors' expectations, including how likely "extreme" movements are thought to be.

Changes in estimated probability density functions over time illuminate how market uncertainty about Federal Reserve monetary policy intentions or actions evolved during significant episodes or events during the period June 2003 through April 2006.² The events we study are as follows:

- *A pre-commitment to extended policy accommodation:* In August 2003, the Federal Reserve publicly committed itself to maintaining monetary policy accommodation for a "considerable period."
- *A signal of an impending target change:* In May 2004, the Federal Reserve signaled that its first target-rate increase in four years was forthcoming.
- *A pre-commitment to gradual removal of policy accommodation:* Beginning in June 2004, the Federal Reserve publicly committed itself to a policy of raising the federal funds target rate at a "measured pace."
- *Devastating hurricanes:* In August and September 2005, a series of hurricanes devastated parts of the U.S. Gulf Coast, creating uncertainty about their economic impacts and the Federal Reserve's likely response.
- *Congressional testimony and public communication:* Reports of Chairman Bernanke's April 2006 testimony before the Joint Economic Committee whipsawed financial markets.

In each case, we study the federal funds futures option-implied probabilities assigned by market participants to possible Federal Reserve target-rate choices at upcoming meetings. In the first and third cases listed above, our data allow us to evaluate the (evolving) credibility of Federal Reserve commitments to future actions. The second and fourth cases are examples of market uncertainty about both economic fundamentals

and the Federal Reserve's likely reactions to these fundamentals. Finally, the last case clearly illustrates pronounced market reactions to Federal Reserve communication efforts.

The remainder of the article is organized as follows. The next section briefly discusses federal funds futures contracts as market-based indicators of expected monetary policy actions. Then, we describe option contracts on federal funds futures and explain how one can extract probability density functions over future Federal Reserve target-rate choices from such option prices. Finally, we use daily option-derived risk-neutral probability density functions to explore the evolution of market uncertainty about future interest rates during several recent episodes.

FEDERAL FUNDS FUTURES CONTRACTS AND EXPECTED MONETARY POLICY ACTIONS

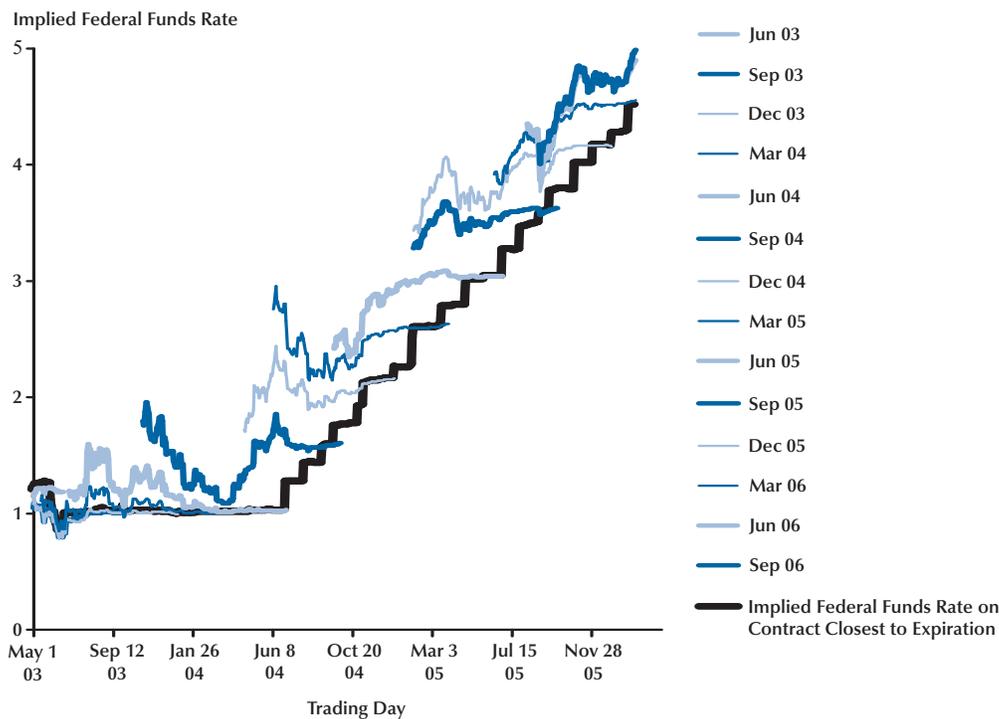
Figure 1 displays the implied federal funds rate from the futures contract closest to expiration (heavy black line), as well as the implied average rate on every third federal funds rate futures contract traded between May 1, 2003, and February 9, 2006 (all other lines). Several futures contracts trade on any given day, each written on a different future month. For example, 12 different futures contracts traded on December 2, 2005—one referring to each month from December 2005 through November 2006. Figure 1 shows only those from December 2005 and March, June, and September 2006.

The final settlement price on each month's contract depends on the average effective daily federal funds rate during that contract month. That is, the December 2005 settlement price was 95.84, calculated as 100 minus the 30-day average of actual effective federal funds rates observed during December 2005, which was 4.16 percent. As each contract trades over time—until settlement on the first business day after the end of the contract month—the market price converges toward the final settlement price. The figure illustrates that the volatility of futures prices varies over time, indicating that uncertainty about future interest rates likewise varies. Note that, while

² In related research, Neely (2005) relates surprises in federal funds target changes to large changes in the implied volatility of 3-month eurodollar rates.

Figure 1

Daily Federal Funds Target Rate and Futures-Implied Yields Between May 1, 2003, and February 9, 2006



NOTE: The thick black line is the implied federal funds rate from the contract closest to expiration. The other lines represent implied yields from daily settlement of federal funds futures contracts traded between May 1, 2003, and February 9, 2006.

uncertainty (volatility) about a particular contract’s settlement price decreases over time, the decline in uncertainty is not monotonic.

Federal funds futures contracts usefully gauge market expectations about future FOMC monetary policy actions, although there are more sophisticated approaches to forecasting rate changes and levels (e.g., Sarno, Thornton, and Valente, 2005). There is some evidence that econometric models may improve on the implied forecasts from futures prices, particularly at long horizons, where risk premia might be larger and futures trading volume is much lower.

Expected federal funds targets derived from federal funds futures contracts represent only the central tendency (the mean) of market expectations, not the dispersion of expectations about

potential outcomes. Dispersion of expectations increases with the forecast horizon. The next section explains how options on short-dated money-market instruments inform us about expected volatility (uncertainty), the direction of risks (asymmetry), and the relative probability of extreme events (kurtosis). One can interpret the dispersion of expectations as measuring the public’s uncertainty about monetary policy.

OPTIONS ON FEDERAL FUNDS FUTURES CONTRACTS

Option contracts written on federal funds futures contracts provide a tool to measure (and speculate on) the uncertainty among market participants about future monetary policy actions.

The Bank of England has used the information contained in option prices for informational purposes for some time, and other central banks may follow.

There is a large academic literature that uses market data to forecast interest rates. Recent examples using data from the federal funds futures market to forecast future Federal Reserve policy actions include Poole, Rasche, and Thornton (2002), Sack (2004), and Piazzesi and Swanson (2005). Another strand of the literature investigates the use of options on interest rate futures contracts to assess market expectations of future short-term interest rates. Papers investigating option-based forecasts include Abken (1995), Soderlind and Svensson (1997), Bliss and Panigirtzoglou (2002), Andersen and Wagener (2002), Hordahl and Vestin (2005), and Carlson, Craig, and Melick (2005). This article builds on the option-based forecasting research pioneered in these papers.

How Liquid Are Federal Funds Futures and Futures Options?

Although one would like to estimate expectations of federal funds rate targets for the indefinite future, futures and futures-option contracts do not have sufficient liquidity to derive expectations more than a few months ahead. Figure 2 shows trading volume and open interest (log scale, by forecast horizon) for futures and options on futures for trading days in November 2005. The greatest trading volume occurs in options on futures contracts expiring 1 to 3 months in the future; there is still non-negligible volume in options 4 to 5 months ahead and practically no volume more than 6 months ahead. The open interest charts tell a similar story. Open interest falls off from 3 to 4 months and then to very low levels at 6 months.

