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# Economic Review

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November/December 1991  
Volume 76, Number 6

Federal Reserve  
Bank of Atlanta

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# Economic Review

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In his discussion of the consequences of financial liberalization, the author distinguishes between measures of economic performance and economic welfare and considers some of the economic issues involved in both internal and external liberalization. The close examination of Taiwan's experience leads to the conclusion that, although liberalization may not immediately serve to increase economic growth, by expanding choice sets and more efficiently allocating resources liberalization is likely to increase economic welfare.

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# A Liberal Discussion of Financial Liberalization

Thomas J. Cunningham

**I**n 1986 Taiwan enjoyed a real, or inflation-adjusted, growth rate of about twelve and a half percent, a trade surplus that exceeded U.S. \$15 billion, an unemployment rate of two and two-thirds percent (and falling), a personal savings rate of about one-third, with additional capital from overseas desiring entry but legally restricted, and prices, as measured on the wholesale level, that were falling at about three and a half percent per year.<sup>1</sup> In 1987 the country briefly undertook a dramatic set of financial liberalization measures, substantially opening the economy to international flows of capital. Consistent with standard open-economy macroeconomic theory, growth slowed, inflation became less negative, and the current account deteriorated. By standards of other industrial nations, Taiwan was, and still is, performing quite nicely. Nevertheless, in view of the immediate consequences, the question should be asked: Why would a country want financial liberalization?

The point of this article is to examine that question. The next section begins with a brief discussion making the important distinction between measures of economic performance (as generally thought of in the United States) and the more important but less familiar measures of economic welfare. Although analysts typically talk about economic growth in terms of the former, they usually mean to talk about it in terms of the latter. The third section of the article formally discusses the process of both internal and external liberalization and comments on some of the economic issues involved. The article then applies the concepts of the previous two sections to the process of economic liberalization as it has occurred in Taiwan, one of the premier newly industrialized economies that has recently undergone substantial liberalization. The concluding section provides a summary.

*The author is a senior economist in the macropolicy section of the Atlanta Fed's Research Department. He thanks Ramon Moreno for helpful comments.*

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## A Digression on Measures of Economic Performance and Economic Welfare

Even though growth in Taiwan has slowed, that fact does not necessarily mean that the economy, on net, is not as well off as it otherwise might have been. Economic growth is usually treated as the benchmark against which judgments of economic welfare are made, but it is not always the appropriate metric.

The distinction between growth and welfare is best illustrated by discussing the difference between growth as simply measured by the percentage change in real gross national product (GNP) during some period and growth in per capita GNP over that same time. Growth per se is largely unavoidable in an economy with a growing population. A larger population creates a larger labor pool, which in turn is capable of producing more goods and services as well as creating a demand for additional output. These forces account for simple real growth. Of more importance, however, is whether aggregate GNP growth is outpacing the growth in population, in which case per capita GNP is rising and everyone in the economy could, potentially, be better off. If simple economic growth is lagging population growth, the economy is generally thought of as becoming poorer (though possibly quite large). So long as economic growth—that is, income—lags population growth, people will continue to feel poorer because, on average, they are.

In addition to the issue of growth versus per capita growth there is the matter of income distribution. While per capita real income growth is a necessary condition for everyone in the economy to benefit, it is clearly not sufficient. The fact that per capita income is growing says nothing about the ultimate distribution of individual incomes. If the distribution of income is considered part of the measure of overall economic welfare, a rapidly growing economy with a sufficiently unequal distribution of income could conceivably be characterized by declining social welfare, even as average per capita income grows. Although not the focus of this article, it should be noted that during the period of Taiwan's substantial industrialization, income inequality measures showed a pronounced drop. For example, from 1960 to 1980, the ratio of the income share of the highest quintile to the lowest was more than cut in half, from 8.9 to 4.2.<sup>2</sup>

The importance of these welfare criteria will become apparent as they are applied to the discussion of

liberalization in Taiwan in a later section. Before that, however, an overview of the literature regarding liberalization is in order.

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## Liberalization

Financial development and financial liberalization often go hand in hand. The purpose of this section is to set out the notion of financial liberalization as it commonly applies to developing nations. It is not necessary, however, to confine such a discussion to economies in the process of industrialization. Nations with developed financial and industrial markets can be studied within this framework as well because the financial development process is ongoing. The United States, in fact, is continuously developing and is quite far from the "full and complete" set of financial markets of which economists frequently speak.

Nevertheless, the importance of the idea of financial liberalization is usually seen in the context of developing nations, where some industrial and general economic development has taken place but secondary debt and equity markets have not yet emerged and where international capital movements may be regulated. This discussion of financial liberalization divides the process into its domestic and international components.

**Domestic Financial Liberalization, or Easing Financial Repression.** Financial intermediation is the process of matching up savings held by people or firms with people or firms that wish to borrow. Banks are an obvious example of financial intermediaries and are found fairly universally. However, their ability to allocate savings among alternative uses is frequently hampered by regulation. Interest rate ceilings on loans and deposit accounts, for example, are common restrictions. In the face of limitations on rates of return (interest rate ceilings on their loans) banks will choose relatively safe loans and forgo riskier but potentially more profitable and developmentally useful projects. In this simple case, liberalization can aid development by allowing lenders seeking a higher rate of return and borrowers having projects with a higher rate of return to come to mutually beneficial (and possibly socially beneficial) terms.

Ronald I. McKinnon (1973) and Edward S. Shaw (1973) make precisely this argument. The crux of McKinnon-Shaw, as the hypothesis has become known, is that regulation of the banking system (particularly interest rates) should be liberalized in develop-



ing nations to speed the development process. Because banks are frequently the sole purveyors of financial intermediation, eliminating the economic distortions brought about by financial regulations would promote a more efficient allocation of capital within the economy, which, in turn, would promote economic development and growth. Stated differently, financial "repression," to use McKinnon's term, may specifically hamper the banking sector, stifling economic development by misallocating capital resources. Easing the financial repression—liberalization—thus would result in a more efficient allocation of capital and a higher rate of economic growth.

In later work discussing empirical support for his earlier hypothesis, McKinnon (1989) examines several Pacific Basin economies in search of evidence that an easing of financial repression coincides with relatively high (or higher) real rates of economic growth. He finds that high—sometimes astonishingly high—interest rates, both real and nominal, are associated with an easing of financial repression. These rates reflect a high demand for capital, in turn indicating the high productivity of additional investment. Thus he finds a seemingly puzzling result that supports the McKinnon-Shaw paradigm: high interest rates are associated with high growth rates.

At first glance paradoxical, the finding is not really surprising. If the real return on investment is high, the implication is that the growth resulting from a given quantity of investment will also be relatively high. At the same time, a high real rate of interest encourages savings. The net result is that when interest rates are high as a result of market forces alone, relatively high growth can be expected. Moreover, the higher income growth may promote even greater savings, implying a higher future growth rate, too.

Critics of McKinnon-Shaw (called "nestructuralists") argue that the easing of financial repression may not lead to higher growth rates, though it certainly will attract funds to the banking industry. The nestructuralists argue that informal, loosely organized intermediation will occur in economies whose primary financial intermediary is a repressed banking sector. An easing of interest rate ceilings would allow banks to compete more aggressively for capital, thereby shifting it from the informal markets to banks. However, that adjustment would not necessarily lead to more growth because banks are faced with reserve requirements that would tie up a significant quantity of the newly attracted funds. The nestructuralists contend that for McKinnon-Shaw to work, higher interest rates must not only attract funds to the banking sector but,

on net, increase the total pool of savings (in both the banking and informal intermediaries sectors) by enough to offset the loss to required reserves imposed on the banking system. Their conclusion is that developing economies might as well leave interest rate ceilings in place and not interfere with the informal intermediation process (see Paul Burkett 1987).

Yoon Je Cho (1990) has pointed out that the disagreement between McKinnon-Shaw and the nestructuralists is not about the value of financial liberalization per se but the way to go about achieving it. Both parties, Cho claims, want to expand the intermediation process. The question is whether the informal sector or the formal banking sector is more efficient. Unfortunately, relatively little hard and systematic information is available about informal markets because they are, in fact, informal. It seems important to acknowledge, however, that even informal intermediaries, if they are pooling savings, must hold some reserves against "withdrawals." Moreover, because the formal banking system often has access to sources of temporary funding and insurance not available informally, the banking sector may actually be able to get by with a lower overall ratio of reserves to deposits. Further, as the absolute size of the banking sector expands, a simple appeal to the law of large numbers provides some predictability of the demand for withdrawals—that is, as the number of depositors increase, deposit flows will become increasingly predictable (see Valerie R. Bencivenga and Bruce Smith 1991).

In addition to the debate about increasing the overall amount of intermediation activity, another issue is the desirability of relatively high interest rates in the allocation of capital. The McKinnon-Shaw proposition holds that a higher formal rate of interest is likely to draw capital away from relatively inefficient self-financed or informally financed projects toward projects having a high rate of real return. Cho argues that as an economy liberalizes domestically the set of investment opportunities available to the banking sector should be larger than the set available to the informally organized market. Although this question is, in a strict sense, an empirical one that cannot be pursued because of lack of data about informal markets, Cho argues that only under extreme circumstances would informal markets be able to match the allocative performance of an unfettered banking system. In addition, informal markets are likely to find themselves constrained by a smaller information set, further enhancing the banking sector's relative advantage in terms of efficiency.

The process of developing financial intermediation—called “financial deepening”—goes beyond simply unrepressing, or liberalizing, the banking sector. Financial deepening involves developing active stock and bond markets as well. Nevertheless, because the development of secondary debt and equity markets usually comes relatively late in the overall economic development process, empirical measures of financial deepening typically focus exclusively on development of the banking sector.

The standard measure of financial deepening used for developing economies is the ratio of M2 to GNP. Although M2 is generally thought of simply as a measure of “money,” in fact it actually measures the sum of currency plus various forms of deposits in banks. If the banking sector is not functioning as an attractive or useful financial intermediary, the economy will, in aggregate, minimize its holdings of wealth in banks. As a consequence the M2/GNP number will be low, signaling the banking system’s shortcomings as a financial intermediary. According to McKinnon-Shaw, if financial repressions were lifted and the banking sector allowed to function effectively, the result would be growth in banks’ balance sheets and thus a rising ratio of M2 to income (GNP).

McKinnon (1989) argues that this process is indeed observed in economies that have experienced relatively rapid growth in the last few decades. For example, from 1960 to 1980 the M2-to-GNP ratio has moved from 0.29 to 0.91 in Germany, from 0.11 to 0.34 in Korea, and from 0.17 to 0.75 in Taiwan. In contrast, for the same period the ratio fell from 0.24 to 0.23 in Argentina and rose only incrementally from 0.15 to 0.16 and from 0.19 to 0.22 for Brazil and Colombia, respectively.

Moreover, McKinnon shows that measures of financial asset growth for the banking sector were positively related to relatively high real growth rates and positive real interest rates for the period from 1971 to 1980. He provides an interesting comparison of countries grouped into three categories (using International Monetary Fund classifications): countries with positive real interest rates, moderately negative real interest rates, and severely negative real interest rates. Countries with high real interest rates had high, frequently double-digit, financial asset growth and high single-digit real growth. Furthermore, he found that countries with severely negative real rates had low and often negative rates of financial growth and real growth rates.

Bencivenga and Smith (1991) have presented a formal model broadly consistent with the McKinnon-

Shaw story. Their model is quite general, featuring savings that can be held in liquid forms (consumption goods) or illiquid forms (like “fixed” capital) as well as financial intermediaries that face reserve-requirement restrictions. They show that under relatively reasonable circumstances (in which savers are adequately risk averse) an economy with formal financial intermediaries is likely to invest more of its savings in capital (the illiquid asset) than an economy relying on self-financing (that is, informal financing) and thus to enjoy a higher rate of real growth. In Bencivenga and Smith’s model a higher rate of real growth occurs even though the presence of intermediaries in the economy may not necessarily increase the overall rate of saving.

