

Q1
2000

Economic & Financial

Review

*Federal
Reserve
Bank of
Dallas*



Natural Resource Scarcity and Technological Change

Stephen P. A. Brown and Daniel Wolk

EMU at 1

Mark A. Wynne

Measuring the Benefits of Unilateral Trade Liberalization Part 2: Dynamic Models

Carlos E. J. M. Zarazaga

Economic and Financial Review

Federal Reserve Bank of Dallas

Robert D. McTeer, Jr.
President and Chief Executive Officer

Helen E. Holcomb
*First Vice President and
Chief Operating Officer*

Robert D. Hankins
Senior Vice President, Banking Supervision

Harvey Rosenblum
Senior Vice President and Director of Research

W. Michael Cox
Senior Vice President and Chief Economist

Editors
Stephen P. A. Brown
Senior Economist and Assistant Vice President

Jeffery W. Gunther
Research Officer

Mark A. Wynne
Research Officer

Director of Publications
Kay Champagne

Associate Editors
Jennifer Afflerbach
Monica Reeves

Design and Production
Gene Autry
Laura J. Bell
Ellah Piña

Economic and Financial Review (ISSN 1526-3940), published quarterly by the Federal Reserve Bank of Dallas, presents in-depth information and analysis on monetary, financial, banking, and other economic policy topics. Articles are developed by economists in the Bank's Economic Research and Financial Industry Studies departments. The views expressed are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Dallas or the Federal Reserve System.

Articles may be reprinted on the condition that the source is credited and the Public Affairs Department is provided with a copy of the publication containing the reprinted material.

Subscriptions are available free of charge. Please direct requests for subscriptions, back issues, and address changes to the Public Affairs Department, Federal Reserve Bank of Dallas, P.O. Box 655906, Dallas, TX 75265-5906; call 214-922-5254; or subscribe via the Internet at www.dallasfed.org. *Economic and Financial Review* and other Bank publications are available on the Bank's web site, www.dallasfed.org.

Natural Resource Scarcity and Technological Change

Stephen P. A. Brown and Daniel Wolk

Page 2

Nonrenewable natural resources, such as aluminum and crude oil, exist only in fixed amounts on Earth. Consequently, some observers are concerned that natural resource scarcity will eventually limit future economic growth and human well-being. Others remain optimistic that technological change will overcome geophysical scarcity. Brown and Wolk examine the evidence for natural resource scarcity and find that over the past century reliance on free markets has promoted sufficient technological change to overcome geophysical scarcity for most nonrenewable natural resources. Rather than rising—as would result from increased scarcity—the relevant real prices of most nonrenewable natural resources have fallen. Although declines in real prices have moderated since World War II, the authors find little evidence of increased scarcity in the postwar era. Increased reliance on markets during the closing decades of the twentieth century is cause for optimism that these trends will continue in the twenty-first.

EMU at 1

Mark A. Wynne

Page 14

Economic and monetary union (EMU) among eleven of the fifteen members of the European Union began on January 1, 1999. The national currencies of the eleven were abolished and replaced with a new single currency, the euro. Responsibility for monetary policy shifted from the national central banks to the European Central Bank. Many commentators in the United States thought EMU would never come about or, if it did, that it would not last long.

In this article Mark Wynne reviews EMU's first year. He looks at how the economy of the euro area has fared under the single monetary policy, examines how successful the ECB has been in fulfilling its mandate for price stability, and considers the prospects for the future. Despite the dramatic decline in the euro against the dollar over the course of 1999, the first year of EMU must be judged a success. While it is still too early to say whether in the long run the euro will be a strong currency like the Deutsche mark, the institutional design of EMU and the performance of those institutions over the first year are promising.

Measuring the Benefits of Unilateral Trade Liberalization Part 2: Dynamic Models

Carlos E. J. M. Zarazaga

Page 29

This is the second of two articles examining the potential welfare gains or losses from a unilateral move toward free trade. Part 1 concluded that applied static models of international trade fail to produce eye-popping positive welfare effects. In Part 2, Carlos Zarazaga reviews available applied dynamic general equilibrium models. He finds that the promises of larger welfare gains from unilateral trade liberalization do materialize in some dynamic models. However, other models cannot completely dismiss some common objections to the adoption of unilateral free trade policies.

Zarazaga also identifies the controversial theoretical and empirical issues behind those objections that will have to be resolved before unilateral trade liberalization is accepted as the definitive, welfare-improving alternative to costly and prolonged multilateral trade agreements.

Natural Resource Scarcity and Technological Change

Stephen P. A. Brown and Daniel Wolk

In this article, we examine trends in the real prices of nonrenewable natural resources to determine whether technological change is outpacing geophysical scarcity of these natural resources.

Stephen P. A. Brown is director of energy economics and microeconomic policy analysis in the Research Department at the Federal Reserve Bank of Dallas.

Daniel Wolk is a research analyst in the Research Department at the Federal Reserve Bank of Dallas.

In 1972, an interdisciplinary research group called the Club of Rome predicted worldwide catastrophe by 2050 (Meadows et al. 1972). They based their prediction on three trends they thought they observed: increasing scarcity of nonrenewable natural resources, increasing environmental degradation, and continuing population growth. They saw the combination of these trends as unsustainable and economic misery as inevitable.

The Club of Rome was not original in its pessimism about the future. English economist Thomas R. Malthus raised similar concerns in 1798. His analysis led him to conclude that misery was the inevitable state of humans (Malthus 1798). According to Malthus, if per capita income were above subsistence, population would expand until per capita income was reduced to subsistence level. (See the box entitled “An Overview of Malthus’ Principle of Population.”) At the time Malthus was writing—the early stages of the Industrial Revolution—poverty was widespread in English cities, so perhaps his pessimism was understandable.

Fortunately for us, Malthus was wrong. Since at least the late 1800s, per capita income in Western society has generally increased. Technological change occurred at a rapid pace, causing per capita income to rise even as the population grew. In fact, per capita income rose so much, the Club of Rome’s pessimism seems hard to understand, except that Malthus’ original analysis did not take into account natural resource scarcity or environmental degradation.

This essay examines whether the potential scarcity of nonrenewable natural resources is a reason for concern. Previous research (Barnett and Morse 1963, Jorgenson and Griliches 1967, Nordhaus 1973, Brown and Field 1978, Fisher 1979, Hartwick and Olewiler 1986, and Schmidt 1988) is mixed, but it generally has found that the economic evidence is inconsistent with the increasing scarcity of nonrenewable natural resources. In fact, technological change driven by free market forces has increased natural resource availability. Given the time elapsed since the previous research was conducted, however, it is appropriate to reexamine the evidence.

WHAT IS NATURAL RESOURCE SCARCITY?

Nonrenewable natural resources, such as aluminum and crude oil, exist in fixed amounts on Earth. When we use up all the crude oil on the planet, we will have no more of this resource. In addition, we tend to use the most easily obtainable natural resources first. Over

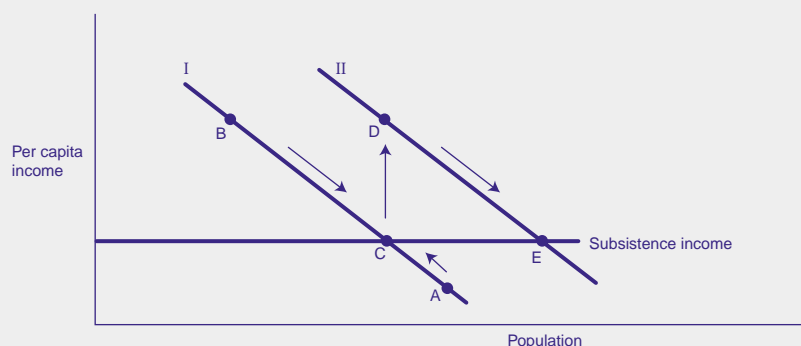
An Overview of Malthus' Principle of Population

Malthus thought an increase in population would reduce per capita income. His conclusion followed from the law of diminishing marginal productivity: as population increases, each worker has less land with which to work. Curve I in the figure represents this proposition for a given amount of land and level of technology. Curve II represents this proposition for a higher level of technology and/or greater acreage. The subsistence level of income is also represented in the figure.

For a given amount of land and level of technology, Malthus argued that a population would tend toward a subsistence level of income. If per capita income were below the subsistence level (as illustrated by point A on curve I), starvation would reduce the population. If per capita income were above the subsistence level (as illustrated by point B on curve I), people would have more children and population would grow. In either case, population would adjust until income just reached the subsistence level (at point C on curve I). Therefore, he concluded that misery was the inevitable state of humankind. This conclusion is often referred to as the "dismal theorem" and may be the historical basis for calling economics "the dismal science."

Malthus' analysis is similar to that now made by ecologists studying animal populations and ecosystems. For example, if the deer population is smaller than a given ecosystem can support, the deer will reproduce and multiply in number. If the population is greater than the ecosystem can support, the weak will die off and the population will be reduced. The deer population tends toward a subsistence level of nutrition.

Malthus further argued that—without moral restraint in human reproduction—improved technology or increased resources would only increase human misery in the long run. An increase in technology or land temporarily increases well-being (as shown by a shift from point C on curve I to point D on curve II). Eventually, however, the increased capacity of the economy will lead to population growth, which will only be checked when per capita income reaches subsistence (point E on curve II). Hence, Malthus concluded that increased technology or land availability would result in more people living at subsistence, not an improvement in living conditions. This conclusion is often referred to as the "utterly dismal theorem."



time, natural resources become more difficult to extract. For example, at the beginning of the California gold rush, people were picking up gold off the ground. Toward the end of the gold rush, they were blasting the mountains with water, using much more capital and labor.

Geophysical scarcity may be irrelevant, however, if technological change increases resource availability. Consequently, economists prefer to measure scarcity in economic terms—that is, through market prices. Economists are interested in whether the prices of nonrenewable natural resources reflect increasing scarcity. In other words, are the real prices of natural resources rising to reflect increasing scarcity?

The economics perspective can be illustrated by examining a production function for the overall economy:

$$(1) \quad Q = Q(K, L, NR),$$

where Q is output, K is capital, L is labor, and NR is natural resource use.¹ We expect normal economic conditions for production, which mean a positive marginal product for each input:

$$(2) \quad \frac{\partial Q}{\partial K} > 0, \quad \frac{\partial Q}{\partial L} > 0, \quad \frac{\partial Q}{\partial NR} > 0.$$

For each input, output increases with its use, as is shown by the positive first derivative.

Normal economic conditions for production also mean a diminishing marginal product for each input:

$$(3) \quad \frac{\partial^2 Q}{\partial K^2} < 0, \quad \frac{\partial^2 Q}{\partial L^2} < 0, \quad \frac{\partial^2 Q}{\partial NR^2} < 0.$$

For each input, output increases at a decreasing rate with increased use of the input, as is shown by the negative second derivative.

Economic theory also suggests how the increased provision of capital, labor, and natural resources affects the productivity of each other input. For instance, the productivity of capital and labor is expected to increase as natural resource use increases:

$$(4) \quad \frac{\partial^2 Q}{\partial K \partial NR} > 0, \quad \frac{\partial^2 Q}{\partial L \partial NR} > 0.$$

In words, the marginal product of capital and the marginal product of labor increase when more of the natural resource is used.

Similarly, the productivity of the natural resources increases if either capital or labor increases:

$$(5) \quad \frac{\partial^2 Q}{\partial NR \partial K} > 0, \quad \frac{\partial^2 Q}{\partial NR \partial L} > 0.$$

In words, the marginal product of natural resources is greater when either more capital or more labor is used.

If we take increasing natural resource scarcity to mean natural resource availability decreases over time, then as capital and labor grow the production conditions described above can explain the economic manifestation of natural resource scarcity and why it might be expected to limit economic growth. The conditions expressed in inequalities 4 and 5 show that if natural resource use declines while capital and labor grow, the marginal productivity of natural resources will rise and the marginal productivity of capital and labor will fall. Hence, increasing natural resource scarcity would imply that nat-

ural resource prices rise relative to wages and the return to capital.

The economic conditions described above also suggest that in a world without technological change, output cannot keep pace with population growth unless natural resource use and capital grow at the same rate. In fact, if natural resource use grows more slowly than capital and labor—as greater natural resource scarcity would imply—output must grow more slowly than capital and labor unless there is technological change.

ANOTHER PERSPECTIVE ON NATURAL RESOURCE SCARCITY

Hotelling (1931) develops a model to explain how the prices of nonrenewable natural resources—such as oil, natural gas, coal, copper, nickel, bauxite, zinc, and iron—would evolve over time in the absence of technological change. Hotelling’s analysis exploits the proposition that the quantity of nonrenewable resources is fixed. The consumption of the resource today reduces the amount available for future consumption, and the owner of such a resource must decide how to distribute its use over time.

In an economy in which other investments earn a market rate of interest, individuals saving nonrenewable natural resources for future periods also must expect to earn the market interest rate (including the appropriate risk premium). If the expected return to saving a nonrenewable natural resource for future periods is less than the market interest rate, managers of that resource will save less of it for the future. This will make the resource more plentiful today and less plentiful in the future, which will lower today’s price, raise future prices, and increase the expected return to saving the resource for future periods.

On the flip side, if the expected return is greater than the market interest rate, managers will save more of the resource for future periods, making it less plentiful today and more plentiful in the future. This will raise today’s price, lower future prices, and decrease the expected return to saving the resource for the future. Only when the expected return is equal to the market interest rate will managers of the resource consider their production plans finalized. Under these conditions, the difference between the price and marginal cost of producing a nonrenewable natural resource will rise at the market interest rate unless production costs are affected by re-

source depletion (Solow 1974):

$$(6) \quad P_{NR,t} = C_{NR,t} + \lambda e^{rt},$$

where $P_{NR,t}$ and $C_{NR,t}$ are the price and marginal cost of producing the natural resource at time t , respectively, r is the market interest rate, and λe^{rt} is the value of holding an additional unit of the resource off the market until a future period (a practice economists call “user cost”). The relationship described by Equation 6 is commonly called the “Hotelling rule.”

With $C_{X,t}$ representing the effects of cumulative production on the cost of producing the natural resource at time t , Peterson and Fisher (1977) show

$$(7) \quad \dot{\lambda} = -e^{-rt} C_{X,t},$$

which means λ is constant over time and the user cost grows at the interest rate unless production costs change with cumulative extraction ($C_{X,t} \neq 0$). If production costs rise with cumulative extraction ($C_{X,t} > 0$), the user cost rises more slowly than the interest rate.² The price of the natural resource is expected to rise over time, however, whether or not production costs rise with cumulative extraction ($C_{X,t} \geq 0$).³

Financial markets and forecasts of future prices are generally consistent with theory reflecting expectations that prices for nonrenewable natural resources will rise over long periods of time.⁴ In fact, the Hotelling rule is best interpreted as a market efficiency condition describing how current and expected future prices for these resources are simultaneously determined by current market conditions and expectations about future market conditions. For nonrenewable natural resources, current prices and expectations about future prices depend on the information and technology available at the time.

MARKET-INDUCED TECHNOLOGICAL CHANGE

As demonstrated above, if a nonrenewable natural resource is expected to become more scarce in an economic sense, its price will be expected to rise. In a market system, expectations of higher prices increase the incentive to find new technology that will offset geophysical scarcity. When they expect higher prices, consumers have an incentive to look for new technology that lets them use less of a natural resource. When they anticipate higher production costs, producers have an incentive to develop new technology to lower costs. In short, the very mechanism that signals increasing economic scarcity of a nonrenewable resource helps

Table 1

Natural Resource Prices Deflated by the Consumer Price Index

Commodity	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	1998
Aluminum	*	*	*	55.71	33.92	23.21	20.27	18.96	10.46	12.48	10.51	13.12	8.20	5.87
Anthracite coal	100.00	87.95	91.90	103.42	117.74	140.26	177.33	164.84	214.19	152.98	161.58	298.63	177.85	122.07
Bituminous coal	100.00	81.90	69.67	79.04	76.00	118.75	64.60	86.40	128.07	100.89	102.92	224.38	135.58	96.32
Copper	100.00	132.27	103.56	116.08	82.45	52.28	47.43	49.21	53.65	65.35	89.50	73.52	57.43	29.64
Iron	100.00	112.49	79.15	91.99	71.52	93.41	47.98	71.10	86.47	98.13	83.42	113.36	NA	NA
Lead	100.00	105.67	102.15	107.87	96.31	81.72	67.42	75.88	113.06	82.23	82.74	105.46	73.34	58.38
Natural gas	*	*	*	*	*	97.78	94.86	66.87	56.26	98.50	91.76	401.75	277.63	257.20
Nickel	100.00	97.25	71.47	59.38	42.41	20.78	20.78	24.74	18.53	24.77	32.93	35.58	31.05	13.11
Oil	100.00	31.91	28.08	46.86	21.45	50.37	23.43	23.91	34.27	31.96	26.92	86.05	51.30	22.52
Silver	100.00	113.30	111.11	70.86	55.10	48.57	21.71	23.81	29.32	29.31	43.48	238.64	35.83	30.64
Steel	*	*	*	162.63	128.97	125.84	87.37	129.27	121.53	161.71	151.56	165.62	134.21	99.56
Tin	*	100.00	110.51	166.75	169.80	112.24	88.39	165.32	184.67	159.39	208.72	477.54	140.11	109.43
Zinc	100.00	102.96	110.58	95.54	104.69	70.57	49.94	81.43	104.66	79.56	71.42	82.20	105.35	58.67

* All commodities indexed to 1870 = 100 except aluminum (1895 = 100), natural gas (1919 = 100), steel (1897 = 100), and tin (1880 = 100).

SOURCE: Authors' calculations using data from Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

stimulate the technological change that will offset that scarcity.⁵ Whether technology advances rapidly enough to prevent a rise in the prices of the resources, however, is a question best left to the evidence.

WHAT IS THE EVIDENCE?

The conditions described above form a basis to test whether nonrenewable natural resources are becoming more scarce in an economic sense or whether technological advance is making them more plentiful. Rising real prices for nonrenewable natural resources would provide evidence that technological advance has not offset increased geophysical scarcity; constant real prices would indicate that technological advance has just offset increased scarcity; and falling real prices would signify that technological advance has more than offset increased geophysical scarcity.

In this article, we examine trends in the real prices of twelve nonrenewable natural resources—aluminum, anthracite coal, bituminous coal, copper, iron, lead, natural gas, nickel, crude oil, silver, tin and zinc—and one basic manufactured product, steel, to determine whether technological change is outpacing geophysical scarcity for nonrenewable natural resources. To obtain real prices from the nominal ones, we deflate the time series in two ways. The first method, suggested by the Hotelling rule and used by Fisher (1979) and Hartwick and Olewiler (1986), uses an overall price index, such as the U.S. Consumer Price Index (CPI), to deflate the prices of individual natural resources. This approach is the standard method for converting nominal prices to real

prices and provides a conservative estimate of the extent to which technological progress has reduced the scarcity of nonrenewable natural resources.

The second method, suggested by the production function and used by Nordhaus (1973), deflates the prices of individual natural resources with the average manufacturing wage. This approach shows how much human effort is required to produce a given commodity and provides an aggressive estimate of the extent to which technological progress has offset resource scarcity.