Thus, futures and options on futures may not be very informative at long horizons. Note, however, that the trading volume and open interest in options—which include all strike prices—are much greater than that in the underlying futures contract. Fluctuations in trading volume over longer periods appear to indicate that trading increases during turbulent periods, precisely when information is most needed.

Probability Densities Over the Federal Funds Target Rate

The payoffs to options on federal funds futures depend only on the average federal funds rate over the contract expiration month. Therefore, the price of the option provides some information on the likelihood of various outcomes. For example, if the price of a given call option rises, then—all else equal—the market expects a greater probability of a higher final settlement price (a lower interest rate).

To translate option prices into risk-neutral probabilities of specific outcomes, however, one must make some assumption about the risk premia that investors require (or are willing to pay) to take certain risks. Carlson, Craig, and Melick (2005) compare the task of obtaining probabilities from option prices to estimating the probability of a fire from the price of fire insurance. If fire insurance companies demand a risk premium to insure houses, then one must know this premium to accurately estimate the probability of a fire from the price of insurance and the firm's contingent liability.

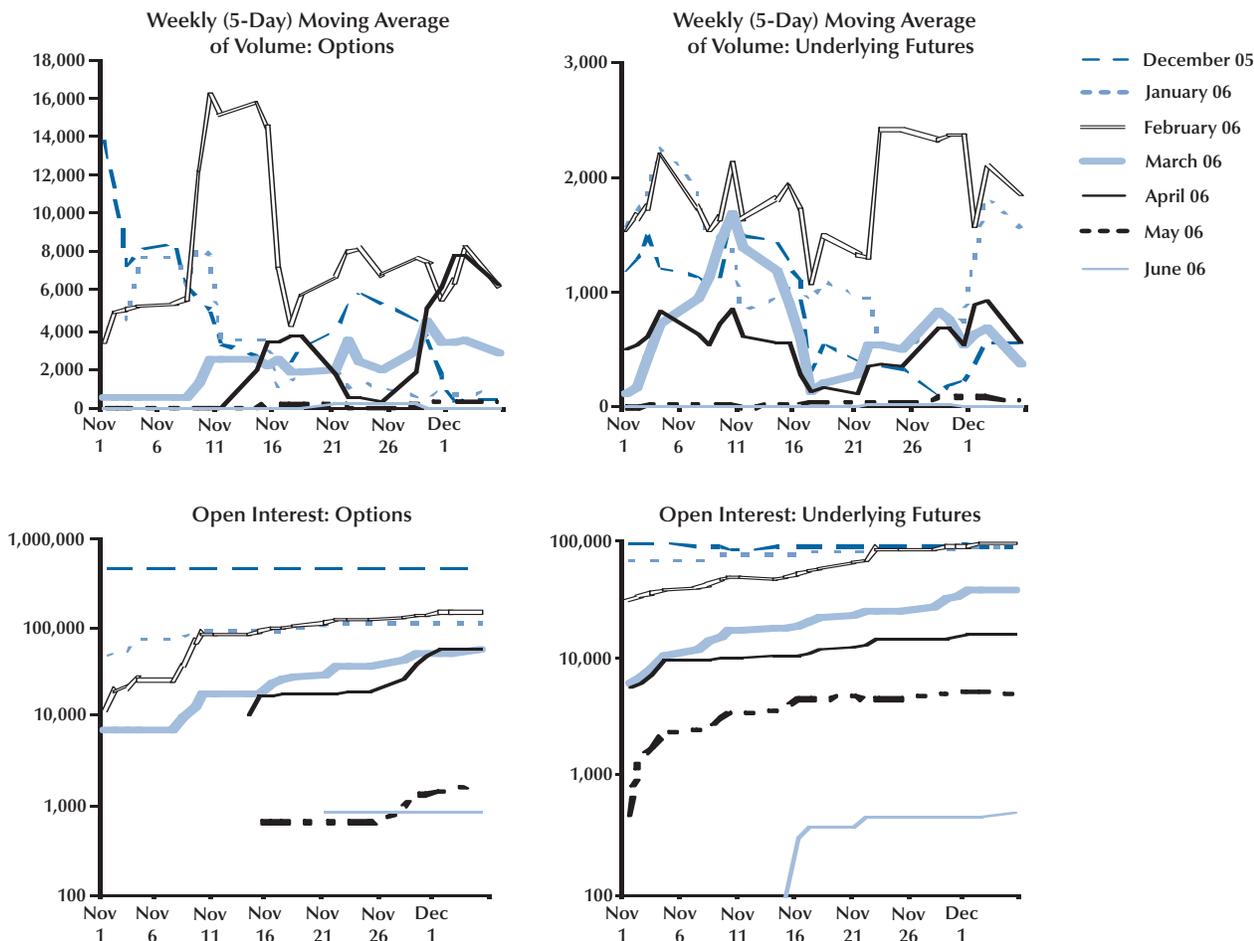
Similarly, to infer the probability density function over possible federal funds target rates from option prices, one must make some assumptions about risk premia embedded in federal funds futures prices. One hypothesis is that the marginal investors (buyers and sellers) are risk-neutral (i.e., that observed prices are actuarially fair). However, Hordahl and Vestin (2005), among others, find evidence of important differences between risk-neutral and objective (i.e., realized) probability distributions in bond prices.

In general, it is not clear whether these discrepancies represent risk premia in the economic sense of compensation for risk. Piazzesi and Swanson (2005) document substantial prediction biases in federal funds futures prices and label them risk premia. Table 1, excerpted from Piazzesi and Swanson (2005), shows the estimates of the difference between futures-rate predictions and realized interest rates n months ahead. The estimated regression is as follows:

$$(1) \quad f_t^n - r_{t+n} = \alpha^{(n)} + \varepsilon_{t+n}^n,$$

Figure 2

Trading Volumes and Open Interest on Federal Funds Futures and Futures Options During November 2005



NOTE: The figure displays open interest (lower panels) and trading volumes (upper panels) from federal funds futures contracts (right panel) and option contracts (left panel) in November 2005. The vertical scales for the lower panels are in logarithmic form.

where f_t^n is the n -period-ahead interest rate implied by the federal funds futures price in month t and r_{t+n} is the actual (realized, ex post) average funds rate in month $t+n$, to which the federal funds futures price should converge. Thus, the value of $\alpha^{(n)}$ in the table corresponding to the 1-month horizon (3.4) indicates that the futures-implied forecast of the interest rate exceeds the realized 1-month-ahead interest rate by 3.4 basis points, on average.

Table 1 indicates that the forecasted federal funds rate exceeds the actual rate by 3 to 6 basis points per month of the forecast horizon. At a 6-month horizon, Piazzesi and Swanson estimate a 73-basis-point risk premium on an annualized basis. This appears implausibly large to Carlson, Craig, and Melick (2005), who point out that one observes only a prediction bias; its meaning is unclear. For this reason, they assume no risk premium at all.

Table 1**Piazzesi and Swanson (2005) Estimates of Federal Funds Futures Risk Premia**

<i>n</i>	1	2	3	4	5	6
$\alpha^{(n)}$	3.4	7.4	12.5	19.2	27.6	36.7
(<i>t</i> -statistic)	(3.9)	(3.6)	(3.2)	(3.2)	(3.2)	(3.1)
Annualized	41.2	44.6	49.9	57.6	66.3	73.4

NOTE: The table is excerpted from Piazzesi and Swanson (2005). The table shows results from regressing the difference between the implied average federal funds rate, *n* months ahead, on the realized federal funds rate for that month, from 1988:10 to 2003:12: $f_t^n - r_{t+n} = \alpha^{(n)} + \varepsilon_{t+n}^{(n)}$. Standard errors are heteroskedastic and autocorrelation consistent; *t*-statistics from those standard errors are in parentheses; $\alpha^{(n)}$ is measured in basis points.

Although we are uncertain about the existence and magnitude of risk premia in futures prices, we think that it is reasonable to assume that the prediction bias is 1 basis point per month in the empirical work that follows. For our purposes in illustrating broad movements of market expectations over time, the precise nature of our risk-premium assumption is not critical. The second boxed insert, on risk premia versus term premia, discusses whether one should interpret any observed prediction bias in the federal funds futures market as a term premium, a common interpretation of a risk premium in fixed-income markets.