**Opening the Economy to International Capital Movements.** Eliminating domestic financial repression is an important component of financial liberalization, and the policy issues surrounding domestic liberalization are relatively clear-cut: imposing distortions on domestic financial intermediation hinders growth. Although there may be some legitimate and important debate about the appropriate means of managing, with minimal cost, the transition to a financially deep economy, the concerns are about means and not ends. The desirability of effective intermediation and its contributions to growth are not in question.

A much less settled issue involves the liberalization of international capital movements. Economies frequently impose a series of restrictions on capital movements across borders that may take the form of exchange rate controls and currency restrictions or capital restrictions limiting investment abilities (frequently in both directions across borders). Exchange rate controls usually manifest themselves in a fixed exchange rate, perhaps with restrictions on which institutions may engage in foreign exchange transactions. Currency restrictions generally prohibit the use of currencies other than that issued by the domestic monetary authority. Of restrictions limiting cross-border investments, those that prohibit domestic residents from investing abroad are usually motivated by a desire to stop capital flight, while those forbidding foreign ownership of domestic assets tend to grow out of sovereignty-related fears or concerns about the repatriation of profits to external owners of capital. Capital inflows today represent an outflowing stream of debt or equity claims that will mean debt service or profit repatriation to be paid abroad in the future, and this flow may potentially account for a large portion of domestic output.

The two forms of restrictions are not independent, for balance of payments mechanics connect trade and

capital flows with exchange rate movements. Consider an economy with a fixed exchange rate that has a surplus in the balance of trade. There are two ways this surplus can be accommodated. Either the economy takes an offsetting quantity of foreign financial instruments (that is, the balance of trade surplus is matched by a capital account deficit; the country is a net lender) or the monetary authority intervenes, selling enough of its assets to keep the exchange rate constant. This latter strategy can become problematic when the monetary authority runs out of assets, as in the example presented later.

In an economy such as that described above, the acquisition of foreign assets by domestic residents seems to pose no problem. If, however, instead of a trade surplus an economy is experiencing a balance-of-trade deficit, foreign agents are likely to acquire domestic assets. This development may not be particularly popular. Without the economy's central bank specifically intervening (subordinating its domestic economic concerns) in the adjustment process, the two accounts must balance after exchange rate changes. In imposing exchange restrictions, the ability of an economy to run a balance-of-trade deficit is thus financially constrained.

External financial liberalization removes barriers to international capital flows, but the free flow of capital internationally may or may not improve economic performance and welfare. Effects on economic performance are fairly easy to evaluate. Aggregate production is, in a general sense, a function of labor, capital, technology, and natural resources. Economic growth requires that at least one of these components change. Financial liberalization affects economic performance through its impact on the growth rate of the capital stock. There are two possibilities. If the economy offers attractive investment opportunities but simply cannot internally generate enough savings for growth, then capital will, on net, flow into the economy as liberalization occurs. The economy will grow faster, and (ignoring issues of the repatriation of profits and debt service and a political fear of foreign ownership of domestic assets) welfare can improve.

The more common result of liberalization, however, is a net outflow of capital. Domestically generated savings go abroad, where risk-adjusted real rates of return are higher. Especially in a relatively undeveloped economy, watching domestic savings leave the country can be politically and economically painful. Indeed, the reason such controls were established in the first place often is to force domestic investment of domestically accumulated capital—to attempt to limit “capital flight.”<sup>3</sup> These controls usually enjoy only

limited success. Nonetheless, to the extent that they do contain capital movement, the net result of removing the controls may be a decrease in the capital growth rate at home as capital is free to flow out in search of a higher rate of return. In this case the liberalization process may lead to a lower rate of real growth.

While having capital controls in place enhances domestic capital growth to some degree, simply raising the possibility of establishing capital controls can be detrimental. Controls are frequently imposed in something of a crisis environment—when relatively large portions of domestic capital seem to be moving abroad—and the

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*External financial liberalization removes barriers to international capital flows, but the free flow of capital internationally may or may not improve economic performance and welfare.*

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threat of controls may only serve to make the crisis worse. In the face of potential capital flight restriction, the most reasonable thing for holders of capital to do is to move it abroad before restrictions are imposed. This reaction only compounds the problem. The threat of controls also may discourage foreign capital from flowing into the country as investors fear they may not be able to recapture all the fruits of their investment. Consequently, anticipated capital restrictions may induce a capital outflow prior to the imposition of the restrictions, the magnitude of which may be greater than what would have happened in their absence.

The welfare issue surrounding financial liberalization is generally less clear. It is simple only in the case of capital inflow that creates a rise in domestic incomes and that is not complicated by repatriation of profits. (Scenarios can be devised wherein profit repatriation keeps domestic incomes from rising, but in principle the issue is clear-cut.) In contrast, the prohibition of capital flight has complex effects on welfare that are difficult to measure. The reason domestic residents wish to hold their savings abroad is that they expect to earn a higher return abroad, raising their

income. Thus, while capital flight may slow domestic economic growth, its effect on income may be ambiguous. Specifically, domestic residents investing abroad will have higher incomes than they would have if capital controls were imposed, whereas those who do not have additional capital with which to work will have lower relative incomes. The usual test applied here is to gauge whether there is, in principle, some means by which the winners could compensate the losers so that the winners still come out ahead while the losers would be indifferent to whether or not there are restrictions on investing abroad. Under these conditions, this surrogate measure of overall welfare indicates improvement.<sup>4</sup>

Considering these issues establishes a framework for thinking about the overall problems of financial liberalization. The following discussion focuses specifically on financial liberalization in Taiwan and its economic effects.

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## The Recent Experience of Taiwan

**Mercantilism Run Amok.** Before Adam Smith published *The Wealth of Nations* (in 1776) the predominant way of thinking about measuring a nation's wealth was in terms of its stock of gold. Mercantilists, as they are called, believed that the way to increase a nation's wealth was to increase its gold stock by running a trade surplus and letting the resulting inflow of gold simply pile up. Smith argued that a more appropriate measure of a nation's wealth was its sustainable flow of income, so the mercantilist prescription for lopsided trade was not really appropriate. David Hume later, and for the purposes of this discussion quite importantly, argued that the mercantilist prescription itself was unsustainable because a gold inflow would tend to result in inflation and, with fixed exchange rates, thus increase the relative price of an economy's goods in world markets to the point that the goods would lose their international competitiveness, ending the trade surplus.

During the last few decades Taiwan accumulated a large stock of international reserves, specifically dollars and gold. By mercantilist standards, their actions would have to be judged quite successful.

While Taiwan was running a sustained balance-of-trade surplus, it restricted exchange transactions in such a way as to channel reserves into the central bank. Domestic holdings of foreign currency were restricted, and all proceeds from exports were surrendered to the

central bank, which controlled the exchange rate as a managed float, or, before the mid-1980s, a fixed rate against the U.S. dollar. The immediate consequence of this institutional arrangement was that the central bank monetized the trade surplus. A firm that exported goods (the trade surplus) would be paid in a foreign currency, then would take that currency to the central bank and exchange it for domestic currency. As a result, the central bank ended up with the international reserves yielded by the net export surplus. The process generated a high rate of central bank money growth.

Because inflation in prerevolution China was a substantial problem for the nationalist government then on the mainland, the relatively rapid rate of money growth was of concern to the nationalist government of Taiwan. The central bank had to perform what amounted to domestic open-market operations, selling securities domestically (not international reserves) in exchange for its previous money issue. In effect the central bank was trading its domestic assets for international reserves. However, these operations were conducted on such a large scale that the central bank had to start issuing its own bonds (on which it paid interest) in exchange for foreign reserves (on which it earned little).

More importantly, however, from a theoretical viewpoint, the central bank was simply trading one form of its liabilities—central bank bonds—for another, central bank money, in an effort to control the growth rate of the latter. The latter did not pay interest, though, while the former did. Thus, the central bank was trying to slow the rate of money growth by issuing bonds that promised to pay even more money when the bonds matured. Serious issues of feasibility appeared and had to be addressed.

**Liberalization.** On July 15, 1987, Taiwan lifted all restrictions on current account transactions and up to a net nontrade-related outflow of U.S. \$5 million per year and net inflow of \$50,000, which increased with time. In particular, firms no longer were required to give up their foreign exchange earnings from trade, effectively meaning that the central bank was no longer forced to monetize the trade surplus.

Later that year, on October 1, restrictions on foreign investment into Taiwan were lifted. The effective investment intermediaries were commercial banks, whose total foreign liabilities had been frozen at U.S. \$13.8 billion on May 31, 1987. During the day of the liberalization these foreign liabilities increased by more than 17 percent, resulting in an immediate deliberalization the next day.

While the rather dramatic events of October 1 highlighted the desire of the rest of the world to invest in Taiwan, in fact there was a substantial pool of savings waiting to get out, too. As the *Far Eastern Economic Review* reported at the time of the liberalization ("Opening the Floodgates" 1987), firms engaging in trade had always had a standard set of devices, such as under- or overinvoicing, to elude foreign exchange controls. However, these options were not readily available to individuals, so they had accumulated a substantial pool of savings that were expected to start flowing abroad quite soon. Indeed, in 1988 a capital outflow of U.S. \$4.9 billion occurred, and in 1989 an outflow of U.S. \$8.2 billion. The capital outflow for 1990 looks stronger still.

It is still relatively early to draw many serious long-term conclusions about the liberalization's effect on the economy. Savings rates are down from preliberalization levels, but that result, in itself, conveys little information: in 1987 gross national savings were about 38 percent of GNP, which, by industrialized economies' standards, seems unsustainably high. By contrast, the United States has a gross national savings rate of about 4 percent. Taiwan's savings rate has declined to approximately 28 percent of GNP, which is still quite high. There are two possible explanations for this decline.

First, the decline in savings may represent an increase in economic welfare. External investment opportunities may offer a higher risk-adjusted real rate of return, and the expanded set of investment options may allow more portfolio diversification, allowing for higher real returns with little net addition to risk. As a result of the larger opportunity set and greater diversification, the same net return from savings may be achieved with a lower overall savings rate. It is still too early to draw implications from postliberalization data about the change in domestic income from abroad. On the other hand, it could just be that the savings rate is returning to a more reasonable level.

The decline in savings did *not* initially adversely affect capital formation rates (a measure of investment), which have climbed about 3 percentage points as a fraction of GNP from the time of liberalization through 1989 as measured in either gross or fixed capital terms. Therefore, the slowdown in growth since the liberalization—from almost 12 percent in 1987 to (a forecast of) slightly more than 6 percent for 1991—cannot necessarily be attributed specifically to a decline in capital formation resulting from the liberalization.<sup>5</sup> The growth rate of a relatively small economy may be expected to be relatively volatile, as

indeed Taiwan's has been, and the slowdown may not be outside "normal" variations in the economy's growth. Moreover, by industrial economies' standards, Taiwan is still growing at a very healthy pace. The slowdown is nevertheless, and understandably, a major concern domestically ("Export Machine Revs" 1991). It is also too early to tell whether this change in capital formation is a permanent rate change or simply a transitional effect resulting from the liberalization.

One clear consequence of the liberalization is a diminishing of the central bank's ability to influence domestic real rates of interest. Earlier work (Rosemary Thomas Cunningham and Thomas J. Cunningham 1990; T.J. Cunningham and R.T. Cunningham 1991) has shown that prior to liberalization the Central Bank of China (Taiwan) had some influence over the behavior of the domestic real rate of interest. After the liberalization, however, the effect disappeared. This development is to be expected in a small, open economy, for which movements in real rates in the rest of the world force similar movements domestically.

