Articles

The Search for a New Exchange-Rate Regime

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The regime of unmanaged floating exchange rates was implicitly judged a failure when, with the Plaza Agreement, attempts at cooperative exchange-rate management were reintroduced primarily because of concern at the size of misalignments. Any satisfactory successor regime will need to limit misalignments while retaining the genuine social benefits of exchange-rate flexibility. It is argued that a system of target zones for exchange rates, ideally embedded in a more comprehensive set of guidelines for international economic policy coordination, could best reconcile these needs.

THE WORLD HAS STILL NOT FOUND A SATISFACTORY exchange-rate regime to replace the unmanaged floating that was implicitly judged a failure when the ministers of the Group of Five (the United States, United Kingdom, France, West Germany, and Japan) resolved to push the dollar down in the Plaza Agreement of September 1985. Since then exchange rates have continued to float, in the sense that the governments of the major countries have refrained from formal commitments to hold rates within any published bounds, but there has been heavy official intervention in the foreign exchange markets as well as much "jawboning," and even changes in interest rates motivated by attempts to influence exchange rates. This management has remained without the inspiration of any agreed set of guidelines and has therefore involved repeated confrontations between the United States and its principal partners. A more satisfactory regime is much to be desired.

In this article, I start by describing and analyzing the major source of dissatisfaction with the regime of unmanaged floating that prevailed from 1973 to 1985. I proceed to highlight the important social functions that exchange-rate flexibility can fulfill and then describe a system of "target zones" intended to preserve the benefits of flexible rates while remedying the weaknesses of unmanaged floating. I then outline a recent modeling exercise in which I have been engaged that was directed at developing guidelines for more comprehensive policy coordination to complement a target zone system. I conclude by noting some of the reasons that my views remain controversial among economists.

Misalignment

Figure 1 shows quarterly movements of the real effective exchange rate (*1*) of the U.S. dollar from the beginning of 1976 to the end of 1986. It can be seen that the dollar appreciated by more than 50 percent between mid-1980 and early 1985. It subsequently declined, until by the end of April 1987 its value was similar to that in 1980. It can be argued that to some modest extent a real appreciation of the dollar was called for in the early 1980s by changes in "the fundamentals." Nevertheless, the vast bulk of the swing appears to reflect changes in misalignments, from a modest undervaluation of the dollar in the 1978 to 1980 period to a vast overvaluation in the 1982 to 1986 period.

An exchange rate is said to be "misaligned" if it deviates substantially for a protracted period from the level consistent with a sustainable and satisfactory longer run equilibrium of the economy. Use of the word "satisfactory" in this definition indicates that the concept contains a normative element. A "satisfactory" equilibrium is usually interpreted to require both that the economy be operating at the highest level of activity consistent with the control of inflation and that the balance of payments be sustainable and appropriate from the standpoint of the savings-investment balance in the economy.

An appropriate balance of payments need not necessarily involve balance in the current account (which consists of the sum total of all receipts from exports of goods and services, less payments for imports of goods and services, plus net transfers). A country (like Japan) with a high savings rate relative to its opportunities for profitable domestic investment can rationally aim to run a surplus so as to be able to invest part of its savings abroad. Similarly, a country (like Canada in the past) with a need for heavy investment in capital-intensive projects, such as those in the energy and resource extraction sectors, and limited domestic savings, can quite rationally borrow abroad: it then needs to run a current account deficit in order to transfer the real resources that can be commanded with the financial borrowing. And a country with both savings and investment opportunities that are typical of the world as a whole should set itself the objective of trying to balance its current account.