In addition to a risk premium in the level of the futures price, there might be significant risk premia associated with exposure to option-price changes caused by changing volatility. Such premia are more difficult to estimate, although some researchers have begun to do so. Nevertheless, even in the presence of constant but unknown risk premia, changes in estimated PDFs still presumably tell us about changes in the true, physical density.

Estimating Federal Funds Target Probability Densities

Densities for asset prices (or interest rates) have been derived under a variety of assumptions about the functional form of the distribution. For asset prices that take continuous values, such as equities or foreign exchange, estimating densities quickly becomes very complicated and technical. Fortunately, the fact that the federal funds target rate historically has taken on a discrete set of

values—in multiples of 25 basis points since 1989—greatly simplifies its estimation.

Consider a scenario in which the Fed is certain to choose from only three possible target rates, $\{T_1, T_2, \text{ and } T_3\}$. Each of these three targets implies a unique average federal funds rate $\{F_{T,1}, F_{T,2}, \text{ and } F_{T,3}\}$ for the month of the FOMC meeting if the target is known to change only on the date of the FOMC meeting, day *N*. Given an initial value for the federal funds target at the start of the month, T_0 , and a given target, T_1 (set at the FOMC meeting), one can solve for the average federal funds rate, $F_{T,1}$, that T_1 implies, as follows:

$$(2) \quad F_{T,1} = T_0 N / 30 + T_1 (30 - N) / 30.$$

If three options, with strike prices $X_1, X_2, \text{ and } X_3$, are actively traded on a given day, where X_1 is the strike on a call and X_2 and X_3 are the strikes on puts, then the probability of the selection of each target can be estimated using the following regression:

$$(3) \quad \begin{bmatrix} e^{r(T-t)}C(t, T, X_1, F_t) \\ e^{r(T-t)}P(t, T, X_2, F_t) \\ e^{r(T-t)}P(t, T, X_3, F_t) \end{bmatrix} = \begin{bmatrix} \max(0, F_{T,1} - X_1) & \max(0, F_{T,2} - X_1) & \max(0, F_{T,3} - X_1) \\ \max(0, X_2 - F_{T,1}) & \max(0, X_2 - F_{T,2}) & \max(0, X_2 - F_{T,3}) \\ \max(0, X_3 - F_{T,1}) & \max(0, X_3 - F_{T,2}) & \max(0, X_3 - F_{T,3}) \end{bmatrix} \begin{bmatrix} \pi_1 \\ \pi_2 \\ \pi_3 \end{bmatrix} + \begin{bmatrix} \varepsilon_{t,1} \\ \varepsilon_{t,2} \\ \varepsilon_{t,3} \end{bmatrix},$$

where the variables on the left-hand side are the riskless values of the current option prices at expiry and the explanatory variables are the payoffs to the options under the three states of the

RISK PREMIA VERSUS TERM PREMIA IN THE FEDERAL FUNDS FUTURES MARKET

Futures prices of non-storable commodities embody only market expectations of future supply and demand conditions. Non-storable commodities are perishables—things that cannot be set aside and carried into future periods. Fresh eggs, for example, are non-storable because they spoil quickly and cannot be frozen or otherwise preserved.

Federal funds futures prices reflect the value today of a future claim on deposit balances at the Federal Reserve (reserves). Reserves are non-storable because a bank cannot hold reserves today to satisfy future reserve requirements. Thus, today's federal funds futures prices reflect market expectations of future reserve-market conditions. In other words, they are an indicator of future Federal Reserve monetary policy actions.

There could be a market-risk or liquidity premium associated with trading of federal funds futures contracts because their expected returns co-vary with other returns and because this market is not perfectly liquid. However, any such premium should not be thought of as a traditional term premium. Because every future period's reserve-market conditions are independent of all previous period's conditions—that is, there is no possible riskless arbitrage between them—we would not expect any systematic relationship between a futures price and the contract's term to maturity (i.e., a term premium).

world (possible FOMC target-rate choices).³ The coefficients $\{\pi_1, \pi_2, \pi_3\}$ are the probabilities that set the expected payoffs of the options (right-hand side) equal to the values of the options at expiry. Probabilities of specific targets on FOMC meeting dates can be calculated from probabilities of the average funds rates over a month, as in (2).

Carlson, Craig, and Melick (2005) discuss in detail how the system can be estimated by ordinary least squares, imposing equality restrictions such as $\pi_1 + \pi_2 + \pi_3 = 1$. Alternatively, one can numerically maximize the likelihood function, under some assumption about the distribution of the error terms. Estimation by maximum likelihood permits more elaborate constraints, such as positive probabilities or requiring the probabilities to be consistent with the futures-implied rate.

As discussed earlier, Piazzesi and Swanson (2005) showed that, on average, federal funds

futures prices have implied interest rates that exceeded the actual realized federal funds rate. To adjust for this bias, the estimated probabilities can be constrained to imply a risk-adjusted target. However, because Piazzesi and Swanson's (2005) estimate of the risk premia may be too large, we adjust the federal funds futures-implied rate downward by 1 basis point for each month of the forecast horizon.

How should one interpret the error terms? The error terms result from market frictions such as (i) bid-ask spreads in both the option and the underlying asset, (ii) imperfect liquidity, and (iii) approximations in formulating the model, such as incorrect market risk premia, imposition of zero probabilities to unlikely actions, and ignoring the possibility of early exercise. In the absence of such approximations and frictions, the probabilities would be estimated exactly and the estimation would be an inversion of prices to probabilities. The facts that the errors are small and the probabilities are precisely estimated indicate that the approximations are probably reasonable and the frictions unimportant.

³ Notice that this estimation method assumes (counterfactually) that the options are European—that is, that they can be exercised only at maturity. The discrepancy introduced by this assumption is likely to be small, as the amount of early exercise of federal funds options is very small.

Let's consider a concrete example. After the June 25, 2003, FOMC meeting, the federal funds target rate stood unchanged at 1 percent. What probabilities did the option market assign to various outcomes at the August 12, 2003, FOMC meeting? There were 13 options (seven calls and six puts) with eight different strike prices on June 25. The five possible targets that the Fed was likely to choose from were 0.5, 0.75, 1, 1.25, and 1.5. The following system is estimated by maximum likelihood:

$$(4) \begin{bmatrix} 0.00250 \\ 0.00250 \\ 0.00501 \\ 0.02003 \\ 0.03506 \\ 0.05259 \\ 0.17280 \\ 0.14775 \\ 0.10017 \\ 0.05259 \\ 0.00751 \\ 0.00250 \\ 0.00250 \end{bmatrix} = \begin{bmatrix} 0.0101 & 0 & 0 & 0 & 0 & 0 \\ 0.0726 & 0 & 0 & 0 & 0 & 0 \\ 0.1351 & 0 & 0 & 0 & 0 & 0 \\ 0.1976 & 0.0363 & 0 & 0 & 0 & 0 \\ 0.2601 & 0.0988 & 0 & 0 & 0 & 0 \\ 0.3226 & 0.1613 & 0 & 0 & 0 & 0 \\ 0.4476 & 0.2863 & 0.1250 & 0 & 0 & 0 \\ 0 & 0.0262 & 0.1875 & 0.3488 & 0.5101 & 0 \\ 0 & 0 & 0.1250 & 0.2863 & 0.4476 & 0 \\ 0 & 0 & 0.0625 & 0.2238 & 0.3851 & 0 \\ 0 & 0 & 0 & 0.1613 & 0.3226 & 0 \\ 0 & 0 & 0 & 0.0363 & 0.1976 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.1351 \end{bmatrix} \begin{bmatrix} \pi_{0.5} \\ \pi_{0.75} \\ \pi_{1.0} \\ \pi_{1.25} \\ \pi_{1.5} \end{bmatrix} + \varepsilon_t,$$

where ε_t is a 13-by-1 vector of normally distributed errors.