Outside of immediate domestic considerations, several longer-run concerns make liberalization desirable. Internationally, Taiwan's persistent and large trade surpluses may annoy foreign political leaders to the point that they erect some form of trade barrier. Liberalization may not, by itself, address the trade-balance problem, but to the extent that a mercantilist-like accumulation of foreign assets is slowed, so too, by definition, must the trade surplus diminish. Taiwan's trade surplus has fallen about one-third from 1987 (U.S. \$18.6 billion) to 1990 (U.S. \$12.2 billion), with the shrinkage continuing into 1991.<sup>6</sup> Domestically, large accumulations of savings denied access to international markets or constrained in rate of return by domestic financial repression may result in domestic political pressure for both international and domestic liberalization.

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## Conclusion

Dramatic institutional reform, financial or otherwise, rarely happens outside of a substantial domestic political or economic crisis. Taiwan's liberalization, however, while accompanied by some relatively minor political demonstrations, seems to be the consequence of coming of age industrially. As such, it may provide some relatively "clean" evidence regarding the consequences of financial liberalization.

Liberalization, as discussed, has some rather substantial benefits. Though it may not immediately serve to increase economic growth, by expanding choice

sets and more efficiently allocating resources liberalization will likely increase economic welfare.

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### Notes

1. According to the State Department, the U.S. government no longer refers to Taiwan as the "Republic of China." Taiwan, however, still calls itself the Republic of China.
2. The Gini coefficient during that time was also cut by a third, from 0.44 to 0.30. See Kuo (1983, 96-97). The larger issues surrounding income distribution and growth are outside the scope of this work. Readers interested in the topic should see Phelps (1973) or Rawls (1971).
3. See Cunningham (1988) for a review of Naylor that contains a taxonomy and discussion of capital flight motivation issues.
4. Critics of the compensation approach to welfare analysis point out that this criterion seems inappropriate because the compensation is rarely made. Proponents respond that there are winners and losers in virtually any economic event, and some standard of welfare analysis needs to be made. More recently, see Pollak (1991). In fact, the entire issue of the *Journal of Econometrics* containing Pollak's article is devoted to welfare issues.
5. The 1991 forecast is from Republic of China (1990, 24).
6. The welfare benefits of reducing a trade surplus to mollify major trading partners are unclear.

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# Evaluating Embedded Options

Hugh Cohen

**I**n an effort to control interest rate exposure many banks, financial institutions, and investors are buying complicated financial instruments. Many of these are difficult to understand (and thus difficult to value) because of the embedded options they contain. This article discusses a procedure that in some instances greatly eases the way that embedded options may be valued: the technique is to value it as though it were separate from the financial contract. Treating the embedded option independently is desirable when it is accurate because it is usually simpler to ignore the details of the surrounding contract.

In this article, two examples will be used to demonstrate this method. The first is valuing the call option sometimes embedded in Treasury bonds by separating the embedded option from the contract; for this option the technique results in a correct value. The second example involves valuing the wild card option (an option that allows a trader to sell a Treasury bond between 2:00 P.M. and 8:00 P.M. at a price fixed at 2:00 P.M.) embedded in Treasury bond futures contracts. In the latter case, separating the embedded option leads to an incorrect value for it.

It is important to understand the procedure because many financial texts mistakenly value the wild card option by separation, even though doing so produces erroneous results. Additionally, callable Treasury bonds have been mispriced although they could have easily been priced correctly by separation. The discussion that follows details ways to determine if the separation technique can be correctly applied.

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## Callable Treasury Bonds

Callable Treasury bonds represent a significant portion of the Treasury bond market (which is composed of Treasury securities with more than ten years to maturity when issued). In the fall of 1990, the Treasury reported almost \$100 billion in callable bonds outstanding, representing approximately one-fourth of the total par value of Treasury bonds (*Bulletin* 1990).

The payment stream of a Treasury bond has two parts. The bond's face value is the lump sum to be paid at maturity, which is usually thirty years from the date the bond is first issued. Semiannual coupon payments are made until the bond matures. A noncallable Treasury bond has a fixed maturity, so its payment stream is fixed. A call option gives its holder the right, but not the obligation, to buy the underlying security at a specified price, called the exercise price, over a specified period, called the exercise period. A callable Treasury bond gives the Treasury the right, but not the obligation, to accelerate the bond's maturity at any of the coupon payment dates during the five-year period before the original maturity date, provided that bondholders are given four months notice. When a Treasury bond is called, the Treasury pays the bearer the face value payment and a final coupon payment, and the Treasury is released from obligations to make later coupon payments.

The embedded call option becomes valuable for the Treasury to exercise when the bond's coupon rate is higher than the prevailing interest rate. In this scenario the Treasury can call the bond and refinance the debt by issuing a new one at the current, lower interest rate. Thus, after the call-protection period, investors in callable bonds risk losing their coupon payments at a time when interest rates are lower than coupon rates. Furthermore, if the coupon rate is lower than the prevailing interest rate the Treasury will not exercise the option, and the bondholder will be forced to continue receiving the lower coupon rate.

For the first time since December 1962, the Treasury called a bond on October 9 of this year. With interest rates at approximately 5 percent, the Treasury called \$1.8 billion of callable Treasury bonds. The called issue was the August 1993 bond, with a coupon rate of 7.5 percent. (The next, and now final, coupon payment will be on February 15, 1992, because the Treasury gave the required four months' notice.) Refinancing the debt saved the Treasury approximately \$18 million. At the same time it was called the bond was trading at \$101.41 per \$100 of

face value, a surprisingly high price for a bond that could be called at face value (*Wall Street Journal*, October 10, 1991). This premium was possible partly because of disbelief by the market that the Treasury would call any bond after nearly three decades of not doing so. For whatever the reason, this callable Treasury bond was clearly mispriced.

### Determining a Callable Treasury Bond's Value.

One approach to determining the value of a callable Treasury bond is to begin by valuing the embedded call option as though it were stripped from the Treasury bond. Subtracting the value of this stripped call option from that of an otherwise identical but noncallable Treasury bond yields the proper value of the callable Treasury bond. To determine that they are comparable, the cash flows of the two portfolios must be analyzed and shown to be identical.

In the thirty-year callable bond described here, the first fifty coupon payments are guaranteed by the call-protection period. The final ten coupon payments may or may not be paid, depending upon whether the Treasury decides to exercise its call option, resulting in eleven possible payment streams (outlined in Chart 1). There are also eleven possible payment streams to the portfolio of a long, noncallable Treasury bond with one short call option on the final ten coupon payments and the payment of face value at maturity, with an exercise price equal to the face-value payment, as shown in Chart 2. (The investor who purchases an option is said to hold the contract long. An option's seller is said to hold the contract short.)

Because the cash flow of a callable Treasury bond and the cash flow of the portfolio composed of buying a noncallable Treasury bond and selling a separate call option on the payments during the call period are identical for every possible date on which the Treasury may exercise the call option (compare Charts 1 and 2), the value of the two portfolios must be identical to avoid arbitrage. If the two portfolios had different prices, shorting the higher-priced portfolio and longing the lower-priced portfolio would capture the difference in prices without taking any risk. Thus the embedded call option in the callable Treasury bonds may be valued as a separate contract.

For example, the value of a \$100 callable Treasury bond that will mature between August 15, 2007, and August 15, 2012, with a coupon rate of 8 percent can be calculated from the following portfolio of securities: the value of a \$100 noncallable bond maturing on August 15, 2012, with a coupon rate of 8 percent is \$109.00. The value of a call option on the payments occurring over the final five years of this noncallable



bond with an exercise price of \$100.00 is \$5.25. The noncallable bond's value less the value of the option is the value of the callable bond—\$103.75. As will be demonstrated, not all embedded options can be accurately valued in this way.

## The Wild Card Option in Treasury Bond Futures

The Treasury bond futures contract traded on the Chicago Board of Trade (CBOT) is a heavily traded contract that contains many embedded options.<sup>1</sup> One of these, the wild card option, is an example of an option that cannot be priced by being examined separately from the contract. Before discussing the embedded option, the following section first reviews the Treasury bond futures contract as it is traded on the CBOT.

**The Treasury Bond Futures Contract.** Upon entering a futures contract, the long trader, who will buy the

underlying security, and the short trader, who will sell the underlying security, agree upon a futures price that will be used to calculate future cash flows. Although it can be entered into without cost, a futures contract obligates its traders to perform a series of future cash flows. The values of these cash flows are a function of the contract's settlement price, which is set by the settlement committee of the exchange at the close of trading (2:00 P.M.) to reflect the futures contract's market value at that time. After the settlement price is determined, every position in the futures contract is "marked to market." For an established long position in the futures contract, the value of the cash flow of marking to market is today's settlement price minus the previous settlement price. The cash flow for an established short position is minus one times the value of the cash flow of the long position. For a long position opened in the last trading session, the value of the cash flow of marking to market is today's settlement price minus the futures price when the position was taken. This value times minus one is the value of the

**Chart 1**  
**Cash Flow of a Callable Treasury Bond**  
**Called at the Fiftieth Coupon Payment**

| Semiannual Coupon Payment Number | 1   | 2   | 3   | 4   | ... | 48  | 49  | 50          | 51 | 52 | ... | 59 | 60 |
|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-------------|----|----|-----|----|----|
| Cash Flow                        | +CP | +CP | +CP | +CP | ... | +CP | +CP | +CP<br>+FVP | 0  | 0  | ... | 0  | 0  |

**Called at the Fifty-first Coupon Payment**

| Semiannual Coupon Payment Number | 1   | 2   | 3   | 4   | ... | 48  | 49  | 50  | 51          | 52 | ... | 59 | 60 |
|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-------------|----|-----|----|----|
| Cash Flow                        | +CP | +CP | +CP | +CP | ... | +CP | +CP | +CP | +CP<br>+FVP | 0  | ... | 0  | 0  |

**Not Called**

| Semiannual Coupon Payment Number | 1   | 2   | 3   | 4   | ... | 59  | 60          |
|----------------------------------|-----|-----|-----|-----|-----|-----|-------------|
| Cash Flow                        | +CP | +CP | +CP | +CP | ... | +CP | +CP<br>+FVP |

+CP= Coupon Payment  
+FVP= Face Value Payment

**Chart 2**  
**Cash Flows of the Portfolio of One Long Noncallable Treasury Bond**  
**And One Short Call Option on the Callable Payments**  
**With an Exercise Price Equal to the Face Value of the Bond**

**When the Option Is Exercised at the Fiftieth Payment**

|  |     |     |     |     |       |     |             |     |     |       |     |             |  |
|--|-----|-----|-----|-----|-------|-----|-------------|-----|-----|-------|-----|-------------|--|
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50          | 51  | 52  | . . . | 59  | 60          | Long, Noncallable<br>Treasury Bond               |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP         | +CP | +CP | . . . | +CP | +CP<br>+FVP |  |
|  |     |     |     |     |       |     |             |     |     |       |     |             |  |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50          | 51  | 52  | . . . | 59  | 60          | Short Option<br>Exercised at Fiftieth<br>Payment |
| Cash Flow                              | 0   | 0   | 0   | 0   | . . . | 0   | +FVP        | -CP | -CP | . . . | -CP | -CP<br>-FVP |  |
|  |     |     |     |     |       |     |             |     |     |       |     |             |  |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50          | 51  | 52  | . . . | 59  | 60          | Resulting<br>Portfolio Cash Flow                 |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP<br>+FVP | 0   | 0   | . . . | 0   | 0           |  |

