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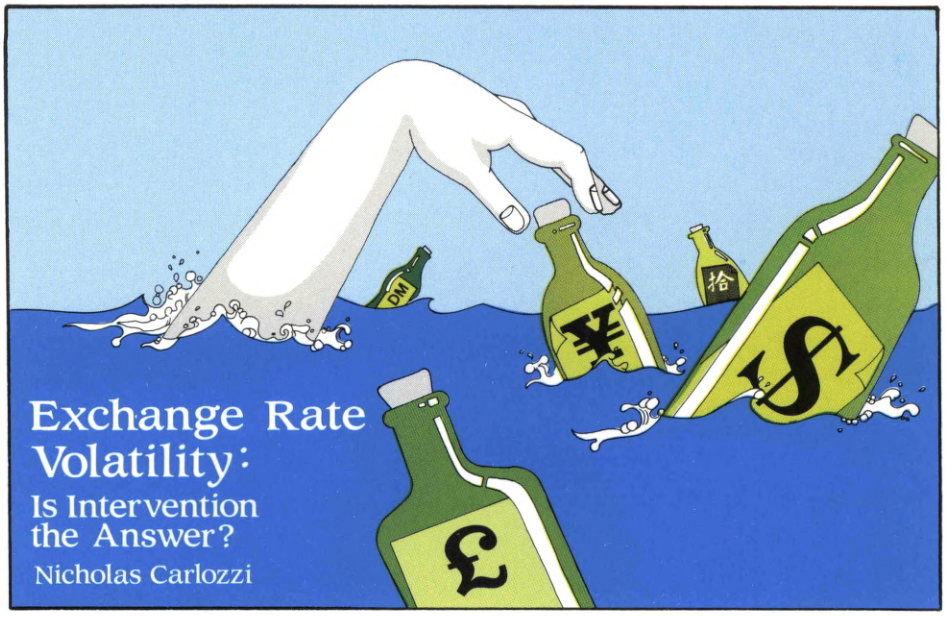

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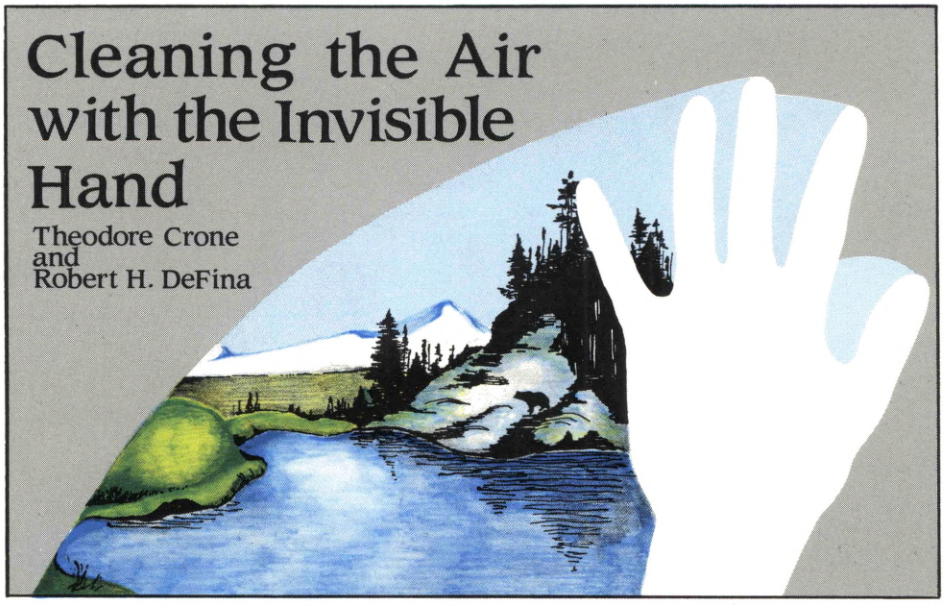

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Federal Reserve Bank of Philadelphia
Ten Independence Mall
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Whether exchange rates are too volatile or not is a topic of debate among market analysts, as well as politicians. Each side agrees, however, that the crucial point is whether the volatility means the market is efficient or inefficient. At present, tests of efficiency in this market have not produced conclusive results. But this inconclusiveness itself underscores the need to deepen our analysis of the workings of the market before passing judgment.

Recent efforts to improve air pollution control have enlisted the power of market mechanisms to complement or replace long-standing regulations aimed at specific pollution sources. Programs providing economic incentives for firms themselves to control pollution may prove not only more cost-effective than direct regulation, but also more successful at achieving the goal of cleaner air.

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Exchange Rate Volatility:
Is Intervention the Answer?

*Nicholas Carlozzi**

In early 1973, coordinated efforts to peg exchange rates were abandoned, and a new era of international monetary relations began. Currently, countries are free to choose the degree of exchange market intervention that best suits their overall economic objectives. Most of the major developed countries no longer rigidly support internationally agreed upon parities.[1] Thus, market forces play a greater role, and official intervention a lesser role, in the determination of exchange rates today than they did before 1973.

Whether consequence or coincidence, the move toward less government intervention in the exchange market has been accompanied by more volatility in exchange rates. Both day-to-day fluctuations and longer-term swings of exchange rates have been larger. Furthermore, this increased volatility has been observed not only in the exchange rates of less frequently traded currencies, but also in the exchange rates of those currencies used most frequently in international trade and finance. (See: THE DOLLAR'S BEHAVIOR.)

Should governments intervene extensively in the foreign exchange market in an attempt to reduce this volatility? Some market analysts say yes, arguing that increased exchange rate volatility is evidence that the market overreacts to per-

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[1] Most members of the European Economic Community (EEC) maintain their currencies within a prearranged range vis-a-vis other EEC currencies, but not vis-a-vis the dollar. For a description of the range of current exchange policies, see Nicholas Carlozzi, "Pegs and Floats: The Changing Face of the Foreign Exchange Market," this *Business Review*, (May/June, 1980), 13-23.

THE DOLLAR'S BEHAVIOR

The Trade Weighted Index (TWI) of the dollar's exchange value exemplifies the increased volatility that has accompanied the reduction in exchange market intervention by the major developed nations. It is evident not only in day-to-day fluctuations of the TWI but also in its longer-term movements.

Longer-term cycles in the TWI were nearly imperceptible during the final years of active government exchange market intervention, 1967 through 1972, but longer-term cycles became more pronounced with the reduction in official intervention in March 1973. Moderate swings in the TWI occurred from March 1973 through July 1977. Then, in mid-1977, the dollar began a more dramatic decline in exchange value.[a] Between July 1977 and October 1978, the TWI declined by 18 percent. In mid-1980, several factors stimulated a rebound in the dollar's exchange value; for example, interest rates in the U.S. rose relative to those abroad, and the U.S. current account balance moved into surplus. Between October 1980 and December 1982, the TWI increased by 32 percent.