An Overview of the Price Data

Under the conservative approach of deflating natural resource commodity prices by the CPI, most series generally decline, as shown in Table 1.⁶ All but three of the commodities—anthracite coal, natural gas, and tin—had lower real prices in 1998 than they did in the first year for which data are available. In 1998, the prices of anthracite coal and tin were 22.07 percent and 9.43 percent above their respective initial values. The price of natural gas was 157.2 percent above its 1919 value. The prices of steel and bituminous coal were 0.44 percent and 3.68 percent below their initial values, respectively. The prices for the remaining eight commodities declined by more than 40 percent from the first year for which we have data to 1998. Most notable are nickel and aluminum prices, which in 1998 were 13.11 percent and 5.87 percent of their initial real prices, respectively.

Under the more aggressive approach of deflating natural resource commodity prices by manufacturing wages, we see stronger evidence of downward trends, as shown in Table 2. By

Table 2

Natural Resource Prices Deflated by Manufacturing Wages

Commodity	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	1998
Aluminum	*	*	*	55.71	29.99	15.19	11.06	7.24	3.14	2.94	2.19	2.67	1.75	1.24
Anthracite coal	100.00	67.12	65.30	68.04	68.49	60.40	63.64	41.41	42.33	23.70	22.14	40.05	24.92	16.98
Bituminous coal	100.00	62.50	49.50	52.00	44.21	51.14	23.18	21.70	25.31	15.63	14.10	30.09	19.00	13.39
Copper	100.00	100.94	73.58	76.37	47.96	22.51	17.02	12.36	10.60	10.12	12.26	9.86	8.05	4.12
Iron	100.00	85.85	56.24	60.52	41.61	40.22	17.22	17.86	17.09	15.20	11.43	15.20	NA	NA
Lead	100.00	80.65	72.58	70.97	56.03	35.19	24.19	19.06	22.35	12.74	11.34	14.14	10.28	8.12
Natural gas	*	*	*	*	*	96.78	78.25	38.61	25.56	35.08	28.90	123.85	89.41	82.21
Nickel	100.00	74.22	50.78	39.06	24.67	8.95	7.46	6.21	3.66	3.84	4.51	4.77	4.35	1.82
Oil	100.00	24.35	19.95	30.83	12.48	21.69	8.41	6.01	6.77	4.95	3.69	11.54	7.19	3.13
Silver	100.00	86.47	78.95	46.62	32.05	20.92	7.79	5.98	5.80	4.54	5.96	32.00	5.02	4.26
Steel	*	*	*	162.63	114.04	82.37	47.66	49.36	36.51	38.08	31.57	33.76	28.58	21.04
Tin	*	100.00	102.88	143.75	129.43	63.33	41.56	54.41	47.83	32.36	37.48	83.92	25.72	19.94
Zinc	100.00	78.57	78.57	62.86	60.90	30.39	17.92	20.45	20.68	12.33	9.79	11.02	14.76	8.16

* All commodities indexed to 1870 = 100 except aluminum (1895 = 100), natural gas (1919 = 100), steel (1897 = 100), and tin (1880 = 100).

SOURCE: Authors' calculations using data from Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

1998, all the commodities had lower real prices than they did in the first year for which data are available, and over half the commodities had prices that were less than one-tenth of their initial values. The 1998 prices of anthracite coal, natural gas, and tin, which show gains in the CPI-adjusted series, were 16.98 percent, 82.21 percent, and 19.94 percent of their initial values, respectively. The real 1998 prices of steel and bituminous coal stood at 21.04 percent and 13.39 percent of their initial values, respectively. The prices of nickel and aluminum were 1.82 percent and 1.24 percent of their first reported prices.

Because commodity prices vary over the business cycle, we also analyze data that coincided with peaks of both U.S. and world business cycles. We find substantially similar price trends to those reported in Tables 1 and 2.

Econometric Tests of Resource Scarcity: 1870–1998

Although prices for most nonrenewable natural resources generally fell from the first year for which data are available, they also exhibited considerable volatility. Over short periods, price data may reflect a number of market conditions other than resource scarcity and technological advance, such as monopolization, cartelization, taxation, and regulation. To abstract from possible short-term fluctuations, we test for time trends in the prices of resources, using annual data from 1870 through 1998 as follows:⁷

$$(8) \quad \ln P_i = \alpha_i + \beta_i t + e_{i,t}$$

for each nonrenewable natural resource i , where P_i is the real price of resource i , t is time,

α_i and β_i are parameters to be estimated, and $e_{i,t}$ is a normally distributed error term. As before, we measure real prices for each of the thirteen commodities by two methods—deflating with the CPI and deflating by average U.S. manufacturing wages.

Estimating Equation 8 for the more conservative, CPI-adjusted data yields mixed results, as shown in Table 3. Prices for five of the commodities—anthracite coal, bituminous coal, natural gas, steel, and tin—show significant positive annual trend rates of growth, varying from a low of 0.2 percent for steel to a high of 2 percent for natural gas. Prices for iron and crude oil show no significant trends. Prices for the other six commodities—aluminum, copper, lead, nickel, silver, and zinc—show significant negative annual trend rates of growth, varying from –0.3 percent for lead and zinc to –2.2 percent for aluminum.

Estimating Equation 8 for the more aggressive, wage-adjusted data yields stronger declines in commodity prices, as shown in Table 4. With the exception of natural gas, all the commodity price indexes show significant negative trends. Annual rates range from –1.2 percent for anthracite and bituminous coal to –4.1 percent for aluminum. Natural gas has no significant trend.

To control for potential variation of commodity prices over the business cycle, we also estimate Equation 8 by including measures of world and U.S. GDP. Although business cycles are shown to be significant in a few of the real commodity prices, the signs and significance of the trend coefficients are substantially similar to those in Tables 3 and 4.

Econometric Tests of Resource Scarcity: Subperiods

When working with such a long time series, breaks in the trends are possible. Casual observation suggests the possibility of such breaks for most price series around the end of World War II. To test formally for breaks in the individual series, we conduct Chow tests using data from 1870 through 1945 in the first period and 1946 through 1998 in the second period.⁸ The results show that at the 95 percent confidence level every price series, except lead and tin deflated by manufacturing wages only, has a significant break between 1945 and 1946.

Armed with this information, we repeat the econometric exercises described in Equation 8 for two periods—from 1870 through 1945 and from 1946 through 1998. For most of the commodities, strong downward trends in prices are found from 1870 through the end of World War II, but price declines moderate or reverse in the postwar era.

With the CPI-deflated commodity prices, ten of the thirteen pre-1946 series trend downward (*Table 5*). Anthracite coal and tin trend upward, and bituminous coal shows no price trend. After 1945, however, price declines moderate. Five of the commodity price series show significant positive trends, four show no significant trend, and four show significant negative trends.

With the wage-deflated commodity prices, all eleven of the pre-1946 series trend downward (*Table 6*). As with the CPI-adjusted data, price declines moderate after 1945. Four of the commodity price series show no significant trend, and six show significant negative trends. Only natural gas shows a significant positive trend after 1945.

As we did for the entire sample period, we control for potential variation of commodity prices over the business cycle in the subperiods using measures of both world and U.S. GDP. Although business cycles are significant in a few commodity prices, the signs and significance of the trend coefficients are substantially similar to those in Tables 5 and 6.

Econometric Tests of Resource Scarcity Reconsidered

Econometric tests conducted for the entire period or subperiods generally suggest similar results for samples that include the post-World War II data. Using the more conservative CPI-adjusted data, we find that real prices for some nonrenewable natural resources have positive trends while others have negative trends. Using

Table 3

Estimated Trends in Natural Resource Prices Deflated by the CPI, 1870–1998

Commodity	Constant	Trend growth rate
Aluminum	.73**	-.022**
Anthracite coal	1.75**	.007**
Bituminous coal	1.26**	.006**
Copper	-.54**	-.007**
Iron	4.65**	.001
Lead	-1.75**	-.003**
Natural gas	-3.34**	.020**
Nickel	.98**	-.012**
Oil	1.16**	.001
Silver	1.05**	-.007**
Steel	1.50**	.002**
Tin	-.26**	.006**
Zinc	-1.67**	-.003**

** Denotes significance at the 95 percent confidence level.

SOURCE: Authors' estimates using data from the Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

Table 4

Estimated Trends in Natural Resource Prices Deflated by Manufacturing Wages, 1870–1998

Commodity	Constant	Trend growth rate
Aluminum	1.71**	-.041**
Anthracite coal	2.66**	-.012**
Bituminous coal	2.18**	-.012**
Copper	.38**	-.025**
Iron	5.65**	-.019**
Lead	-.83**	-.022**
Natural gas	-2.64**	.004
Nickel	1.89**	-.031**
Oil	2.08**	-.017**
Silver	1.97**	-.025**
Steel	2.48**	-.017**
Tin	.67**	-.013**
Zinc	-.75**	-.021**

** Denotes significance at the 95 percent confidence level.

SOURCE: Authors' estimates using data from the Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

the more aggressive wage-adjusted data, we find no significant upward trends in commodity prices. Breaking the series into two periods, however, we find evidence that price declines for nonrenewable natural resources may have moderated (or reversed for some CPI-adjusted price series) since World War II.⁹ Predicting future price increases from this moderation is unwarranted, however.¹⁰

At issue is whether the more conservative or the more aggressive approach to analyzing the price data is more appropriate for assessing resource scarcity. The CPI-deflated price data measure the scarcity of the nonrenewable natural

Table 5

Estimated Trends in Natural Resource Prices Deflated by the CPI, 1870–1945 and 1946–1998

1870–1945			1946–1998		
Commodity	Constant	Trend growth rate	Commodity	Constant	Trend growth rate
Aluminum	1.32**	-.033**	Aluminum	-.48**	-.010**
Anthracite coal	1.64**	.010**	Anthracite coal	2.39**	0
Bituminous coal	1.43**	0	Bituminous coal	1.29**	.006**
Copper	-.26**	-.016**	Copper	-.41*	-.007**
Iron	4.92**	-.008**	Iron	3.82**	.012**
Lead	-1.71**	-.006**	Lead	-.37*	-.016**
Natural gas	-.22	-.028**	Natural gas	-5.55**	.041**
Nickel	1.54**	-.030**	Nickel	-.51*	.003
Oil	1.52**	-.010**	Oil	.49	.009**
Silver	1.60**	-.024**	Silver	-.50	.009**
Steel	1.84**	-.006**	Steel	1.80**	-.001
Tin	-.25**	.005**	Tin	.50	-.001
Zinc	-1.54**	-.007**	Zinc	-1.53**	-.004**

** Denotes significance at the 95 percent confidence level.

* Denotes significance at the 90 percent confidence level.

SOURCE: Authors' estimates using data from Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthly (1978).

Table 6

Estimated Trends in Natural Resource Prices Deflated by Manufacturing Wages, 1870–1945 and 1946–1998

1870–1945			1946–1998		
Commodity	Constant	Trend growth rate	Commodity	Constant	Trend growth rate
Aluminum	2.59**	-.057**	Aluminum	-.71**	-.017**
Anthracite coal	2.58**	-.008**	Anthracite coal	2.16**	-.007**
Bituminous coal	2.36**	-.017**	Bituminous coal	1.07**	-.001
Copper	.68**	-.034**	Copper	-.64**	-.014**
Iron	5.85**	-.026**	Iron	4.32**	-.003
Lead†			Lead†		
Natural gas	1.37**	-.057**	Natural gas	-5.78**	.033**
Nickel	2.48**	-.048**	Nickel	-.74**	-.004*
Oil	2.45**	-.028**	Oil	.26	.001
Silver	2.53**	-.042**	Silver	-.73*	.002
Steel	3.14**	-.030**	Steel	1.57**	-.008**
Tin†			Tin†		
Zinc	-.61**	-.025**	Zinc	-1.75**	-.011**

** Denotes significance at the 95 percent confidence level.

* Denotes significance at the 90 percent confidence level.

† Authors chose not to estimate this series in two periods because there was no break in trend.

SOURCE: Authors' estimates using data from Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthly (1978).

resources relative to a given basket of goods. Because improved technology increases the availability of all goods, the CPI-deflated measures of prices tend to underestimate the effect of technological change in increasing the availability of the resources.¹¹

Deflating the price data with manufacturing wages captures technological change that increases the availability of all goods, but it also reflects the rising educational attainment of manufacturing workers from 1870 to 1998. As such, the wage-deflated price measures tend to overestimate the effect of technological change in increasing the availability of nonrenewable

natural resources. The relevant real price—and the correct assessment—lies somewhere between those found with the two measures. Table 7 presents a summary of what we can conclude from the relevant measures of the real prices of the nonrenewable natural resources in question. (Also, see the appendix.)

SUMMARY AND CONCLUSIONS

Some observers remain concerned that increasing natural resource scarcity will limit future economic growth and human well-being, while others remain optimistic that technologi-

cal change will overcome geophysical scarcity. Reliance on free markets can promote the requisite technological change. The increasing scarcity of a natural resource increases its price. When they expect higher prices, consumers look for technology that lets them use less of a natural resource. Producers turn to technology that lowers production costs in expectation of higher profits.

The question is whether technological change can outpace geophysical scarcity, and economic theory suggests a test. Rising real prices for nonrenewable natural resources would provide evidence that technological advance has not offset increased geophysical scarcity; constant real prices would indicate that technological advance has just offset increased geophysical scarcity; and falling real prices would signify that technological advance has more than offset increased geophysical scarcity.

Using econometric tests to examine the trends in the real prices of thirteen commodities, we find little evidence of increased natural resource scarcity from 1870 through 1998. For none of these commodities do we find conclusive evidence that the relevant real price has risen. Our results indicate that the relevant real prices could have risen or remained unchanged for natural gas; could have risen or fallen for anthracite coal, bituminous coal, steel, and tin; could have remained unchanged or fallen for iron and crude oil; and have fallen for aluminum, copper, lead, nickel, silver, and zinc.

Although we find evidence that price declines for nonrenewable natural resources may have moderated (or reversed for some CPI-deflated price series) since World War II, we find little evidence of increased scarcity. For only one of the thirteen commodities—natural gas—do we find conclusive evidence that the relevant real price has risen. The real price of tin could have risen or fallen. The real prices could have risen or remained unchanged for bituminous coal, iron, crude oil, and silver; could have remained unchanged or fallen for anthracite coal, nickel, and steel; and have fallen for aluminum, copper, lead, and zinc.

In short, the evidence suggests that over the past century, new technology driven by free market forces has overcome the geophysical scarcity of nonrenewable natural resources. Increased reliance on markets during the closing decades of the twentieth century is cause for optimism that these trends will continue in the twenty-first.

Table 7

Summary of Trends in the Real Prices of Nonrenewable Natural Resources

Commodity	Whole period (1870–1998)	Post–World War II
Aluminum	Falling	Falling
Anthracite coal	Rising to falling	Unchanged to falling
Bituminous coal	Rising to falling	Rising to unchanged
Copper	Falling	Falling
Iron	Unchanged to falling	Rising to unchanged
Lead	Falling	Falling
Natural gas	Rising to unchanged	Rising
Nickel	Falling	Unchanged to falling
Oil	Unchanged to falling	Rising to unchanged
Silver	Falling	Rising to unchanged
Steel	Rising to falling	Unchanged to falling
Tin	Rising to falling	Rising to falling
Zinc	Falling	Falling

SOURCE: Authors' estimates using data from the Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

NOTES

The authors would like to thank W. Michael Cox for providing manufacturing wage data.

- ¹ For illustrative purposes, we assume constant returns to scale for the world economy—that is, a doubling of all inputs doubles output.
- ² If $C_{X,t}$ is negative, the user cost rises more rapidly than the interest rate.
- ³ For extremely high values of $C_{X,t}$, the user cost and price of the natural resource would fall over time. These conditions do not generally exist. See Dasgupta and Heal (1979).
- ⁴ Futures markets for nonrenewable natural resources occasionally go into backwardation, reflecting short-term supply constraints and the cost to users of stocking out.
- ⁵ Of course, technological advance may occur without such stimulation, but a historical comparison of the rates of technological growth in free market economies with those occurring in the Communist-bloc countries demonstrates the importance of incentives to technological change.
- ⁶ The 1980 prices show evidence of the commodity price explosion in the 1970s, as prices for most commodities rise dramatically, then begin to fall.
- ⁷ Price data for aluminum, iron, natural gas, steel, and tin cover the periods 1895–1998, 1870–1981, 1919–98, 1897–1998, and 1880–1998, respectively.
- ⁸ The data may show additional or more-optimal breaks than between 1945 and 1946, but exhaustive testing of breaks is of relatively low power econometrically.
- ⁹ The commodity price explosion in the 1970s may have contributed to the break in trend. Residuals for trends estimated over the entire period and the 1870–1945 subperiod are white noise, but residuals

for most trends estimated over the 1946–98 period are not.

¹⁰ Using CPI-adjusted data, Slade (1982) uses a quadratic time-trend to predict that prices for nearly all nonrenewable natural resources would eventually begin rising. Berck and Roberts (1996) show that other specifications are preferred and that Slade's conclusions are unwarranted.

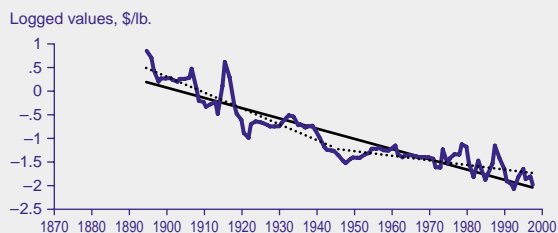
¹¹ Consider the case in which technology changes in such a way that all goods and services, including nonrenewable natural resources, could be produced with half as much effort. The CPI-deflated measure of prices for nonrenewable natural resources would suggest no change in availability.

REFERENCES

- Barnett, H. J., and C. Morse (1963), *Scarcity and Growth: The Economics of Natural Resource Scarcity* (Baltimore: Johns Hopkins University Press for Resources for the Future).
- Berck, Peter, and Michael Roberts (1996), "Natural Resource Prices: Will They Ever Turn Up?" *Journal of Environmental Economics and Management* 31 (July): 65–78.
- Brown, G. M., and B. C. Field (1978), "Implications of Alternative Measures of Natural Resource Scarcity," *Journal of Political Economy* 86 (April): 229–44.
- Dasgupta, P. S., and G. M. Heal (1979), *Economic Theory and Exhaustible Resources* (Cambridge: Cambridge University Press).
- Fisher, Anthony C. (1979), "Measurements in Natural Resource Scarcity," in *Scarcity and Growth Reconsidered*, ed. V. Kerry Smith (Baltimore: Johns Hopkins University Press).
- Hartwick, John M., and Nancy D. Olewiler (1986), *The Economics of Natural Resource Use* (New York: Harper and Row).
- Hotelling, H. (1931), "The Economics of Exhaustible Resources," *Journal of Political Economy* 39 (April): 137–75.
- Jorgenson, D., and Z. Griliches (1967), "The Explanation of Productivity Change," *Review of Economics and Statistics* 34: 250–82.
- Malthus, Thomas R. (1798), *An Essay on the Principle of Population* (London: J. Johnson).
- Manthey, Robert S. (1978), *Natural Resource Commodities: A Century of Statistics* (Baltimore: Johns Hopkins University Press for Resources for the Future).
- Meadows, Donella H., Dennis L. Meadows, Jorgen Randers, and William W. Behrens (1972), *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe).
- Nordhaus, W. D. (1973), "World Dynamics: Measurement Without Data," *Economic Journal* 83 (December): 1156–83.
- Peterson, F. M., and A. C. Fisher (1977), "The Exploitation of Extractive Resources," *Economic Journal* 87 (December): 681–721.
- Schmidt, R. H. (1988), "Hotelling's Rule Repealed? An Examination of Exhaustible Resource Pricing," Federal Reserve Bank of San Francisco *Economic Review*, Fall, 41–54.
- Slade, M. E. (1982), "Trends in Natural Resource Commodity Prices: An Analysis of the Time Domain," *Journal of Environmental Economics and Management* 9 (June): 122–37.
- Solow, Robert W. (1974), "The Economics of Resources or the Resources of Economics," *American Economic Review* 64 (May): 1–14.