**When the Option Is Exercised at the Fifty-first Payment**

|  |     |     |     |     |       |     |             |     |     |       |     |             |   |
|--|-----|-----|-----|-----|-------|-----|-------------|-----|-----|-------|-----|-------------|---|
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 50  | 51          | 52  | 53  | . . . | 59  | 60          | Long, Noncallable<br>Treasury Bond                  |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP         | +CP | +CP | . . . | +CP | +CP<br>+FVP |   |
|  |     |     |     |     |       |     |             |     |     |       |     |             |   |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 50  | 51          | 52  | 53  | . . . | 59  | 60          | Short Option<br>Exercised at Fifty-first<br>Payment |
| Cash Flow                              | 0   | 0   | 0   | 0   | . . . | 0   | +FVP        | -CP | -CP | . . . | -CP | -CP<br>-FVP |   |
|  |     |     |     |     |       |     |             |     |     |       |     |             |   |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 50  | 51          | 52  | 53  | . . . | 59  | 60          | Resulting<br>Portfolio Cash Flow                    |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP<br>+FVP | 0   | 0   | . . . | 0   | 0           |   |

Chart 2 (continued)

When the Option Is Not Exercised

|  |     |     |     |     |       |     |     |     |     |       |     |             |                                    |
|--|-----|-----|-----|-----|-------|-----|-----|-----|-----|-------|-----|-------------|------------------------------------|
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50  | 51  | 52  | . . . | 59  | 60          | Long, Noncallable<br>Treasury Bond |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP | +CP | +CP | . . . | +CP | +CP<br>+FVP |                                    |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50  | 51  | 52  | . . . | 59  | 60          | Short Option<br>Not Exercised      |
| Cash Flow                              | 0   | 0   | 0   | 0   | . . . | 0   | 0   | 0   | 0   | . . . | 0   | 0           |                                    |
| Semiannual<br>Coupon Payment<br>Number | 1   | 2   | 3   | 4   | . . . | 49  | 50  | 51  | 52  | . . . | 59  | 60          | Resulting<br>Portfolio Cash Flow   |
| Cash Flow                              | +CP | +CP | +CP | +CP | . . . | +CP | +CP | +CP | +CP | . . . | +CP | +CP<br>+FVP |                                    |

cash flow of marking to market a new short position. Thus, a short trader profits when the settlement price decreases from the previous day, and a long position profits when the settlement price increases from the previous day. Additionally, the settlement price is used to determine the delivery price for contracts when the delivery process is initiated on that day.

To understand marking to market, consider a trader who enters a futures contract at a futures price of \$100. At the end of the trading session the settlement price is \$102. Because of marking to market, a long trader would receive \$2, and a short trader would pay \$2. If at the end of the next trading session the new settlement price were \$101, a long trader would pay \$1, and a short trader would receive \$1. If at the end of this last trading session a short trader initiated the delivery process, the price that the long trader would pay to the short trader for the Treasury bond would be calculated using the \$101 settlement price.<sup>2</sup>

The short trader has many delivery options, a few of which will be detailed here. The quality option gives the short trader the right to deliver any \$100,000 U.S. Treasury bond, provided it has at least fifteen years remaining until maturity, if the bond is non-callable, or has at least fifteen years to its first call date

if it is callable. The short trader also has a timing option—the option to deliver the underlying Treasury bond on any business day during the delivery month. Additionally, the short trader has what is known as the wild card option. When the market closes, the settlement committee meets and establishes the settlement price for that day at approximately 2:00 P.M. (central standard time) and marking to market occurs. During the delivery month, the short trader has until 8:00 P.M. to decide whether to initiate the delivery process and to receive an invoice amount calculated using the 2:00 P.M. settlement price. Specifically, the short trader may wait until 8:00 P.M., monitoring bond markets, and then decide to deliver on the futures contract, receiving for the bond an amount calculated using the 2:00 P.M. settlement price. If the short trader decides not to initiate delivery, this same scenario is repeated the following business day until the final settlement price is posted. With the posting of the final settlement price, the wild card option expires.

**Valuing the Wild Card Option.** Determining the value of the wild card option embedded in the Treasury bond futures contract involves several questions. How much is it worth to the short trader to be allowed to wait until 8:00 P.M. to initiate the delivery process at

the 2:00 P.M. settlement price? Suppose the option is removed from the futures contract. How much would someone not involved in the Treasury bond futures contract pay for a series of options permitting, until 8:00 P.M. for a Treasury bond to be sold at a price set at 2:00 P.M.? Clearly, the option has value. If Treasury bond prices decreased significantly between 2:00 P.M. and 8:00 P.M., the bonds could be purchased at the new lower price and sold at the higher price, resulting in a profit. Alternatively, if Treasury bond prices rose over the six-hour period, the option would not be exercised, in favor of waiting until the next day when there would be another opportunity. This process could continue until the option expired. Thus, as an option separated from the futures contract the wild card option's

sold from the short trader to the long trader, and the contract is fulfilled. It should be kept in mind that the wild card option belongs to the short trader of the Treasury bond futures contract, who profits from marking-to-market payments when the settlement price declines. As discussed, the value of the separated wild card option comes from the opportunity to exercise the option when Treasury bond prices decline drastically between 2:00 P.M. and 8:00 P.M. However, if a short trader exercises the wild card option in this scenario, closing the position, the next marking-to-market payment is not made. Given that bond prices have decreased drastically, the lost marking-to-market payment appears to be a profitable opportunity sacrificed by exercising the wild card option. Thus, to value the wild card option embedded inside the futures contract the short trader must consider that exercising the wild card option may result in closing a profitable futures position. This fact is not taken into account in valuing the wild card option separately because the option's holder has no short position in the futures contract and thus would not be involved with marking-to-market payments.

Including the consequence that exercising the wild card option will close the futures contract position changes not only the value of the wild card option but the conditions under which it will be exercised. An investor may not exercise the wild card option embedded inside the futures contract, even though it results in a large positive cash flow if the marking-to-market cash flow is believed to be larger. Furthermore, an investor may exercise the wild card option when the cash flow is negative to avoid an even larger expected loss from the marking-to-market payment.

Clearly, a wild card option separated from the futures contract is of an entirely different nature than when it is embedded inside the futures contract. However, analyzing embedded options by separation, even though it may be inappropriate, is quite common. Contributing to this tendency is the fact that most textbooks discussing the wild card option of the Treasury bond futures contract actually discuss the separated wild card option, as in the following passages: "Occasionally, news that causes a significant fall in the value of bonds can occur after the market closes, but before the deadline for announcing plans to deliver. The short trader can then announce the intention to deliver, thereby locking-in the settlement price for that day, a price that does not reflect the bearish information for bonds. The next day, the bond will open at a lower price, and the short trader simply acquires the now cheaper bond for delivery at the old higher

**Table 1**  
**The Value of Separated and Embedded Wild Card Options<sup>a</sup>**

| Wild Card Plays Remaining <sup>b</sup> | Embedded Wild Card | Separated Wild Card |
|--|--------------------|---------------------|
| 1                                      | .017               | .199                |
| 2                                      | .026               | .312                |
| 3                                      | .033               | .371                |
| 4                                      | .037               | .421                |
| 5                                      | .043               | .454                |
| 6                                      | .045               | .486                |
| 7                                      | .050               | .528                |
| 8                                      | .054               | .559                |
| 9                                      | .056               | .590                |
| 10                                     | .058               | .612                |
| 11                                     | .060               | .627                |
| 12                                     | .062               | .653                |
| 13                                     | .063               | .666                |
| 14                                     | .065               | .680                |
| 15                                     | .067               | .697                |
| 16                                     | .068               | .700                |

<sup>a</sup> In dollars, with a standard error of one cent. For comparison purposes, the futures price of the futures contract is approximately \$88.

<sup>b</sup> The number of business days left for the short trader to exercise the wild card option.

value comes from the opportunity to exercise the option when Treasury bond prices decline during the six-hour period.

However, it is incorrect to value the option embedded inside the futures contract in this way. Exercising the wild card option has the additional consequence of closing the futures contract position. After the wild card option has been exercised, the Treasury bond is

price" (Robert Kolb 1988, 198). The idea that the next marking to market will also be profitable is not addressed. Another example exactly matches the description of a wild card option separated from the futures contract: "Restricting attention to a particular deliverable bond whose invoice price is (fixed) at the 2:00 P.M. settlement price, the short effectively holds a put option on the bond (with an exercise price equal to the invoice amount of the bond) which expires at 8:00 P.M. Since there are actually many deliverable bonds, the wild card option is somewhat more complicated, as well as somewhat more valuable" (Darrell Duffie 1988).

Mispricing the wild card option can be costly to investors in two different ways. First, investors may exercise the option at times that are less than optimal because they have not taken into account the full effects of exercising it. Second, by separating the embedded option investors may agree to an incorrect futures price when they enter the contract. Valued as an embedded option the wild card option is worth significantly less than as a separated option, as shown in Table 1. Table 1 presents the results of a simulation run to value both the embedded and the separated wild card option by simulating the change in interest rates during the six-hour period when the option may be exercised. (See the appendix for a more detailed discussion of the simulation.) In the simulation, separating

the wild card option from the Treasury bond futures contract results in an option worth approximately ten times that of the embedded option. It should be clear that separating the option from the futures contract does not properly value the embedded option.

## Conclusion

Two examples have been presented to illustrate a problem in valuing embedded options. Often, the process used does not value the embedded option but rather, because it is simpler to calculate, a similar option separated from the contract. The separated option's value may or may not be equivalent to the embedded option's. In callable Treasury bonds the separated and embedded call options have equal value. In Treasury bond futures contracts, however, the embedded wild card option is worth considerably less than the separated one. Thus, when comparing the separated and embedded options, it is important to determine that all implications of exercising the embedded option match those of exercising the separated option. Specifically, all cash flows of one must match the cash flows of the other. Otherwise, the embedded option may be an entirely different security, and valuing it incorrectly could prove to be costly.

## Appendix

A computer simulation was performed to observe the difference in value between the wild card option embedded in the Treasury bond futures contract and a wild card option separated from the contract. The term  $b(t,T)$  is defined as the price at time  $t$  of a default-free zero-coupon bond that pays one dollar at its maturity, time  $T$ . It is assumed that, at any fixed point in time, prices exist for all possible zero-coupon bonds. Further,  $f(t,T)$  is defined as the instantaneous forward interest rate at time  $T$  as seen from time  $t$ :  $f(t,T)$  is the forward interest rate that one could contract for at time  $t$  on a default-free loan during the forward period  $[T, T + dT]$ . To avoid arbitrage, there exists the following relationship between bond prices (assuming the prices are smooth) and the forward rate curve:

$$b(t,T) = \exp \left[ - \int_t^T f(t,\mu) d\mu \right].$$

Thinking of each payment of a Treasury bond as its own zero-coupon bond implies that noncallable Treasury bonds may be priced as the sum of zero-

coupon bonds. Thus the prices of noncallable Treasury bonds can be calculated from the forward interest rate curve.

For the purpose of the simulation, it is assumed that the forward rate curve's fluctuation over time was according to the Heath, Jarrow, and Morton continuous time constant model, which was chosen because of its simplicity.<sup>1</sup> This model assumes changes in the forward rate curve over time to be random parallel shifts (with the inclusion of a small correction term to make the model arbitrage-free), such that

$$df(t,T) = \sigma dW(t) + \alpha(t,T)dt,$$

where

$$\alpha(t,T) = \sigma^2 t \left( T - \frac{t}{2} \right).$$

The term  $\sigma$  is the constant volatility over the entire forward rate curve,  $W(t)$  is a standard Wiener process, and  $\alpha$  is a function necessary to avoid arbitrage. Typically,  $\alpha$

Appendix (continued)

is very small. The fact that the change in the forward rate curve is independent of the value of the initial forward rate curve means that negative forward rates are possible in the future, even if the initial forward rate curve is strictly positive. However, this forward rate model was chosen because small parallel shifts in the forward rate curve seem reasonable over the six-hour period during which the wild card option may be exercised.