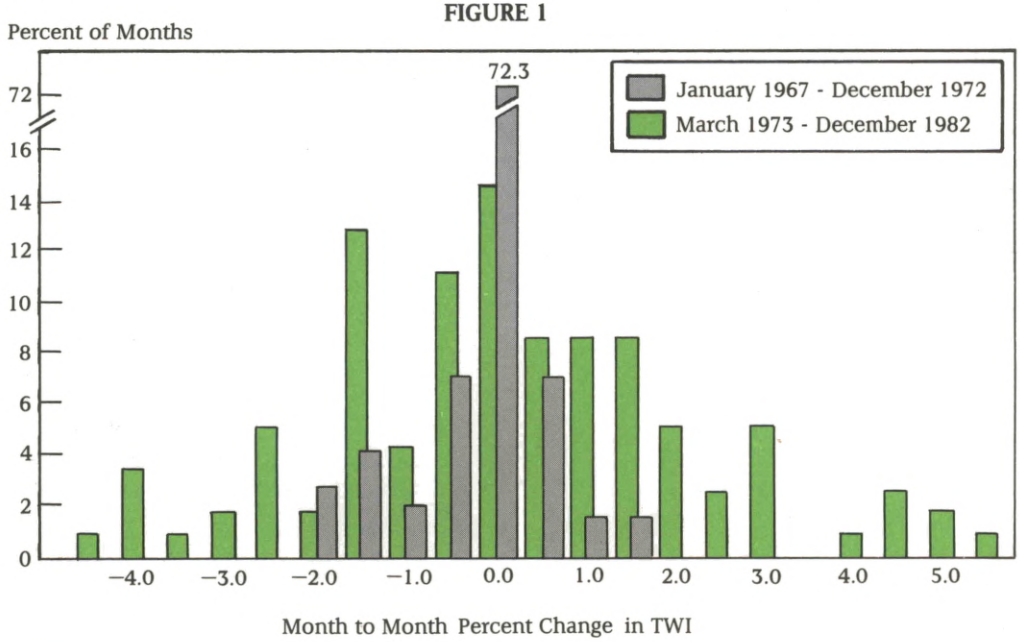
The month-to-month variability of exchange rates also increased with the reduction in official exchange market intervention in 1973. The increase in variability with the move from pegged to floating exchange rates is illustrated in Figure 1. Figure 1 plots the distribution of frequencies of monthly percentage changes in the TWI during the final years of pegged exchange rates, January 1967 through December 1972, together with monthly percentage changes during the period of floating exchange rates, March 1973 through December 1982.[b] Large month-to-month changes in the TWI clearly have become more frequent under floating rates.[c]

[a]"Storm in a Dollar Teacup," *The Economist*, (July 9, 1977), p. 111; and "Treasury and Federal Reserve Foreign Exchange Operations," *Federal Reserve Bulletin*, 63 (September 1978), pp. 793-810, particularly pages 794-795.

[b]The average monthly change in the TWI from January 1967 through December 1972, 71 observations, was -.12 percent. From March 1973 through December 1982, 118 observations, this change averaged .15 percent.

[c]Stronger evidence of increased exchange rate variability is provided by Janice M. Westerfield, "An Examination of Foreign Exchange Risk Under Fixed and Floating Rate Regimes," *Journal of International Economics*, 7 (1977), 181-200.

FIGURE 1



SOURCE: Computed from the monthly levels of the TWI reported in various issues of the *Federal Reserve Bulletin*.

ceived changes in economic conditions, and that this volatility is harmful. They urge a much bigger role for official intervention in order to temper the market's response and to reduce volatility. Other analysts disagree, arguing that increased exchange rate volatility is the correct response to more uncertain economic conditions. Such uncertainty could be due to natural disasters, such as a storm that destroys part of a country's wheat crop, or to unanticipated changes in economic conditions and in economic policies here and abroad. These analysts claim that, in those circumstances, exchange market intervention would itself be harmful, because it would delay the market's adjustment to the "correct" exchange rate.

From an economic point of view, the variability of exchange rates does not in itself condemn the current policy of limited exchange market intervention. The case for greater intervention to reduce exchange rate variability turns instead on knowing whether the market reacts appropriately to economic news. Economic well-being is promoted when exchange rates fully reflect all information that has a bearing on present and future economic conditions. If market participants ignore relevant information or if they overreact or underreact to economic news, then economic well-being suffers. Economists refer to a market where prices correctly reflect all currently available information at all times as an "efficient" market.

If the exchange market under floating rates is efficient, then intervention is likely to be counterproductive; that is, it is likely to reduce economic well-being, regardless of how variable exchange rates happen to be.[2] If, however, the exchange market under floating rates is inefficient, then there may be a valid case for some sort of corrective government intervention.

WHAT IS AN EFFICIENT MARKET?

The theory of market efficiency revolves around the relation between prices and information. In an efficient market the price "accurately reflects all the relevant information." In other words, all the factors that matter to buyers and sellers in the market, including their expectations of future events, are built into the market price. In a sense, the price is always right in an efficient market.

Economists can set up conditions that practically guarantee a market will be efficient. If it costs nothing to buy or sell, if information is free, if there are many market participants, and if people strive to maximize their welfare, then prices must accurately convey relevant information.

Does this mean that prices are stable in an efficient market? Far from it—prices will adjust promptly every time new information becomes available. For example, news of crop failures, technological innovations, or unexpected changes in government policies will cause prices to change.

The price changes generated by new information are viewed as beneficial by economists. They signal to everyone who looks at the price that something has occurred that calls for people to rethink their decisions on how to allocate resources.[3] When all markets are efficient the reactions of individuals to price changes will produce the best possible economy-wide allocation of resources—no one could be made better off without injuring someone else. This is why economists use efficiency as a yardstick when they evaluate the operation of a market.

How do we know whether a particular market is efficient? Unfortunately, the conditions that guarantee efficiency—costless transactions, free information, etc.—simply don't exist in the real world. Economists therefore rely on hypothesis-testing to tell them something about efficiency.

TESTS OF EXCHANGE MARKET EFFICIENCY

In principle, economists might test the notion

[2]As a general principle, it may be possible to improve economic welfare by intervening in a market that is efficient, as long as there are other inefficiencies elsewhere in the economy. In a sense, introducing a distortion in an efficient and undistorted market may offset a distortion somewhere else, and improve welfare. Though this is a possibility in theory, it is very difficult to apply this principle in practice. This possibility is discounted in the discussion that follows.

[3]The oil crises of the 1970s bring to mind a vivid example of how people reallocate their resources when prices change. Oil prices soared, and what was once a cheap commodity became a precious one. In response, motorists and homeowners, for example, cut their consumption of oil drastically, and instead spent their money on energy-efficient cars, insulation and solar devices for homes.

that the foreign exchange market is efficient by checking to see whether exchange rates reflect all the relevant information. But they don't, because, in practice, they can't. For one thing, they can never know what "all the relevant information" really is. Instead, economists look for signs of inefficiency—cases where markets do not seem to be making good use of information. And they rely on indirect evidence to tell them how well a market works. This procedure is not unique to economics. Physicists cannot "see" elementary particles such as quarks, but they infer something about their behavior from what they *can* see. And theory tells them what to look for. In other words, rather than testing a theory directly, scientists sometimes focus on the *implications* of a theory. This is how economists address the issue of whether exchange markets are efficient.