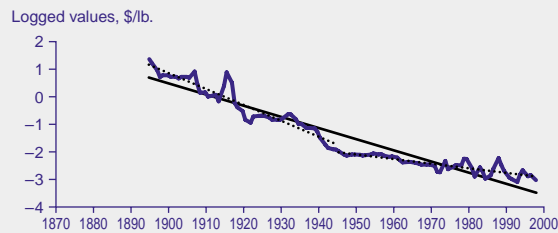
Appendix Trends in Natural Resource Prices

Deflated by the CPI



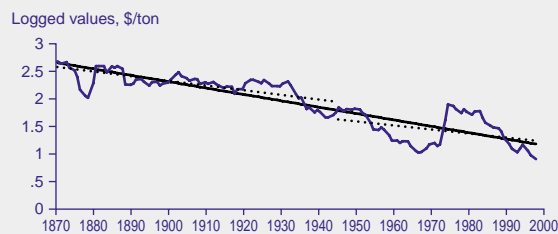
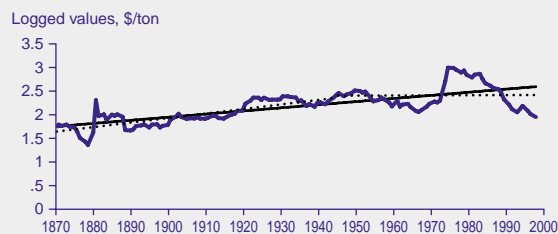
Aluminum

Deflated by manufacturing wages



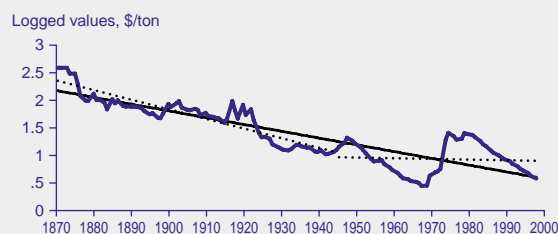
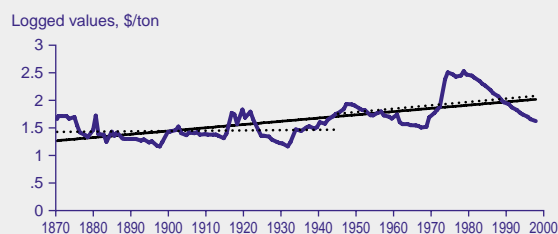
By all measures, relevant real price fell during entire period, as well as after World War II.

Anthracite coal



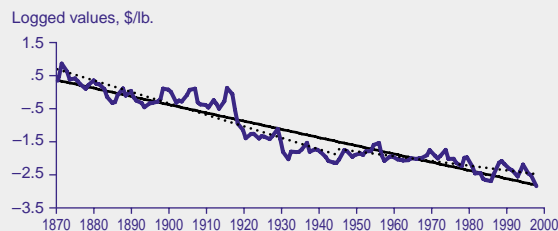
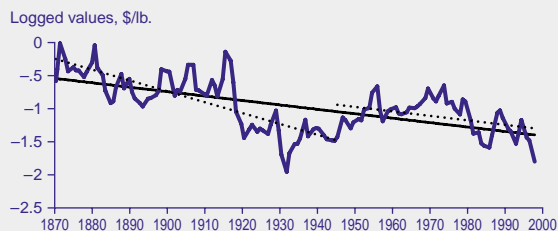
Relevant real price could have risen or fallen during entire period but has remained unchanged or fallen since World War II.

Bituminous coal



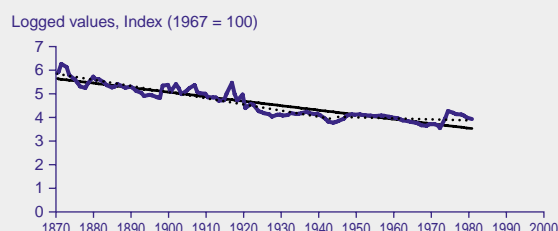
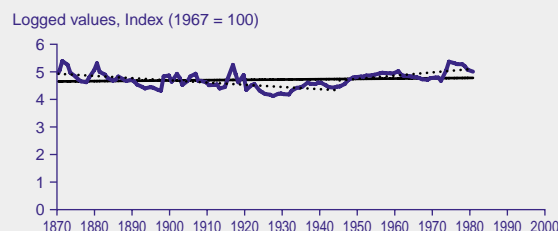
Relevant real price could have risen or fallen during entire period but has risen or remained unchanged since World War II.

Copper



By all measures, relevant real price fell during entire period, as well as after World War II.

Iron



Relevant real price could have remained unchanged or fallen during entire period but has risen or remained unchanged since World War II.

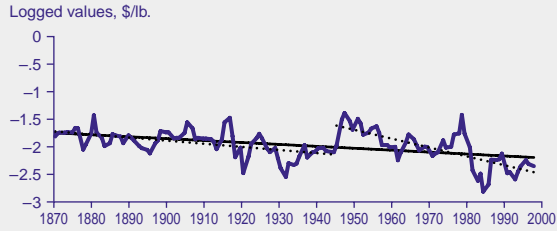
— Actual price — Trend whole period Trend pre-1946 and post-World War II

(continued on next page)

Appendix (continued)

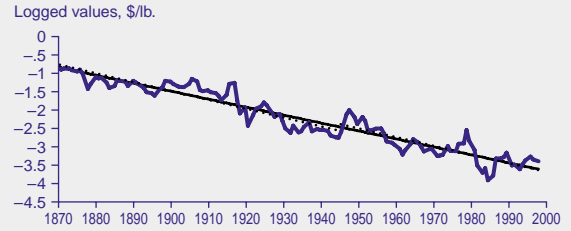
Trends in Natural Resource Prices

Deflated by the CPI



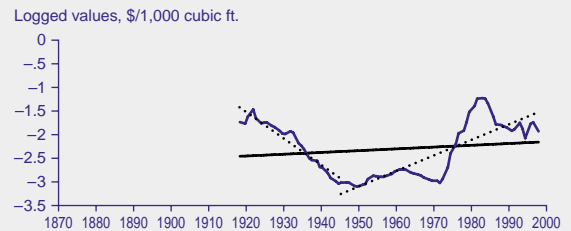
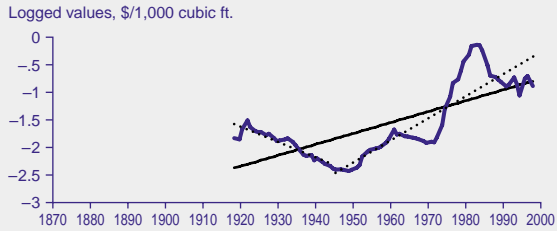
Lead

Deflated by manufacturing wages



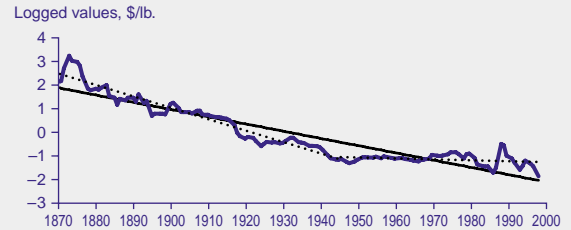
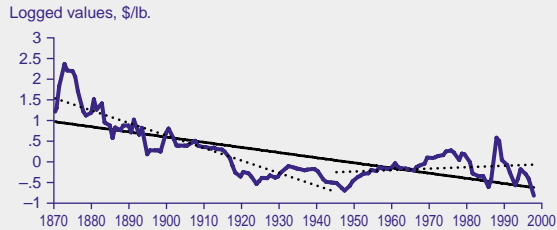
By all measures, relevant real price fell during entire period, as well as after World War II. Chow test indicates price data deflated by manufacturing wages should not be split into the two periods 1870–1945 and 1946–1998.

Natural gas



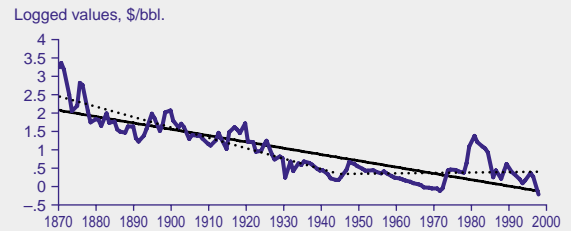
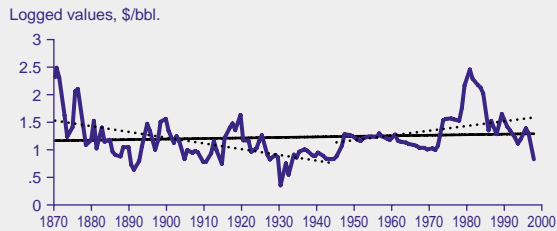
Relevant real price could have risen or remained unchanged during entire period but, by all measures, has risen since World War II.

Nickel



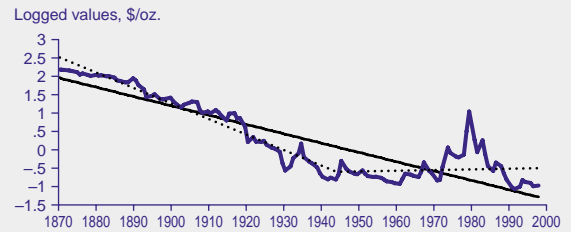
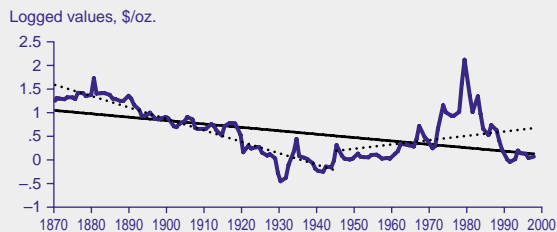
Relevant real price fell during entire period but has remained unchanged or fallen since World War II.

Oil



Relevant real price could have remained unchanged or fallen during entire period but has risen or remained unchanged since World War II.

Silver



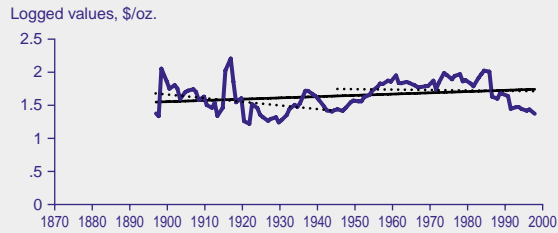
Relevant real price fell during entire period but has risen or remained unchanged since World War II.

— Actual price — Trend whole period Trend pre-1946 and post-World War II

(continued on next page)

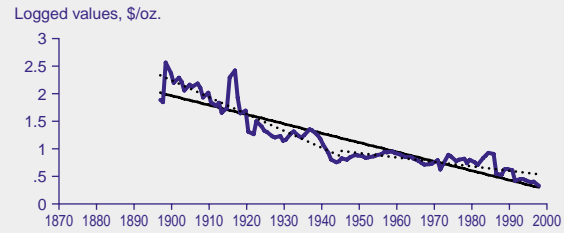
Appendix (continued)
Trends in Natural Resource Prices

Deflated by the CPI



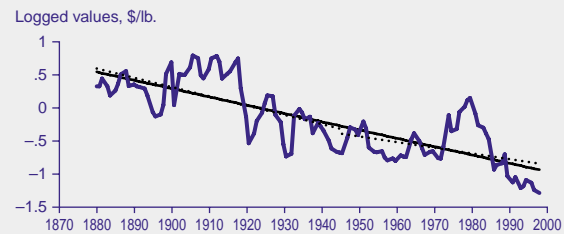
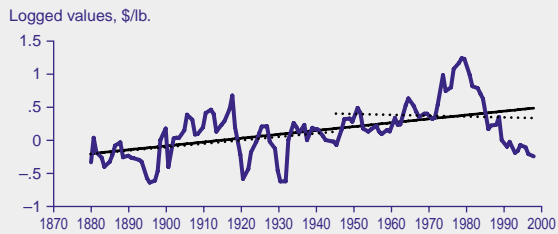
Steel

Deflated by manufacturing wages



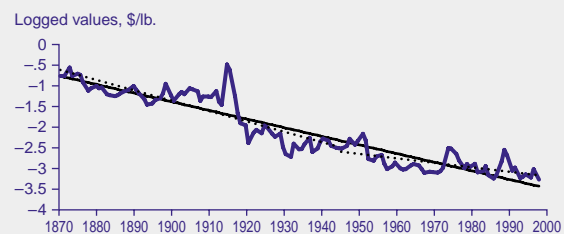
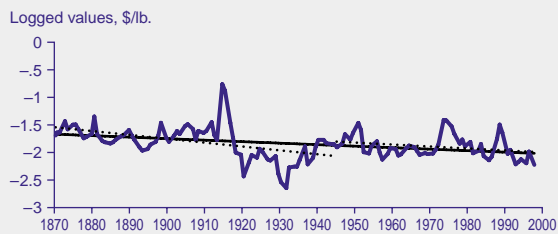
Relevant real price could have risen or fallen during entire period but has remained unchanged or fallen since World War II.

Tin



Relevant real price could have risen or fallen during entire period, as well as since World War II. Chow test indicates price data deflated by manufacturing wages should not be split into the two periods 1870–1945 and 1946–1998.

Zinc



By all measures, relevant real price fell during entire period, as well as after World War II.

— Actual price — Trend whole period Trend pre-1946 and post-World War II

SOURCE: Authors' calculations and estimates using data from the Bureau of Labor Statistics, Department of the Interior, Department of Energy, and Manthey (1978).

EMU at 1

Mark A. Wynne

The economic and monetary union is now one year old, and it seems appropriate to review what has happened during the first year and assess the prospects for the future.

Mark Wynne is a research officer and senior economist in the Research Department at the Federal Reserve Bank of Dallas.

On January 1, 1999, the European Union (EU) launched what will surely be one of the most ambitious political and economic undertakings of the twenty-first century: economic and monetary union (EMU), incorporating eleven of the fifteen current members of the EU. A new currency, the euro, replaced the national currencies of the eleven countries,¹ and a new institution, the European Central Bank (ECB), took over responsibility for monetary policy for the euro area. Many commentators in the United States thought EMU would never take place or, if it did, that it would not last very long. The successful launch of EMU was thus a surprise in some quarters, and some of the skeptics have been forced to reevaluate their positions. EMU is now one year old, and it seems appropriate to review what has happened during the first year and assess the prospects for the future.

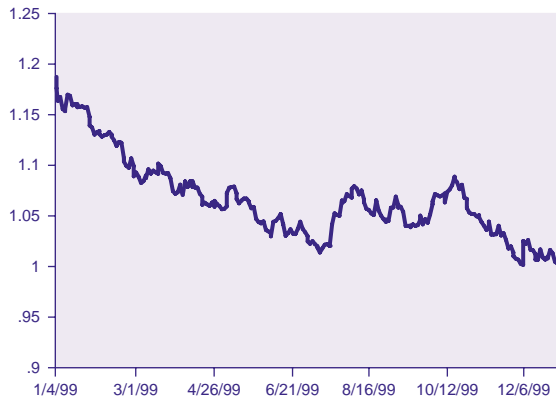
Over the course of 1999, the euro depreciated steadily against the dollar. The ECB made its first rate moves, lowering interest rates in April in response to deflation risk in the euro area and raising them in November as the recovery took hold and the inflation outlook deteriorated. The ECB successfully defended its independence against challenges from the finance minister of one of the larger member states and has worked to establish credibility for its commitment to price stability. The TARGET payments system, key to the integration of euro area money markets, came online and has operated without any major problems. The euro has emerged as an important international currency, second only to the dollar. The volume of international bonds denominated in euros exceeded dollar-denominated issuance during 1999. The four EU countries that currently do not participate in EMU all moved closer to eventual membership. However, there were few moves toward the fiscal, labor, and product market reforms that may ultimately determine the fate of EMU.

MAIN DEVELOPMENTS DURING 1999

The euro officially became the currency of the eleven participating nations on January 1, 1999. The rates to be used for converting national currency units into euros were announced on December 31, 1998. During the changeover weekend, January 1 through January 3, the financial community had to reconfigure computer and accounting systems to handle the new currency. Furthermore, all government debt of the euro-area countries was redenominated in euros, as were the share prices

Figure 1
Dollar–Euro Exchange Rate

Dollars per euro



SOURCE: Policy Analysis Computing & Information Facility in Commerce (PACIFIC) Exchange Rate Service <<http://pacific.commerce.ubc.ca/xr/>>. Copyright 1998 by Prof. Werner Antweiler, University of British Columbia, Vancouver, Canada. Reprinted by permission.

of all companies listed in the euro area, along with millions of bank accounts.

The most striking and oft analyzed development during 1999 was the steady depreciation of the euro against the dollar. The euro also declined against the yen and the pound sterling. When the euro made its debut on world financial markets on January 4, 1999, it was trading at \$1.18. It immediately began to depreciate against the dollar, coming close to parity (and briefly below in intraday trading) by December 1999 (*Figure 1*).² The depreciation took many commentators by surprise and was contrary to the confident predictions of many that the euro would rapidly appreciate against the dollar, given the relative current account positions of the United States and the euro area.

However, if we take a longer-term perspective, the decline of the euro against the dollar over the past year is less remarkable. Figure 2 shows the exchange rate of the euro's predecessor, the European Currency Unit (ECU), against the dollar from 1996 through 1998, along with the exchange rate of the euro against the dollar during 1999.³ Under the terms of the transition to EMU, one ECU was required to equal one euro at midnight December 31, 1998. As Figure 2 shows, in late 1998, the ECU, or rather the legacy currencies of the euro, experienced a strong appreciation against the dollar in the wake of Russia's default and the failure of the hedge fund Long Term Capital Management in the United States. Some of this appreciation may also have been driven by the "europhoria" in the period between the Brussels summit in May 1998—at which the EU heads of govern-

ment decided which countries would participate in EMU—and the actual launch of EMU.

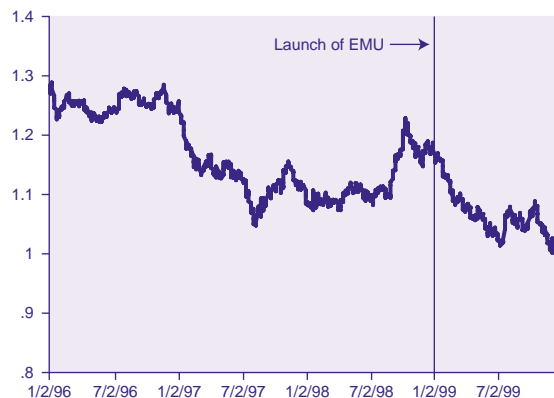
Perhaps more important for the evolution of the dollar–euro exchange rate was the fact that over the course of 1999 the U.S. economy continued to grow at a robust pace, while the euro area experienced a growth recession. Through the third quarter, GDP increased only 2.3 percent in the euro area, and in autumn 1999 the European Commission forecast an increase of only 2.1 percent for the year as a whole. Unemployment in the euro area remained stubbornly high, declining from 10.6 percent of the labor force in December 1998 to 9.6 percent at the end of 1999. Evidence strengthened that trend productivity growth was accelerating in the United States, but there were few signs that much-needed structural reforms were being undertaken in Europe.