Measuring misalignments is inevitably controversial, since estimates of "fundamental equilibrium exchange rates" (FEERs)—exchange rates that are consistent with a satisfactory longer run equilibrium—depend not just on the macroeconometric model adopted but also on judgments with a normative element, concerning the highest level of activity consistent with the control of inflation and the appropriate target for the current account. I have nevertheless attempted to make such estimates for the major currencies. Figure 1 shows (as small squares) the FEERs that I estimated for the dollar on three dates: the average for 1976–77, the first quarter of 1983, and the last quarter of 1984. It can be seen that my calculations suggest a modest appreciation of the dollar's FEER would have been appropriate in the early 1980s: the "fundamentals" that lie behind this result are the 1979–80 oil price increase (which had less adverse balance of payments implications for the United States than for most other industrial countries) and a reversal in direct investment flows (from net outflows to net inflows). The subsequent depreciation of the FEER results from the need to service the foreign debt that the United States is accumulating.

Figure 1 also slows linear interpolations between the FEERs that I estimated on specific dates, as well as extrapolations beyond those dates, so as to give a rough idea of the path of the FEER. My

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estimates of misalignments are then given by the vertical distance of the actual real effective exchange rate from the FEER path. The dollar's overvaluation peaked in early 1985 approaching 50 percent. The misalignment had disappeared by the spring of 1987.

Despite this, most forecasts of the U.S. balance of payments continue to show a very large deficit, on the order of $140 billion, for the next few years. Although I certainly regard a deficit of that size as dangerously in excess of a sustainable level, which is surely not more than $50 billion per year, I am not convinced that those forecasts invalidate my estimates of the longer run equilibrium rate. One reason is skepticism regarding those forecasts: many forecasters, including the International Monetary Fund, have a record of systematically underestimating the eventual impact of exchange rate changes on trade flows (*2*). By contrast, the estimates at the Institute for International Economics are that maintenance of present exchange rates and projected growth rates can be expected to produce a reduction in the trade deficit on the order of $60 billion during the next 2 years.

Another reason for maintaining my estimated misalignments is that trade flows are determined not just by relative prices (which are strongly influenced by exchange rates) but also by relative incomes. The reason for the large U.S. trade deficit is not just that the dollar has been overvalued, but also that the rest of the world has not since 1982 had the spurt of catch-up growth that normally follows a recession. Changes in fiscal policies are needed to complement the changes in exchange rates and induce that catch-up growth. One of the failures of the floating rate regime is that it encouraged the illusion of more policy independence than countries really have and thus discouraged the search for a coordination of fiscal policy.

The main criticism of floating, however, is the size of the misalignments that have occurred. If, for example, a currency appreciates for a prolonged period much above the level consistent with simultaneous achievement of both satisfactory domestic performance (low unemployment and low inflation) and an appropriate current account, then one or the other of those objectives will be compromised. The economy may enter into a prolonged recession and perhaps see a substantial portion of its manufacturing industry destroyed, as happened in Britain when the pound sterling appreciated excessively in the early 1980s. Or it may develop a much larger current account deficit that can be justified, as happened in the United States in the mid-1980s, where the deficit has reached some 3.5 percent of gross national product (GNP) and the country has gone from being the world's largest creditor to the largest debtor.

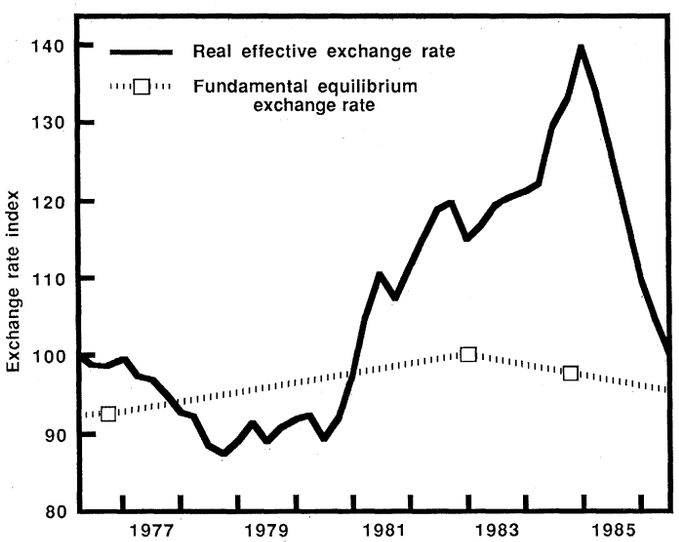

Fig. 1. Real effective exchange rate of the U.S. dollar (index 1976 second quarter = 100).