What implication do economists use to test whether exchange markets are efficient? If exchange rates accurately reflect all information, then it follows that people should not be able to exploit existing information to earn abnormally large profits from speculating. In particular, if exchange markets are efficient, then it should be hard to make lots of money by "buying low" and "selling high." The reason is that any information that might have been used to implement such a strategy would *already* have been acted upon, and it would therefore be reflected in current exchange rates. Making large profits in an efficient market is, therefore, a matter of luck or a result of extraordinary skill. So economists can indirectly test whether the exchange markets are efficient by looking at the behavior of profits associated with speculation. If profits appear to be random, then the evidence is consistent with the view that the exchange market is efficient.

But suppose it appears that some people do earn above-average profits from speculation. Does this mean the exchange market is inefficient? The answer is, not necessarily. There may be other reasons why large profits accrue to speculation. In particular, it may be the case that speculators require a premium to compensate them for the risk that they may lose rather than make money. If so, finding above-normal profits from speculation may simply reflect the fact that the market, in effect, "pays" such a risk premium.

If economists knew the size of the risk premium, they could simply subtract the payment for bearing risk from any profits associated with speculation. Unfortunately, little, if anything, is known about the size of the risk premium in the exchange market. The best economists can do, therefore, is *assume there isn't any risk premium.*[4] In technical jargon, economists assume speculators are "risk-neutral," that is, speculators do not require a premium to compensate them for the risk that they may lose money. Then nothing needs to be subtracted from the profits from speculation. But, in this context, if above average profits are discovered, it could mean either that (1) the market indeed is inefficient, or (2) speculators are not risk-neutral, contrary to the assumption, or both. All this suggests that testing for exchange market efficiency is a fairly tortuous process, complicated not just by the lack of useful measurements, but also by the necessity of examining two hypotheses (market efficiency and risk-neutrality) *at the same time.*

Economists go about testing for efficiency in the foreign exchange market by focusing their attention on the forward market.[5] In the forward market, foreign exchange is traded for *future delivery* at prices agreed upon today. Since a price pertaining to a future date can be "locked in" today, there is an obvious opportunity to speculate in the forward market. For example, a speculator could purchase German marks today at a known price for delivery three months from now. She would plan to sell them at that date (in the spot market) when she expects the price to be higher than today's forward rate ("buy low, sell high"). If the speculator believed the future price would be lower than today's forward rate, she would, of course, sell

[4]The factors that are thought to determine the risk premium required by speculators are described in the Appendix. Other assumptions made in these market efficiency tests generally concern the amount of information that is available to speculators when they transact in the exchange market. The effects of changing this information set are discussed briefly in the Appendix.

[5]Earlier investigations also consider the efficiency of the spot exchange market. The results are similar to those for the forward market and are not discussed here. For a survey of the exchange market efficiency literature, see Richard M. Levich, "On the Efficiency of Markets for Foreign Exchange," in Rudiger Dornbusch and Jacob A. Frenkel (eds.), *International Economic Policy: Theory and Evidence,* (Baltimore: Johns Hopkins Press, 1979), 246-267.

marks in the forward market and buy in the spot market ("sell high, buy low"). In an efficient market, any such strategies should yield, at best, a normal profit. In other words, if market participants are risk-neutral our speculator should do about as well buying a safe-asset, like a Treasury bill, as she would trading in forward exchange.[6] This implication makes it possible to examine the market efficiency hypothesis by calculating the profitability of forward trading over time.

Statistical Evidence. Statistical tests of forward exchange market efficiency under floating exchange rates try to determine whether market prices are set so as to eliminate extraordinary profits available through forward speculation, on average. If the efficiency theory is correct it should not be possible to make extraordinary profits (more than the rate of return on Treasury bills) from predictable fluctuations in exchange rates.

Typical tests of forward market efficiency examine historical returns from forward speculation to see whether future speculative profits are predictable or random (average out to zero). One way to predict future returns is to use past speculative returns as information. If past speculative returns fail to predict future returns, this suggests that profits from forward speculation are random, which supports the joint hypothesis of market efficiency and risk-neutrality. Any success in predicting profits from forward speculation suggests that those profits are not purely random, which contradicts the joint hypothesis. The results available to date (discussed in the Appendix) indicate that profits do include a significant predictable component. During the 10-year period of floating exchange rates, the market did not set rates so as to eliminate profits from predictable exchange rate fluctuations. Statistical tests, then, reject the joint hypothesis that the market is efficient and speculators are risk-neutral.

Technical Trading Rules. Researchers also have analyzed the profitability of using technical trading rules as an alternative measure of exchange market efficiency. Technical rules are designed to identify troughs and peaks in exchange rates.[7] If exchange rates are cyclical, then a speculator would make a profit by buying just after the cyclical trough and by selling just after the cyclical peak.

Speculators who identify a trough using a technical rule will shift their assets into the currency whose value they expect to increase.[8] But if the efficiency theory holds, it should not be possible to profit from buying and selling foreign exchange by using technical rules.

Researchers can statistically examine how profitable different rules would have been by varying the size of the percent change required to identify troughs and peaks. But rejecting efficiency in the market requires more than showing that a particular trading rule *could have been* exploited profitably. The point of the test is to see whether the profits from using such a rule persist long enough that speculators have time both to learn of the rule's profitability *and* to exploit it.

The results of these tests suggest that, while using trading rules based on large percentage changes would not have been profitable, using those rules based on changes between 1 and 5 percent would have been profitable. Moreover, the tests indicate that these trading rules have consistently yielded profits.[9] Tests of efficiency based on technical trading rules, like those based on the predictability of profitable speculation, reject the joint hypothesis that the market is efficient and that speculators are risk-neutral.

Other Evidence. The conclusions from these

[6]Note, however, that in practice, dealing in the forward exchange market requires only a security deposit, so, strictly speaking, the risk-neutral speculator's return should be zero, on average.

[7]A simple percentage trading rule compares the current spot rate to its past history. A percentage rule identifies a trough by comparing the current exchange rate to the *lowest* rate recorded after the most recent peak. If the current exchange rate exceeds the lowest rate by a predetermined percentage, then the *lowest* exchange rate is identified as the trough rate, and the exchange rate is predicted to appreciate until it reaches its next peak. The procedure is reversed for identifying peaks.

[8]For example, if the exchange value of the dollar against the German mark appears to have reached its trough, then the trading rule suggests that speculators sell marks and buy dollars in order to profit from an anticipated rebound in the dollar's exchange value.

[9]Michael P. Dooley and Jeffrey R. Shafer, "Analysis of Short-Run Exchange Rate Behavior: March, 1973 to November, 1981," in David Bigman and Teizo Taya (eds.), *Exchange Rate and Trade Instability* (Cambridge, Mass: Ballinger, 1983).

tests are reinforced by studies of the effectiveness of professional foreign exchange rate forecasters. Professional forecasters use a broad range of procedures to generate their forecasts. Some rely on technical analysis similar to the trading rules, some rely on econometric models, and still others rely on subjective judgments of the economic, regulatory, and political factors that affect the exchange market. In independent studies, Goodman and Levich have tested the predictive abilities of these advisory services; their results indicate that, overall, speculators are able to earn profits by following the advice of foreign exchange rate forecasters.[10] The results also show that the technical services have outperformed the econometric and judgmental services up to now. The success of exchange rate forecasting services in predicting future fluctuations in exchange rates provides evidence of unexploited opportunities for profitable speculation. Once again, the joint hypothesis of exchange market efficiency and risk-neutrality is rejected.