It is too early to take the decline as symptomatic of fundamental problems with the new currency. Over the long run, the nominal exchange rate of the euro against the dollar will reflect the relative success of the ECB in maintaining the euro's purchasing power, but over the short run, cyclical and other factors will be more important.

The ECB made its first rate moves in 1999, lowering its repo rate from 3 percent to 2.5 percent in April and then raising it back to 3 percent in November.⁴ It is significant that in neither case was there much political opposition from the countries most likely to have opposed these moves. The rate cut in April was probably

Figure 2
Dollar–ECU, Dollar–Euro
Exchange Rates, 1996–99

Dollars per ECU, dollars per euro



SOURCE: Policy Analysis Computing & Information Facility in Commerce (PACIFIC) Exchange Rate Service <<http://pacific.commerce.ubc.ca/xr/>>. Copyright 1998 by Prof. Werner Antweiler, University of British Columbia, Vancouver, Canada. Reprinted by permission.

the last thing the rapidly growing economies on the fringe of the euro area (Ireland, Finland, Spain and Portugal) needed. Indeed, Ireland, which has come to be known as the “Celtic Tiger,” seems to be exhibiting the symptoms of a classic asset price bubble, with house prices rising by as much as 20 percent to 30 percent a year. Likewise, when it came time to raise rates in November, the sluggish German economy probably could have benefited from a longer period of lower interest rates. However, the ECB’s mandate is to maintain price stability in the euro area as a whole. Thus, it has explained its decisions to raise or lower interest rates on the basis of developments at the euro-area level rather than in terms of what has happened in individual member states.⁵

THE CHALLENGE OF CONDUCTING MONETARY POLICY FOR THE EURO AREA

One of the most important tasks prior to EMU was to ensure that the ECB would have at its disposal adequate statistical information to make monetary policy decisions for the euro area. This required some degree of harmonization of statistical practices across the EU, in particular for inflation and monetary statistics. Primary responsibility for the production of official statistics in the EU rests with Eurostat, which is one of the Directorates General of the European Commission. Eurostat produces statistics for the euro area and the member states in conjunction with national statistical institutes and plays a key role in ensuring that statistics are harmonized. GDP estimates for the euro area are constructed on a consistent basis using the ESA95 version of the European System of Accounts (ESA). Unemployment rates for the euro area are calculated using a definition put forward by the International Labour Office in 1982.⁶

The ECB defined price stability in terms of the rate of increase in the Harmonised Index of Consumer Prices (HICP) for the euro area. The HICP program originated in the need for a common measure of inflation to assess EMU membership candidates’ compliance with the convergence criteria stipulated in the treaty. The various national consumer price indexes (CPIs) differ significantly in their concept and coverage. According to the European Commission (1998), as much as 13 percent of expenditures covered by the HICP are excluded from some national CPIs, while as much as 17 percent of expenditures covered by some national CPIs are excluded from the HICP. The HICP differs from

the U.S. CPI, for example, beginning with the pricing concept. While the U.S. Bureau of Labor Statistics uses the theory of the cost of living index as the framework for constructing the U.S. CPI (U.S. Bureau of Labor Statistics 1997), the HICP uses “household final monetary consumption,” which means that only the prices paid in monetary transactions are included. The HICP does not, therefore, include the imputed costs of agricultural products grown for personal consumption or the services of owner-occupied dwellings. The latter is included in the U.S. CPI and accounts for approximately one-fifth of the basket.⁷

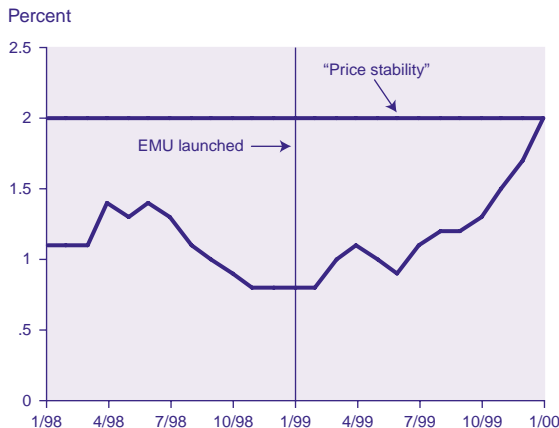
A more serious problem from the ECB’s perspective is that the HICP program only began in 1997. Aggregate HICP data are available for a slightly longer period, but the fact remains that the ECB must work with price statistics for which there are a limited number of observations. Even if a long time series on prices were available, it is not clear how useful it would be to the ECB. Since Lucas (1976), economists have been sensitive to the instability of estimated empirical relationships in the face of policy regime changes. While there is some debate in macroeconomics as to what exactly constitutes a regime change, few would deny that EMU is a major change in the monetary policy regime for all the participating countries.

PRICE STABILITY

Article 105 (1) of the Maastricht Treaty states that the primary objective of the ECB shall be to maintain price stability but leaves it to the ECB to define what exactly, in terms of measured inflation, constitutes price stability. Prior to EMU, the ECB announced that it would define price stability as a “year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%.” Furthermore, price stability is to be maintained “over the medium term.”⁸ At the launch of EMU, HICP inflation in the euro area was running at an annual rate of about 1 percent, having slowed from rates in excess of 2 percent in early 1996. An energy price deceleration in 1997 and decline in 1998 contributed significantly to the favorable inflation situation at the launch of EMU. However, as Figure 3 shows, during 1999 the inflation rate accelerated as energy prices started to increase and the euro declined against the dollar and other major currencies.

Furthermore, there has been some divergence of inflation rates across the euro area over the past year. Figure 4 shows highest and

Figure 3
Euro-Area HICP Inflation



SOURCE: Eurostat.

lowest inflation rates across the eleven euro area countries, along with the limit set down in the Maastricht Treaty.⁹ Since mid-1998, inflation in Portugal, Spain, and Ireland has exceeded the limit set down in the treaty, although as of December 1999 only Ireland's inflation rate was more than 1.5 percentage points above the average of the three lowest. The ECB does not yet include a measure of core inflation for the euro area in the statistical appendix to its *Monthly Bulletin*, although Eurostat, the EU's statistical agency, does include a core measure ("All items excluding energy, food, alcohol, and tobacco") on its web site.¹⁰

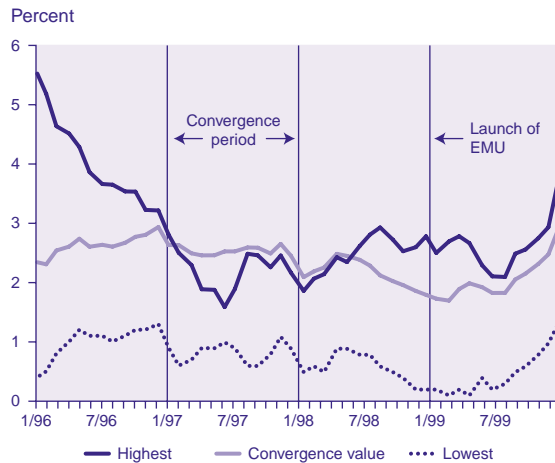
THE REFERENCE VALUE FOR M3

The twin pillars of the ECB's monetary policy strategy are a reference value for the growth rate of the broad money aggregate M3 and a broadly based assessment of the outlook for future price developments and the risks to price stability in the euro area. The choice of M3 rather than a narrower aggregate was based on research indicating the M3 aggregate has desirable characteristics in terms of stability and information about future inflation.¹¹

The reference value for M3 is derived from three assumptions:

1. Price stability is defined as a rate of increase in the HICP of 2 percent or less.
2. The trend rate of growth of real GDP in the euro area is 2 percent to 2.5 percent.
3. The trend rate of decline in M3 velocity is about 0.5 percent to 1 percent a year.

Figure 4
Inflation in the Euro Area

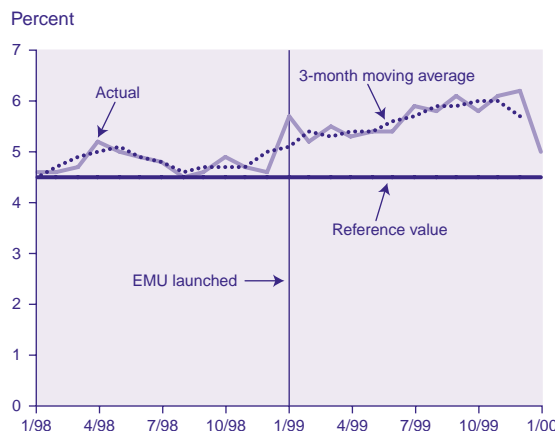


SOURCE: Eurostat.

These three assumptions, together with a standard quantity theory view of the determination of the price level, led the Governing Council to choose a reference value of 4.5 percent for M3 growth during 1999.¹² The monthly statistics on M3 growth are assessed in relation to this reference value using a centered three-month moving average of monthly growth rates. It should be noted that the ECB's derivation of the reference value for the euro area's M3 aggregate is similar to the Bundesbank's procedure to derive its annual M3 target (see Deutsche Bundesbank 1995).

As Figure 5 shows, M3 growth drifted steadily away from its reference over the course of the year. As of December 1999, M3 growth was almost 2 percentage points above the reference value. The ECB discounted some of the deviation as due to temporary factors associated with the euro's introduction. The ECB's failure

Figure 5
Euro-Area M3 Growth



SOURCE: European Central Bank.

Monetary Aggregates for the Euro Area

Before EMU, each of the EU member states constructed monetary aggregates using national definitions that differed across countries. It was not possible to arrive at a consistent aggregate for the euro area by simply adding together these differing national aggregates. Thus, a key challenge prior to EMU's launch was to harmonize definitions to allow consistent measures to be constructed for the single currency area. As part of this harmonization process, the European Monetary Institute and the national central banks developed the concept of a Monetary Financial Institution (MFI), consisting of three types. The first is central banks. The second is resident credit institutions as defined by EU law, and the third is "all other resident financial institutions whose business is to receive deposits and/or close substitutes for deposits from entities other than MFIs and, for their own account...to grant credits and/or to make investments in securities." This third category consists primarily of money market funds.

The main broad monetary aggregates for the euro area are defined below. The M1 aggregate consists of currency in circulation and overnight deposits and differs little from the old national definitions of M1. The category overnight deposits includes balances on prepaid cards in those countries where prepaid card schemes exist. M2 adds to M1 deposits with agreed maturity up to two years and deposits redeemable at notice up to three months. The M3 aggregate adds to M2 repurchase agreements, liabilities of money market funds and debt securities up to two years. Note that prior to EMU, repurchase agreements were excluded from the national definitions of monetary aggregates in France and Italy, while money market fund shares/units were included only in the national monetary aggregates of France. For further information on the new euro-area aggregates and how they relate to old national definitions, see European Central Bank (1999b).

Definitions of Euro-Area Monetary Aggregates

	M1	M2	M3
Currency in circulation	✓	✓	✓
Overnight deposits	✓	✓	✓
Deposits with agreed maturity up to two years		✓	✓
Deposits redeemable at notice up to three months		✓	✓
Repurchase agreements			✓
Money market fund shares/units and money market paper			✓
Debt securities up to two years			✓

SOURCE: European Central Bank.

to raise interest rates aggressively in response to the deviation suggests that it may take a pragmatic view of the reference value for M3, much as the Bundesbank did of its M3 target. From the time the Bundesbank set its first monetary target (in 1974) until the start of EMU, it succeeded in hitting its target only about half the time.

COMMUNICATION: TRANSPARENCY AND ACCOUNTABILITY

One criticism levied against the ECB during its first year is that it is not sufficiently transparent in making monetary policy decisions and is not held adequately accountable for those decisions (see, for example, Buiter 1999 and Begg et al. 1998). The critics argue that the ECB should publish the minutes of Governing Council meetings, the votes of individual council members, and the reasoning and forecasts that underlie council decisions. The ECB has resisted publication of minutes and

votes, arguing that making such information public would increase pressure on council members to vote along national lines rather than in the interests of the euro area as a whole (see Issing 1999).

Transparency in monetary policymaking has many dimensions, and much of the criticism of the ECB seems unwarranted. Table 1 compares practices of the ECB, the Federal Reserve System, and the Bank of England as they relate to transparency and accountability. The policy-making committee of the ECB—the Governing Council—meets much more frequently than the Federal Reserve System's Federal Open Market Committee (FOMC) or the Bank of England's Monetary Policy Committee (MPC). Through 1999 the ECB's Governing Council met every two weeks (except during August) at the ECB's headquarters in Frankfurt, although the Maastricht Treaty requires only that it meet at least ten times a year (Protocol No. 3 on the Statute of the European System of Central Banks and the European Central Bank, Article 10.5). A press conference was held after the first of the two meetings in each month, and the tradition seems to be evolving that rate moves are only made at the meetings that are followed by a press conference. At the press conference the president of the ECB summarizes recent economic developments, then he and the vice president hold a question-and-answer session with journalists. The opening statement and the Q&A are posted on the ECB's web site (<http://www.ecb.int>) within hours. The ECB views the press conference, along with the editorial that appears in each issue of its *Monthly Bulletin*, as a substitute for the publication of minutes. (Neither the FOMC nor the MPC holds a press conference after its meetings.) Transparency is a slippery concept, and there is no meaningful way to evaluate whether a press conference following a policy decision constitutes more or less transparency than the publication of votes and minutes.¹³

The second issue concerns the publication of forecasts. The Bank of England has been an innovator in this regard, publishing on a regular basis its inflation forecast and not just a point forecast. The FOMC does not publish forecasts (although the chairman does report the range of forecasts of committee members in his twice-yearly Humphrey-Hawkins testimony).

Article 109b.3 of the Maastricht Treaty requires that

The ECB shall address an annual report on the activities of the ESCB [European System

of Central Banks] and on the monetary policy of both the previous and current year to the European Parliament, the Council and the Commission, and also to the European Council. The President of the ECB shall present this report to the Council and to the European Parliament, which may hold a general debate on that basis.

The ECB submitted its first annual report in April 1999, and the European Parliament's Committee on Economic and Monetary Affairs reviewed it. In its response, the committee called for greater transparency from the ECB (see European Parliament 1999). Specifically, the committee noted that it

7. Regrets that the ECB has fallen short of the transparency practiced by other leading central banks; notes that the U.S. Federal Reserve Board [sic], Bank of Japan, Bank of England and Swedish Riksbank now report both sides of arguments about monetary actions; and calls for summary minutes taken at meetings of the ECB Governing Council to be published shortly after the following meeting reporting explicitly the arguments for and against the decisions taken, as well as the reasoning used in reaching these decisions;

8. Calls on the ECB to publish macro-economic forecasts on a six-monthly basis which set out the prospects and the risks attached to those prospects for: domestic demand and its principal components, net exports, nominal and real gross domestic product, consumer price inflation, unemployment and the current account balance, together with such relevant data and research on which such forecasts are based, in order to permit a reliable assessment of monetary decisions, avoid market misinformation, ensure market transparency and hence counter speculation;

9. Calls on the ECB to publish a regular overall report of economic developments in each of the participating euro-area countries together with a summary of the national data which will facilitate comparisons of best practice; enable early warnings of potential problems within the euro-area which might require policy action by respective governments; and inform national wage bargainers of sustainable earnings developments given their own productivity, price and competitiveness trends....

Table 1

Transparency in Monetary Policymaking at the Federal Reserve, the ECB, and the Bank of England

	ECB	Federal Reserve System	Bank of England
Policymaking committee	Governing Council	Federal Open Market Committee	Monetary Policy Committee
Frequency of meeting	Every two weeks	Every six or seven weeks	Every month
Announced strategy	Yes	No	Yes
Quantitative definition of price stability	Yes	No	Yes
Publication of forecasts	Not yet	No	Yes
Publication of minutes	No	Yes	Yes
Publication of votes	No	Yes	Yes
Press conference	Yes	No	No
Accountable to elected body	Yes	Yes	Yes

SOURCES: European Central Bank, Federal Reserve System, Bank of England.

At the subsequent hearings the ECB president acceded to the request to publish forecasts and promised they would be published during 2000, along with the economic models used to produce these forecasts. However, he rejected the request that the ECB publish summary minutes, arguing as before that the information the ECB provided at its press conferences and in its *Monthly Bulletin* came "very close in substance to the publication of summary minutes." He also rejected calls for reports on each euro-area country, arguing that the production of such reports would impede the development of a euro-area perspective. The Committee on Economic and Monetary Affairs called for publication of votes on monetary policy actions after a two-year delay, but this proposal was rejected when put to a vote of the full European Parliament.

Concerns about the ECB's accountability to the European electorate have two dimensions. The first is whether the provisions of the Maastricht Treaty that require the ECB to report to the European Parliament satisfy the need of accountability in a democratic society. The second is whether the European Parliament has the stature to represent the European electorate's concerns. Regarding the latter, two significant developments took place during 1999. In March, the Parliament for the first time forced the resignation of the European Commission over allegations of financial misconduct, thereby enhancing the Parliament's standing among EU institutions and its authority as the representative body of the EU electorate. And on May 1, the Amsterdam Treaty entered into

Table 2
Functions of International Currencies

	Private use	Official use
Unit of account	Pricing/quotation currency	Pegging currency
Medium of exchange	Payment/vehicle currency In exchanges of goods and services In currency exchange	Intervention currency
Store of value	Investment/financing currency	Reserve currency

SOURCES: Cohen (1971), Hartmann (1998).

force, substantially extending the right of co-decision of the European Parliament, making it the council's legislative equal in many areas.¹⁴

EMERGENCE OF THE EURO AS AN INTERNATIONAL CURRENCY

Prior to the euro's launch, there was much discussion about the extent to which it would compete with or even displace the dollar as the world's most important international currency. Some argued it would take a long time for the euro to replace the dollar in international transactions because of network effects. (I find it more useful to conduct transactions in dollars when more of my trading and investment partners also conduct transactions in dollars). Others argued that EMU itself was a shock of sufficient magnitude to trigger rapid adoption of the euro (see, in particular, Portes and Rey 1998).

The ECB has stated repeatedly that "internationalisation of the euro...is not a policy objective...[and] will be neither fostered nor hindered by the Eurosystem." Table 2 lists the main functions of international currencies, using the traditional classification of the functions of money (see Cohen 1971 and Hartmann 1998). The U.S. dollar is used to quote prices for industrial commodities, and many countries maintain some type of currency peg to the dollar. There are significant holdings of U.S. dollars in countries that have experienced high inflation, while foreign central banks typically use dollars to intervene in foreign exchange markets to support their local currency. Until last year the dollar was the currency of choice for international bond issuance, and most central banks continue to hold the bulk of their foreign exchange reserves in dollar-denominated assets.

Since the introduction of the euro, most commodity prices continue to be quoted in dollars, but large European firms now use the euro for quotation purposes. For instance, Airbus no longer uses the dollar to quote aircraft prices. As of the end of 1999, three countries (Estonia, Bulgaria, and Bosnia-Herzegovina) were pegging

their currencies to the euro through currency board arrangements. A larger group of countries (Cyprus, Macedonia, Cape Verde, Comoros, and the fourteen countries of the West African Colonies Françaises d'Afrique [CFA] zone) had more traditional fixed exchange rate pegs to the euro. Denmark and Greece are also pegged to the euro, albeit under a cooperative arrangement under the terms of ERM II, the successor to the Exchange Rate Mechanism (ERM) of the European Monetary System.¹⁵ A third group (Croatia, the Czech Republic, the Slovak Republic, and Slovenia) has managed floats vis-à-vis the euro. A fourth group (Hungary, Iceland, Malta, Poland, Turkey, Bangladesh, Botswana, Burundi, Chile, Israel, and the Seychelles) has either fixed or crawling pegs to baskets of currencies that include the euro. Finally, a fifth group of countries pegs to the Special Drawing Right (SDR) issued by the International Monetary Fund in which the euro has a weight of about one quarter. (The other currencies in the SDR basket are the U.S. dollar, the Japanese yen, and the pound sterling).