It is instructive to see how one transforms the market data to the data in (4). The first variable on the left-hand side (0.00250) is the price of the first call option, with a strike price of 99.3125, evaluated at the expiration date of the option, in about 3 months ($e^{r(T-t)}C(t, T, X_1, F_t)$), at an interest rate of 0.925 percent. The variable in the first row, first column, on the right-hand side is the payoff to a call option with a strike of 99.3125, assuming that the FOMC chooses a target rate of 0.5 percent on August 12. A target of 1.0 percent prior to August 12, combined with a move to 0.5 percent on August 12, would produce an average target rate of 0.6774 ($= 1 * 11/31 + 0.5 * 20/31$) during August, which translates into a final settlement price on the futures contract of $(100 - 0.6774 =) 99.3226$. If that 0.5 percent target were chosen, a call option with a strike of 99.3125 would be worth $(99.3226 - 99.3125 =) 0.0101$, using the formula $\max(0, F_{T,1} - X_1)$. Similarly, if one looks at the first row, second column, which assumes that the FOMC chooses a 0.75 percent target on August 12,

the final settlement price for the futures contract would be 99.1613 ($= 100 - 1.0 * 11/31 - 0.75 * 20/31$) and so a call option with a strike of 99.3125 would be worthless. That is, the term in the first row, second column of the right-hand side is 0. Each column of the regressor matrix is associated with a unique FOMC target, and each row is associated with a unique option.

Estimating this system, subject to the following constraints that the probabilities are positive and sum to 1 and that the mean of the PDF equals the term premium-adjusted futures price, produces the following coefficients for the five elements of the π vector: $\pi = \{0.114, 0.188, 0.697, 0, 0\}$. The standard errors for the estimated probabilities range from almost zero to 0.015.

The estimation constrains the probabilities to generate the interest rate implied by the futures price, adjusted for risk. In the example, the futures price for August was 99.045, which implied an interest rate of 0.955 percent for August. Adjusting this implied interest rate for the 67-day forecast horizon—June 25 through August 31—and assuming 1 basis point every 30 days, one obtains a risk-adjusted implied rate for August of $(0.955 - (67/30) * 0.01 =) 0.9327$. When numerically optimizing the likelihood function to calculate probabilities, one can force the implied interest rate to equal this risk-adjusted interest rate. In the present example, one can verify that the estimated probabilities imply a federal funds rate for August of 0.9327 percent.⁴

To informally assess the importance of the constraints—the fit of the model—one can estimate the unconstrained model to see whether the results are sensitive to the imposition of the constraints. If the results are highly sensitive, it might suggest that the model doesn't fit the data well and the probabilities are not reliable. Reassuringly, the unconstrained system produces a plausible and roughly similar probability vector of $\pi = \{0.050, 0.226, 0.686, 0.023, 0.013\}$, whose standard errors are of similar magnitudes to those from the constrained system.

⁴ The federal funds rates implied by the five targets (0.5 to 1.5 percent) are 0.6774, 0.8387, 1, 1.1613, and 1.3226. Thus, the expected funds rate is 0.9327 ($= 0.6774 * 0.11439026 + 0.8387 * 0.18845445 + 1 * 0.69715529 + 1.1613 * 0 + 1.3226 * 0$).

Finally, one might wonder whether a normal likelihood function for the errors is appropriate. The error terms, ε_i , cannot literally be normal, as unbounded support for ε would be inconsistent with the requirement that option prices must be non-negative. To investigate whether the distributional assumption for ε is important, we re-estimated the example with a truncated normal distribution that required option prices be non-negative. The truncated distribution produced comparable results with those from a normal distribution. The estimated probabilities for the five targets were 0.1057, 0.2059, 0.6884, 0, and 0, respectively. The largest change in a probability estimate from the normal distribution was a very modest 1.7 percentage points.

USING OPTIONS TO GAUGE MARKET UNCERTAINTY ABOUT FUTURE FEDERAL FUNDS TARGETS

Even when the strategy driving monetary policy decisions is well understood and when the central bank seeks to operate in a transparent manner, market expectations can change when the policy strategy changes or when new information about economic conditions arrives. This section uses daily PDFs to explore the evolving uncertainty among market participants about future monetary policy actions.

August 2003: FOMC Pre-Commits to Monetary Policy Accommodation for a “Considerable Period”

By the fall of 2002, U.S. inflation was consistent with price stability as commonly understood today (i.e., inflation was of little consequence in making economic decisions). In fact, inflation had declined so much that the Federal Reserve began to consider further declines to be unwelcome because they might lead to deflation.

Financial analysts may have misinterpreted statements by Federal Reserve officials in the fall of 2002 and the spring of 2003 to imply that there would be a prolonged period of lower short-term rates and/or the purchase of long-term bonds by

the Fed in order to implement “easier” monetary policy (Neely, 2004). Moreover, the FOMC statement of May 6, 2003, was widely misinterpreted to confirm such incorrect beliefs.⁵ Thus, by early June 2003, bond markets had come to expect lower interest rates for a longer period than may have been warranted by the state of the economy. Neely (2003) provides some evidence to suggest that these developments were related to expectations of lower real growth, rather than lower inflation.

The top panel of Figure 3 shows that, in the days prior to the June 25, 2003, FOMC meeting, investors perceived a 50 to 70 percent chance that the target rate would be lowered from 1.25 percent to 0.75 percent. This is indicated by the thick, light-blue line in the top panel of the figure, which plots the daily implied probability estimates associated with each possible target rate.

The FOMC, in fact, decided to cut the target rate only from 1.25 percent to 1.00 percent. This action not only resolved the near-term uncertainty investors faced, but also caused them to revise their expectations for future monetary policy. The second panel of Figure 3 shows that expectations during July of further rate cuts at the August meeting rapidly declined. The two lines showing the probabilities assigned by investors to a 0.75 percent target and to a 0.50 percent target after the August meeting converged toward zero as July passed. By late July, markets were fairly certain that the FOMC would choose a 1 percent target at the August meeting.

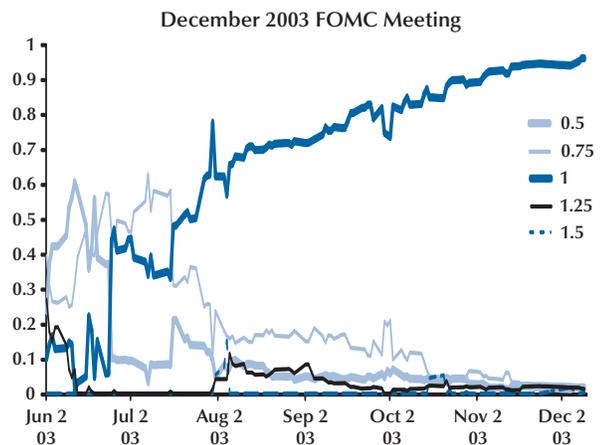
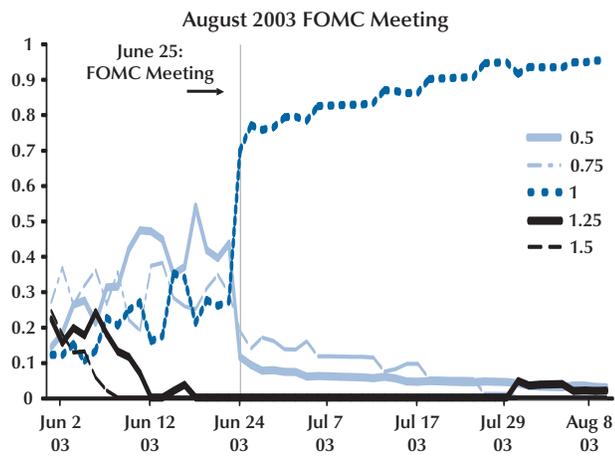
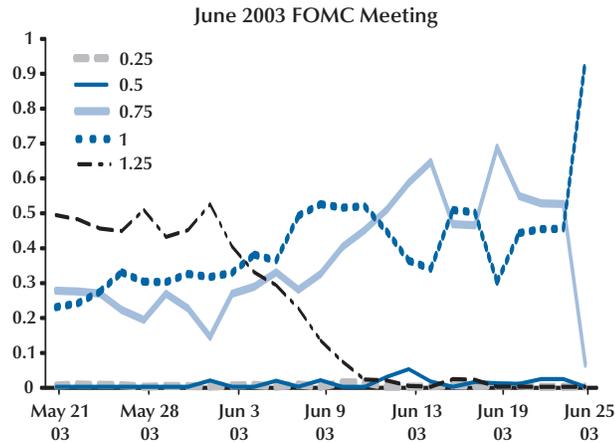
The third panel of Figure 3 shows the analogous probabilities of various target outcomes for the December 2003 meeting, as assessed each day from June onward. This panel shows that by late July or early August, markets had started to assign positive probabilities to the possibility of an increase to 1.25 or 1.50 percent at the December meeting.