In summary, the evidence contributed by statistical analyses, by the profitability of technical trading rules, and by the forecasting expertise of exchange rate services all points toward the same conclusion. The joint hypothesis of market efficiency and risk-neutrality is not consistent with the exchange rate behavior observed during the current regime of floating exchange rates.

WHAT CAN WE CONCLUDE?

The case for government intervention in exchange markets rests on the notion that exchange rates are "too volatile"—that the market swings too far in one direction or another in light of changes in economic conditions and events. This view obviously conflicts with the premise that exchange markets are efficient, that the price of foreign currency is "always right."

Proponents of intervention therefore might see the empirical evidence on exchange market efficiency as mostly supporting their view. But that judgment would overlook the fact that existing tests involve a *joint hypothesis*—market efficiency and risk-neutrality. It would also discount some independent, but relevant, evidence on efficiency in other markets for financial assets.

While it may be true that the existing statistical evidence does not support the notion that exchange markets are efficient, the findings in these studies may just as well reflect the fact that market participants are not risk-neutral. Rather, market participants may require compensation for placing funds at risk in the exchange market. If so, the evidence of extra-normal profits from speculation in foreign exchange may simply reflect the existence of such a risk premium, rather than suggest that markets are not efficient. To discover which part of the joint hypothesis—market efficiency or risk-neutrality—accounts for these statistical findings, economists need to find out more about the size of risk premia in exchange markets and the factors that might influence their variability. At the moment, very little is known about either.

Until they can provide stronger evidence that exchange market participants do not care much about risk, advocates of intervention cannot rely on the body of existing evidence on efficiency to buttress their case. Indeed, there is reason to be skeptical on other grounds that exchange markets are inefficient. In particular, economists have studied the efficiency hypothesis in a number of other markets for financial assets, including stocks, bonds, and options. They have found it very difficult to reject the efficiency hypothesis in these other markets. Why should the exchange market be any different?

Even if tests could firmly establish that exchange markets were inefficient, government intervention may not be the best form of response. Identifying the cause of an observed inefficiency (high information costs, liquidity constraints, thin markets, regulation) would be a necessary ingredient in the design of a policy to cope with the problem.

Some observers thought the debate over intervention would be settled by the results of the study of the Working Group on Exchange Market Intervention established at the Versailles Economic Summit in June, 1982. The results of the group's

[10]The records of the advisory services are examined by: Richard M. Levich, "How to Compare Chance with Forecasting Expertise," *Euromoney* (August 1981), 61-78; and Stephen H. Goodman, "Foreign Exchange Rate Forecasting Techniques: Implications for Business and Policy," *Journal of Finance* 34 (1979), 415-427. Some analysts have suggested that the success of the technical services has resulted from a shortage of speculative capital. See Michael R. Rosenberg, "Is Technical Analysis Right for Currency Forecasting?" *Euromoney* (June 1981), 125-131.

research were aired at the 1983 Summit in Williamsburg. Each side finds some support for its views from the study—which, of course, is another way of saying the results remain inconclusive. What we can conclude is that we need to know a lot more than we do at the moment.

TECHNICAL APPENDIX

STATISTICAL TESTS OF EXCHANGE MARKET EFFICIENCY

A simple way to test forward exchange market efficiency is to estimate the relationship between current and lagged values of the return to forward speculation. This test assumes risk-neutrality, that is, the expected fair return to speculation in the forward market is assumed to equal zero. Therefore, rejection of the efficiency hypothesis can be attributed either to the inconsistency of the risk-neutrality assumption or to a fundamental market inefficiency.

Single market efficiency tests involve statistical estimation of the parameters in the relation

(1) $$P_t = \beta_o + \beta_i \sum_{i=1}^{n} P_{t-i} + \varepsilon_t$$

in which P_t is the return to forward speculation, ε_t is an unobserved error, and β_o through β_n are parameters. The return to forward speculation is defined by

(2) $$P_t = \frac{S_t - F_{t-1}}{F_{t-1}}$$

where S_t is the spot exchange rate in the current period and F_{t-1} is the one-period ahead forward rate observed in the previous period. When the current spot rate exceeds last month's 30-day forward rate, for example,

those who had the foresight to buy foreign currency for forward delivery profit by selling the currency in the spot market. The joint hypothesis of market efficiency and risk-neutrality is not rejected as long as parameters β_o through β_n do not differ significantly from zero. The joint hypothesis is rejected when any of these parameters is significantly positive or negative. Tests of this hypothesis for a number of foreign currencies provide weak evidence for the rejection of the joint hypothesis.[a]

Efficiency tests like those of equation (1) are not particularly powerful, and they only reject the joint hypothesis when exchange rate behavior differs markedly from what would be observed if the joint hypothesis were true. More sensitive tests have been constructed by increasing the amount of information used to test the randomness of speculative returns. These tests, referred to as multimarket efficiency tests, take the form

(3)
$$P_t^a = \gamma_o + \gamma_i^a \sum_{i=1}^{n} P_{t-i}^a + \gamma_i^b \sum_{i=1}^{n} P_{t-i}^b + \eta_t$$

$$P_t^b = \delta_o + \delta_i^a \sum_{i=1}^{n} P_{t-i}^a + \delta_i^b \sum_{i=1}^{n} P_{t-i}^b + \nu_t$$

in which P_t^a is the return to forward speculation in foreign currency *a*, P_t^b is the return to speculation in foreign currency *b*, and η_t and ν_t are unobserved errors. Parameters γ_o through γ_n^b and δ_o through δ_n^b should equal zero if the forward markets for currencies *a* and *b* are jointly efficient and speculators are risk-neutral. Rather than focusing on the efficiency of the forward market for a particular foreign currency, multimarket tests examine the overall efficiency of the forward market. That approach makes multimarket efficiency tests more sensitive measures of forward market efficiency. Multimarket efficiency tests reject the joint hypothesis of market efficiency and risk-neutrality much more frequently than single market tests.[b]

Failure of the joint hypothesis has led many observers to suggest that the risk-neutrality assumption is at fault. This interpretation has generated interest in modeling the economic determinants of exchange risk. The value of the premium demanded by risk-averse speculators is determined in theory by a number of factors.[c] The premium is sensitive to the degree of risk-aversion among private investors, the variances and covariances among the economic disturbances occurring in different nations, and the supplies of assets outstanding. Early tests have failed to explain predictable exchange rate fluctuations (attributed to risk aversion) in terms of the theoretical determinants of the fair return to bearing exchange risk.[d] This failure can be attributed either to risk-neutrality (in which the fair return always equals zero) or to the simplicity of these models. As models of risk-bearing become more sophisticated, exchange market efficiency can then be retested while allowing a fair return to speculation.