Unlike short-run volatility in the exchange rate, against which it is possible to take defensive measures by use of the forward foreign exchange markets (and now also the options markets), longer term misalignments are immensely destructive. Even highly efficient operations in the industries producing tradable goods may become unviable because of foreign competition when the exchange rate is seriously overvalued and have to be closed down. Not all such closures will be reversed when the exchange rate eventually declines again (*3*). Because foreign competition becomes intolerable, pressures for protection spread far beyond their customary home in the sunset industries and threaten to destroy the liberal trading system (as almost happened in 1985). Multinational corporations diversify their physical plant in order to hedge their currency exposure even if this is less efficient than production at a single source. The level of investment declines too, because foreign companies will not invest to exploit an export boom that they fear may be terminated at any time by a reversal of a misalignment, while the home companies that are being squeezed will most certainly not invest in the mere hope of such a reversal.

Meanwhile foreign debt builds up, thus magnifying the need for an ultimate balance of payments improvement: the $500 billion plus of foreign debt that the United States will have accumulated by 1990 will require an extra $25 billion of net exports to service even if the interest rate is only a modest 5 percent. And when eventually the exchange rate does decline, there is a danger that rising import prices will intensify inflation, that confidence will collapse and the exchange rate fall too far, and that to limit the damage the authorities will be forced to raise interest rates and create a recession. The United States was lucky that in 1986 the oil price decline coincided with the depreciation of the dollar and prevented this sequence from starting, but the inflationary pressures from an undervalued currency have often been just as painful as the costs of overvaluation. The acceleration of inflation in early 1987 and the subsequent rise in interest rates provide a foretaste of the costs that may be expected if the dollar declines much further.

The Social Functions of Exchange-Rate Flexibility

Disappointing as the experience with floating rates has been, however, it is important to recognize also that the previous system of (largely) fixed exchange rates broke down for good reasons. Fixed rates were not able to adjust to changing realities or help promote needed adjustment. The Bretton Woods system of fixed but occasionally adjustable parities proved too brittle to survive the advent of extensive international capital mobility.

One can distinguish four social functions of exchange-rate flexibility. All can be fulfilled under a regime of floating exchange rates, but they do not require floating in the sense of unlimited flexibility with the exchange rate treated as a residual in policy determination. So-called "limited flexibility," involving either a wide band around a parity that can itself be gradually altered to reflect changes in fundamentals, or else a system of target zones as described below, can also accommodate these four legitimate social functions of flexibility.

The first of these is the ability to accommodate differential inflation. A country with slower inflation can repel imported inflation by appreciating, while a country with faster inflation can depreciate in order to prevent its tradable goods sectors from becoming uncompetitive and a payments deficit developing. Some economists see this as a disadvantage because it allows countries the "soft option" of accommodating inflation instead of overcoming it.

My own view is that inflation certainly needs to be resisted, but that this should be done by a general control of demand and, if necessary, of incomes rather than by incurring the risks of destroying the tradable goods sector inherent in trying to stop inflation through a fixed exchange rate. In fact the fixed parity commitment did not prove strong enough to prevent countries like Britain and France from being forced to devalue to neutralize their excessive inflation in the late 1960s.

A second function of exchange-rate flexibility is to facilitate the adjustment process by changing the incentives to export and import when payments adjustment proves necessary. No one should be under the illusion that exchange rate changes are sufficient to accomplish adjustment, but, except in the special case where the imbalance is a result exclusively of excess or deficient demand, an attempted adjustment that does not include a change in the exchange rate will involve unnecessarily high unemployment (or inflation, where the need is to adjust away an excessive surplus).