The simulation started at the settlement time, with one wild card play remaining, and the change in the forward interest rate curve was calculated from 2:00 P.M. to 8:00 P.M. using the continuous time constant model of Heath, Jarrow, and Morton. At 8:00 P.M. the values of both wild card options were computed from the simulated forward rate curve. The calculation of the separated wild card option's value is straightforward, being simply the difference between the value of payment received for the bond calculated from the 2:00 P.M. settlement price and the current 8:00 P.M. bond price. To do the more complicated calculation of the value of the embedded wild card option, the upper bound as detailed by Hugh Cohen (1991) was used.<sup>2</sup>

Once the values of both wild card options were determined at the point of having one exercise period remaining, the values at the settlement time with two wild card plays available were calculated, assuming that the option was exercised only if the payoff was greater than the expected payoff with one wild card play remaining. Working backward in this manner, the values of both wild card options were calculated over the entire delivery month.

A standard deviation of .02 was used as the annual standard deviation in the forward rates. The bonds used and their conversion factors were taken from Kolb (1988) as the bonds available for delivery on June 1, 1987. In addition, the following initial stepwise forward rate curve was used for each run of the simulation:

$$f_w(0, 0.25, 0.5, 1, 5, 10, 35) = (0.076, 0.079, 0.082, 0.087, 0.089, 0.09, 0.09).$$

The values of the two wild card options are given in Table 1 as a function of the number of business days remaining for the short trader to exercise the wild card option.

#### Notes

1. For a complete explanation of this model see Heath, Jarrow, and Morton (forthcoming).
2. In Cohen (1991), under the assumption of the existence of an unique equivalent martingale measure, a theoretic

cal upper bound for the value of the wild card option is established. This upper bound is used as the value of the wild card option in the simulation.

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#### Notes

1. According to the *Wall Street Journal*, the open interest was more than 260,000 on July 11, 1991. Because each futures contract is on a \$100,000 face value U.S. Treasury bond, the collective face value of the open interest is \$26 billion.
2. The actual invoice amount depends on which Treasury bond the short trader chooses to deliver. Every possible deliver-

able bond (the terms of which are defined later) has a factor that is multiplied by the settlement price. This product plus the accrued interest of the delivered bond is the amount paid by the long trader to the short trader.

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# FYI

## Prospects for Energy Supplies

Gene D. Sullivan

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**E**nergy costs and availability are national and international concerns. Oil shocks such as the embargoes in the 1970s and recent hostilities in the Persian Gulf have taught users and policymakers that both the quantity and price of energy, especially oil, significantly affect standards of living. In the light of price changes associated with these shocks it has become clear that there are additional supplies of oil and a variety of alternative energy sources that could be exploited in the event of increases in the real price of oil that are expected to persist.

Because continuing use is likely to diminish the world's oil reserves, or at least force use of reserves with more expensive extraction costs, a number of experts anticipate a long-term tendency for prices of oil and other energy sources to rise whether there are supply shocks or not. Further exploitation of potential oil and other energy sources is likely to limit future price increases and may well influence current output and pricing decisions of the Organization of Petroleum Exporting Countries (OPEC) cartel. The array of energy sources that could be available at higher prices is broad and not always fully understood. This article presents an inventory of these sources and attempts to present unit-cost-of-production data when available.

Costs of production are explicitly considered in order to provide some sense of which of these alternatives might come into play first if oil price increases that were expected to persist occurred. It should be kept in mind that this cost information is not very satisfactory because the range of costs for each alternative under consideration is quite wide and would depend on variables such as location, necessary technology, and environmental problems. Rather than any one alternative dominating the market, it is most likely that several would be used at the same time, with the mix determined by the lowest cost when all factors are taken into account.

*The author is a retired research officer in the Atlanta Fed's research department. He thanks Frank King and Mary Rosenbaum for their contributions to the article.*

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## Short-Run and Long-Run Price Influences

The relationship between a product's price and the amount supplied and demanded in the short run almost always differs from that relationship over longer periods because during longer periods opportunities for adjustments in consumption and production patterns can be substantial. Such adjustments take time because they require investment in production, distribution, or use facilities. In turn, once that investment is made the new facilities and patterns are likely to continue in use as long as variable costs are covered.

In the very short run, demand for oil shows little sensitivity to price changes because few immediate options are available to energy users (see William C. Hunter and Mary S. Rosenbaum 1991). Price sensitivity increases as time passes because a number of alternative energy sources or means of conservation can be adopted.

The sensitivity of oil supply to price may also increase over time—quantity at a given (now higher) price may increase—owing to a number of factors. For instance, investment in exploration and production drilling can eventually increase output from new oil fields. Applying existing technologies to wider areas can increase the amount of oil recovered from known deposits. New technologies may be developed and dispersed as well, in response to prices that increase the potential profit rewards to developments. Time also opens possibilities that political restrictions on exploration or production can be altered or removed.

Another potential reaction to higher oil prices is an increase in supplies of oil substitutes. Coal, alcohol from biomass, natural gas, and nuclear energy are clearly substitutes in some uses, though each has its drawbacks. Commercial quantities of wind and solar energy are also being developed as alternatives. Clearly, the projected permanence of current price levels will strongly influence overall supply changes.

However, factors that would tend to raise the costs of some energy sources relative to oil may also affect their viability. For example, external costs such as those involved in abating the environmental pollution that frequently accompanies coal usage add to the cost structure specifically of coal and of overall energy supplies. As these external costs are increasingly recognized, especially in the United States, they can significantly influence the total costs of placing a product on the market.

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## Expanding Oil Supplies

Oil, the dominant energy form in commercial use, is the most likely source of substantial additional energy supply for the world market, at least in the next decade. Availability will be an important factor. In the 1980s the quantity of proved reserves actually expanded in relation to oil production, as shown in Tables 1 and 2.<sup>1</sup> All reserves do not have the same extraction costs, however, and a number of the newly identified reserves will be more expensive to extract than those counted in earlier years. Rising prices are also likely to contribute to increased oil production. OPEC actions have helped raise prices, and prices of oil in real terms have increased consequently. At the same time that an increase can be expected in the quantity of oil produced at higher prices, it is possible that political barriers blocking exploration could be reduced, resulting in discovery of some oil extractable at less than current average costs.

**Exploratory Oil Drilling.** New exploration activity for oil and gas offers the most immediate possibilities for extending energy supplies. Such drilling has typically been an economical means of enlarging the quantity of usable energy. Sustained price increases would make it likely that enough economic potential would be perceived to draw capital and technology even to remote locations.

Various constraints have limited exploration in the major areas of the world believed to hold the most promise for new petroleum discoveries. In the area historically known as the Soviet Union and in China and Alaska political restrictions of various sorts have hampered exploration; in the vast deep-water areas of the continental shelves, technological limitations have, until recently, prevented drilling.

Despite the Soviet Union's position as the largest single producer of crude oil since the mid 1970s, Soviet production has remained flat since 1980. Siberia is considered an especially good prospect for discovery of substantial oil reserves, similar to the Prudhoe Bay in northern Alaska. The lagging investment and lack of technological know-how for drilling in harsh climates that has limited Soviet exploration activity in recent years is likely to be turned around now that the potential for large finds to be sold at the higher prices promises a sufficiently low unit cost to make new explorations attractive. In addition, joint ventures with the more capital-rich and technologically advanced western oil companies make significant new discoveries in the coming decade increasingly likely.



**Table 1**  
**Crude Oil Production**  
**By Principal Country and Region**  
*(percentage of world total)*

|                                      | 1938 | 1950 | 1960 | 1970 | 1980 | 1985 | 1989 |
|--------------------------------------|------|------|------|------|------|------|------|
| North America                        | 63.4 | 54.6 | 37.2 | 24.9 | 20.2 | 24.6 | 19.3 |
| Canada                               | 0.4  | 0.8  | 2.5  | 2.7  | 2.4  | 2.7  | 2.2  |
| Mexico                               | 1.9  | 1.9  | 1.3  | 1.1  | 3.3  | 5.2  | 4.3  |
| United States                        | 61.1 | 51.9 | 33.5 | 21.1 | 14.5 | 16.7 | 12.7 |
| South America                        | 13.2 | 16.9 | 16.5 | 10.4 | 6.1  | 6.7  | 6.6  |
| Brazil                               | NA   | 0.01 | 0.4  | 0.4  | 0.3  | 1.1  | 1.0  |
| Venezuela                            | 9.5  | 14.4 | 13.6 | 8.1  | 3.7  | 3.1  | 3.2  |
| USSR                                 | 10.5 | 7.2  | 14.0 | 15.3 | 19.3 | 21.0 | 20.2 |
| Western Europe                       | 0.2  | 0.7  | 1.3  | 0.7  | 4.1  | 6.9  | 6.3  |
| Norway                               | NA   | NA   | NA   | NA   | 0.9  | 1.4  | 2.6  |
| United Kingdom                       | NA   | 0.01 | 0.01 | 0.0  | 2.7  | 4.7  | 2.9  |
| Africa                               | 0.1  | 0.4  | 1.4  | 13.3 | 10.3 | 10.0 | 10.1 |
| Algeria                              | NA   | NA   | 0.9  | 2.3  | 1.9  | 1.9  | 1.9  |
| Egypt                                | 0.1  | 0.4  | 0.3  | 0.7  | 1.0  | 1.7  | 1.5  |
| Libya                                | NA   | NA   | NA   | 7.3  | 3.0  | 2.0  | 2.3  |
| Nigeria                              | NA   | NA   | 0.1  | 2.4  | 3.5  | 2.8  | 2.7  |
| Middle East                          | 6.0  | 16.9 | 25.0 | 30.6 | 31.1 | 19.3 | 26.7 |
| Iran                                 | 3.9  | 6.4  | 5.0  | 8.4  | 2.8  | 4.2  | 4.8  |
| Iraq                                 | 1.6  | 1.3  | 4.6  | 3.4  | 4.2  | 2.7  | 4.6  |
| Kuwait                               | NA   | 3.3  | 7.7  | 6.5  | 2.8  | 1.9  | 2.7  |
| Saudi Arabia                         | 0.03 | 5.3  | 5.9  | 8.3  | 16.7 | 6.3  | 8.1  |
| United Arab Emirates                 | NA   | NA   | NA   | 1.7  | 2.9  | 2.2  | 3.2  |
| Far East                             | 3.9  | 2.3  | 3.1  | 3.9  | 8.2  | 10.7 | 10.3 |
| China                                | NA   | 0.02 | 0.5  | 0.9  | 3.6  | 4.7  | 4.6  |
| Indonesia                            | 2.9  | 1.3  | 2.0  | 1.9  | 2.7  | 2.2  | 2.4  |
| Total World<br>(Billions of barrels) | 2.0  | 3.8  | 7.7  | 16.7 | 21.8 | 19.6 | 21.9 |

Source: *Twentieth Century Petroleum Statistics* (1990).

Exploration in China has also been limited, primarily for political reasons. China promises to yield major finds once the country is opened to the use of modern technology. More intensive exploration in China during the past two decades has led to a doubling of crude oil output since 1975 and a tenfold increase since 1968. Even so, Chinese production still accounts for only about 5 percent of the world's total

and, as of 1990, known reserves were less than 2.5 percent of the total.