Perhaps the most significant benefit to the EU from internationalization of the euro would be the seigniorage revenue it would earn from foreign demand for euros. Although euro notes and coins will not be introduced until 2002, it is worth considering the revenue this may generate. At the end of 1999, approximately \$600 billion of U.S. currency was in circulation. According to Porter and Judson (1996), more than half the stock of U.S. currency—and possibly as much as 70 percent—was held outside the United States at the end of 1995. If we choose a conservative estimate of 50 percent and assume that absent these foreign holdings the federal government would have to issue an equivalent amount of short-term debt at the then-prevailing interest rate of 5.3 percent, the flow of seigniorage to the U.S. Treasury from the foreign holdings was about \$15.6 billion (= \$600 billion × 50 percent × 5.3 percent). As of November 1999, there was approximately €330 billion of currency outstanding in the euro area. Since euro notes and coins have not yet been introduced, this total consists of the notes and coins of the ten legacy currencies (Luxembourg was in a monetary union with Belgium prior to EMU). It is unlikely that many of the legacy currencies circulated to a significant extent beyond their national borders, with the exception of the Deutsche mark. Seitz (1995) estimates that approximately 40 percent of the stock of Deutsche marks circulates outside Germany. In November 1999, Deutsche mark notes and coins

in circulation amounted to €126 billion, or about 38 percent of the euro-area total. Thus, the estimated seigniorage revenue currently accruing to the euro area (specifically, to Germany) from non-euro-area holdings of Deutsche marks amounts to about €2 billion a year ($= €126 \text{ billion} \times 40 \text{ percent} \times 4 \text{ percent}$, using the interest rate on two-year euro-area government bonds as of November 1999 as an estimate of what the government would have to pay to raise the funds by borrowing).¹⁶ This probably constitutes a lower bound on the amount of seigniorage the EU will earn from non-EU holdings of the euro once the notes and coins are introduced. The euro's domestic habitat is significantly larger in economic terms than that of the Deutsche mark, making the euro more attractive to non-EU residents than the Deutsche mark was. The estimated foreign seigniorage revenue currently earned by the United States is probably an upper bound on what the EU can expect to earn.

Euro notes will include €100, €200, and €500 denominations.¹⁷ Currently, the highest denomination note issued by the Federal Reserve is the \$100 bill. Higher denomination notes may make the euro an attractive alternative to the dollar as a store of value in countries undergoing high inflation. It may also make the euro more attractive for transactions in the underground economy. The existence of high-denomination euro notes in and of itself will not cause individuals who currently hold dollars as a secure store of value in high-inflation countries or for illicit purposes to immediately switch to euros. These individuals will also have to be convinced that the euro will retain its value as well as, or better than, the dollar. This, in turn, will depend on the ECB's track record in maintaining price stability in the euro area.

TARGET

The architects of EMU faced a key challenge in the creation of a payments system that integrated money markets in all EU countries. The TARGET system (TARGET stands for Trans-euro-pean Automated Real-time Gross settlement Express Transfer) consists of fifteen national real-time gross settlement systems and the ECB payment mechanism. It provides a uniform platform for processing cross-border payments. Prior to EMU, payments between EU countries relied almost exclusively on correspondent banking arrangements. Since the beginning of 1999, these relationships have declined dramati-

cally, although most banks seem to be maintaining one or two correspondent accounts for each euro-area country until the euro notes and coins are introduced in 2002.

The TARGET system was created, first, to provide a pan-European payments system that would integrate national money markets and support the monetary policy of the ECB, and second, to safeguard financial markets and institutions from systemic events. The former was accomplished by linking the existing national payments systems. The latter was accomplished by moving to a real-time gross-settlement standard for national payments systems prior to EMU and away from end-of-day settlement, or netting systems, in which participants accumulate large open positions against their counterparties.

On January 4, 1999, its first day of operation, the TARGET system processed about 156,000 payments, with a total value of about €1.18 trillion. Of these, about 5,000 were cross-border payments, totaling about €245 billion. The volume of cross-border payments rapidly increased to 20,000 to 30,000 a day, with a total value between €300 billion and €400 billion, after only a week of operation. The successful launch of TARGET—and the consolidation of national money markets—was reflected in the rapid reduction in interest rate spreads in overnight money markets in January 1999.

Of the other systems available for processing payments in euros, the three largest are Euro 1, Euro Access Frankfurt (EAF), and the Système Net Protégé (SNP) (known since April 1999 as Paris Net Settlement, PNS). There are also two smaller local systems: Servicio Español de Pagos Interbancarios (SEPI) in Spain and Pankkien väliset On-line Pikasiirrot ja Sekit (POPS) in Finland. Together these systems settle a daily average volume of €400 billion, and the Euro 1 system (a cooperative undertaking between EU-based commercial banks and the EU branches of foreign banks) is by far the most extensively used alternative to TARGET. The existence of competitively priced alternative payments systems caused some concern (see, for example, Prati and Schinasi 1999) that TARGET might not attract the volume of high-value payments needed to significantly contribute to a lowering of payments-system systemic risk. That concern appears to have been unfounded: through September 1999, the average value of TARGET payments was €5.8 million. The average value of cross-border payments was €12.9 million, while the average value of domestic payments was €4.4 million.

The average values of the payments settled by the three biggest other systems (Euro 1, EAF, and PNS) were €2.8 million, €3.3 million, and €4.5 million, respectively.

WHAT ABOUT THE OUTS?

Not all fifteen members of the EU chose to participate in EMU from the outset. Greece failed to meet the convergence criteria laid down in the Maastricht Treaty, while the UK, Sweden, and Denmark chose to stay out for domestic political reasons. Greece formally applied for membership in March and hopes to become a member at the beginning of next year. As part of the convergence process, the Greek drachma was revalued on January 17, 2000. The situation in the UK, Sweden, and Denmark as to eventual membership in EMU is less clear.

When the Maastricht Treaty was first put to a referendum in Denmark, it was decisively rejected by the electorate. The treaty was ratified in a subsequent referendum, but only after it had been amended to provide an opt-out from the single currency for Denmark (Protocol No. 12 of the Maastricht Treaty). However, since the start of EMU the Danish krone has been pegged to the euro with a ± 2.25 percent fluctuation band under the terms of ERM II, meaning that, in effect, Danish monetary policy is dictated by the ECB. The Danish prime minister has already launched a political campaign to bring Denmark into EMU, and in September the ruling Social Democrats will hold a referendum on Denmark's entry into EMU.

Although Sweden satisfied all the convergence criteria for participation in EMU, it did not join at the outset because of domestic "Euroscepticism." Some of this skepticism waned in the closing months of 1998, when Denmark and Sweden were more adversely impacted by fallout from the Russian default than was Finland, which had elected to join EMU. Over the past year, attitudes in Sweden have wavered between joining and not joining. However, in January the ruling Social Democratic Party announced for the first time that it formally supports Swedish membership in EMU.

Which leaves only the UK. The government secured an opt-out from EMU when the Maastricht Treaty was negotiated (Protocol No. 11 of the Maastricht Treaty). With the change of government in the UK in 1997, official attitudes toward the EU changed significantly, and the new Labor government declared its intention to

take the UK into EMU when the time is right. In late 1997 the UK Treasury announced five economic tests that would be used to determine when the UK should join (see HM Treasury 1997):

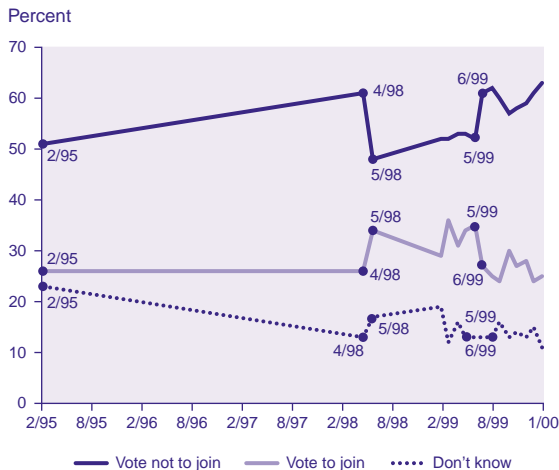
1. Are business cycles and economic structures compatible so that the UK and other members of EMU could live comfortably with a common interest rate on a permanent basis?
2. If problems emerge, is there sufficient flexibility to deal with them?
3. Would EMU membership enhance the attractiveness of the UK to overseas investors?
4. How would EMU membership affect the competitive position of the UK's financial services industry?
5. Will EMU membership promote higher growth, stability, and a lasting increase in jobs?

These tests are sufficiently vague that the government could easily announce that the tests are satisfied at any time. The UK took a further step forward in February 1999 with the publication of a National Changeover Plan (HM Treasury 1999) that details how UK membership in EMU might come about and presents a timetable for replacing sterling with the euro.

A more binding constraint on UK membership is the Labor government's commitment to put the issue to a referendum. As Figure 6 shows, the UK public remains skeptical about the single currency, and in the June 1999 elections to the European Parliament, the anti-euro Conservative Party won 36 seats, compared with the Labor Party's 29 seats. However, while public opinion in the UK remains decidedly against membership in EMU, a significant segment of British industry believes it is in the UK's interest to join. A June 1999 survey of members of the Institute of Directors revealed that 67 percent were in favor of the UK joining the single currency (in principle). In July the Confederation of British Industry (CBI) announced that it was in favor of the UK joining EMU. The CBI adopted a pro-EMU stance after a poll of its members showed that some 52 percent backed eventual membership.¹⁸ However, the CBI has subsequently announced that it will no longer actively campaign for UK membership until the government takes a more active role in promoting the issue.

Opponents of UK membership in EMU often argue that the UK business cycle is more closely aligned with the U.S. business cycle than

Figure 6
UK Attitudes to the Single Currency



SOURCE: ICM Research.

with the cycle in continental European countries and that the criterion of cyclical convergence will never be satisfied. This fact is documented by Wynne and Koo (forthcoming), among many others. They show that the correlation between the cyclical component of output in the UK and the United States is 0.67, which exceeds the correlation of UK output with that in France (0.58) or Germany (0.45). The relative magnitudes are similar if we look at employment instead of output. However, the relevance of this fact to the debate about UK membership in EMU is not obvious. To begin with, we do not fully understand why the UK business cycle is more closely correlated with the U.S. cycle than with the cycle in the rest of Europe. The correlation may reflect the significant volume of trade and investment flows between the UK and the United States (most U.S. foreign direct investment in Europe goes to the UK), or it may be due to other factors.

These flows, in turn, may be influenced over time by the UK's attitude toward EMU. If the UK were to remain outside EMU permanently, some of these investment flows might shift to the euro area. Already a number of Asian investors in the UK have indicated they will rethink their location choices should the UK delay for long its decision on EMU membership. Rose (1999) presents evidence suggesting the real effects of a monetary union may be substantial. Specifically, he shows that two countries that share a common currency tend to trade three times as much as they would if they had different currencies. Furthermore, Frankel and Rose (1998) demonstrate that the closer the

trade links between countries, the more highly correlated their business cycles are.

OUTLOOK

I noted at the beginning of this article that many commentators in the United States doubted EMU would ever happen or thought that, if it did, it would be a source of conflict within the EU and between the EU and the United States (see Feldstein 1997a,b). The common thread in the skeptics' arguments was that the EU does not constitute an optimum currency area in the sense of Mundell (1961).¹⁹ While there were some differences in economic performance across the euro area over the past year, we did not see the kind of dramatic asymmetries the skeptics believe will cause EMU to collapse. Despite sluggish growth in two of the larger economies (Germany and Italy), unemployment continued to decline across the euro area, although it does remain at unacceptably high levels. Germany, which accounts for about one-third of euro-area economic activity, only experienced one quarter of negative growth (at the end of 1998) rather than a full-blown recession. How well the institutions of EMU will deal with more severely asymmetric cycles if and when they occur is an open question.²⁰

In the near term it is also essential that the EU address the issue of lender of last resort for the euro area. The ECB has a very limited role in bank supervision and regulation, and the Maastricht Treaty does not spell out what exactly the responsibilities of the ECB are in the event of a major financial crisis. Article 105 of the Maastricht Treaty mandates that the European System of Central Banks (ESCB) shall "promote the smooth operation of the payments system." The same article also states that "the ESCB shall contribute to the smooth conduct of policies pursued by the competent authorities relating to the prudential supervision of credit institutions and the stability of the financial system" and that the European Council may confer upon the ECB specific tasks related to supervision. Begg et al. (1998) argue that the current arrangements are unsafe and that there is no secure mechanism for creating liquidity in the event of a crisis. Banking supervision remains a national responsibility, and there are questions about whether the ECB would have access to the relevant information to allow it to make quick decisions if a crisis occurs.²¹ The European Parliament's Committee on Economic and Monetary Affairs (EPCMA) recently noted that "...the ESCB's arrangements for the emer-

agency provision of liquidity to financial institutions in distress have been called into question by the International Monetary Fund and by private sector observers, and EPCEMA urges the ESCB to make clear that the necessary procedures for approval and disbursement of such 'lender of last resort' facilities are in place and have been rehearsed."

In its convergence report prepared as part of the transition to EMU, the European Monetary Institute (the forerunner of the ECB) drew attention to the long-term problems posed by pay-as-you-go pension systems in the EU.²² The ECB reiterated this point in its January 2000 *Monthly Bulletin*, noting that "the ageing of populations represents a serious challenge to the sustainability of the pay-as-you-go financed public pension schemes" in the euro area. To give some sense of the scale of the problem faced by the euro-area economy, Figure 7 presents projections of the number of potential workers per retired person over the next fifty years for the United States and the EU.²³

The decline in the ratio in the United States reflects the aging of the baby-boom generation and is the primary demographic factor fueling the debate over the long-term sustainability of the Social Security program here. However, as Figure 7 shows, the aging problem is more severe in the EU than in the United States. The figure presents four variants for the EU. The first two are for the euro area (EU11) and the current fifteen members of the EU (EU15). Variant 3 (EU21) shows the projections if the EU expands to include the six current applicants considered the most likely candidates for early membership (Estonia, Poland, the Czech Republic, Hungary, Slovenia, and Cyprus). The final variant (EU28)

shows what happens if the EU expands to include all thirteen of the current applicants (in addition to the six just mentioned, Latvia, Lithuania, the Slovak Republic, Bulgaria, Romania, Malta, and Turkey).

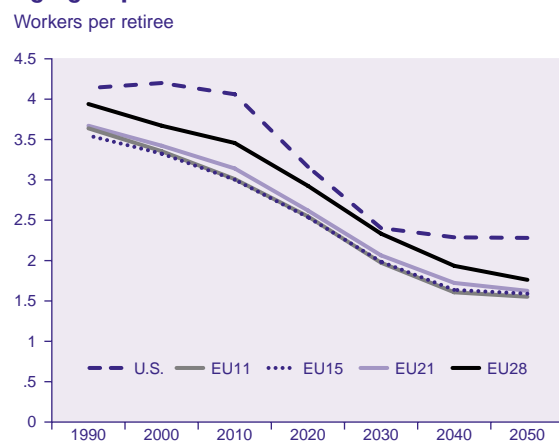
The rapid rise in the dependency ratio (decline in the number of workers per retiree) in the EU reflects declining birth rates and increased longevity. The decline in the birth rate in three of the largest euro-area economies (Germany, Italy, and Spain) has been so dramatic in recent years that, were it not for immigration, the populations of these countries would have fallen.²⁴ The aging of the population might not be so problematic were it not for the extensive reliance on publicly funded pensions in these countries and the relatively generous nature of these pensions. In Germany, for example, workers are entitled to a public pension equal to 72 percent of their average net lifetime earnings. Additionally, public expenditure on health care for the elderly is high and has risen with recent costly advances in medical technology. In short, demographic developments over the next decades could prove a serious threat to the fiscal positions of many of the euro-area governments that will necessitate painful reforms at some point. Some changes have recently been made (France now indexes pensions to prices rather than wages; Germany switched from indexing to gross wages to indexing to net wages), but more remains to be done.

Obviously the aging of the EU population is independent of whether the countries share a common currency. Rather, its significance stems from the institutional framework of EMU and, in particular, the restrictions on national fiscal policies as set out in the Maastricht Treaty and elaborated upon in the Growth and Stability Pact.

Article 104 of the Maastricht Treaty states that

1. Member States shall avoid excessive government deficits.
2. The Commission shall monitor the development of the budgetary situation and of the stock of government debt in the Member States with a view to identifying gross errors. In particular it shall examine compliance with budgetary discipline on the basis of the following two criteria:
 - (a) whether the ratio of the planned or actual government deficit to gross domestic product exceeds a reference value....
 - (b) whether the ratio of government debt to gross domestic product exceeds a reference value....

Figure 7
Aging Populations in the EU and U.S.



SOURCE: United Nations.

5. If the Commission considers that an excessive deficit in a Member State exists or may occur, the Commission shall address an opinion to the Council.

6. The Council shall, acting by a qualified majority on a recommendation from the Commission...decide after an overall assessment whether an excessive deficit exists.

7. Where the existence of an excessive deficit is decided...the Council shall make a recommendation to the Member State concerned with a view to bringing that situation to an end within a given period....

9. If a Member State persists in failing to put into practice the recommendations of the Council, the Council may decide to give notice to the Member State to take, within a specified time-limit, measures for the deficit reduction which is judged necessary by the Council in order to remedy the situation....

11. As long as a Member State fails to comply with a decision taken in accordance with paragraph 9, the Council may decide to apply or, as the case may be, intensify one or more of the following measures:

- to require the Member State concerned to publish additional information, to be specified by the Council, before issuing bonds and securities;
- to invite the European Investment bank to reconsider its lending policy towards the Member State concerned;
- to require the Member State concerned to make a non-interest-bearing deposit of an appropriate size with the Community until the excessive deficit has, in the view of the Council, been corrected;
- to impose fines of an appropriate size.

The Growth and Stability Pact adopted at the Dublin Summit in December 1996 is intended to clarify and strengthen the provisions of the treaty in regard to excessive deficits by strengthening fiscal discipline under EMU.²⁵ The existence of large, unfunded public pension liabilities will certainly complicate EMU participants' ability to abide by the terms of the treaty and the Growth and Stability Pact.²⁶

CONCLUSIONS

By any reasonable standards, the first year of EMU must be judged a success. The changeover weekend went by without incident, the TARGET payments system was launched without any major problems, and the ECB has

successfully taken over monetary policy for the euro area. The ECB faced the first serious challenge to its independence and effectively defended its status. It also conducted its first policy moves, easing monetary policy in April in the face of a growing threat of deflation and weak real activity in the euro area. In November it reversed course, tightening policy as the balance of risks shifted to higher inflation, and the euro-area recovery took hold.

The success of the first year does not mean that it will be all plain sailing from here on. Many challenges remain, and how the EU and the ECB tackle these will determine the ultimate fate of EMU. One issue highlighted in this article is the rapidly aging population of the EU. The aging of the population over the coming decades in conjunction with generous pension provisions will put a severe strain on the public finances of the euro-area economies. One solution might be to admit large numbers of immigrants, but Europe does not have a tradition of encouraging large-scale immigration. The only alternative is drastic reform of the public pension programs in all the countries, something no government has yet been willing to tackle. More generally, structural reforms of labor and product markets are crucial if the EU is to address the high unemployment rates and sluggish growth that have plagued it for the past decade. Small moves have been made in this direction, but a lot more needs to be done.