To reassure markets that the target rate would not be raised in the near future, the FOMC issued a statement after the August 12, 2003, meeting

⁵ The May 6, 2003, statement contained the following sentence: “The probability of an unwelcome substantial fall in inflation, though minor, exceeds that of a pickup in inflation from its already low level”; www.federalreserve.gov/boarddocs/press/monetary/2003/20030506/default.htm.

Figure 3

Option-Implied Probabilities of Federal Funds Target Rates To Be Chosen at the June, August, and December 2003 Meetings



that contained the first commitment by the FOMC that the current low target rate would persist: “The Committee judges that, on balance, the risk of inflation becoming undesirably low is likely to be the predominant concern for the foreseeable future. In these circumstances, the Committee believes that policy accommodation can be maintained for a considerable period.”⁶ This language was repeated in the September 16, 2003, FOMC statement. The bottom panel of Figure 3 illustrates that, in the 3 months after August 12, market expectations coalesced on the idea that a 1 percent target would be the outcome of the December meeting. The FOMC announcements successfully anchored market expectations on a 1 percent funds target rate for at least the next 4 months.

May 2004: FOMC Signals Its First Rate Increase in Four Years

The Federal Reserve never defined what a “considerable period” was, but no one doubted that the FOMC’s target rate would be raised eventually. From Figure 4 it appears that speculation about impending rate increases began in earnest in March 2004 and that expectations about the timing and magnitude of rate increases evolved considerably during the course of the year.

Figure 4 displays a term structure of expected target rates extracted from 1-, 3-, 6- and 9-month-ahead federal funds futures contracts on each trading day during 2004. The fixed calendar-month nature of federal funds futures contracts means that the “roll forward” day occurs on the first trading day of each month. For example, on May 28, 2004, the expected average funds rate for “next month” referred to the average for June 2004 and was 1.02 percent.⁷ The next business day was June 1, when the May contract was settled and “next month” became July 2004. The thin line representing the 1-month-ahead expected federal funds rate shows a jump to 1.23 percent on June 1,

implying that market expectations for a 25-basis-point increase by “next month”—effectively, by the end of June—was considered very likely.

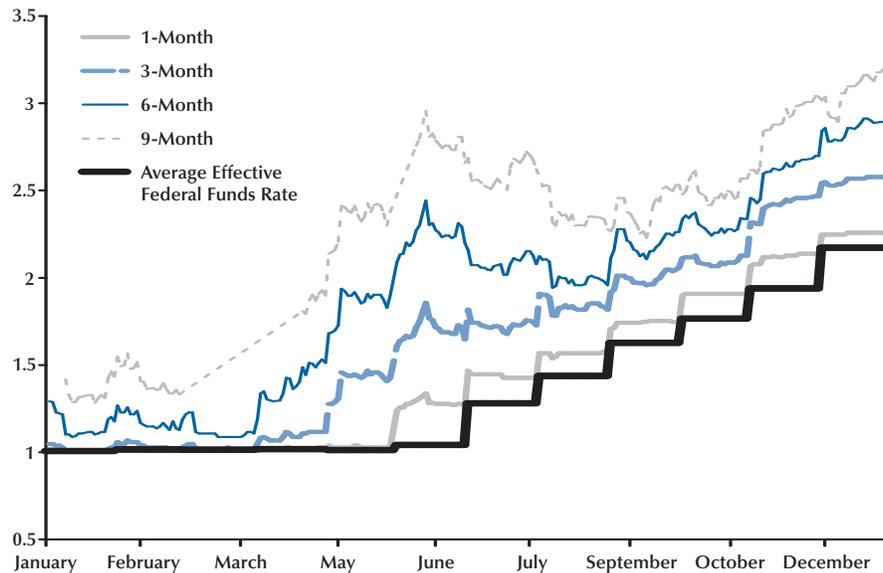
Figure 4 allows us to pinpoint evolving market expectations about the timing of the first target increase in four years. The line representing 9-month-ahead expectations shows that, during January and February 2004, market expectations were for a funds target in the 1.25 to 1.50 percent range during October and November 2004. But when would these increases occur? The line representing 3-month-ahead expectations jumped abruptly on May 3, 2004, from 1.11 percent to 1.27 percent. This coincided with the roll-forward from July to August 2004 of the 3-month-ahead contract. The jump implies that market expectations at that time (May 3) were tilted toward an initial increase in the funds target at the August 10 meeting, rather than at the June 29-30 meeting. Only later during May 2004 did expectations shift toward an initial increase at the June meeting, as described above in the context of the 1-month-ahead contract.

The distance between the 1-, 3-, 6- and 9-month-ahead implied yields in the figure illustrates the expected pace of funds target increases at any given point in time. On June 14, 2004, for example, the market expected the funds target to average 1.33 percent during July 2004 (next month), 1.85 percent during September 2004 (3 months ahead), 2.44 percent during December 2004 (6 months ahead), and 2.95 percent during March 2005 (9 months ahead). In the event, the actual average effective funds rates during those months were 1.26, 1.61, 2.16, and 2.63 percent, respectively.

Given the difficulty of separating the timing from the magnitude of future rate increases from federal funds futures alone, it is helpful to examine risk-neutral PDFs derived from federal funds futures options. The top panel of Figure 5 displays the evolving probabilities attached to various possible rate targets to be chosen at the June 2004 FOMC meeting. While Figure 4 demonstrates that market expectations of a *sequence* of future rate increases emerged after the May 4, 2004, FOMC meeting, the top panel of Figure 5 shows that, in early summer of 2004, market participants became

⁶ Press release issued by the Federal Reserve’s FOMC, August 12, 2003; www.federalreserve.gov/boarddocs/press/monetary/2003/20030812/.

⁷ The average effective rate can deviate slightly from the FOMC’s target rate because of daily fluctuations in actual reserve-market conditions.

Figure 4**Federal Funds Futures–Implied Yields from Contracts Traded in 2004**

NOTE: The figure shows the average federal funds rates implied by the 1-, 3-, 6-, and 9-month-ahead federal funds rate futures contracts for 2004.

convinced that the rate increases were to start with the June FOMC meeting. The bottom panel of Figure 5 shows that the FOMC's June 30 decision to raise the funds target from 1.00 percent to 1.25 percent prompted agents to expect further increases at the August meeting.

June 2004: FOMC Pre-Commits to Increasing Its Target Rate at a "Measured Pace"

Apparently wary of disrupting financial markets with rapid rate increases, the FOMC signaled after its June 30, 2004, meeting that it intended to raise its target rate gradually over time: "With underlying inflation still expected to be relatively low, the Committee believes that policy accommodation can be removed at a pace that is likely to be measured. Nonetheless, the Committee will respond to changes in economic prospects as needed to fulfill its obligation to maintain price stability."⁸ Figure 4 shows that, after the FOMC's June 30 statement, with the target rate at 1.25

percent, expectations of longer-term increases moderated and stabilized. That is, the level and volatility of the 3-, 6-, and 9-month-ahead implied rates declined and stabilized after June 30. This suggests that the "measured pace" language was well-understood by market participants.

The bottom panel of Figure 5 confirms this view by showing probabilities of targets to be chosen at the August 2004 FOMC meeting. Prior to the June 2004 FOMC meeting there were substantial expectations of a 50- or even 75-basis-point increase, to 1.75 or 2.0 percent at the August meeting. But after the statement at the June FOMC meeting, the market gradually became convinced that the increase was going to be in increments of 25 basis points, to 1.5 percent at the August 2004 meeting.

⁸ Press release issued by the Federal Reserve's FOMC, June 30, 2004; www.federalreserve.gov/boarddocs/press/monetary/2004/20040630/default.htm.