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[a]Results of single market efficiency tests are reported by John Geweke and Edgar Feige, "Some Joint Tests of the Efficiency of Markets for Forward Foreign Exchange," *Review of Economics and Statistics*, 61 (1979), 334-341, and Lars Peter Hansen and Robert J. Hodrick, "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy*, 88 (1980), 829-853.

[b]Geweke and Feige report the results of multimarket efficiency tests involving the forward rates of Belgian francs, Canadian dollars, French francs, German marks, Netherlands guilders, Swiss francs and British pounds against the U.S. dollar. Hansen and Hodrick report the results of multimarket tests for the same currencies excluding the Belgian franc and Netherlands guilder.

[c]Jeffrey A. Frankel, "The Diversifiability of Exchange Risk," *Journal of International Economics*, 9 (1979), 379-393.

[d]Jeffrey A. Frankel, "In Search of the Exchange Risk Premium: A Six-Currency Test Assuming Mean-Variance Optimization," *Journal of International Money and Finance*, 1 (1982), 255-274.

Cleaning the Air with the Invisible Hand

*Theodore Crone and Robert H. DeFina**

Through the centuries, lawmakers have resorted to a variety of measures to combat air pollution. During the middle ages, for example, King Edward I of England established a reputation as an uncompromising environmentalist by executing a man for burning coal instead of oak. Although they may share Edward's sense of urgency, most modern-day advocates of a cleaner environment favor less harsh measures. Indeed, economists have long argued that Adam Smith's invisible hand can be more effective than the regulatory axe in controlling pollution.

In the United States, efforts to maintain an acceptable level of air quality involve the direct regulation of individual sources of pollution, such as coal-burning generators. Under this system, each polluter must abide by rules, developed at various levels of government, that specify both the required amount of pollution abatement and the technology to be used at each source of pollution.

Although this source-by-source approach has resulted in some improvement in air quality, it has come under fire from both business and environmental groups. Business claims that the complex of regulations is cumbersome and cost-ineffective and that it inhibits industrial development. Environmentalists express dismay at what they consider an unacceptably slow pace of progress in meeting stated air quality goals.

In response to these concerns the federal government has begun complementing direct regulation with a number of financial incentives

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for pollution control. The introduction of these so-called controlled trading options has been applauded by economists, who have long maintained that financial incentives are the most effective policy tool in the fight for cleaner air. In fact, many economists have recommended a full-blown market in pollution rights, placing maximum reliance on incentives and minimum reliance on direct controls. Such a market holds the promise of achieving the desired air quality at a lower cost.

STRIVING FOR CLEAN AIR

Legislators face two tasks in regulating air pollution. First, they must decide what level of air quality is to be maintained and when that level should be achieved. Second, they must determine how to reach the desired level within the specified time limit.

Since clean air is a common good shared by all, the decision on the level of air quality is ultimately a political one.[1] Currently, the national air quality goals are set forth in the 1963 Clean Air Act and its amendments [see MAJOR FEDERAL LEGISLATION ON AIR POLLUTION]. In that legislation, Congress mandated that pollution levels be set low enough to eliminate all adverse effects on health and public welfare, and entrusted the Environmental Protection Agency (EPA) with the responsibility for setting specific air quality standards for major pollutants.[2] These standards are nationwide maximum allowable limits on pollutant concentrations in the atmosphere.

In 1977 Congress also established a timetable for compliance, requiring each state to submit to the EPA a State Implementation Plan (SIP) by July 1, 1979. These plans were to guarantee that regions which did not already meet the national standards for major pollutants (*nonattainment* areas) would achieve these standards by December 31, 1982.[3] The SIPs were also to contain regulations to "prevent significant deterioration" of air quality in regions which already met the national standards (*attainment* areas). Neither deadline in this timetable was met. By the end of 1981 only twelve SIPs had been approved by the EPA. And by February 1983, over 470 counties (out of 3,041) still did not meet the national standard for at least one major pollutant.

A key factor in these delays was *how* regulators chose to achieve the national air quality standards. Initially, the government relied exclusively on direct regulation of individual pollution sources. (A source is defined as any installation which emits one or more pollutants. Under this definition, a single industrial plant can have several separate sources.) When formulating pollution control guidelines for firms in attainment and nonattainment areas, regulators identify what is considered the best available control technology for each emissions source, given the source's special characteristics.[4] Polluters then must adopt that technology and reach the lowest achievable emissions rate possible. If a firm wants to use an alternative technology to reduce emissions, it normally has to present evidence that the alternative technology will be at least as effective as the

[1] The political approach does not make economic considerations irrelevant. From the point of view of the total welfare of the community, pollution should be reduced to the level where the cost of preventing a bit more pollution is equal to the benefit of the resulting cleaner air. Air quality is a public good, however, so there are incentives to misrepresent the benefit one receives from cleaner air. And in practice it is not possible to measure accurately the costs and benefits of improving air quality. Nevertheless, these economic considerations should inform the political decision. For a theoretical discussion of the optimal level of pollution, see W. J. Baumol and W. E. Oates, *The Theory of Environmental Policy* (Englewood Cliffs, N.J.: Prentice-Hall, 1975), chapter 4.

[2] See Paul R. Portney, et al., eds., *Current Issues in U.S. Environmental Policy*, (Baltimore, Md.: Johns Hopkins University Press/ Resources for the Future, 1978), pp. 30-36 for a discussion and critique of the standard-setting procedure. For a detailed study of the health effects of air pollution, see Lester B. Lave and Eugene P. Seskin, *Air Pollution and Human Health* (Baltimore: Johns Hopkins University Press, 1977).

[3] For carbon monoxide and ozone, extensions to December 31, 1987, could be authorized if a state demonstrated that attainment of the standards before December 31, 1982, was impossible.

[4] We use the term regulators to include both the EPA and the individual state agencies because they share responsibility for achieving the mandated air quality levels. The major mechanism for enforcement is the State Implementation Plan, but this plan is subject to review and approval by the EPA. The federal agency also has general oversight authority to ensure that the provisions of the SIP are fulfilled. For further details on the overlapping responsibility of the federal and state governments, see *13th Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1982), pp. 72-78.

method mandated by the government.

This process has proved quite time-consuming. It requires numerous studies both by regulators and by those who are regulated. Moreover, formal hearings are often necessary to gather information and to resolve disputes.[5] The inordinate amount of time involved in this process might be tolerable if direct source-by-source regulation achieved the national air quality goals at the lowest possible

[5]The delays inherent in the process are illustrated by the 1981 report of the National Commission on Air Quality which analyzed the preconstruction review procedures for new sources seeking to locate in pristine areas. The Commission found that the time involved between submission of a construction application and receipt of a permit averaged about 16 months. If we add to this the requirement to furnish one year's air quality monitoring data with the application, an applicant's typical delay for the entire permitting process can be as long as two or three years. This example is cited in Kenneth W. Chilton and Ronald J. Penoyer, *Making the Clean Air Act More Cost-Effective*, (St. Louis, Mo.: Center for the Study of American Business, Washington University, 1981), pp. 15-16.