NOTES

I thank Bill Gruben, Evan Koenig and Carlos Zarazaga for comments on an earlier draft and Eric Millis for research assistance. Martin Boon at ICM Research in London kindly supplied the results of the ICM Research/Guardian polls of UK attitudes to the single currency. Responsibility for remaining errors rests with the author.

¹ The eleven countries participating in EMU are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

² On January 27 the euro closed at below parity for the first time (\$0.9883 in New York).

³ The European Currency Unit (ECU) was a synthetic currency defined on the basis of a basket of the currencies of the EU member states. Specifically, on December 31, 1998, one ECU consisted of 3.301 Belgian francs, 0.6242 German marks, 0.1976 Danish kroner, 6.885 Spanish pesetas, 1.332 French francs, 0.08784 British pounds, 1.44 Greek drachmas, 0.008552 Irish punts, 151.8 Italian lira, 0.13 Luxembourg francs, 0.2198 Dutch guilders and 1.393 Portuguese escudos (see European Central Bank 1999a, 72).

- ⁴ Arguably the first policy action of the ECB was taken in December 1998, when the eleven euro-area central banks (the so-called Eurosystem) coordinated a reduction in their short-term interest rates to a common 3 percent level before the formal launch of EMU.
- ⁵ To this end, in its *Monthly Bulletin* the ECB publishes statistics only for the euro area as a whole and not for individual member states. Statistical information is provided on developments in the four EU countries that do not participate in EMU (Denmark, Greece, Sweden, and the UK) and also on developments in the United States and Japan.
- ⁶ Formally, people are counted as unemployed if they are without work, are available to start work in the next two weeks, and have actively sought employment at some point during the previous four weeks.
- ⁷ The relative importance of owner's equivalent rent in the U.S. CPI as of December 1997 was just over 20 percent.
- ⁸ Interestingly, the ECB does not define how long the "medium term" is.
- ⁹ The Maastricht Treaty stipulates that, as one of the convergence criteria for assessing suitability for EMU membership, a country's inflation rate should not exceed the average rate of the three best performers by more than 1.5 percentage points.
- ¹⁰ See <http://europa.eu.int/comm/eurostat/>.
- ¹¹ See, for example, the recent working paper by Coenen and Vega (1999), which builds on other research conducted by the ECB's predecessor, the European Monetary Institute.
- ¹² In December 1999, the Governing Council announced that this value will also be used for 2000.
- ¹³ Note also that the president of the ECB has indicated that none of the decisions to change interest rates were made by a formal vote.
- ¹⁴ One of the objectives of the Intergovernment Conference that drew up the Amsterdam Treaty, which was signed in October 1997, was to enhance the democratic accountability of EU institutions.
- ¹⁵ The main components of the European Monetary System, which existed prior to EMU, were the Exchange Rate Mechanism, which was essentially a system of fixed exchange rates between the currencies of the participating countries, and the European Currency Unit, which has now been replaced by the euro.
- ¹⁶ Note that the seigniorage revenue will be distributed among participating countries using a formula prescribed in the Maastricht Treaty Protocol No. 3 on the Statute of the European System of Central Banks and the European Central Bank, Articles 29 and 31.
- ¹⁷ The denominational structure of the euro will consist of coins at the 1, 2, 5, 10, and 20 euro cent denominations, coins at the €1 and €2 denominations, and notes at the €5, €10, €20, €50, €100, €200, and €500 denominations.
- ¹⁸ *The Economist* newspaper surveyed British economists in early 1999 and found that about 65 percent favored UK membership in EMU.
- ¹⁹ Ironically, the critics seem to overlook the later papers by Mundell (1973a,b) in which he proposes additional criteria for evaluating the suitability of a single currency for a group of countries. As a result of these works, he has been referred to in some circles as the father of the euro. See also Mundell (1998a,b).
- ²⁰ The studies of Frankel and Rose (1998) and Rose (1999) just cited are also relevant to this question. Insofar as sharing a common currency enhances trade flows within the euro area and these trade flows lead to more synchronous business cycles, the concern about asymmetric shocks may prove unfounded. However, within a monetary union as long-standing and fully credible as the United States, asymmetric cycles may occasionally emerge. Through the 1980s and 1990s different regions of the United States experienced shocks that caused localized recessions of varying degrees of severity; the term "rolling recessions" entered policy debates to describe this phenomenon.
- ²¹ Prati and Schinasi (1999) articulate similar concerns.
- ²² See also the recent report by the G-10 (Group of Ten 1998).
- ²³ Specifically, the figure shows the ratio of the population aged 25 to 64 to the population aged 65 and older and is taken from the "medium variant" projections in United Nations (1998).
- ²⁴ In its most recent forecasts the United Nations (1998) projects that the population of Italy will fall from 57.3 million in 2000 to 41.2 million in 2050, that of Germany from 82.2 million to 73.3 million, and that of Spain from 39.6 million to 30.2 million.
- ²⁵ For further details see the May 1999 issue of the ECB's *Monthly Bulletin*.
- ²⁶ The need for fiscal rules under a monetary union is a contentious issue. Artis and Winkler (1997) argue that the excessive deficit provisions of the treaty can be justified on the grounds that under monetary union the costs of an overly expansionary fiscal policy will be borne by all members of the monetary union and not just by the country pursuing the policy, creating an incentive for countries to be more lax with their fiscal policy. Bergin (2000), arguing from the perspective of the fiscal theory of the price level, makes a similar point.

REFERENCES

- Artis, Michael J., and Bernhard Winkler (1997), "The Stability Pact: Safeguarding the Credibility of the European Central Bank," European University Institute Working Paper RSC no. 97/54 (Florence, Italy: European University Institute).
- Begg, David, Paul De Grauwe, Francesco Giavazzi, Harald Uhlig, and Charles Wyplosz (1998), "The ECB: Safe at Any

- Speed?" *Monitoring the European Central Bank*, no. 1 (London: Center for Economic Policy Research).
- Bergin, Paul R. (2000), "Fiscal Solvency and Price Level Determination in a Monetary Union," *Journal of Monetary Economics* 45 (February): 37–53.
- Buiter, Willem H. (1999), "Alice in Euroland," Center for Economic Policy Research Policy Paper no. 1.
- Buiter, Willem H., Giancarlo Corsetti, and Nouriel Roubini (1993), "Excessive Deficits: Sense and Nonsense in the Treaty of Maastricht," *Economic Policy* 16 (April): 57–100.
- Coenen, Günter, and Juan-Luis Vega (1999), "The Demand for M3 in the Euro Area," European Central Bank Working Paper no. 6.
- Cohen, Benjamin J. (1971), *The Future of Sterling as an International Currency* (London: Macmillan).
- Deutsche Bundesbank (1995), *The Monetary Policy of the Bundesbank* (Frankfurt am Main: Deutsche Bundesbank).
- European Central Bank (1999a), *Annual Report 1998* (Frankfurt am Main: European Central Bank).
- (1999b), *Euro Area Monetary Aggregates: Conceptual Reconciliation Exercise* (Frankfurt am Main: European Central Bank).
- European Commission (1998), *Report from the Commission to the Council: On the Harmonisation of Consumer Price Indices in the European Union* (Brussels: Commission of the European Communities).
- European Parliament (1999), *Report on the Annual Report for 1998 of the European Central Bank*, European Parliament Session Document, October 15, 1999.
- Feldstein, Martin (1997a), "EMU and International Conflict," *Foreign Affairs* 76 (November/December): 60–73.
- (1997b), "The Political Economy of the European Economic and Monetary Union: Political Sources of an Economic Liability," *Journal of Economic Perspectives* 11 (Fall): 23–42.
- Frankel, Jeffrey A., and Andrew K. Rose (1998), "The Endogeneity of the Optimum Currency Area Criteria," *Economic Journal* 108 (July): 1009–25.
- Group of Ten (1998), *The Macroeconomic and Financial Implications of Ageing Populations* (Basle: Bank for International Settlements).
- Hartmann, Philipp (1998), *Currency Competition and Foreign Exchange Markets: The Dollar, the Yen and the Euro* (Cambridge: Cambridge University Press).
- HM Treasury (1997), *UK Membership of the Single Currency: An Assessment of the Five Economic Tests* (London: HM Treasury).
- (1999), *Outline National Changeover Plan* (London: HM Treasury).
- Issing, Otmar (1999), "The Eurosystem: Transparent and Accountable or 'Willem in Euroland,'" Center for Economic Policy Research Policy Paper no. 2.
- Lucas, Robert E., Jr. (1976), "Econometric Policy Evaluation: A Critique," *Carnegie–Rochester Conference Series on Public Policy* 1: 19–46.
- Mundell, Robert A. (1961), "A Theory of Optimum Currency Areas," *American Economic Review* 51 (September): 657–65.
- (1973a), "A Plan for a European Currency," in *The Economics of Common Currencies*, ed. Harry G. Johnson and Alexander K. Swoboda (London: George Allen and Unwin), 143–72.
- (1973b), "Uncommon Arguments for Common Currencies," in *The Economics of Common Currencies*, ed. Harry G. Johnson and Alexander K. Swoboda (London: George Allen and Unwin), 114–32.
- (1998a), "The Case for the Euro–I," *Wall Street Journal*, March 24, A22.
- (1998b), "The Case for the Euro–II," *Wall Street Journal*, March 25, A22.
- Porter, Richard D., and Ruth A. Judson (1996), "The Location of U.S. Currency: How Much Is Abroad?" *Federal Reserve Bulletin* 82 (October): 883–903.
- Portes, Richard, and Hélène Rey (1998), "The Emergence of the Euro as an International Currency," *Economic Policy* 26 (April): 307–43.
- Prati, Alessandro, and Garry J. Schinasi (1999), "Financial Stability in European Economic and Monetary Union," Princeton Studies in International Finance no. 86 (Princeton, N.J.: Princeton University Printing Services).
- Rose, Andrew K. (1999), "One Money, One Market: Estimating the Effect of Common Currencies on Trade," NBER Working Paper Series, no. 7432 (Cambridge, Mass.: National Bureau of Economic Research, December).

Seitz, Franz (1995), "The Circulation of Deutsche Mark Abroad," Discussion Papers of the Economic Research Group of the Deutsche Bundesbank, no. 1/95.

United Nations (1998), *World Population Prospects: The 1998 Revision*, vol. I, Comprehensive Tables (New York: United Nations).

U.S. Bureau of Labor Statistics (1997), *BLS Handbook of Methods* (Washington, D.C.: U.S. Government Printing Office).

Wynne, Mark A., and Jahyeong Koo (forthcoming), "Business Cycles Under Monetary Union: A Comparison of the EU and U.S.," *Economica*.

Measuring the Benefits of Unilateral Trade Liberalization

Part 2: Dynamic Models

Carlos E. J. M. Zarazaga

T*his series of two articles has examined the potential gains or losses from unilateral trade liberalization predicted by available general equilibrium models of international trade.*

Carlos Zarazaga is a senior economist and executive director of the Center for Latin American Economics at the Federal Reserve Bank of Dallas.

The drive for a multilateral trade agreement encompassing the Americas gained momentum about two years ago, with the U.S. Congress poised to grant the president fast-track authority to negotiate Chile's inclusion in the North American Free Trade Agreement (NAFTA). But the series of severe financial crises that rattled the world almost immediately upon NAFTA's inception frustrated the fast-lane approach and slowed progress toward the agreement. Perhaps this delay reflected that policymakers, businesspeople, and even the general public were reconsidering the benefits of trade agreements with crisis-prone partners.

With the prospect of agreement postponed indefinitely, would countries in the area benefit from lowering, even if unilaterally, their trade barriers? This is the issue addressed in this series of two articles begun in the third quarter 1999 *Economic and Financial Review*.

Part 1 concluded that static applied general equilibrium models could make a mild case for unilateral trade liberalization. However, the article raised the possibility that dynamic models, which incorporate the dimension of time, might do substantially better. That conjecture was partially inspired by numerical experiments with models in which the level of capital after the tariff reduction is changed exogenously (from outside the model).

For example, a static applied general equilibrium model by KPMG Peat Marwick (1991) delivers larger welfare gains when the level of capital in Mexico is increased exogenously to make the rate of return to capital the same both before and after NAFTA. The study starts by assuming that the level of capital is the same before and after the inception of NAFTA. Mexico's gains from NAFTA are negligible in this exercise, the equivalent variation of 0.32 percent of GNP.¹ But the assumption of a constant level of capital implies a higher real rate of return to capital after NAFTA. Because this is an unrealistic outcome under free capital mobility, the study lets capital rise to the level needed to ensure that the rate of return is the same before and after NAFTA. Under this assumption, the welfare gain is equal to 4.6 percent in GNP.²

Two qualifying comments are in order. First, the capital increase necessary to make the rate of return the same before and after NAFTA is about 8 percent, which is substantial and, for all we know, has not yet materialized, even six years after NAFTA's inception. Second, this expansion in capital is introduced from outside the model. It is impossible to determine, therefore, whether this new capital level is consistent

with the optimal consumption (and, thus, saving) decisions of the agents populating the artificial economy. To answer this question, it is necessary to formulate dynamic models that not only lay out the microeconomic foundations of consumers' and firms' behavior by specifying preferences, endowments, and technology but also incorporate the dimension of time in their decisions. The solution to consumers' and firms' maximization problems will dictate the society's desired level of savings and, therefore, of capital, after trade reform. In other words, in dynamic models the level of capital following a trade reform is determined endogenously—that is, within the model—rather than in some ad hoc fashion from outside of it.

Part 2 of this series investigates the extent to which applied dynamic general equilibrium models deliver on their promise of large welfare gains from unilateral trade liberalization.

APPLIED DYNAMIC GENERAL EQUILIBRIUM MODELS OF INTERNATIONAL TRADE

Applied dynamic general equilibrium models, unlike static ones, can address investment issues because they introduce the dimension of time in consumers' and firms' decisions. As a result, consumers can postpone consumption today and save to be able to consume more tomorrow. Recall that in dynamic general equilibrium models, in contrast to static ones, capital accumulation is determined endogenously rather than exogenously.

Operationally, this difference between the models is most apparent in the utility function and budget constraint used to represent consumers' behavior. Intuition suggests that a simple dynamic version of the static utility function presented in Part 1 could be

$$(1) \quad \text{Welfare} = \sum_t \beta^t \sum_i \alpha_i \log c_{it},$$

where c_i denotes real consumption of good i , α_i is a parameter that measures the relative importance the representative consumer attaches to each good, t indexes the time of consumption, and β is the factor by which consumers discount the future, with $0 < \beta < 1$.

This formulation of the utility function conveys the idea that consuming a unit of a good in the future is less attractive than consuming this same unit today. Postponing consumption is costly in terms of utility, and that is why a bundle of goods consumed today yields utility $\sum \alpha_i \log c_{it}$ while that same bundle consumed tomorrow yields the utility $\beta \sum \alpha_i \log c_{it}$. (Recall that $\beta < 1$ by assumption.)

The intertemporal dimension of the problem also appears in consumers' budget constraint, which typically takes the form

$$\sum_i p_{it} c_{it} \leq y_t + (1 + r_{t-1})b_{t-1} - b_t$$

for each period t , where y_t is the household's endowment in terms of, say, good 1; b_t is the household's net holding of assets measured also in terms of good 1 (positive if the household is a net creditor, negative if it is a net debtor) at the beginning of period t ; and r_{t-1} is the real interest rate consumers receive (if net lenders) or pay (if net borrowers) on their previous-period asset holdings.

Rearranging the equation as

$$b_t \leq y_t + (1 + r_{t-1})b_{t-1} - \sum_i p_{it} c_{it}$$

makes it apparent that b_t is the current period savings: the excess of revenues from all sources, the endowment y_t , and interest payments from assets $(1 + r_{t-1})b_{t-1}$, minus current consumption of goods and services, $\sum_i p_{it} c_{it}$.

The presence of savings in the budget constraint makes clear that, in contrast to the static case, a consumer can now borrow or lend (depending on whether a negative or a positive b_t is chosen) to increase or decrease consumption from the level that current income would otherwise permit.

In a dynamic setting, the consumer's problem is no longer to choose the single consumption bundle c_b but rather, the whole sequence of consumption bundles $\{c_{i,t}\}_{t=0}^{\infty}$ that maximizes utility. Correspondingly, the consumer will choose the sequence of asset holdings $\{b_{i,t}\}_{t=0}^{\infty}$ consistent with the ability to finance that optimal consumption stream.

Technical Challenges of International Trade Models with Endogenous Capital Accumulation

The addition of the dynamic dimension could potentially increase welfare because the removal of tariffs can prompt a decline in the cost of the imported goods used in the production of domestic capital goods. The corresponding declines in the unit cost of production of capital goods and, therefore, in their prices provide the necessary incentives for a higher rate of investment. The resulting expansion of the capital stock increases labor productivity and, hence, the output of consumer goods and services. But the introduction of the temporal dimension also raises technical complications worth exploring to understand the limitations of the measures of the benefits from trade liberalization reported below.

One of the challenges facing international economists is the problem posed by a constant

discount factor, β . The assumption of a constant discount factor is standard in many intertemporal models but is problematic in international applications, particularly for small open economies. This is because models with a constant β usually generate an explosive (implosive) consumption path, in the sense that consumption as a fraction of income constantly increases (declines) over time. Such paths are highly counterfactual, as consumption–income ratios tend to be stable in actual economies.

The reasons for the odd outcome are outlined in the box entitled “Undesirable Implications of the Constant Discount Factor Assumption.” Here, it suffices to say the source of the mischief is the combination of a constant discount factor and the small open economy assumption. Under this latter assumption, a small economy is capable of borrowing and lending unlimited amounts at a constant world interest rate. Of course, this assumption is a good approximation to reality only within certain limits. Eventually, if the economy keeps borrowing without bounds, it will absorb all worldwide available savings, at which point the economy will cease to be small and either the interest rate will rise or the country will be unable to continue borrowing.

International economists dealing with dynamic models—that is, models of endogenous capital accumulation—have tried to solve the problems created by the small open economy assumption in several ways. One popular route has been to abandon the assumption, in Equation 1, that the discount factor, β , is constant over time and assume instead that it is a function of consumption.³ Mathematically, such an assumption is represented as

$$\beta = \beta(c_t),$$

which says the discount factor, β , at any point in time is a function of consumption.