Figure 5

Option-Implied Probabilities of Federal Funds Target Rates To Be Chosen at the June and August 2004 FOMC Meeting

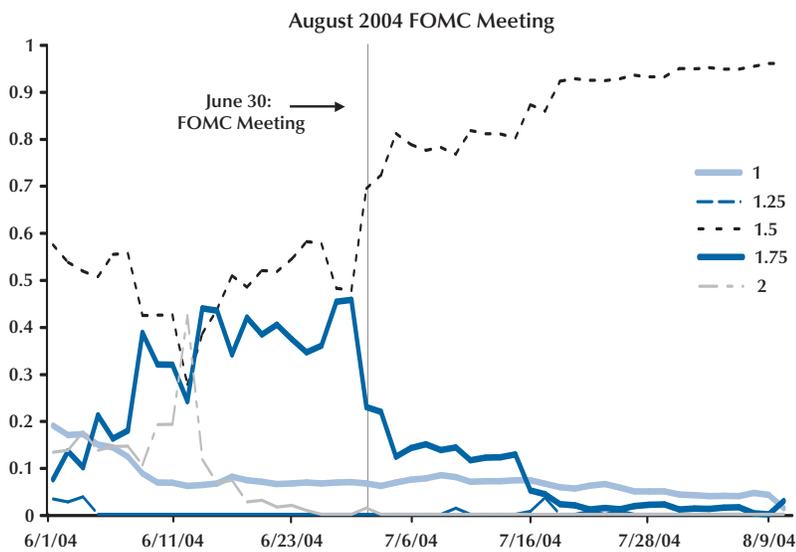
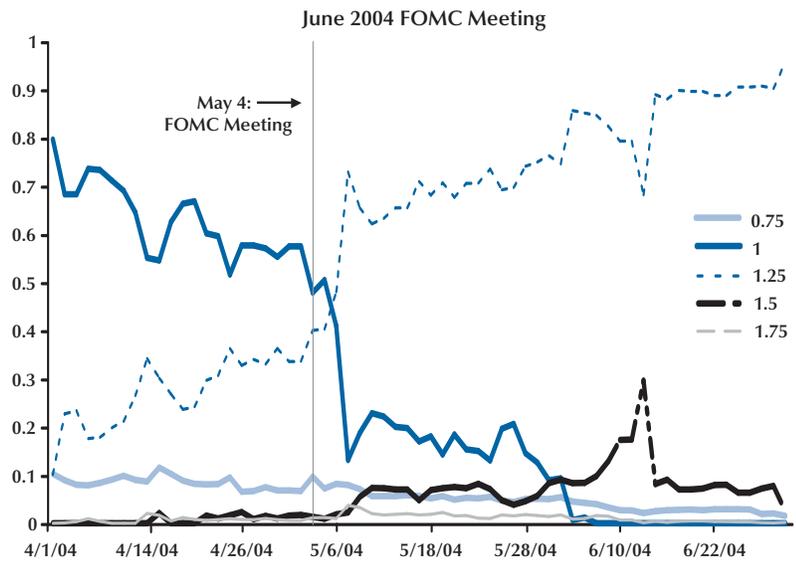
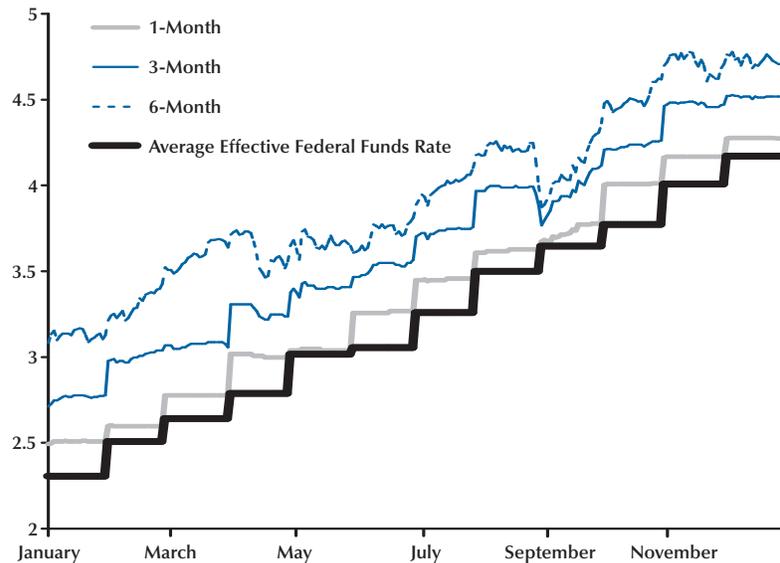


Figure 6**Federal Funds Futures–Implied Yields from Contracts Traded in 2005**

NOTE: The figure shows the average federal funds rates implied by the 1-, 3-, 6-, and 9-month-ahead federal funds rate futures contracts for 2005.

August/September 2005: Gulf Coast Hurricanes Create Uncertainty About the FOMC's Likely Rate Increases

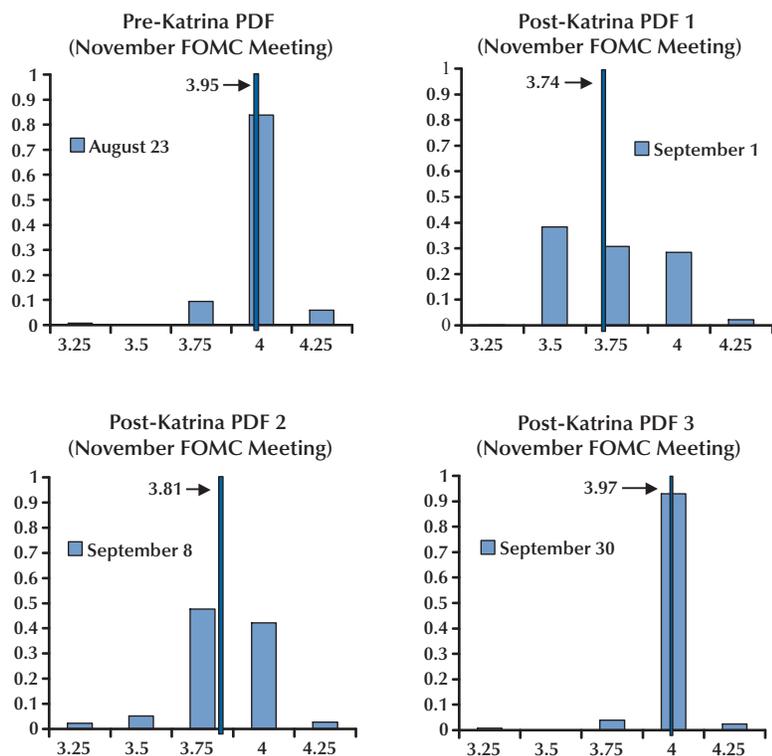
The devastation along the Gulf Coast caused by hurricanes Katrina and Rita in August and September 2005 substantially revised market expectations about monetary policy actions. Figure 6 displays the federal funds futures–implied target rates derived from 1-, 3-, and 6-month-ahead futures contracts traded in 2005. The impact of the hurricanes, especially Katrina, is clearly visible about September 1, 2005. Fearing that Katrina might significantly slow the U.S. economy, market participants revised down their expectations of 3- and 6-month-ahead target rates.

One also can examine the PDFs from option prices before and after Katrina's second landfall (near New Orleans, after traversing the southern tip of Florida) on August 29 to infer the evolution of expectations for the November 1, 2005, FOMC meeting over this turbulent period. The upper left

panel of Figure 7 shows that, on August 23—when the funds target was 3.5 percent—the markets expected a greater-than-80 percent chance of a 4.0 point target rate at the November 1 meeting, with some modest chance of a 3.75 or 4.25 percent target. On September 1, three days after Katrina made second landfall, market expectations of the funds target on November 1 had declined and dispersed significantly (top right subpanel). The mean futures rate was 3.74 percent, and the chances of a funds target of 3.5, 3.75, or 4.0 percent were approximately 38, 31, and 28 percent, respectively. In other words, the markets assessed the probability that the target at the November meeting would be 4.0 percent or greater declined from about 90 percent to about 30 percent.