MAJOR FEDERAL LEGISLATION ON AIR POLLUTION[a]

Date of Enactment	Popular Title	Key Provisions
July 14, 1955	1955 Air Pollution Control Act	Authorized federal program of research on air pollution control.
December 17, 1963	Clean Air Act	Gave the federal government the right to hold hearings, call conferences, and take court action in the case of interstate air pollution and to assist states with intrastate pollution problems.
October 20, 1965	Motor Vehicle Air Pollution Control Act	Gave the Department of Health, Education, and Welfare (HEW) authority to set emissions standards for automobiles.
November 21, 1967	Air Quality Act of 1967	Authorized HEW to oversee the setting of state standards for ambient air quality and the development of state implementation plans; set national standards for automobile emissions.
December 31, 1970	Clean Air Act Amendments of 1970	Expanded the role of the federal government in setting and enforcing ambient air quality standards; established stricter emissions standards for automobiles.
August 4, 1977	Clean Air Act Amendments of 1977	Authorized an emissions offset policy to allow new sources to enter an area as long as pollution is offset by reduction at other sources; set even more stringent standards for automobile emissions.

[a]A more comprehensive description of this legislation is found in Allen V. Kneese and Charles L. Schultze, *Pollution, Prices, and Public Policy* (Washington, D.C.: The Brookings Institution, 1975), Winston Harrington and Alan J. Krupnick, "Stationary Source Pollution Policy and Choices for Reform," *Natural Resources Journal*, (July, 1981), pp. 539-564, and Paul R. Portney, et al., eds., *Current Issues in U.S. Environmental Policy* (Baltimore, Md.: Johns Hopkins University Press/Resources for the Future, 1978) Chapter 2.

cost; that is, if it were efficient. Unfortunately, this has not been the case. While some improvements in air quality have been achieved, the gains have been expensive [see PROGRESS AND COSTS...].

Several factors contribute to the inefficiency of the traditional approach to pollution control. Direct source-by-source regulation ignores differences in abatement costs among sources when allocating responsibility for pollution abatement. It also limits the development and introduction of cost-saving abatement technology, and unnecessarily restricts industrial development.

Direct Regulation Ignores Cost Differences . . . Due to diverse production technologies and changing economic conditions, some firms can reduce emissions of a particular pollutant at some sources more cheaply than at others. But because it is applied uniformly, direct source-by-source regulation fails to take advantage of this difference in the cost of reducing emissions. Consider, for example, a plant which emits sulphur dioxide (SO_2) from two different sources. Due to differences in production processes, the cost of reducing SO_2 emissions at Source A is $2,000 a ton, and the cost of reducing emissions at Source B is $4,000 a ton. If source-by-source regulation requires the reduction of SO_2 by two tons, emissions at *each* source would have to be reduced by one ton, at a total cost of $6,000. It is easy to see, however, that the cheapest way to reduce SO_2 by two tons is to concentrate all of the reduction at Source A at a total cost of $4,000. In general, uniform reduction of emissions at all sources does not minimize the costs of pollution control.

Although in theory regulators could devise a cost-minimizing plan for pollution control, in practice, information requirements preclude the possibility. Government regulators cannot know the costs, the technological opportunities, and the alternative raw materials available for every plant in every industry. And even if they could determine the most efficient allocation of responsibility for pollution abatement for each source, they would have to revise their regulations continually in light of changing economic conditions. Consequently, regulators simply require the same degree of abatement from each source, namely, the lowest achievable emissions rate consistent with the chosen technology. But because the cost of reducing emissions a bit more (the marginal cost of abatement) varies from source to source, direct regulation has not been cost-efficient.

. . . Limits Innovation in Abatement Technology . . . Regulations have focused on the use of pollution control devices such as scrubbers or filters because they are easy to evaluate and can be applied at several kinds of sources. As a result, innovations in pollution control technology are biased toward these devices, and opportunities to reduce emissions by modifying or redesigning parts of an existing manufacturing facility may be lost. It is often possible to design fundamental cost-saving innovations in existing manufacturing techniques that will reduce emissions. Outside engineers employed by regulators, however, are unlikely to be able to recommend fundamental changes in manufacturing processes, because knowledge of these processes is often proprietary. While the regulated firms themselves are in a position to discover more efficient abatement procedures, they are discouraged from introducing them by the bureaucratic complexities they face when trying to supplant the mandated technique.

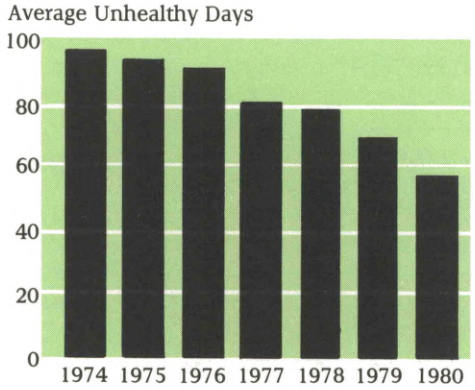
. . . And Unnecessarily Restricts Industrial Development. Inefficiencies also arise because the regulations aimed at maintaining a region's air quality limit industrial development in that area. The 1970 amendments to the Clean Air Act do not allow major new emissions sources to be built in nonattainment areas, for example. The law also stunts development in attainment areas, since the requirement to prevent significant deterioration in air quality limits the entry of new polluters. These regulations can prevent a prospective new business from ever operating, or they can force it to operate at a less profitable location, no matter how much the new business would be willing to pay for a portion of the emissions quota currently used by existing sources. Such restrictions raise the cost of pollution abatement needlessly.

TOWARD A MARKET APPROACH

The shortcomings of source-by-source regulation spell a case for reform, and in the late 1970s the EPA began to examine alternative methods for controlling airborne emissions. Of particular interest were market-like schemes for pollution abatement. Instead of directly controlling the behavior of each emissions source, the market

PROGRESS AND COSTS IN CLEANING THE AIR

TRENDS IN URBAN AIR QUALITY 1974-1980



The graph shows the average number of days that the EPA's Pollutant Standards Index (PSI) reached 100 ("unhealthy") for 19 metropolitan areas: Chicago, Cincinnati, Denver, Houston, Los Angeles, Louisville, Milwaukee, Philadelphia, Portland (OR), San Bernardino, Rochester, Sacramento, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse, Tampa, and Washington, D.C.

The reduction in pollution between 1974 and 1980 is probably not wholly attributable to official abatement measures and may be due in part to changes in industrial activity or automobile use.

Source: *12th Annual Report of the Council on Environmental Quality* (Washington: GPO, 1981), Table A-51.

NATIONAL EXPENDITURES FOR AIR POLLUTION ABATEMENT AND CONTROL[a]

Year	Current Dollars (billions)	1972 Dollars (billions)
1972	$6.5	$6.5
1973	8.3	7.8
1974	10.4	8.1
1975	12.8	9.1
1976	14.2	9.5
1977	15.6	9.8
1978	17.1	10.1
1979	20.5	10.4
1980	25.4	11.2

[a]Source: *13th Annual Report of the Council on Environmental Quality* (Washington: GPO, 1982), Table A-80.

approach introduces financial incentives for firms to reallocate responsibility for abatement among themselves in order to achieve air quality goals at least cost. Unlike the traditional approach which places all decisionmaking in the hands of government regulators, a financial incentives policy enlists the expertise of the regulated firms in the fight for cleaner air. Allowing the firms to decide *how* to achieve mandated air quality levels can overcome many of the drawbacks of source-by-source regulation.