A third function of exchange-rate flexibility is that of liberating monetary policy to pursue interest rate targets at variance with those in the rest of the world. If one country is suffering a deeper recession than its partners, it may legitimately wish to ease monetary policy relative to other countries, and that will be feasible only if its currency can depreciate so as to create an expectation of a subsequent rebound that will compensate investors for the temporarily low interest rates. Conversely, a country with abnormally severe inflation may legitimately seek to raise real (that is, inflation-adjusted) interest rates temporarily, which will require a real appreciation. A wide band within which exchange rates are allowed to move around parity provides scope for such temporary variations in monetary policy to pursue anticyclical objectives.

The final legitimate function of exchange rate flexibility is that of absorbing a part of speculative pressures. Instead of requiring that every change in speculative sentiment lead to a change in international reserves, interest rates, or both, one can allow changes in the exchange rate to take the strain. Provided these changes do not lead to the prolonged and substantial movements away from equilibrium that constitute misalignments, they do little harm.

Target Zones

Recognition of the need both to preserve enough exchange-rate flexibility to satisfy the four social functions identified above, and at the same time to limit misalignments as well as to reintroduce pressures for effective policy coordination, has led me to favor a system of "target zones" for exchange rates. The target zone proposal envisages a limited number of the major countries negotiating a set of mutually consistent targets for their exchange rates. The minimum number of countries needed for a meaningful system would be the three biggest: the United States, West Germany, and Japan. Current proposals for policy coordination involve rather more countries: the Group of Five includes also France and the United Kingdom, while the Tokyo summit added Canada and Italy, to make the Group of Seven.

The exchange-rate targets would be chosen as the levels consistent with a satisfactory longer run equilibrium on the lines described at the beginning of this article. Nominal exchange-rate targets would be adjusted automatically to compensate for differential inflation so as to prevent the targets from becoming outdated as a result of inflation.

The participating countries would be expected to conduct their macroeconomic policies with a view to limiting deviations of their exchange rates from the agreed targets, and particularly with a view to preventing exchange rates from going outside a broad zone

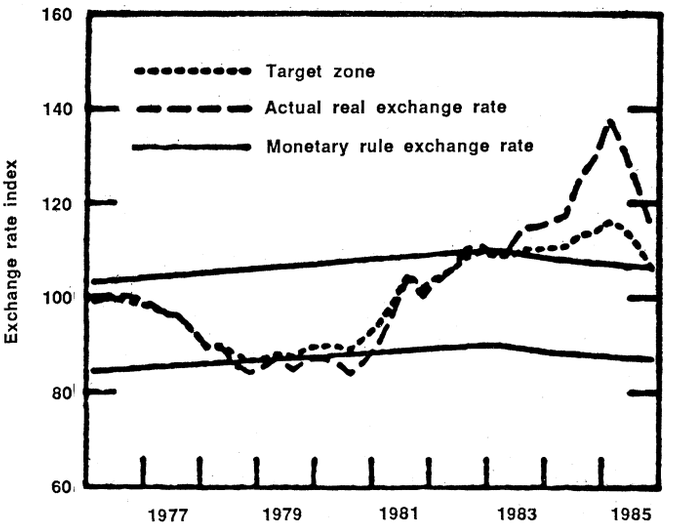

Fig. 2. Simulated impact of target zones on the real effective exchange rate of the U.S. dollar, 1976–1985 (index 1976 second quarter = 100).

(perhaps ±10 percent) around their targets. If an exchange rate threatened to breach the edge of its zone, the country involved would be expected to change its interest rate and intervene so as to pull the rate back toward the center of the zone: that is, a country with a weak (strong) currency would be expected to raise (lower) its interest rate and sell (buy) foreign exchange from (for) its reserves. If these changes in monetary policy threatened to push the domestic economy into recession or inflation, that threat might be countered by adjusting fiscal policy (taxes or government expenditures) in an expansionary or contractionary direction respectively.