By September 8, panic had subsided a bit; the bottom-left subpanel shows that the implied probabilities of 3.75 and 4.0 percent targets were 48 percent and 42 percent, respectively (bottom-left subpanel). Finally, by September 30—after a

Figure 7
Option-Derived Probability Density Functions (PDF) Surrounding Hurricane Katrina



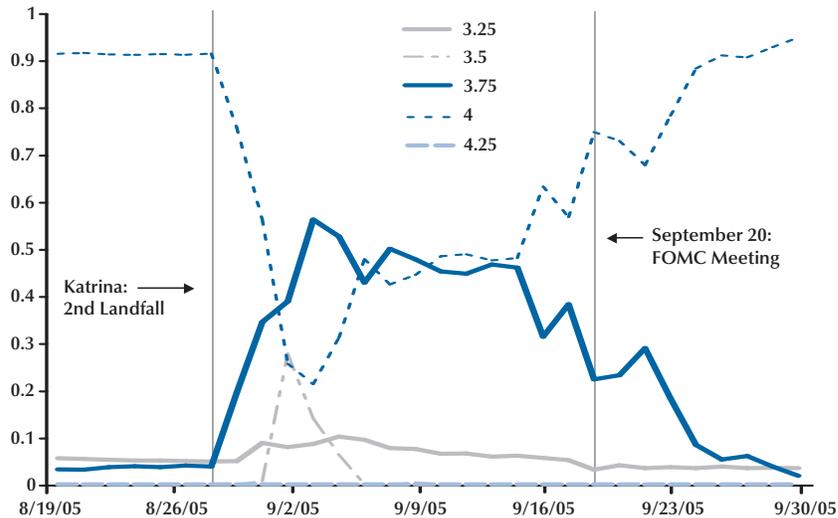
NOTE: The figure shows option-implied probability density functions around the time of Hurricane Katrina, which made second landfall on August 29, 2005. The vertical bars denote the rate implied by the federal funds futures contract price.

25-basis-point target increase to 3.75 percent at the September 20 FOMC meeting—the PDF showed that market expectations had returned to approximately the pre-Katrina level, with a more-than-90 percent chance of a 4.0 target at the November meeting (bottom-right subpanel).

Figure 8 shows another way of looking at the same information; it plots the probabilities of various outcomes at the November meeting over time. Four days after Katrina made landfall, the possibility that the Fed would increase the funds rate all the way to 4.0 percent by November 1 declined significantly, from 85 percent to 25 percent. At the same time, the possibility that the FOMC would not change the funds target at all increased to almost 30 percent for a day.

April 27, 2006: Chairman Bernanke Testifies Before the Joint Economic Committee

The weeks prior to the May 10, 2006, FOMC meeting were unusually active ones in the federal funds futures and options markets. Market expectations were quite sensitive to incoming economic data and statements. For example, the top panel of Figure 9 shows that strong reports on housing and durable goods on April 25 and 26 raised the expected federal funds rate from 5.11 percent to 5.16 percent and the lower panel shows that the implied probability of a 5.25 percent target rate after the June FOMC meeting rose from under 40 percent to about 60 percent.

Figure 8**Option-Implied Probabilities of Federal Funds Target Rates To Be Chosen at the November 2005 FOMC Meeting**

On April 27, Chairman Bernanke (2006) spoke before the Joint Economic Committee of Congress on the outlook for the U.S. economy. The Chairman was broadly optimistic about the state of the U.S. economy, describing the prospects for maintaining solid growth as “good” and the outlook for inflation as “reasonably favorable.” The Chairman went on to note that the FOMC had increased the federal funds rate by 25 basis points at each of its previous 15 meetings and that the current federal funds target was 4.75 percent. The Chairman cautioned that

[P]olicy will respond to arriving information that affects the Committee’s assessment of the medium-term risks to its objectives of price stability and maximum sustainable employment...[A]t some point in the future the Committee may decide to take no action at one or more meetings in the interest of allowing more time to receive information relevant to the outlook. Of course, a decision to take no action at a particular meeting does not preclude actions at subsequent meetings, and the Committee will not hesitate to act when it determines that doing so is needed to foster

the achievement of the Federal Reserve’s mandated objectives.

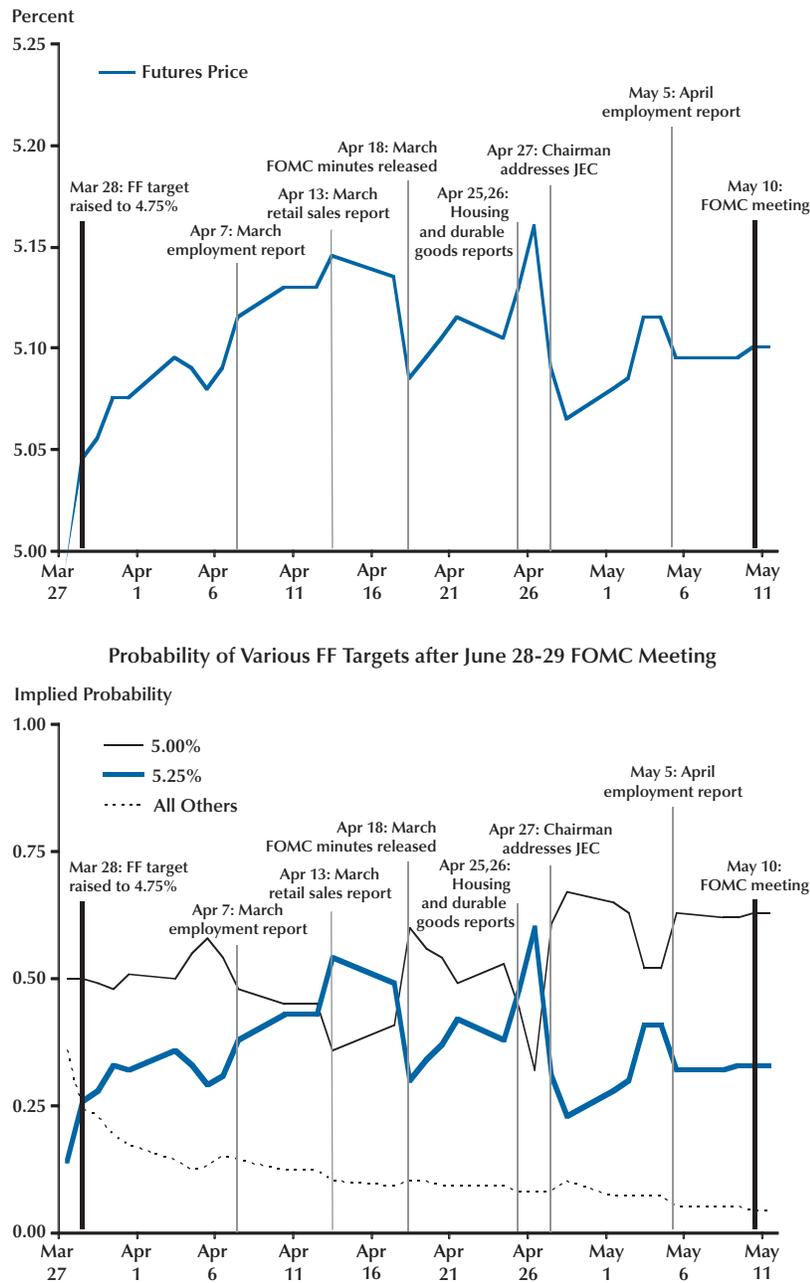
Economists might interpret such a comment as a judicious statement of the obvious: The FOMC’s policy decisions will respond to news and changing economic conditions. It was widely reported that financial markets interpreted the statement to mean that a pause in the interest rate increases was imminent. Equity markets rallied; the S&P 500 finished up over 4 points on April 27. The top panel of Figure 9 shows that the expected federal funds target for the May FOMC meeting fell from 5.16 percent to 5.07 percent between April 26 and April 28 in response to the Chairman’s testimony. The lower panel shows that this was generated by a shift in the probability of a 5.25 percent target from 60 percent to 23 percent and a similar rise in the probability of a 5.0 percent target.