Thus far, the EPA has proceeded cautiously. Rather than wholly abandoning direct regulation, it has approved only limited use of financial incentives. To date, three incentive schemes, or controlled-trading options as they are known, have been developed. These are *bubbles, offsets,* and *banks,* and each is aimed at eliminating some shortcoming of the source-by-source approach.[6]

Bubbles. The bubble concept is designed to take account of the different incremental costs of controlling pollution, both across processes within a particular plant and across plants and firms. A figurative "bubble" is placed around an entire plant or area, treating it as a single source of emissions rather than as a series of independent sources. The bubble program allows regulators to set emissions limits for a plant as a whole, while managers are free to allocate pollution abatement among the various sources so long as the overall emissions target is attained. Consequently, the bubble provides an important incentive for keeping down the cost of abatement. Because the decisions by the managers on how to meet emissions limits will directly affect the profits of their firms, managers are encouraged to reduce overall outlays by increasing pollution control at sources where incremental abatement costs are low and decreasing control where costs are high. Under certain conditions, the bubble program can be expanded to include more than one plant or firm. The bubble

[6]A more extensive explanation of these procedures and their legislative histories is found in Sue Anne Batey Blackman and William J. Baumol, "Modified Fiscal Incentives in Environmental Policy," *Land Economics* 56 (November, 1980) pp. 417-431, Bruce Yandle, "The Emerging Market in Air Pollution Rights," *Regulation,* 2 (July/August, 1978), pp. 21-29, and Michael T. Maloney and Bruce Yandle, "Bubbles and Efficiency," *Regulation* 4 (May/June 1980), pp. 49-52.

concept is limited to existing firms, however, and excludes potential emissions sources.

Experience with bubbles suggests the type of cost-savings the approach can achieve.[7] In Tampa, Florida, for instance, an electric utility used the bubble to reduce the costs of controlling SO_2. The utility reported savings of $20 million. By including two side-by-side power plants within a bubble, the New England Electric System in Providence, Rhode Island has been able to use different fuels at each plant and to save $4 million in fuel costs in two and a half years. In Middletown, Ohio, Armco substituted dust-reducing actions on its plant site for pollution controls in its steelmaking process. The company was able to save $20 million in capital costs and $2.5 million a year in operating costs. Regulators are currently involved in over 200 prospective bubbles, and it is estimated that these projects alone could save $600 million in capital and first-year operating costs.

Offsets. The offset program was developed primarily as a way to allow new plants to open and old ones to expand in nonattainment areas, while ensuring that air quality did not deteriorate. The offset differs from the bubble in two ways. Bubbles apply to existing sources only; offsets make room for new sources. And while bubbles do not necessarily reduce the amount of air pollution, offsets do. Prior to the introduction of offsets, construction of new emissions sources and expansions of existing ones were prohibited in nonattainment areas. The offset program allows such construction and expansions if the new emissions that result are *more than offset* by reductions in emissions from existing sources. These reductions can be effected either within the expanding firm or at another firm in the area. The new pollution source must use the best available control technology and attain the lowest achievable emissions rate. Moreover, an existing firm cannot participate in an offset program until it has achieved the level of abatement already required by regulators.

The offset policy allows firms that wish to introduce new sources of pollution to strike bargains with existing firms by offering to buy emissions reductions for them. For example, a potential entrant might agree to purchase extra pollution-control equipment and services for an established plant. Besides allowing for growth in nonattainment areas, offsets exert downward pressure on the cost of any additional abatement that is required. Prospective polluters will always try to deal with firms that have the lowest pollution control costs, since this will minimize their cost of entering the nonattainment area.

Since the program began in early 1977, the EPA reports that hundreds of offsets have taken place. Most arrangements have been internal, with companies finding offsets to expand their own facilities. An example is Phillips Petroleum Co., which added new pollution sources in order to double the capacity of its refinery in Brazoria County, Texas. The emissions from these new sources were offset by providing better control of hydrocarbon emissions from existing storage tanks and other facilities. Likewise, the Corpus Christi Petrochemical Co., a partnership formed by three companies, offset emissions from a new $600 million ethylene plant by closing down a vacuum distillation unit owned by one of the partners.[8] Offsets involving different companies are not yet common.

Banks. The emissions bank program is really an extension of the offset program, affording greater flexibility in terms of timing the trade of emissions reductions. If a firm reduces its daily emissions below mandated levels, it can "bank" those reductions, that is, hold them in reserve at a clearinghouse, for trade at some future date. In this way, the basic offset program is made more efficient, since potential polluters don't have to expend substantial amounts of resources trying to locate offset partners; instead, they can simply consult the clearinghouse inventory. By lowering the costs involved with offsets, the bank program increases the incentive for firms to engage in offset transactions. Normally, only some fraction of the reduction in emissions is eligible for sale and is determined by the regulators on a case by case basis. For example, if a source reduces its SO_2

[7] This and the following examples are cited in Timothy B. Clark, "New Approaches to Regulatory Reform—Letting the Market Do the Job," *National Journal*, 32 (August 11, 1979); and Steven J. Marcus, "Bubble Policy: Pros and Cons," *The New York Times*, (June 30, 1983), p. D2.

[8] These two examples as well as others are found in Timothy B. Clark, "New Approaches...," p. 1319.

emissions by 1,000 lbs. per day more than the standard requires, it may only be able to sell 750 lbs. per day in the banking program. Thus, each transaction under the bank program results in a net reduction in emissions.

Experience with emissions banks is very limited. Banking programs have recently begun in San Francisco, Puget Sound, and Louisville, but few transactions have actually taken place. Interest is growing, however, and at last count, about thirty states were formally considering the banking approach.[9]

HOW FAR HAVE WE COME?

It is understandable that regulators' first steps away from exclusive reliance on source-by-source regulation have been hesitant. Despite the intellectual appeal of a market-based environmental policy, it would not have been in anyone's interest to rush headlong into schemes whose practical difficulties and consequences had not been explored. But exactly how far have we come from the traditional approach?

The controlled-trading options are only supplements to a continued primary dependence on source-by-source regulation.[10] Indeed, the trading options retain some of the inflexibilities of direct regulation and consequently blunt the potential for substantial cost-saving. For example, all trading procedures are subject to full review on a case by case basis, involving federal, state, and local regulators. The consequences of operating in this bureaucratic maze are highlighted by the attempt of Standard Oil of Ohio to use the offset program.[11] Standard Oil proposed to build a major pipeline terminal in a nonattainment area in California. To offset the pollution from the terminal, Standard Oil offered to pay $90 million to control emissions at a nearby power plant, three dry cleaning plants, and a glass manufacturing facility. The company cancelled its plans in early 1979, however, blaming delays in obtaining government licenses and permits.