When I first developed the target zone approach on the basis sketched above in 1983 (*4*), economic fashions were strongly opposed to governments having views on where exchange rates ought to be or seeking to coordinate their policies. The governments of the major powers subscribed to the view that if only all countries subscribed to the old-fashioned virtues of monetary discipline, fiscal probity, and market liberalization, then the world economy would look after itself without the need for conscious management.

Just over 2 years later that stance almost led to disaster. Even though already substantially overvalued, the dollar continued to appreciate until early 1985, bringing the vast expansion in the U.S. current account deficit in its wake. This fueled protectionist pressures to the point where the new team in the U.S. Treasury decided that it was necessary to make a sharp break with previous policy. The first result was the Plaza Agreement of 22 September 1985, which recognized that the dollar was overvalued and sought to engineer a correction, a sharp break with the previous hands-off policy toward the exchange rate. The follow-up was in some ways even more surprising. In the meetings associated with the IMF Interim Committee in April 1986, there was a sudden interest in exploring a set of "indicators" of macroeconomic policy and performance that could be used to improve the process of international economic policy coordination. The summit leaders who met at Tokyo in May instructed their Finance Ministers to review economic forecasts embodied in a series of ten indicators (*5*) with a view to ensuring their mutual consistency and seeking remedial measures when outcomes deviate significantly from the intended course.

The willingness of the major countries to explore ideas for extensive policy coordination prompted a new study (*6*), intended to develop a formal set of guidelines for international policy coordination to complement the target zone proposal. (One speaks

of guidelines rather than rules in recognition of the fact that the social world is too complex and unpredictable to make it either likely or desirable that governments will renounce their ultimate responsibility for policy choice in favor of a set of predetermined rules.)

Our study contains two parts. The first involves a simulation of one of the large macroeconometric multicountry models intended to explore how a target zone system would have worked had it been implemented for the last decade. We postulated that interest rates would have been modified from their historical level according to the cubic form

$$r = r_b + [(c - \bar{c})/n]^3 \quad (1)$$

where r is the 3-month treasury bill rate, r_b is its baseline level, c is an index of the level of competitiveness or the real effective exchange rate against the four other countries included in the model, $\bar{c}$ is the target level of competitiveness, and n is half the width of the target zone. We selected $\bar{c}$ by placing the four-country index of c the same percentage above or below $\bar{c}$ in the fourth quarter of 1976 as the composite real effective exchange rate index was above or below my estimate of its FEER described above, with changes from that level determining equivalent changes of $\bar{c}$ in other periods.

The essence of the policy reaction function, Eq. 1, is that the monetary authorities are assumed to have adjusted interest rates whenever the exchange rate deviated from the center of its target zone. However, the adjustment is rather small when the exchange rate lies within the target zone since $(c - \bar{c})$ is less than one. The adjustment increases rapidly once the exchange rate leaves the zone, as can be seen in Fig. 2, where the historical and simulated paths of the dollar's value are compared. Since the implied changes in interest rates turned out to be rather modest, we might with advantage have chosen a somewhat stronger policy reaction function than embodied in Eq. 1.

Figure 2 suggests that a policy of varying the interest rate so as to limit misalignments could indeed be expected to have that effect. According to the simulation, it would have done that at a distinctly modest cost in terms of undermining the anti-inflation program (at least in the short run). But the simulation also suggested that, again at least in the short run, the lower value of the dollar would on its own have done little to curb the enormous U.S. current account deficit that built up in the mid-1980s. The reason is that the greater competitiveness of U.S. tradable goods would have been offset by the higher imports resulting from the bigger GNP caused by the lower interest rates and more competitive dollar. A second simulation showed that if one prevented that rise in GNP by tightening up on fiscal policy then the effect on the current account balance would have been quite significant (an annual rate of $40 billion by the end of the forecast period). In other words, action to prevent the large rise in the budget deficit would have been critical.