SUMMARY

This article uses the method of Carlson, Craig, and Melick (2005) to extract an implied risk-

Figure 9

Expected Federal Funds Targets and Option-Implied Probabilities of Federal Funds Target Rates To Be Chosen at the May 2006 FOMC Meeting



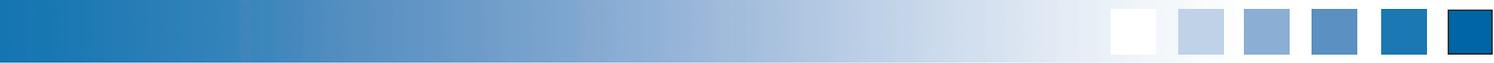
NOTE: FF, Federal funds; JEC, Joint Economic Committee.

neutral probability density function over possible future federal funds target rates from daily option prices. Option-based forecasts are most useful when more than two federal funds target outcomes are plausible at an upcoming FOMC meeting. If only one or two meeting outcomes are plausible, a futures-based forecast is simpler and more appropriate.

We assess evolving market uncertainty about Federal Reserve monetary policy actions in a variety of recent events and episodes, including (i) a commitment by the FOMC to maintain monetary policy accommodation for a “considerable period”; (ii) a signal by the FOMC that the first target-rate increase in four years was forthcoming; (iii) a commitment by the FOMC to raise the target rate over time at a “measured pace”; (iv) the devastating aftermath of Hurricane Katrina; and (v) April 2006 testimony by Chairman Bernanke before the Joint Economic Committee. These episodes illustrate how federal funds futures options can be used to supplement the information derived from federal funds futures and other sources of market expectations about Federal Reserve monetary policy actions.

REFERENCES

- Abken, Peter A. “Using Eurodollar Futures Options: Gauging the Market’s View of Interest Rate Movements.” Federal Reserve Bank of Atlanta *Economic Review*, 1995, 80(2), pp. 10-30.
- Andersen, Allan B. and Wagener, Tom. “Extracting Risk Neutral Probability Densities by Fitting Implied Volatility Smiles: Some Methodological Points and an Application to the Three-Month Euribor Futures Option Prices.” Working Paper 198, European Central Bank, December 2002.
- Bernanke, Ben S. “Outlook for the U.S. Economy.” Testimony Before the U.S. Congress, Joint Economic Committee, April 27, 2006; www.federalreserve.gov/boarddocs/testimony/2006.
- Bliss, Robert R. and Panigirtzoglou, Nikolaos. “Testing the Stability of Implied Probability Density Functions.” *Journal of Banking and Finance*, March 2002, 26(2-3), pp. 381-422.
- Carlson, John B.; Craig, Ben R. and Melick, William R. “Recovering Market Expectations of FOMC Rate Changes with Options on Federal Funds Futures.” *Journal of Futures Markets*, December 2005, 25(12), pp. 1203-42.
- Hordahl, Peter and Vestin, David. “Interpreting Implied Risk-Neutral Densities: The Role of Risk Premia.” *Review of Finance*, 2005, 9(1), pp. 97-137.
- Neely, Christopher J. “Bond Market Mania.” Federal Reserve Bank of St. Louis *Monetary Trends*, October 2003.
- Neely, Christopher J. “Miscommunication Shook Up Mortgage, Bond Markets.” Federal Reserve Bank of St. Louis *Regional Economist*, April 2004, pp. 4-9.
- Neely, Christopher J. “Using Implied Volatility to Measure Uncertainty About Interest Rates.” Federal Reserve Bank of St. Louis *Review*, May/June 2005, 87(3), pp. 407-25.
- Piazzesi, Monika and Swanson, Eric. “Futures Prices as Risk-Adjusted Forecasts of Monetary Policy.” NBER Working Paper 10547, National Bureau of Economic Research, 2005; www.nber.org/papers/w10547.
- Poole, William; Rasche, Robert G. and Thornton, Daniel L. “Market Anticipations of Monetary Policy Actions.” Federal Reserve Bank of St. Louis *Review*, July/August 2002, 84(2), pp. 65-93.
- Sack, Brian. “Extracting the Expected Path of Monetary Policy from Futures Rates.” *Journal of Futures Markets*, August 2004, 24(8), pp. 733-54.
- Sarno, Lucio; Thornton, Daniel L. and Valente, Giorgio. “Federal Funds Rate Prediction.” *Journal of Money, Credit, and Banking*, June 2005, 37(3), pp. 449-71.
- Soderlind, Paul and Svensson, Lars E.O. “New Techniques to Extract Market Expectations from Financial Instruments.” *Journal of Monetary Economics*, October 1997, 40(2), pp. 383-429.



Federal Reserve Bank of St. Louis *Review*, Annual Index, 2006

JANUARY/FEBRUARY

William Poole, “The Fed’s Monetary Policy Rule.”

Thomas A. Garrett and Russell M. Rhine, “On the Size and Growth of Government.”

Souphala Chomsisengphet and Anthony Pennington-Cross, “The Evolution of the Subprime Mortgage Market.”

Thomas B. King, Daniel A. Nuxoll, and Timothy J. Yeager, “Are the Causes of Bank Distress Changing? Can Researchers Keep Up?”

Richard G. Anderson, “Replicability, Real-Time Data, and the Science of Economic Research: FRED, ALFRED, and VDC.”

MARCH/APRIL

Yannis Georgellis and Howard J. Wall, “Entrepreneurship and the Policy Environment.”

Christopher H. Wheeler, “Human Capital Growth in a Cross Section of U.S. Metropolitan Areas.”

Kevin L. Kliesen and Frank A. Schmid, “Macroeconomic News and Real Interest Rates.”

Michael J. Dueker, “Using Cyclical Regimes of Output Growth to Predict Jobless Recoveries.”

MAY/JUNE

William Poole, “Inflation Targeting.”

Cletus C. Coughlin, Thomas A. Garrett, and Rubén Hernández-Murillo, “The Geography, Economics, and Politics of Lottery Adoption.”

Richard G. Anderson and Kevin L. Kliesen, “The 1990s Acceleration in Labor Productivity: Causes and Measurement.”

James B. Bullard, “The Learnability Criterion and Monetary Policy.”

JULY/AUGUST

Federal Credit and Insurance Programs

Laurence J. Kotlikoff, “Is the United States Bankrupt?”

Douglas J. Elliott, “On the Importance of the Plumber: The Intersection of Theory and Practice in Policymaking for Federal Financial Institutions.”

John M. Quigley, “Federal Credit and Insurance Programs: Housing.”

Zvi Bodie, “On Asset-Liability Matching and Federal Deposit and Pension Insurance.”

J. David Cummins, “Should the Government Provide Insurance for Catastrophes?”

Robert E. Litan and Joseph E. Stiglitz, “Panel Discussion: What Is the Appropriate Role of the Federal Government in the Private Markets for Credit and Insurance? What Is the Outlook?”

Commentaries by:

Anjan Thakor

George J. Benston

John C. Weicher

Deborah J. Lucas

Dwight M. Jaffee

SEPTEMBER/OCTOBER

Carlos Garriga, William T. Gavin, and Don Schlagenhauf, “Recent Trends in Homeownership.”

David C. Wheelock, “What Happens to Banks When House Prices Fall? U.S. Regional Housing Busts of the 1980s and 1990s.”

Michael J. Dueker and Andreas M. Fischer, “Do Inflation Targeters Outperform Non-targeters?”

Miguel Casares, “A Close Look at Model-Dependent Monetary Policy Design.”

NOVEMBER/DECEMBER

William Poole, “Chinese Growth: A Source of U.S. Export Opportunities.”

Jerry L. Jordan, “Money and Monetary Policy for the Twenty-First Century.”

Kevin L. Kliesen, “Rising Natural Gas Prices and Real Economic Activity.”

Bruce Mizrach and Christopher J. Neely, “The Transition to Electronic Communications Networks in the Secondary Treasury Market.”

William R. Emmons, Aeimit K. Lakdawala, and Christopher J. Neely, “What Are the Odds? Option-Based Forecasts of FOMC Target Changes.”



Federal Reserve Bank of St. Louis

P.O. Box 442

St. Louis, MO 63166-0442