A second shortcoming is that the substitutions or trades allowed under the different options are very restrictive. Under the bubble policy, for instance, trades exclude potential entrants. And under the offset and bank programs, neither trading partner can end up emitting more than the standard allows for any existing source. As a result, uneconomic differences in pollution abatement costs created by existing regulations are allowed to persist. In addition, the standards specifying allowable control technologies remain in place, further reducing the flexibility of the incentive plans.

The trading options also suffer from the absence of a formal method of organizing prospective trades. As yet, rules and procedures that guide transactions are not well established, and convenient institutional arrangements for facilitating trades, such as clearinghouses, are for the most part absent. Because of these limitations the costs of locating partners and negotiating prices are high, and this works to discourage or prevent trades from taking place.

A final problem with the trading options is the uncertainty surrounding the long-term status of traded permits. Under current practice, should regulators want to tighten an area's standards, traded permits would be rescinded first. This decreases the desirability of traded permits relative to nontraded ones and makes potential trading partners less willing to use the options.

HOW FAR CAN WE GO?

Results from the controlled trading options, while limited, are encouraging. And, as the following quote from the *12th Annual Report of the Council on Environmental Quality* suggests, policymakers are becoming more receptive to the use of financial incentives in environmental programs:

> Whenever possible, the achievement of environmental goals and the protection of environmental standards should be left to free market mechanisms. (p.17)

Regulatory agencies could expand the use of free market mechanisms in a number of ways. One is to

[9]Cited in Winston Harrington and Alan J. Krupnick, "Stationary Source Pollution Policy and Choices for Reform," *Natural Resources Journal*, 21 (1981), pp. 556-557.

[10]The line of discussion that follows parallels one in Robert W. Hahn, "Marketable Permits: What's All the Fuss About?" *Journal of Public Policy*, 2 (October 1982), pp. 395-411.

[11]Cited in Timothy B. Clark, "New Approaches...," p. 1318.

continue the piecemeal approach begun with the controlled-trading options, gradually introducing financial incentives into more and more parts of the regulatory scheme. This conservative strategy does have the virtue of treading lightly in uncharted areas; however, it also has a vice. In the words of Roger Noll, support for the use of economic incentives ultimately

> "... may sink because the new trading methods are so procedurally freighted, so limited in applicability, and so burdened with uncertainties... Too timid a reform leads to few transactions and market imperfections that undermine the efficiency of the trades that take place. Even in the absence of a policy catastrophe, the system could prove so cumbersome that it is uninteresting to polluting entities....."[12]

And, unfortunately, the chance for much more efficient pollution control would sink with it.

The possibility for a more sweeping change in approach exists in the creation of a full-blown market in rights to emit pollution.[13] Under this scheme, regulators first establish within each air quality region a ceiling on total emissions that is consistent with air quality standards. They then issue permits to area sources that allow a specified amount of a pollutant to be emitted per unit of time, where the aggregate quantity of permits accommodates no more than the ceiling level of emissions. Once the permits are initially allocated, a source is free both to choose its desired abatement procedure and to buy or sell permits from other firms in an effort to minimize its pollution control costs. A firm's only restriction is that it may not emit more pollution than is allowed by the permits it holds.[14] Permit prices would be determined by the market, that is, by supply and demand.

Essentially, this market approach incorporates all the benefits of the controlled-trading options while eliminating their restrictive aspects. The market enhances the range of choices and provides flexibility to adapt, for instance. Firms may try to reduce pollution control costs by engaging in voluntary, mutually beneficial agreements that rearrange abatement responsibilities. But the market approach imposes no limitations on the types of trades that can be made. Furthermore, firms are given maximum latitude in picking abatement procedures. As a result, the market automatically guides firms toward achieving a given level of pollution control at the *minimum* possible cost. Use of direct regulation or the controlled-trading options cannot produce the same degree of efficiency.

The market system also automatically allows for economic growth while maintaining the air quality standard. When the desire to hold permits increases because of plans to expand an existing operation or to add to the number of plants in an area, the price of a permit will rise. As this price increases, some firms will find it more economical

[12]Roger G. Noll, "The Feasibility of Marketable Emissions Permits in the United States," California Institute of Technology Social Science Working Paper 397, (July, 1981), p. 58.

[13]The idea of a market in pollution rights was formally introduced in J. H. Dales, *Pollution, Property, and Prices* (Toronto: University of Toronto Press, 1968). More recent studies provide thorough analyses of the practical issues involved in implementing such a market. With regard to air pollution, see Robert W. Hahn and Roger G. Noll, "Designing a Market for Tradable Emissions Permits," California Institute of Technology Social Science Working Paper 398, (July, 1981), and Thomas H. Tietenberg, "Transferable Discharge Permits and the Control of Stationary Source Air Pollution: A Survey and Synthesis," *Land Economics*, 56 (November 1980), pp. 391-416. For a detailed discussion of the application of a market in emissions rights to the problem of water pollution, see M. David, et al., "Marketable Permits for the Control of Phosphorus Effluent Into Lake Michigan," *Water Resources Research*, 16 (April, 1980), pp. 263-270, as well as the companion articles in the October, 1980, and December, 1980, issues of that journal.

[14]A related approach is the imposition of an effluent fee or tax on each unit of pollution emitted. Under this scheme, an emitter is given an incentive to reduce emissions whenever such a reduction would be cheaper than paying the tax. Hence, the tax serves the same purpose as the price of a pollution permit. A great advantage of the permits approach, however, is that once the allowable level of emissions is set, the market mechanism automatically determines the appropriate price. With a tax, regulators must use trial and error to find the right rate. Also, the tax rate would have to be legislatively adjusted on an ongoing basis to reflect changing economic conditions. For a discussion of the problems involved with using pollution taxes, see Susan Rose-Ackerman, "Effluent Charges: A Critique," *Canadian Journal of Economics*, 6 (November, 1973), pp. 512-528.

to increase abatement and sell some permits to potential entrants to the area. In this way, production can increase without increasing emissions.

Finally, a market approach would provide incentives to develop new, more efficient abatement technology, since a firm would be rewarded financially through sales of permits to firms that are less efficient in pollution control. This is beneficial from a long-term perspective, since it allows air quality standards to be met at lower total costs.

Under a permit system, regulators would play a somewhat different role from their current one. They would continue to determine the overall air quality level and to monitor compliance by each firm, responsibilities that are present under any approach.[15] However, they would no longer allocate the abatement efforts among sources or require specific pollution control technologies. The allocation would be left to the market and the choice of technology would be left to the firms themselves. Regulators would now be concerned with the operational aspects of the market,such as issuing permits, determining the maturity and initial distribution of permits, and delimiting market areas.

The tentative movements in the direction of a full-blown market (bubbles, offsets, and banks) suggest that further moves toward a pollution permit system could satisfy the objections of both industry and environmentalists to the current system. On the one hand, the cost of pollution control would be reduced; on the other, there would be less opportunity to delay compliance by exploiting bureaucratic procedures. These advantages would make the permit system not only economically efficient but also politically attractive.

[15]A system of pollution permits would not eliminate the problem of non-compliance. However, monitoring would be easier since regulators would simply have to measure the emissions rate at each source and would not have to determine whether specific equipment was being used and properly maintained.

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