As the box explains, this alternative assumption may give rise to stationary outcomes—that is, to equilibria with constant consumption–output ratios. Applied dynamic general equilibrium models typically assume the function $\beta(c_t)$ decreases in c_t . In other words, as consumption increases, β decreases. This is not an entirely satisfactory specification because there is little evidence that people discount the future more as they become richer.⁴

Goulder and Eichengreen (1992) offer a different solution to the problem posed by the combination of the small open economy assumption and a constant β . Instead of postulating a variable β , they introduce financial assets (wealth) as a determinant of the utility or

welfare function. In particular, they propose evaluating the welfare gains from free trade according to the formula

$$(2) \quad \text{Welfare} = \sum_t \beta^t \frac{\sigma}{\sigma - 1} \left[c_s^\alpha b_s^{1-\alpha} \right]^{\frac{\sigma-1}{\sigma}},$$

where α and σ are standard parameters in the literature, assumed to have values that ensure the concavity of the utility function, and b_s is a composite of foreign and domestic assets in real terms.⁵ This solves the problem of the lack of stationarity when β is constant because assets are treated as just another good and subject to decreasing marginal utility. This will generally ensure a stationary wealth–income ratio and generate a stationary consumption–income ratio as well.⁶

The idea of including financial assets in the welfare function is not new. In fact, many models studying monetary policy issues assume that money, an asset, is a determinant of the utility function. This practice has met with objections because what utility functions such as that in Equation 2 say, if interpreted literally, is that consumers derive pleasure from the mere fact of holding money or bond issues. This is a highly unattractive proposition, as consumers clearly do not derive utility from the pieces of paper but from what they can buy.⁷

Thus, international economists face the difficulty that the assumption of a constant discount factor standard in closed macroeconomic models is unappealing when applied to small open economies, because it tends to produce the counterfactual outcome that consumption as a fraction of income permanently declines or increases. This prediction has typically been eliminated at the cost of counterintuitive preferences, a factor that must be taken into account in evaluating the quantitative results of the applied dynamic general equilibrium models reported in the next section.

Welfare Gains from Trade Liberalization in Applied Dynamic General Equilibrium Models

Progress in quantifying the benefits of free trade with dynamic models has been slow because of the theoretical difficulties discussed above and other computational issues. The few such models available have a mixed record.

Goulder and Eichengreen (1992) find that a U.S. move to unilateral free trade by removing tariffs from an average rate of 4 percent would cut consumption 0.32 percent, which in turn implies a welfare loss equal to 0.44 percent of GDP.⁸ The larger welfare gains dynamic models anticipate do not materialize, therefore, in Goulder and Eichengreen’s study.

Undesirable Implications of the Constant Discount Factor Assumption

A constant discount factor in combination with time-separable additive utility functions like the one represented in Equation 1 of the text can lead to counterfactual implications for the consumption path of the model economy.

As explained, in a dynamic setting a consumer will typically maximize the utility function

$$\sum_{t=0}^{\infty} \beta^t \log c_t$$

subject to the intertemporal budget constraint

$$c_t = y + (1 + r_{t-1}) b_{t-1} - b_t,$$

where all symbols are as in the text, the endowment y is a constant, the real interest sequence $\{r_{t-1}\}_{t=0}^{\infty}$ is exogenous, and there is only one good ($i = 1$), with its units redefined so its price is 1. The solution to this problem will be the selection of a consumption sequence $\{c_t\}_{t=0}^{\infty}$ and an asset-holding sequence $\{b_t\}_{t=0}^{\infty}$ consistent with the ability to finance that optimal consumption stream.

Substituting into the utility function the expression for c_t given by the budget constraint yields the maximization problem

$$\begin{aligned} & \text{Max } \{\beta^t \ln[y + (1 + r_{t-1}) b_{t-1} - b_t] \\ & + \beta^{t+1} \ln[y + (1 + r_t) b_t - b_{t+1}] \\ & + \sum_{j=0}^{\infty} \beta^{t+j+2} \ln[y + (1 + r_{t+j+1}) b_{t+j+1} - b_{t+j+2}]\}, \end{aligned}$$

where the choice variable is b_t in period t , b_{t+1} in period $t+1$, b_{t+2} in period $t+2$, and so on, and j and t are time indexes.

The first-order necessary condition with respect to b_t corresponding to this maximization problem is

$$\begin{aligned} & - \frac{\beta^t}{y + (1 + r_{t-1}) b_{t-1} - b_t} \\ & + \frac{\beta^{t+1}}{y + (1 + r_t) b_t - b_{t+1}} * (1 + r_t) = 0. \end{aligned}$$

Dividing both sides by β^t and using the budget constraint again, the following equivalent expression results:

$$- \frac{1}{c_t} + \frac{\beta}{c_{t+1}} * (1 + r_t) = 0,$$

which, assuming that $r_t = r$, a constant, takes the form

$$c_{t+1} = \beta * (1 + r) * c_t.$$

Assuming, for convenience only, that income is constant over time, the above condition can be represented in terms of consumption-income ratios as

$$(B.1) \quad \frac{c_{t+1}}{y} = \beta * (1 + r) * \frac{c_t}{y}.$$

In a stationary equilibrium, prices and real consumption-income ratios are constant over time. This implies that the above condition in any stationary equilibrium will take the form

$$\frac{c}{y} = \beta * (1 + r) * \frac{c}{y}$$

or, equivalently, that $\beta (1 + r) = 1$. This condition will typically be satisfied only by chance. More generally, either $\beta (1 + r) < 1$ or $\beta (1 + r) > 1$. In the first case, Equation 1 implies that consumption in each period will be lower than in the previous one by the factor $\beta (1 + r)$. In other words, the consumption-income ratio will decrease monotonically to 0. In the second case, the opposite is true: the consumption-income ratio increases monotonically over time. The problem is that the implication of the dynamic model in either of these cases is grossly counterfactual, because observed consumption-income ratios are very stable over time.

As the text mentions, one possible way out of this problem is to abandon the assumption of a constant discount factor and assume, instead, that it is a decreasing function of consumption. This can be seen intuitively by replacing the function β with $\beta(c_t)$ in Equation B.1:

$$\frac{c_{t+1}}{y} = \beta(c_t) * (1 + r) * \frac{c_t}{y}.$$

Suppose that the function $\beta(c_t)$ is decreasing in c_t and that for certain value c of c_t , $\beta(c_t) (1 + r) > 1$. This implies $c_{t+1} > c_t = c$, which in turn implies that $\beta(c_{t+1}) < \beta(c_t)$ and, therefore, that $\beta(c_{t+1}) (1 + r) < \beta(c_t) (1 + r)$. In other words, as consumption increases, $\beta(c_{t+1})$ decreases, and so does $\beta(c_{t+1}) (1 + r)$ until eventually $\beta(c_{t+n}) (1 + r) = 1$ for n large enough. At that point consumption becomes stationary (in the sense that it repeats itself over time) because

$$\frac{c_{t+n+1}}{y} = \frac{c_{t+n}}{y}.$$

However, this way of solving the lack of stationary equilibria in dynamic models with constant discount factor β is somewhat of a mechanical quick fix. Typically, any function $\beta(c_t)$ will be continuous and, therefore, decreasing for some values of c_t (or eventually all of them, as in the example above). At the same time, in any reasonable economic model, consumers want to consume more the wealthier they are. This implies that when $\beta(c_t)$ is decreasing in consumption, it is also decreasing in wealth or, equivalently, that households become more impatient to consume as they get wealthier. Unfortunately, there is no empirical evidence to support this rather ad hoc assumption. The opposite and equally arbitrary assumption that $\beta(c_t)$ is increasing in c_t —that is, that a household's desire to accumulate wealth rises as it becomes richer—cannot be empirically validated either (and introduces the additional technical difficulties mentioned in footnote 4 of the text).

Those gains do seem to materialize—at least for developing countries—in a recent model by Ahearne (1999). It is one of the few dynamic models to quantitatively analyze unilateral trade liberalization's effects for developing countries. Unfortunately, Ahearne focuses on the performance of macroeconomic variables such as aggregate output, consumption, and investment and does not report a measure of welfare, such as that Goulder and Eichengreen report. This omission makes welfare comparison of the two studies difficult. In any case, to the extent the direction of change of consumption and welfare are the same (as they are in Goulder and Eichengreen), Ahearne's outcomes are more favorable to trade reform. He finds that lowering tariffs from an average of 25 percent to 10 percent would result in an increase in consumption of about 3 percent. A reduction to an average rate of 5 percent would raise consumption growth to about 4.5 percent, while the complete removal of tariffs would result in a 6 percent consumption increase.

Six percent consumption growth is by no means negligible and could be seen as an indication that dynamic models can, after all, deliver larger welfare gains from unilateral trade liberalization than their static counterparts. However, it is important to emphasize that the relatively large consumption growth of 6 percent is obtained from removing tariffs originally assumed to be 25 percent. Ahearne's study suggests that consumption growth will be a more moderate 1 percent to 2 percent if the average initial tariff is 4 percent, as in Goulder-Eichengreen.⁹ Still, this increase in consumption after trade liberalization seems to reverse Goulder and Eichengreen's negative finding.

Unfortunately, it is difficult to pinpoint the source of the opposite results of these two dynamic models because their features are quite different, from the specification of the utility function to the underlying assumptions about capital mobility.¹⁰ For example, Ahearne's assumption is that the discount factor depends on the level of wealth (or equivalently, consumption), while Goulder and Eichengreen assume that assets enter into the utility function.

Another important difference is that Ahearne assumes the terms of trade are exogenous. Thus, changes in tariffs alter the relative domestic prices but do not change the international terms of trade against the country that liberalizes. This is not the case in Goulder and Eichengreen because they adopt the so-called Armington, or national product differentiation, assumption. As Part 1 explained, this assump-

tion is introduced mainly to account for the puzzling "cross-hauling" in which many countries appear to export the same goods they import.¹¹ National product differentiation circumvents this problem by assuming each country is the only producer of the good it exports. However, this also means tariffs could help a country exploit its market power. Tariff elimination might be damaging in this case because the optimal tariff typically is not zero under this assumption. This fundamental bias against free trade is absent from Ahearne's model but seems to prevail in Goulder and Eichengreen's.¹²

There are reasons to doubt the welfare losses Goulder and Eichengreen's model delivers because their preferences include assets as a determinant of the welfare function. The resulting welfare measure may reflect consumption changes as much as changes in asset holdings. This is certainly an unappealing way to measure welfare, in light of the general equilibrium theory standard that consumers do not derive utility directly from merely holding assets but from the stream of goods and services those assets can purchase.

Ahearne's study may exaggerate the GDP growth from unilateral trade liberalization because he assumes perfect capital mobility. This may not be the case in practice, as evidence suggests that households tend to invest their savings in their home country rather than in foreign ones. Goulder and Eichengreen capture more aptly this reality by assuming that consumers have a bias for domestic assets, and this implicitly limits the capital mobility responsible for the relatively large GDP and consumption gains in Ahearne's model.¹³

PRODUCT VARIETY AND GAINS FROM TRADE LIBERALIZATION

It was argued that dynamic models of international trade have the potential to deliver the large welfare gains from trade liberalization that their static counterparts have failed to produce. The preceding section suggests that dynamic models cannot fulfill those expectations either, except under nonconventional representation of consumers' preferences.

However, one often-heard criticism of all the models discussed so far is that they fail to incorporate the idea that free trade makes possible access to new technologies that enhance the economy's overall productivity. Perhaps this is why dynamic general equilibrium models produce only less-than-striking welfare gains from unilateral trade liberalization.

Consider, for example, the constant-returns-to-scale production function presented in Part 1 of this series:

$$(3) \quad Y = A L^{1-\alpha} K^\alpha,$$

where Y is aggregate output, L the amount of labor input, K the amount of capital input, and $0 < \alpha < 1$.

In this specification, the total factor productivity, represented by A , is treated as a given parameter, invariant to the trade regime. Therefore, this equation does not capture the idea that trade liberalization will increase an economy's overall productivity. Trade liberalization can raise production only if it leads to the use of more labor or capital inputs.¹⁴ Otherwise, the same amount of labor and capital will produce exactly the same amount of output.

A similar situation arises with the second kind of technology, the increasing-returns-to-scale technology—or, equivalently, decreasing-average-cost technology—considered in Part 1:

$$(4) \quad \text{Total cost} = F + bQ.$$

Again, notice that tariff policy changes can reduce average costs only if they induce an increase in the quantity of the good. But the basic cost structure, defined by fixed cost F or marginal cost b , is the same regardless of the tariff regime under which countries operate.

This invariance of the overall productivity to the trade regime implicit in conventional production functions has been challenged on several grounds. For instance, an important benefit of international trade is that it gives consumers more choices and offers producers more options in terms of inputs. The advantage of variety is particularly important for economies that can produce only a limited range of goods on their own. This is the case with economies characterized by cost functions such as the one in Equation 4—that is, economies with increasing returns to scale.

Recall from the discussion in Part 1 that in such economies each good is produced by one and only one firm. The number of varieties is determined by the number of firms, which is limited when there are increasing returns to scale. To see this, suppose all firms must pay the fixed cost F in terms of a primary input z (for example, land) and that each economy is endowed with Z units of that good. Each economy on its own will be able to produce, at most, Z/F varieties of goods (for simplicity, we assume Z/F is an integer). The number of goods produced domestically will be limited by that upper bound.¹⁵

Thus, suppose prohibitively high tariffs or

restrictions limiting quantities make trade between two economies disappear. This implies that consumers must make do with domestic goods. Although a consumer would like that 27-inch-screen TV and can afford it, he will have to settle for the smaller domestic model without remote control. Likewise, local producers will have to adjust their technologies to the intermediate inputs domestic firms make available. A construction company may prefer a special kind of foreign-made insulation for a building that will have to withstand extreme temperatures, but the firm will have to use a more expensive and less functional building design to achieve the same results with the less suitable insulators produced domestically.

Next, suppose all barriers to international trade are lifted. Firms in this economy will be able to use both domestic and foreign inputs. The examples above suggest that a larger variety of goods, especially of intermediate inputs, may be associated with aggregate productivity gains not appropriately captured by conventional production functions.

To confront this limitation, economists have started to play with less conventional production functions that incorporate the idea of productivity gains from variety. Such production functions can be constructed by a clever reinterpretation of the conventional constant-returns-to-scale production functions.

For simplicity, assume only one final consumption good is produced with the technology

$$Y = L^{1-\alpha} (x_1^\alpha + x_2^\alpha + \dots + x_M^\alpha),$$

where L represents the amount of labor input, x_i represents the quantity of an intermediate input i , $i = 1, 2, \dots, M$, and $0 < \alpha < 1$. Assuming each intermediate input is used in the same quantity,¹⁶ the technology can be rewritten as

$$(5) \quad Y = M L^{1-\alpha} X^\alpha.$$

This appears to be the same old constant-returns-to-scale technology of Equation 3, with capital, K , relabeled x and the total factor productivity, A , relabeled M . Indeed, increasing both the amount of labor input L and the typical intermediate input x by h percent would raise production of the consumption good by h percent, which is exactly what is supposed to occur with a constant-returns-to-scale technology.

The trick is that relabeling A as M is not as innocuous as it might appear because now A is not necessarily fixed. In fact, A (or M)—the number of varieties—can be regarded as an input, just as L or each x_i is. In other words, according to this production function, aggregate

production of final goods Y requires combining three inputs: the number of varieties of intermediate inputs (M), the quantity used of each of them (x), and labor (L).

The reinterpretation of A as the number of intermediate-input varieties represents mathematically the old idea that one-size-fits-all economies will be less productive than highly specialized ones. The intuition is that access to a larger variety of goods will make it more likely that producers will find inputs that better fit the characteristics of their production lines and that consumers will find the products that best fit their tastes and needs.¹⁷

The gains-from-variety effect can be better understood by comparing the nonconventional production function in Equation 5 with

$$Y = L^{1-\alpha} * M * x.$$

According to this production function, doubling the varieties of intermediate-input goods will have the same effect on output as doubling the amount of each of those inputs, as can be seen from the equalities

$$\begin{aligned} L^{1-\alpha} * (2M) * x &= 2L^{1-\alpha} * M * x = 2Y \\ &= L^{1-\alpha} * M * (2x). \end{aligned}$$

This is not the case with the proposed production function of Equation 5, in which doubling the number of varieties M doubles output, but doubling the quantity of each intermediate input x increases output only by a factor of 2^α , which is lower than 2 (recall that $0 < \alpha < 1$).¹⁸

In other words, in Equation 5 any increase in variety has a larger impact on aggregate production than an identical percentage increase in the quantities of the existing intermediate-input varieties. Loosely speaking, this production function captures the idea that a society cannot easily compensate for the loss of variety with more of the same old stuff. This issue is relevant to measuring the gains from unilateral tariff removal because freer trade policies (even if implemented unilaterally) may give a country access to a larger variety of goods. The welfare gains from such policies may be important if a larger variety of intermediate inputs, as the production function suggests, increases the economy's productivity in the manufacturing of domestic goods.

In the reinterpretation (*Equation 5*) of the conventional constant-returns-to-scale technology (*Equation 3*), the total factor productivity parameter A in the latter would be equal to M before trade liberalization but eventually equal to $(M + \Delta M)$ after trade liberalization, where ΔM represents the additional varieties of intermediate inputs resulting from freer trade.

With a production function like that in Equation 5, the gains from freer trade will come from two sources: the traditional one that tariff reductions will make imported intermediate goods cheaper and thus induce higher output levels of the existing varieties of final goods and services, and the nonconventional one of gains from variety from ΔM . This second effect is a good candidate for boosting the welfare gains from unilateral trade liberalization beyond the negligible to moderate results found by models using more conventional production functions. The remainder of this article reports the results of recent work that has exploited this gains-from-variety approach to build a better case for unilateral free trade.

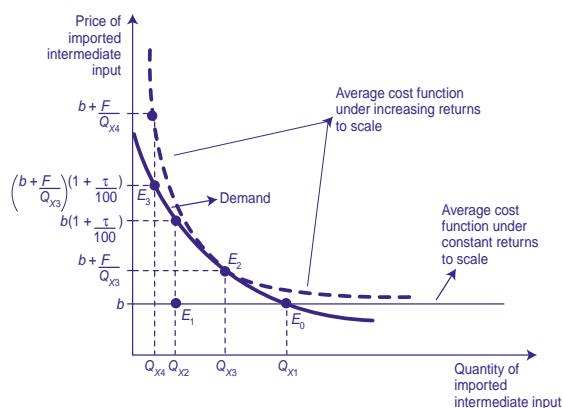
Measuring the Welfare Gains from Variety

In analyzing these studies on welfare gains from product variety, it is important to understand how tariffs reduce the product varieties available to firms and consumers. All the studies discussed below assume that firms face cost functions of the form in Equation 4. Equivalently, they assume all goods are produced with increasing-returns-to-scale technologies.¹⁹ As Part 1 explains, this is the only technology consistent with the national product differentiation assumption, typically introduced to account for the cross-hauling puzzle in trade statistics.

The introduction of increasing-returns-to-scale technologies is not inconsequential for the potential gains from variety with a tariff reduction. The attrition effect tariffs can have on variety starts at much lower tariffs with increasing-returns-to-scale technologies than with constant-returns-to-scale technologies.

Consider a typical final-goods producer's demand for an imported intermediate input produced with a constant-returns-to-scale technology, as represented in Figure 1. Recall that the cost function will look like Equation 4, with F equal to 0, implying a constant marginal and unit average cost of b . Suppose that initially there is no tariff, and the equilibrium demand of the input is at point E_0 , with price b equal to the unit and marginal cost and quantity Q_{x1} . Next, suppose an ad valorem tariff of τ percent is imposed on this intermediate input. For the sake of argument, assume the buyers absorb all the burden of the tariff—that is, the foreign producers of those inputs still receive a price b (equal to their unit cost of production) for each unit of the intermediate good they sell to domestic buyers. These buyers will have to pay a price $b(1 + \tau/100)$ for the imported intermediate input. Suppose that at the new equilibrium

Figure 1
The Effect of Tariffs on Product Variety



price the quantity demanded, Q_{x2} , is one-fourth Q_{x1} , the equilibrium quantity before the tariff was introduced. Foreign producers will have to cut the quantity produced by three-fourths. The question is whether they can stay in business doing that. The answer under constant returns to scale is an unambiguous yes because producers will always receive the price b for each unit, regardless of sales level. Since b is also the unit cost of production, they will cover their costs and be able to stay in business whether they sell Q_{x1} units (as in point E_0) or Q_{x2} (as in point E_1). Thus, under constant returns to scale, the available varieties of intermediate inputs will be the same before and after the introduction of the tariff. The only effect of a tariff is that each intermediate input will now be produced in a smaller amount, to match the decline in the quantity demanded as a result of the tariff-induced price increase. Thus, moderate tariffs will tend not to have any visible consequences for product variety under constant-returns-to-scale technologies.²⁰

Consider the alternative case in which intermediate inputs are produced with an increasing-returns technology, whose cost function will look like Equation 4. The unit cost of producing Q_{x1} is greater than b by F/Q_{x1} . Therefore, b cannot be an equilibrium price because foreign producers of the imported inputs would suffer a loss. Assume, then, that the equilibrium price for the imported intermediate inputs under increasing-returns-to-scale technology is $b + F/Q_{x3}$. The higher price implies, of course, that the equilibrium quantity, Q_{x3} , will be to the left of the equilibrium quantity under constant returns to scale, Q_{x1} .