Vast areas of the South China and East China seas are the largest unexplored offshore basins in the world. Exploration to date has yielded only marginal results, with the exception of one large natural gas field, but the areas of China, both on- and offshore, are considered promising. The possibilities for foreign

**Table 2**  
**Crude Oil Reserves by Principal Country and Region**  
**Beginning of Year**  
*(percentage of world total)*

|                                      | 1952  | 1960  | 1970  | 1980  | 1985  | 1990    |
|--------------------------------------|-------|-------|-------|-------|-------|---------|
| North America                        | 29.1  | 13.3  | 8.3   | 10.2  | 12.0  | 8.8     |
| Canada                               | 1.5   | 1.6   | 1.7   | 1.1   | 1.0   | 0.6     |
| Mexico                               | 1.3   | 0.9   | 1.1   | 4.9   | 6.9   | 5.6     |
| United States                        | 26.2  | 10.9  | 5.6   | 4.2   | 4.1   | 2.6     |
| South America                        | 9.9   | 7.5   | 4.4   | 3.9   | 5.0   | 6.9     |
| Argentina                            | 0.0   | 0.7   | 0.8   | 0.4   | 0.3   | 0.2     |
| Venezuela                            | 8.6   | 6.2   | 2.8   | 2.8   | 3.7   | 5.8     |
| USSR                                 | NA    | NA    | NA    | 10.4  | 9.0   | 5.8     |
| Western Europe                       | 0.5   | 0.5   | 0.4   | 3.6   | 3.5   | 1.9     |
| Norway                               | NA    | NA    | NA    | 0.9   | 1.2   | 1.1     |
| United Kingdom                       | 0.0   | 0.0   | 0.0   | 2.4   | 1.9   | 0.4     |
| Africa                               | 0.2   | 2.5   | 10.3  | 8.9   | 7.9   | 5.9     |
| Algeria                              | NA    | 1.7   | 1.5   | 1.3   | 1.3   | 0.9     |
| Libya                                | NA    | 0.5   | 6.6   | 3.7   | 3.0   | 2.3     |
| Nigeria                              | NA    | 0.0   | 0.9   | 2.7   | 2.4   | 1.6     |
| Middle East                          | 51.0  | 62.3  | 62.7  | 56.3  | 56.9  | 65.9    |
| Abu Dhabi                            | NA    | 0.0   | 3.0   | 4.4   | 4.4   | 9.2     |
| Iran                                 | 14.8  | 12.0  | 10.4  | 9.0   | 6.9   | 9.3     |
| Iraq                                 | 9.5   | 8.6   | 5.2   | 4.8   | 6.4   | 10.0    |
| Kuwait                               | 14.3  | 21.3  | 12.8  | 10.2  | 12.9  | 9.4     |
| Neutral Zone                         | NA    | NA    | 2.4   | 1.0   | 0.8   | 0.5     |
| Qatar                                | 1.1   | 0.9   | 1.0   | 0.6   | 0.5   | 0.4     |
| Saudi Arabia                         | 11.4  | 17.2  | 26.4  | 25.4  | 24.1  | 25.5    |
| Asia-Pacific                         | 1.9   | 3.5   | 2.5   | 6.1   | 5.4   | 4.6     |
| India                                | 0.0   | 0.2   | 0.1   | 0.4   | 0.5   | 0.7     |
| Indonesia                            | 1.2   | 3.1   | 1.7   | 1.5   | 1.2   | 0.8     |
| China                                | NA    | NA    | NA    | 3.1   | 2.7   | 2.4     |
| Total World<br>(Billions of barrels) | 105.0 | 291.3 | 530.7 | 642.2 | 699.8 | 1,001.6 |

Source: *Energy Statistics Source Book* (1990).

participation in offshore exploration increase its potential.

In the United States, the National Wildlife Management Area of northern Alaska has also been closed to exploration. This area is believed to hold crude oil reserves more or less equal to the massive find in Alaska's

Prudhoe Bay field. Concerns for protecting wildlife and the environment have thus far been sufficient to prevent exploration in this preserve. Supply disruptions more severe than are now foreseeable would probably be required to induce opening that region for exploratory drilling. Nonetheless, this region's potential

still hangs over the oil market and may well influence prices.

The remaining additional possibilities for major crude oil discoveries require the use and continued development of new, now relatively expensive technologies to explore the deep-water shelf areas surrounding the continental land masses. The spread of drilling technology allowing wells in water depths greater than 1,000 feet will no doubt yield additional reserves in the North Sea as well as in other locations such as the Gulf of Mexico, the shelves along both the Atlantic and Pacific seaboard of North America, and the seas along the continent of Asia already mentioned.

Deep-water drilling, however, costs substantially more than shallow-water drilling. For example, in 1988 the average offshore drilling cost in the United States was \$289 per foot for wells averaging 10,800 feet deep, versus \$70 per foot for wells averaging 5,050 feet in depth (*Twentieth Century Petroleum Statistics* 1990, 92-93).

Deep-water explorations are likely to proceed rather slowly until oil prices move well above the recent levels (about \$20 per barrel) and show convincing evidence of remaining elevated. A producing well near the 2,000 foot depth level in the Gulf of Mexico was closed down in 1990 because of mechanical difficulties, and further deep-water drilling at the site was halted, reportedly because of unprofitable production at existing and expected prices (Rick Hagar 1990, 30).

**Expanding Existing Wells' Output.** New technologies are enhancing oil producers' ability to expand output from existing wells. Both horizontal drilling and a set of techniques called enhanced oil recovery, which involves injecting various substances into a well to increase accessibility of residual deposits, are proving successful means of further developing known oil fields.

*Horizontal Drilling.* Horizontal drilling, a relatively new technology, allows the lowest per barrel recovery costs of all drilling methods in certain types of existing fields such as the geological formations of the West Texas chalk, where oil is held in vertically configured reservoirs. Vertical drilling into a particular reservoir may fail to tap into oil reserves that have drained elsewhere. By drilling at acute angles from the vertical shaft for distances of several thousand feet, reserve pockets that would otherwise be unavailable can be perforated.

While horizontal drilling techniques are more costly per foot of drilled well, they frequently produce more oil than vertically drilled wells. Costs of horizontal

drilling may range from 40 percent higher to several times the cost of a vertical well. However, output from a horizontal well may also range from three to five times greater than the output from a vertical well. On a per barrel basis, drilling costs can be cut by one-third or more per barrel in some fields. This potential cost advantage explains the growing popularity and rapid adoption of the technique during recent years.

Currently, horizontal drilling has appeal for easy applications. The technique is expected to spread to more difficult applications as producers gain experience and techniques are improved. Its use will probably expand to some older fields outside the United States as well, unless opening new fields keeps oil prices so low that the more costly horizontal drilling technique is uneconomical.

Petroleum experts agree that new fields of major importance are not likely to be found by horizontal redrilling of vertical wells. Because of its higher cost, it is doubtful that horizontal drilling will be used to explore new areas.

*Enhanced Oil Recovery.* In addition to using horizontal techniques, oil producers have succeeded in expanding output from existing wells by injecting various substances, such as water, steam, or carbon dioxide, into a well to make a greater proportion of residual deposits accessible for pumping. The bundle of techniques used for this procedure is referred to as enhanced oil recovery (EOR). The relatively recent commercial application of this technology has achieved significant output increases in older wells generally known as secondary or stripper wells. One major company reported that more than half its domestic crude and condensate production in 1985 came from EOR ("Oil Field Chemicals" 1986). Although the drop in oil prices in the mid-1980s led to reductions in EOR production, the technique remains a promising source of future expansions in oil output.

Continuing development should make EOR even more efficient. A relatively new technique is microbial stimulation, in which producers inject microorganisms and nutrients into a dormant well. Following injection, generation of gases that accompany microbial growth adds pressure, which aids oil recovery. The treated well is then returned to production, and the injection cycle is repeated when production falls off again. The technique is appealing both because it costs less than other EOR techniques and because microorganisms produce a number of by-products that enhance future oil recovery. In addition, microorganisms remove sulphur and nitrogen-containing compounds from oil, reducing air pollution associated with its use. Costs of

the technique are reported to range from \$10 to \$45 per additional barrel of oil recovered (Sidney J. Nelson and Phillip D. Launt 1991). At the lower end of that range, there is room for considerable profit, even at current oil prices.

**Additional Oil Sources.** A potential, but costly, new supply of oil could be obtained by applying existing technology to shale containing oil, of which the United States has enormous deposits. Colorado's Piceance Basin alone contains more proved oil reserves in shale than exist in the Middle East (Ivan V. Klumpar and Malcolm A. Weiss 1988). However, oil recovery from shale has so far proved not to be economical, in spite of massive investments in developing recovery processes. Nevertheless, as in the case of oil in Alaska's National Wildlife Refuge, the potential of this energy source may help limit current prices.

### Energy Sources besides Oil

A number of energy forms may be substituted for oil. Some are reasonable economic alternatives for particular uses and in particular places even at current oil prices. However, the cost structure—including costs of pollution abatement—of most substitutes would require substantial hikes in oil prices from the current level to make them competitive.

**Natural Gas.** As shown in Tables 3 and 4, natural gas supplies are much more abundant in North America than are reserves of crude oil (see also Tables 1 and 2). In addition, because past exploration efforts have tended to target oil, plentiful gas reserves probably remain to be discovered. Because gas is difficult to contain, has high distribution costs, and is seldom found near major areas of energy use, producers have shunned or flared off any produced in conjunction with oil. Although gas is not a good substitute for oil in all uses, viewed from the standpoint of its total cost in use as compared with other fuels, gas ranks second to oil as an affordable energy source.

Recently, heightened concerns about atmospheric pollution from oil and coal combustion have increased interest in gas as a clean-burning fuel for electric power plants as well as for residential and commercial heating and cooling. Decontrol of natural gas prices in the United States in the late 1980s also gave producers an incentive for increasing investment in developing domestic natural gas resources. Exploration and production as well as construction of new pipelines have all increased. Nevertheless, the major

**Table 3**  
**Natural Gas Production**  
**By Principal Country and Region**  
(percentage of world total)

|  | 1975 | 1980 | 1985 | 1989 |
|--|------|------|------|------|
| North America                            | 53.3 | 43.8 | 35.1 | 31.5 |
| Canada                                   | 7.2  | 5.2  | 5.1  | 5.7  |
| Mexico                                   | 1.7  | 2.2  | 2.1  | 1.8  |
| United States                            | 44.3 | 36.4 | 28.0 | 24.0 |
| South America                            | 2.5  | 2.9  | 3.3  | 3.1  |
| USSR                                     | 22.0 | 27.5 | 36.1 | 38.4 |
| Other Communist                          | 3.8  | 4.8  | 4.6  | 4.0  |
| Western Europe                           | 12.8 | 13.1 | 10.8 | 9.1  |
| Netherlands                              | 6.8  | 5.0  | 4.6  | 3.5  |
| Norway                                   | NA   | 1.3  | 1.4  | 1.4  |
| United Kingdom                           | 2.6  | 3.8  | 2.4  | 2.2  |
| Africa                                   | NA   | 1.6  | 2.7  | 3.0  |
| Algeria                                  | NA   | 0.9  | 2.1  | 2.2  |
| Middle East                              | 3.8  | 2.2  | 2.7  | 4.9  |
| Iran                                     | 3.2  | 0.5  | 0.6  | 1.1  |
| Saudi Arabia                             | NA   | 0.5  | 0.3  | 1.5  |
| Asia-Pacific                             | 1.7  | 4.1  | 4.6  | 6.0  |
| Indonesia                                | 0.4  | 1.8  | 1.4  | 1.8  |
| Total World<br>(Trillions of cubic feet) | 46.9 | 55.7 | 62.9 | 73.4 |

Source: *Energy Statistics Source Book* (1990).

problem of delivering gas supplies from remote locations remains.

A technique for solving the problem of capture and transport of the energy from gas is to build electricity-generating facilities near gas wells. The variable costs of transporting electricity by cable to consuming areas would be more economical than transferring gas by pipeline or pressurized container. However, for gas to become a profitable and therefore feasible energy source on a significant scale, extensive front-end costs of building generating facilities would require higher energy prices or technological advances that would sharply reduce transmission costs.

**Table 4**  
**Estimated Proved Natural Gas**  
**By Principal Country and Region**  
*(as of January 1, 1990)*

|                       | Reserves<br>(trillions of<br>cubic feet) | Percentage of<br>World Total |
|-----------------------|--|------------------------------|
| North America         | 336.9                                    | 8.1                          |
| Canada                | 97.0                                     | 2.3                          |
| Mexico                | 72.7                                     | 1.7                          |
| United States         | 167.1                                    | 4.0                          |
| South America         | 163.6                                    | 3.9                          |
| Argentina             | 26.3                                     | 0.6                          |
| Venezuela             | 105.7                                    | 2.5                          |
| Eastern Europe        | 1,564.9                                  | 37.5                         |
| USSR                  | 1,550.0                                  | 37.1                         |
| Western Europe        | 203.6                                    | 4.9                          |
| Netherlands           | 60.9                                     | 1.5                          |
| Norway                | 93.1                                     | 2.2                          |
| United Kingdom        | 19.8                                     | 0.5                          |
| Africa                | 221.6                                    | 5.3                          |
| Algeria               | 114.2                                    | 2.7                          |
| Libya                 | 29.2                                     | 0.7                          |
| Nigeria               | 47.4                                     | 1.1                          |
| Middle East           | 1,341.2                                  | 32.1                         |
| Iran                  | 600.0                                    | 14.4                         |
| Iraq                  | 110.0                                    | 2.6                          |
| Kuwait                | 48.6                                     | 1.2                          |
| Qatar                 | 162.0                                    | 3.9                          |
| Saudi Arabia          | 184.4                                    | 4.4                          |
| United Arab Emirates  | 184.4                                    | 4.4                          |
| Far East              | 345.7                                    | 8.3                          |
| Australia-New Zealand | 77.4                                     | 1.9                          |
| Brunei-Malaysia       | 65.8                                     | 1.6                          |
| China                 | 33.0                                     | 0.8                          |
| India                 | 20.9                                     | 0.5                          |
| Indonesia             | 85.7                                     | 2.1                          |
| Pakistan              | 23.0                                     | 0.6                          |
| Total World           | 4,177.2                                  | 100.0                        |

Source: *Twentieth Century Petroleum Statistics* (1990).

**Coal.** Abundant coal reserves around the world also offer potential for electricity generation and for heating. In cost of acquisition, coal is closely competi-

tive with oil. Based on the amount of energy supplied to electricity-generating plants, coal is only half as expensive as petroleum and 60 percent as costly as natural gas. Furthermore, coal's prices have remained relatively stable during the past decade, while oil and gas prices were highly volatile.

However, impurities contained in coal pose major pollution problems when coal is burned without precautionary treatments of the gases emitted. Further, carbon emissions associated with coal combustion have limited its use in most heating applications in the United States. Electric power generation remains the major stronghold of coal's current market, and that use is increasing with the growth in demand for electricity.

Technology is available to clean up emissions from coal combustion, but, again, the processes require considerable investment. To date in the United States shipping clean-burning (low-sulphur) coal from its predominant locations in the West to major user areas in the East is less expensive than installing equipment to rid high-sulphur eastern coal of its damaging impurities. Rising energy costs could at some point make allocating resources to these treatments economically justifiable, and coal would then become a significant additional energy resource. Worldwide coal production is shown in Table 5.

**Ethanol.** Alcohol or ethanol distilled from various plant starches has long been in practical use on a limited scale as an alternative to petroleum fuels in internal combustion engines. During the fuel crisis of the 1970s investments allowed building plants to increase ethanol output, and ethanol was widely used in the United States in a blend with gasoline as automobile fuel. In some countries with limited domestic crude oil and foreign supplies, ethanol became the primary motor fuel. In the United States, however, subsidies were required to maintain ethanol output, even from the most starch-rich plant sources. It is estimated that crude oil prices of \$40 per barrel or more would be required to make unsubsidized ethanol a competitive fuel source (Sally Kane et al. 1989). Although current market conditions for gasoline suggest that commercial production of ethanol as a substitute for gasoline is not imminent, the technology is available and continues to be refined through ongoing research efforts.

**Nuclear Power.** Nuclear energy is already an important power source in Europe and the United States. It has significant potential for supplying future energy needs. Power from nuclear fission, a process that has been especially adaptable to electricity generation, has been in use for a number of years. Unfortunately, the

**Table 5**  
**Coal Production**  
**By Principal Country and Region**  
*(percentage of world total)*

|   | 1975  | 1980  | 1985  | 1988  |
|---|-------|-------|-------|-------|
| North America                           | 18.8  | 21.0  | 19.8  | 19.8  |
| United States                           | 17.9  | 19.9  | 18.2  | 18.2  |
| USSR                                    | 21.1  | 18.9  | 16.5  | 16.5  |
| Western Europe                          | 21.3  | 19.8  | 18.9  | 17.6  |
| Germany*                                | 13.9  | 12.6  | 11.9  | 10.6  |
| United Kingdom                          | 3.9   | 3.4   | 2.1   | 2.2   |
| Eastern Europe                          | 12.3  | 11.8  | 10.9  | 11.0  |
| Czechoslovakia                          | 3.5   | 3.3   | 2.9   | 2.7   |
| Poland                                  | 6.4   | 6.1   | 5.7   | 6.0   |
| Africa                                  | 2.2   | 3.2   | 4.1   | 3.9   |
| South Africa                            | 2.1   | 3.0   | 4.0   | 3.7   |
| Australia                               | 2.7   | 2.8   | 3.8   | 3.7   |
| China                                   | 15.6  | 16.4  | 19.3  | 20.1  |
| India                                   | 3.0   | 3.0   | 3.6   | 4.1   |
| Total World<br>(Millions of short tons) | 3,665 | 4,173 | 4,844 | 5,231 |

\*Includes East Germany.

Source: *Energy Statistics Source Book* (1990).

process also generates a number of costs that have restricted its development.

Fission plants produce vast quantities of waste heat that can create environmental damage unless costly cooling devices are constructed. Nuclear power-generating plants also produce tons of radioactive wastes annually; these pose serious disposal problems. Further, accidental discharges of radioactivity can occur. Regulations based on the knowledge and fear of such risks have raised investment and operation costs of nuclear power plants in the United States and Europe to such an extent that development of nuclear power programs has stopped. Further energy price increases, however, might be sufficient inducement for power companies to invest in nuclear programs again in the future.

Nuclear fusion is another potential form of nuclear power generation. However, despite recent reports of

cold fusion, fusion's development is quite uncertain and likely to be far in the future.

**Hydropower.** The use of hydropower, already widely used for generating electricity, could be expanded in many areas of the world, but not enough to increase its share of total energy. Hydropower is a cheap energy source where natural water flows can be harnessed to turn generating turbines. Even when lakes and reservoirs must be built to obtain water power, direct costs are relatively low. However, costs associated with losing alternative uses for land and water, coupled with destruction of natural habitat where dams are constructed, may make hydropower intolerably expensive in many places.<sup>2</sup> Furthermore, it is increasingly difficult to obtain approval to dam streams and form reservoirs for power generation. In many underdeveloped countries, the overall costs of hydropower relative to other sources of energy, including the capital investment required, prohibit expanding its availability.

In addition to the sources discussed above, solar power, tidal actions of the oceans, and wind power hold some potential for energy supply. At this point, however, these and similar alternatives are either limited in projected output or await further development of technologies capable of creating usable energy.

## Conclusion

The world's current energy supply can be augmented in a number of ways, but these generally would create higher per unit costs and require investment of resources and time. Nevertheless, the potential that such alternative supplies represent probably serves to limit current prices. A forecast that higher current prices are likely to persist could induce investment in new energy sources that would add to energy supplies even if future prices fell.

Although petroleum is currently the dominant source of energy in use, possibilities exist for increasing the availability of a number of sources. However, the supply of most of these substitutes, like the supply of oil itself, will not respond to higher oil prices in the short run. Little additional output can be produced immediately, even if oil prices increase sharply, leaving consumers seriously vulnerable to short-term swings in petroleum supplies (or quantities offered for sale).

Given time and additional investment, the quantities supplied and the overall relationship between output and price can adjust to changes in oil supply. Steps could be taken to increase output from existing oil and

gas wells and coal mines. New producing areas could be opened up and alternative types of energy production expanded. Various political restrictions on exploration and production could be lifted. In addition to increasing oil supply, efforts could go toward developing alternative sources like natural gas, coal, alcohol from biomass, hydropower, nuclear power, and solar energy. In most cases these alternatives would involve large initial investments.

If incentives are sufficient to set long-term developments in motion, there are likely to be rewards. Over

the long run, the time it takes to convert existing facilities, to build new processing and generating plants, and to perfect new technologies could result in substantial energy output expansions. Although the energy cost curve is steep at the outset of such ventures, it flattens out as longer-run developments bear fruit, even given current technology. Assuming continued developmental research, breakthroughs, and applications of technology, it is likely that the cost curve would even shift down as improved techniques resulted in the same output at lower costs.

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### Notes

1. Proved reserves are the estimated quantities of crude oil that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions.
2. Electricity generation from fossil fuels is a more practical alternative under current price and cost structures.

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# Review Essay

## *Europe 1992: An American Perspective*

Edited by Gary Clyde Hufbauer.  
Washington, D.C.: Brookings Institution, 1990.  
406 pages. \$25.00.

**Janice L. Boucher**

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**I**n the mid-1980s many Europeans in business and government, worried about Europe's economic standing with respect to the United States and Japan, began promoting a movement toward a more competitive, vigorous European economy. In July 1985 the European Community (EC) formalized this vision of "Europe 1992" in the directives of a White Paper titled "Completing the Internal Market," which had at its heart the goal of free (untaxed) movement of goods, services, capital, and labor throughout Europe. These directives were validated in 1987 by the Single European Act—an amendment to the 1957 Treaty of Rome—which embraced the same fundamental economic objectives. A study released in 1988 heralded the net benefits the entire European Community could potentially reap by fully implementing the act's 282 directives. Since then progress on the 1992 plan has continued, watched closely by those on both sides of the Atlantic.

As the deadline nears for implementing Europe 1992, newspapers, trade and academic journals, and books continue to report on the plan and to opine about its expected effects in Europe and worldwide. Many analyses, written mostly from a distinctively European perspective, have explored the potential benefits and costs of the plan for Europe's peoples, businesses, and governments. Some studies have looked specifically at the ways in which reforms will affect the conduct of European business, on matters ranging from hiring and taxation to mergers and acquisitions, from European governmental regulation and fiscal policy to industrial policy. Fewer analyses deal with 1992's impact on U.S. businesses and how they can better prepare for the coming European economic order.

It is generally expected that 1992 either will present the United States with a large market where great business opportunities abound or will create a "Fortress Europe," effectively closing out American business. Few resources

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provide detailed information about the effects of changes in European laws and regulations, government policy, the competitive climate, and the trading environment on industries in the United States and their means of doing business in Europe.

*Europe 1992: An American Perspective* aims to fill this gap but falls short of the mark. In fact, the book's title to some extent belies its contents. The book is a collection of seven essays commissioned by the Brookings Institution from respected figures in fields such as economics, finance, and law. It purports to examine progress on the Europe 1992 agenda as it relates to four U.S. industries—banking and services, automobiles, telecommunications, and semiconductors—and to two aspects of U.S. trade policy, competition and negotiating strategy. However, a substantial part of each article is devoted to explaining the 1992 plan's effect on European businesses and industry market structure as well as on EC trade policy with respect to the United States and Japan. The American perspective touted as the book's theme emerges only through each contributor's warnings to American businesses operating in or exporting to Europe about the obstacles—for example, reciprocity, EC public procurement policies, standard setting, and local content and domestic origin rules—they may confront. The essays offer no fully developed discussions of the importance of these issues to American firms. Despite this shortcoming, the book contains historical background that gives the reader insight into the factors that led to the 1992 plan and how the attitudes toward it have been shaped.