Now suppose the same tariff of τ percent is levied on all imported intermediate inputs and the tariff is borne entirely by the domestic buyers of imported intermediate goods. As a result, the price increases from $b + F/Q_{x3}$ to

$(1 + \tau/100)(b + F/Q_{x3})$ and the quantity demanded drops to Q_{x4} . It appears, then, that the pair $(b + F/Q_{x3}, Q_{x4})$, represented at point E_3 of the demand curve in Figure 1, is a good candidate for the new equilibrium. But the appearance of two different quantities, Q_{x3} and Q_{x4} , in this pair suggests something is wrong with that conjecture. Indeed, unlike in the constant-returns-to-scale case, producers of the intermediate good experience an increase in the average unit production cost by cutting production of the intermediate input from Q_{x3} to Q_{x4} . In fact, the unit costs will be $b + F/Q_{x4}$, higher than the $b + F/Q_{x3}$ per unit they will receive from the price inclusive of tariff $(1 + \tau/100)(b + F/Q_{x3})$. In other words, at the price $(1 + \tau/100)(b + F/Q_{x3})$ producers of the imported intermediate input will suffer a loss. Therefore, they will have to increase the price (before tariff), say, to $b + F/Q_{x4}$. But this higher producer price will result in a higher user price of $(1 + \tau/100)(b + F/Q_{x4})$, which in turn will reduce demand for the intermediate input even further. This will result in a higher unit cost to produce the imported intermediate input and lead to another round of increases in the domestic price of those imports. Eventually, unit costs will keep rising at a higher rate than the price. This shows up in Figure 1 in the fact that for prices above $b + F/Q_{x3}$, the demand curve stays always to the left of and below the unit average cost curve.²¹ This implies producers will always suffer a loss if they cut production below the pretariff level Q_{x3} . Since the tariff reduces demand below that level of production, the producer of the intermediate input will be forced out of business and that input variety will disappear from the market.

Thus, in contrast to the constant-returns-to-scale case, the imposition of even a moderate tariff in the presence of increasing returns to scale may reduce M , the number of intermediate-input varieties available to final-goods producers. This is because the tariff has a “market-size” effect on the intermediate input’s unit production cost that was absent in the constant-returns-to-scale technology case.

The next section discusses how these general ideas have been implemented in recent studies that attempt to take into account productivity gains from variety eventually introduced by policies of unilateral trade liberalization.²²

Welfare Gains from Variety in Static Models of International Trade

I report first a recent study by Klenow and Rodriguez-Clare (1997) because, strictly speak-

ing, their model is static and thus belongs to the class discussed in Part 1 of this series. However, I deferred discussion of this work until now because it is one of the few available studies that explicitly considers the potential gains from variety when measuring the benefits of unilateral trade liberalization.²³

The Klenow and Rodriguez-Clare model incorporates the product variety effect by assuming that importing firms must pay a fixed cost F to operate and a constant price b for each unit of imported good. For all practical purposes, it is as if the imported goods are produced according to a cost function like that in Equation 4.

Tariffs will make imported goods more expensive and, hence, reduce the demand for them. By the mechanism explained earlier, this smaller market size will eventually leave some importing firms unable to cover their fixed costs, forcing them to shut down. Consumers then suffer because they can no longer find the varieties of goods they had been purchasing. Likewise, local producers will become less productive, as Klenow and Rodriguez-Clare assume a production function of the type in Equation 5 (although a much more complicated one), by which a lower M (number of intermediate-input varieties) results in productivity losses and, therefore, in lower output despite the same capital and labor inputs.

The authors quantify the model using data for Costa Rica and find that removal of a 10 percent tariff can quadruple the gains from unilateral trade liberalization compared with a model in which product variety effects are absent. In particular, they find that imposition of a 10 percent tariff on intermediate goods leads to welfare losses equal to about 2 percent of GDP, as opposed to only 0.5 percent in lost GDP when the variety effect is not taken into account.

Thus, incorporation of gains from variety works in the expected direction of increasing the welfare gains from trade liberalization but keeps them within the moderate ranges of the static models without the gains-from-variety effect, as reported in Part 1.

One possible reason for the moderate gains in the Klenow and Rodriguez-Clare model is that the national product differentiation assumption works against unilateral trade liberalization, as explained above. The model's static nature also could be a factor. Thus, the next step is to see if these limitations are overcome by dynamic models—those that incorporate the dimension of time and, hence, saving and investment decisions—in the context of gains-from-variety effects.

Welfare Gains from Variety in Dynamic Models of International Trade

Quantitative dynamic models measuring the effects of unilateral trade liberalization do not abound. Even fewer of them have tackled the gains-from-variety effect. One such model is a study on Austria by Keuschnigg and Kohler (1996).

As explained earlier, all models of international trade that consider tariffs' effects on product variety must introduce, in one way or another, fixed costs of production. In the case of Keuschnigg and Kohler, it is the local producers of final domestic goods (and not importing firms, as in Klenow and Rodriguez-Clare) that face a fixed production cost. This assumption is the same as in the Klenow and Rodriguez-Clare model, except that tariffs will not change the number of foreign varieties but of domestic intermediate-input varieties supplied to local producers.

Because of this fixed cost, and for the same reasons as in the static models, tariff reductions in Keuschnigg and Kohler increase the market size for every good, eventually making it profitable to import or produce varieties unavailable before. In addition to this static effect, Keuschnigg and Kohler introduce a dynamic one by linking the stock of capital with the number of product varieties.

The intuition behind this additional effect is similar to the one given above when describing why, in the presence of a fixed cost, a fixed factor like land may limit the number of product varieties an economy can produce. The same logic works here, replacing land with capital. Suppose each firm in the economy must pay the fixed cost Keuschnigg and Kohler assume in the form of k units of capital. A given capital stock K could support at most K/k product lines or varieties. Since K is implicitly assumed fixed in static models, any increase in varieties must come through reduction in production costs rather than expansions in the capital stock.

But since Keuschnigg and Kohler allow for investment, the capital stock is not fixed. In fact, reductions of tariffs on intermediate and capital goods can induce a process of capital accumulation for the reasons discussed above.²⁴ If the capital stock increases by ΔK as a consequence of a unilateral move to trade liberalization, the economy can eventually support the higher number of product varieties $(K + \Delta K)/k$. This capital accumulation effect induces gains from variety in Keuschnigg and Kohler beyond those induced by the market-size effect present in static models described earlier.

Keuschnigg and Kohler calibrate their model to Austrian data and find that removing a 10 percent average tariff would result in welfare gains equal to about a 4 percent increase in GNP if the scale economies are fairly large (or if fixed costs are fairly big).²⁵ This is more than two times the gains in the Klenow and Rodriguez-Clare static model.

The larger welfare gains in Keuschnigg and Kohler again demonstrate that omitting the time dimension and capital accumulation may lead to a fairly sizable underestimation of the benefits of unilateral trade liberalization.

However, like many models reported above, Keuschnigg and Kohler's does not produce striking welfare gains. The potential for positive terms-of-trade effects from the national product differentiation assumption may be responsible for this. In fact, Keuschnigg and Kohler report that with a milder terms-of-trade effect, the gains from removing a 10 percent average tariff could be as large as 7 percent of GNP.

It is important to remember that the gains-from-variety effect may be a dangerous concept to play with. However beneficial to the case for unilateral trade liberalization, it may paradoxically undermine the very case for free market policies that it is meant to buttress. This literature typically appeals to increasing returns to scale, and, in the presence of such technology, markets cannot achieve the social optimum without government intervention.²⁶

CONCLUSION

Free trade advocates consider the denial of fast-track authority to the U.S. president a worrisome development. The concern is that lack of interest in multilateral trade agreements will create a backlash against the free trade policies Latin American countries adopted in the 1990s. The fear is warranted if each country in the region perceives it will experience welfare losses from adopting free trade policies when some of its major trading partners do not.

This series of two articles has examined the potential gains or losses from unilateral trade liberalization predicted by general equilibrium models of international trade. Negligible to moderate gains are found in static as well as dynamic models that do not incorporate gains from product variety. The results confirm that the omission of the dimension of time and, hence, of capital accumulation can undermine the case for unilateral trade liberalization.

Dynamic models that incorporate gains-from-variety effects seem to have more potential for delivering nonnegligible welfare gains. At the same time, these models include significant increasing-returns-to-scale technologies, a somewhat problematic feature because it opens the door to government intervention and may undermine the case for free market policies that the gains-from-variety effect is meant to boost.

A clear message from the quantitative experiments these two articles report is that neither the introduction of time nor of product variety effects can completely overpower the strong force against unilateral removal of tariffs introduced in almost all models by the national product differentiation assumption.

The strength of such a force is suspect, especially in models that assume monopolistic competition. As explained in Part 1, that assumption puts the market power at the firm—rather than at the country—level, which, in principle, should weaken the case for trade barriers introduced by the national product differentiation assumption. Perhaps more weight should be given to the models discussed in this article that mitigate the country market power effect of national product differentiation. These models deliver moderate to sizable welfare gains from unilateral trade liberalization.

Thus, the advantages of unilateral trade liberalization are cause for optimism. But to the extent that country market power is perceived as important in evaluating alternative trade policies, countries may balk at the prospect of a unilateral free trade policy. Hence, the suspension or slow progress of negotiations for multilateral trade agreements is cause for concern.

The measures of welfare gains (or costs) from unilateral trade liberalization policies presented in this article should be considered with caution for several reasons. First, dynamic models generally pose formidable technical challenges that—in the particular applications discussed in this article—have been circumvented with not completely appealing shortcuts. Second, the theoretical foundations of the national product differentiation assumption and the bias it introduces against unilateral trade liberalization remain controversial, especially in models that assume a monopolistically competitive market structure. Furthermore, the empirical measures of the market power implicit in such an assumption are imprecise. Certainly, international trade researchers still have a lot of work to do before the benefits of unilateral trade liberalization policies can be confidently assessed.

NOTES

The author wishes to thank David Gould, Gregory Huffman, Evan Koenig, and, especially, Steve Brown for comments on earlier drafts that substantially improved the contents and organization of the ideas in both articles of this series. Any remaining errors are, of course, mine.

- ¹ As Part 1 explains, the equivalent variation in income is the change in income that consumers should experience without a trade liberalization to replicate the level of utility they would attain with it. A negative equivalent variation in income implies that consumers are worse off after trade liberalization.
- ² Although this model is frequently put in the applied general equilibrium category, it does not strictly belong there because it implicitly assumes an excess supply of labor (that is, the labor market is in disequilibrium) in Mexico, at least before NAFTA.
- ³ One of the first authors to implement this approach in the context of a small open economy was Mendoza (1991).
- ⁴ The alternative assumption that β is an increasing function of c_t is not less problematic, as it creates the possibility of multiple equilibria, an issue beyond the scope of this article.
- ⁵ As explained in Part 1, concavity is a mathematical property that captures the idea that consumers have a taste for variety.
- ⁶ The counterpart for the lack of stationarity of the consumption-income ratio with a constant β is the lack of stationarity of the wealth-income ratio.
- ⁷ The introduction of money in the utility function has been justified as a shortcut to capture the notion that money facilitates trade. In fact, Feenstra (1986) shows that under certain conditions, transaction costs in trade will operate as if money were an argument of the utility function. However, the same reasoning applies if transaction costs are associated with buying and selling bonds or equities. It is on these grounds that Poterba and Rotemberg (1987), for example, include short-term government debt (and not just fiat money) in the utility function. This shortcut to modeling transaction costs explicitly may be useful for addressing certain monetary policy questions, but its application to the issue of the welfare consequences of alternative trade policies is more controversial.
- ⁸ For the reasons given in Part 1, consumption growth may not be a good measure of well-being, particularly in models in which labor supply is endogenous. For example, households may consume more after trade liberalization but also work harder, so the welfare gains may not be nearly as large as the increase in consumption would otherwise suggest. That's why most applied studies of international trade, like Goulder and Eichengreen's, report the *equivalent* variation in income rather than the *actual* variation in income (or GDP).

- ⁹ I arrived at this figure by assuming that the change in consumption from a removal of tariffs will be a linear function of the original average tariff rate for tariffs in the 0 percent to 10 percent range.
- ¹⁰ Both models assume several sectors, but the details of the disaggregation and technologies in each of them differ. Both models introduce frictions in the investment process but differ in the details. Goulder and Eichengreen assume that changing the capital stock from its current level is costly in terms of resources, while Ahearne assumes it is costly in terms of time—that is, that it takes several periods to bring the capital stock to the desired level.
- ¹¹ As Part 1 discusses, Japan may appear to import and export cars simply because of the way trade statistics are reported. For example, Japan could be importing convertibles and exporting vans. Although these are different products, they might appear simply as “cars” in the broad categories used in trade statistics, giving rise to an apparent cross-hauling puzzle.
- ¹² Unfortunately, none of these authors report an optimal tariff for their models. One conjecture worth exploring is that the 4 percent initial tariff Goulder and Eichengreen assume in their benchmark case is much closer to the optimal tariff than the 25 percent rate Ahearne assumes. Obviously, removing an optimal tariff will cause welfare losses while removing a nonoptimal one might enhance welfare.
- ¹³ In fairness, Ahearne himself reports that GDP gains in his model are more moderate under limited international capital mobility.
- ¹⁴ As explained in the previous section, trade liberalization can result in a higher capital stock, which implies a higher use of capital input in the production process.
- ¹⁵ It is important to note that models of monopolistic competition (as opposed to perfect competition) have established rigorously how the number of goods and the amount produced of each will be determined in a decentralized economy, using two conditions: that each firm will maximize profits by producing the output level at which the marginal revenue equals the marginal cost, and that free entry ensures that in equilibrium no firm will capture monopolistic rents. For a didactic presentation of this material, see Krugman and Obstfeld (1991), chapter 6.
- ¹⁶ This assumption is only for expositional convenience. Strictly speaking, it is a result, not an assumption, that can be obtained as the equilibrium outcome of a monopolistic competition model in which final goods are produced from inputs that enter symmetrically (that is, have the same elasticity of substitution) in a constant elasticity substitution production function. For a more formal discussion, see Romer (1987).
- ¹⁷ Ethier (1982) was among the first to propose production functions of this type. For a nontechnical but persuasive presentation of the benefits of variety in production and consumption, see Cox and Alm (1999).

- ¹⁸ Thus, if $\alpha = 1/2$, output will increase by $2^{1/2} = \sqrt{2} \cong 1.41$.
- ¹⁹ Recall that under increasing-returns-to-scale technologies, in contrast to constant-returns-to-scale technologies, the average unit cost declines with the quantity produced.
- ²⁰ The tariff will affect M only if it gets so high that the price $b(1 + \tau/100)$ is at or above the demand curve's intersection with the vertical axes, where the equilibrium quantity demanded will be zero. As anticipated, the tariff need not be that high to affect product variety in the presence of increasing-returns-to-scale technologies.
- ²¹ For a situation like this to emerge, the demand curve must intersect the vertical axis. Not all utility functions will induce that property. For example, the demand functions induced by the logarithmic utility functions in Part 1 never intersect the vertical axis. Of course, the studies in Part 2 specify utility functions that do induce that property on the demand for the relevant goods.
- ²² Recall that the parameter M , the number of varieties in the nonconventional production function (Equation 5), can be interpreted as a measure of the overall efficiency of technology because it plays the same role as A , the total factor productivity parameter, in the more standard production function (Equation 3).
- ²³ The Klenow and Rodriguez-Clare model contains many interesting details that cannot be discussed here without sacrificing the focus of the article. Therefore, I sketch only those features of the model whose understanding is essential to trace the fundamental forces behind its welfare results.
- ²⁴ Because Keuschnigg and Kohler use an overlapping generation model, they do not have to confront Ahearne's difficulty of how to introduce the time preference parameter β in agents that never die.
- ²⁵ The welfare gains were computed taking into account that the capital stock will gradually adjust to its new long-run equilibrium level after the trade reform is implemented.
- ²⁶ In more technical terms, the Second Welfare theorem does not hold under increasing returns to scale; therefore, a Pareto optimum cannot typically be implemented by a free market economy. Dixit and Stiglitz (1977) show, for example, that corrective measures could involve taxes on some goods and subsidies on others. By analogy, it is not difficult to envision environments in which the remedies would involve tariffs on some imports and subsidies on some exports.

REFERENCES

Ahearne, Alan (1999), "Trade Liberalization and Capital Accumulation in Developing Economies: A Quantitative Analysis," manuscript, International Finance Division, Board of Governors of the Federal Reserve System.

Cox, W. Michael, and Richard Alm (1999), "The Right Stuff: America's Move to Mass Customization," Federal Reserve Bank of Dallas *1998 Annual Report*, 3–26.

Dixit, A., and J. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review* 67 (June): 297–308.

Ethier, Wilfred J. (1982), "National and International Returns to Scale in the Modern Theory of International Trade," *American Economic Review* 72 (June): 389–405.

Feenstra, Robert C. (1986), "Functional Equivalence Between Liquidity Costs and the Utility of Money," *Journal of Monetary Economics* 17 (March): 271–91.

Goulder, Lawrence H., and Barry Eichengreen (1992), "Trade Liberalization in General Equilibrium: Intertemporal and Interindustry Effects," *Canadian Journal of Economics* 25 (May): 253–80.

Keuschnigg, Christian, and Wilhelm Kohler (1996), "Commercial Policy and Dynamic Adjustment Under Monopolistic Competition," *Journal of International Economics* 40 (May): 373–409.

Klenow, Peter J., and Andres Rodriguez-Clare (1997), "Quantifying Variety Gains from Trade Liberalization," manuscript, Graduate School of Business, University of Chicago.

KPMG Peat Marwick/Policy Economics Group (1991), "The Effects of a Free-Trade Agreement Between the U.S. and Mexico" (Washington, D.C.: U.S. Council of the Mexico–U.S. Business Committee, May).

Krugman, Paul R., and Maurice Obstfeld (1991), *International Economics: Theory and Policy*, 2nd ed. (New York: Harper Collins).

Mendoza, Enrique (1991), "Real Business Cycles in a Small Open Economy," *American Economic Review* 81 (September): 797–817.

Poterba, James M., and J. J. Rotemberg (1987), "Money in the Utility Function: An Empirical Implementation," in *New Approaches to Monetary Economics*, ed. William A. Barnett and Kenneth J. Singleton (New York: Cambridge University Press), 219–40.

Romer, Paul (1987), "New Theories of Economic Growth," *American Economic Review* 77 (May, Papers and Proceedings, 1987): 56–62.