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## Overview

Readers unfamiliar with the particulars of the Europe 1992 agenda will benefit from the first chapter's overview of the plan. Gary Clyde Hufbauer, the book's editor, traces the origins of the 1992 agenda to the Treaty of Rome, signed in 1957 by the original six founding members of the European Community, and mentions the United States' encouragement of the plan as a form of containment against the Soviet Union.

The 1992 plan presents an opportunity for American companies to locate in a market with strong growth prospects, notes Hufbauer, the Marcus Wallenberg Professor of International Financial Diplomacy at Georgetown University. He points out that, with this opportunity in mind, U.S. government policy might be directed more toward securing a favorable business

climate for U.S. multinational firms operating in the EC than toward the interests of U.S. firms exporting to Europe.

Some U.S. industries will need to take an activist role, he contends, to maintain competitive strengths and to ensure that the trade climate between the United States and the European Community remains open. For example, the U.S. high-tech industry could find itself at a disadvantage up against a technologically advanced European industry that is subsidized collectively by EC members or that is engaged in pan-European strategic alliances promoted by the member governments. The General Agreement on Tariffs and Trade (GATT)—a post-World War II agreement among industrialized (and, more recently, developing) countries that loosened international trade restrictions and provides a mechanism for settling trade disputes—permits subsidies for research and development. In high-tech businesses, separating out whether subsidies are being used for research and development instead of for production could be difficult. Not only might such subsidies give the EC an advantage in terms of production, but, under GATT rules, U.S. high-tech firms competing with EC consortia could find it difficult to settle accusations of unfair trade.

Hufbauer's discussion of several issues that may crop up in United States-European Community trade negotiations—reciprocity, national quotas, local content and domestic origin rules, technical standards, and public procurement—includes examples of how these issues could potentially affect U.S. economic interests. Probably the least well thought-out section of the chapter touches on some of the broader challenges the United States faces as a consequence of the 1992 program. In an increasingly global market U.S. firms must face such issues as their loss in world ranking by size and deciding what nationality multinational corporations will bear as foreign companies increasingly take stakes in each other. Government officials will face questions like how management of the U.S. economy might respond to successes or failures in Europe and whether the United States will retain the role of "custodian of the international system" or share it with the EC or Japan.

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## Industry Case Studies

Four chapters concentrate on the four industries, identified earlier, that may prove to be the most contentious in terms of negotiating trade policies between

the United States and the European Community. These case studies describe what the European climate will likely be for U.S. businesses operating or hoping to operate there. The authors point out that U.S. firms will need to consider the implications of competing with businesses that may become stronger through pan-European mergers and acquisitions or—in some high-tech industries—strategic alliances (or consortia). Differences between American and EC government procurement policies, product standards, and regulations could also pose difficulties for U.S. companies. Although the case studies' authors adequately describe the business environment emerging from Europe 1992, they fail to suggest tactics that U.S. businesses might want to pursue to compete in the European Community.

For the short-term—until about 1994—the U.S. banking industry will probably feel little impact at home from the 1992 plan. Authors Carter H. Golembe and David S. Holland predict that over the longer run, however, competition with European banks will force changes in U.S. regulations to allow consolidation of banking and service-related industries. To compete with the banking system in Europe 1992, the U.S. system of financial institution regulatory agencies may push to reorganize its power structure.

The case studies of the automobile, telecommunications, and semiconductor industries—written, respectively, by Alasdair Smith and Anthony J. Venables; Peter F. Cowhey; and Kenneth Flamm—emphasize many of the same issues. The role the EC government assumes in supporting European producers in these industries will critically affect American producers exporting to Europe. Although the Directorate General's office, according to the 1992 plan, actively encourages competition, these three industries may be coddled because they are considered "national champions" that are key to Europe's competing effectively throughout the world.

The argument for providing government support to national champions, though contrary to the competitive spirit the 1992 plan seeks to achieve, was perhaps most clearly brought home to the EC by its experience in the semiconductor industry during the 1960s. European computer markets remained protected from U.S. and Japanese competition during this time and emphasized meeting the needs of local rather than foreign computer manufacturers. The EC failed, for a number of reasons, to establish itself as a producer in the global semiconductor market and instead was largely a consumer. Europe had fallen behind the United States and Japan in computer technology and therefore

missed cashing in on the explosive growth of the computer industry. The European industry could not keep pace in production or in the user markets.

Events like these have shaped the EC's attitudes toward the industries it foresees will be crucial to remaining competitive in world markets, and these nationalistic biases cannot be easily dispelled. Moreover, EC policymakers have yet to draw the line between the advantages of unfettered competition and protection in industries whose prosperity tends to spill over to other industries.

U.S. firms must participate in EC standard setting in each of these industries, the case studies' authors caution, or find themselves denied access to European markets because their products do not meet EC standards. In the chapter on the semiconductor industry, Flamm suggests that international standards be negotiated through a GATT-like body to avoid development of standards that will favor EC-produced goods.

Testing and certification standards must also be negotiated, these authors believe. U.S. goods that meet international production standards could still be denied entry into EC countries if their testing and certification results do not meet EC specifications. In the automobile industry, for example, the EC did not adopt the same testing and certification procedures as the United States. As a result, U.S. auto exports could be blocked on grounds of failure to pass European testing and certification even though they may meet manufacturing standards. Of course, European auto producers' exports to the United States could also meet the same obstacle. Smith and Venables neglect to mention that mutual self-interest may help deter such an outcome.

The case studies' authors also discuss the potential complexity of trade disputes that will emerge in a global business environment. How will a decision be made, for example, as to whether the exports of Japanese plants that operate in the United States will be treated as Japanese or U.S. exports? Will U.S. automobiles produced and sold in Europe be treated as European or American goods? Resolution of such issues might not be forthcoming until trade negotiations specify plans for these industries.

The essay on telecommunications, although the most technical, provides the most in-depth discussion of the potential effects of Europe 1992 on U.S. businesses and trade policies. Cowhey contends that, to compete globally, U.S. telecommunications firms must pursue new ways of combining services and equipment into products that satisfy market demands in innovative ways. This goal may best be accomplished by

small and medium-sized firms and could be further promoted by changing regulations in the U.S. telecommunications industry.

Another concern in this industry is that public procurement procedures within the EC may hurt U.S. firms. Although the EC has adopted more transparent public procurement rules, the United States is concerned that these will not be extended to the largest purchasers of telecommunications products like the finance, defense, and transportation ministries. In such an event, U.S. telecommunications exporters would lose an important market segment and any potential clients that might have been exposed to the product through these avenues.

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## Competition Policy and Negotiating Strategy

The chapter on competition policy examines an important question about the 1992 program: if the goals of a more competitive economic environment and improved consumer welfare are in conflict, how will the conflict be resolved? Competitive policy, in some instances, may be superseded in the interests of national security, consumer safety, or environmental protection by means of trade barriers to non-EC goods and services. The author of this chapter, Douglas Rosenthal, does not consider cases in which stricter health, safety, or environmental standards could have the paradoxical effect of encouraging companies to shift production to countries outside the EC with slacker standards.

Rosenthal, a partner in the Washington office of the international law firm Coudert Brothers and a former chief of the Foreign Commerce Section of the Justice Department's Antitrust Division, examines various aspects of competition policy as it relates to intra-EC business activity and U.S.-EC business and trade relations from a legal standpoint. He assumes that the reader has a fairly broad familiarity with technical law terms and the EC's governmental branches and their roles in policy-making. Five features of the 1992 program are examined: deregulation, market restructuring, antitrust enforcement, industrial policy, and external trade policy. The author concludes that European competition and trade policy will not create a "Fortress Europe" because it is not in the EC's interest, although he notes some caveats to this claim. For example, a recession in Europe or conflicting trade and industrial policy goals of the member states may interfere with the progress and resolve to completing the internal market.

Five aspects of European competition policy will be most influential in European Community-United States relations, in Rosenthal's view. These issues are (1) the timing for and extent of removal of government barriers that impede the "four freedoms"—the free mobility of goods, services, capital, and labor; (2) the degree of market access permitted, especially by merger or strategic alliance, based on the principles of national treatment and nondiscrimination; (3) the extent to which outside firms, including U.S. firms, are targeted for private restraints perpetuated by European firms; (4) the degree to which competition is disturbed by EC institutions' or member states' providing subsidies to favored firms or consortia to make them "more competitive" or to give them "short-term relief" from market setbacks; and (5) the question of whether foreign firms can obtain equal access by exporting to European markets.

An important detail Rosenthal highlights is that the channels through and process by which U.S. firms are accustomed to having legal disputes resolved are somewhat different in the EC. In the United States private firms bring antitrust complaints to the attention of the U.S. court system. In the EC the European Commission initiates most antitrust suits.

Another noteworthy point he makes is that the EC's antitrust legislation—and, in fact, much of its competition policy—is "being shaped in the dark" because the rules and cases are new and few precedents have been established. Pursuing and maintaining some of the key directives of the 1992 plan could be hampered because the Directorate-General Offices responsible for ensuring that the plan's competition policy is carried out are not sufficiently staffed to monitor and investigate it. This lack of staffing could also prove a hindrance to any U.S. businesses that bring charges of unfair play before the EC Commission.

In a brief examination of external trade policy in the United States and the European Community since the late 1980s, Rosenthal points out that there is a "separation of the spheres of influence" of antitrust and trade policy in both the United States and the EC. He advises that the United States monitor the degree to which trade policy's effects on competition are considered in shaping the EC's domestic competitive policy. This theme, whether explicit or not, runs through all of the essays.

The chapter on negotiating strategy, written by Joseph Greenwald, an attorney and former U.S. Ambassador to the European Economic Communities, emphasizes that the United States must seek other channels—in addition to the Uruguay Round of the

GATT talks—for negotiating trade policy with the European Community. Given its new economic status as a rival of the United States, the EC has become and will likely continue to be more contentious in trade disputes, Greenwald notes. The current dispute between the United States and the EC over agricultural policy is an example of how problems in one area could spill over into other areas of negotiation.

The author's discussion of general negotiating strategy issues is less well articulated than the other sections of the chapter. Outlining three approaches to negotiating strategy—a global approach using the GATT framework; a national approach pursuing priority issues case by case, possibly through bilateral agreements; and a regional approach establishing an exclusive U.S.-EC deal—Greenwald notes that these approaches may overlap but offers no insight as to which might be the most prudent to use or why.

The chapter discusses three specific trade issues between the United States and the EC: services, standards, and testing and certification. Services, the author suggests, should be included as part of a separate agenda of the GATT talks and perhaps even pursued bilaterally. The United States should monitor standards and testing and certification requirements to ensure that they do not become technical barriers to trade.

Government procurement policies, rules of origin, quotas, and antidumping legislation as they are being shaped in the EC are also discussed in this chapter.

Greenwald closes with some recommendations for strategies the United States may employ in negotiating with the EC and suggestions for some organizational changes in regard to the initiation of U.S.-EC trade policy at the grass roots level.

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## Conclusion

*Europe 1992: An American Perspective* provides particulars of the Europe 1992 agenda and highlights some of the industries on which the plan is expected to have a major impact as well as policy initiatives and current or potential trade concerns. However, readers may find only a few chapters to be of interest, especially given that the industry case study articles are rather technical. The case studies merely touch on general issues such as standard setting, public procurement, mergers and acquisitions, and trade policy and consider the obstacles these matters may pose to American companies doing business in Europe post-1992. The book ultimately is disappointing because it lacks in-depth discussions about carving market niches and exploiting already established market presence, as well as practical suggestions for U.S. businesses preparing for and dealing in a new economic environment. In short, the book is not a “how-to” manual. Perhaps one is sorely needed.

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