In the second part of our study a small analytical model of interdependent economies was used to push the analysis further. Though rather traditional in its approach to the determination of prices and output, this model incorporates the modern "rational expectations" view of exchange rate determination, which stresses the role of expected future interest differentials in determining the current exchange rate (*7*). We searched for a set of robust feedback rules to govern policy choices, rather than assuming that governments individually optimize and that the problem of policy coordination is best viewed as that of imposing a super-optimizer who would take proper account of policy interdependence. We rejected the latter approach in part because of its evident political unacceptability and in part for two economic reasons. The first is that the results of optimal control depend intimately on the precise characteristics of model specification (*8*), which are not precisely known in most economic applications. The second is that, with forward-looking behavior in the foreign exchange market, it turns out that appropriate rules can improve on the outcome of continuous optimization even when the model specification is precisely known, since a rule provides the ability to commit beforehand and thus overcome what is known as the problem of "time inconsistency" (*9*).

The set of guidelines that we were led to suggest, which draws on both Keynesian and monetarist analytical traditions, would involve all the participating countries seeking to keep their exchange rates within target zones established on the principles described previously. The main instrument used for that purpose would be international differences in interest rates. Given the adoption of anti-inflation and anticyclical targets for the growth of nominal income in each country, we argue that the average world level of interest rates should be guided by the evolution of aggregate world nominal income relative to the sum of the national targets. National fiscal policies would need to be consistent with the goal of having national nominal income grow at its target rates, given the setting of interest rates. It will be evident that these proposals go well beyond a narrow concern for exchange rates, as proposals for exchange rate management ideally should, for the fundamental reason that economic phenomena are interdependent.

Conclusion

The sort of guidelines recommended above remain highly controversial among economists. Perhaps the most common basis of criticism is that governments lack both the knowledge and motivation to implement such rules, whereas markets can be expected to do a better job of choosing exchange rates.

My reply to such criticisms is that some care has gone into designing rules that are "robust," in the sense that they will remain helpful in a wide range of circumstances, and that the critics have an idealized view of what markets accomplish when they set prices for forward-looking variables. The latter is a perennial dispute. The former point may be illustrated by the width recommended for target zones: a band as wide as ± 10 percent is suggested in part because of a recognition that economists do not have the ability to calculate FEERs much more accurately than that.

On the question of governmental motivation, however, I have a lot of sympathy with the view of the critics. In fact, I regard the suggested guidelines as a way of constraining the ability of governments to pursue myopic policies or to disregard such (limited) wisdom as economists can offer on macroeconomic management. I am also inclined to the view that policies that are bad for a country's own citizens in the long run often have their first unpleasant impact on foreigners (the overvaluation of the dollar being a prime case in point), and therefore that a strengthening of international pressures in the policy formation process is enlightened self-interest for a country's citizens, even if sometimes inconvenient for their governors.

Questions may also be raised about the wisdom of adopting target zones for exchange rates if the other parts of the package, namely, coordination of fiscal policies and world interest rates, are not adopted at the same time. This issue remains open: at least an element of fiscal coordination seems to me an indispensable complement to a system of target zones, for otherwise there could be a danger of the monetary policies adopted to manage exchange rates having a destabilizing impact on the domestic economy with no countervailing force.

It is not clear to what extent the major governments may be moving toward adoption of the sort of rules recommended above. The agreement reached between the United States and Japan on 31 October 1986, which appeared to envisage an informal target zone for the yen-dollar rate of 150 to 165, suggested a willingness to

move in that direction. The communiqué issued after the Paris meeting of the "Group of Six" (*10*) on 22 February 1987 seemed to generalize that agreement to cover all the participants, although it failed to include the firm commitments to complementary changes in fiscal policy (covering both tax cuts in Germany and Japan and tax increases in the United States) that would have been called for by the guidelines laid out in this paper. In other words, there is still a long way to go from the ad hoc agreements that are back in fashion to the sort of articulated, comprehensive arrangements embodying agreed principles of policy adjustment when variables deviate from published target values that would constitute a new exchange-rate regime. The U.S.–Japan agreement will be significant if, but only if, it can in retrospect be seen as a milestone on the road to a comprehensive reform of the international monetary system.

REFERENCES AND NOTES

1. An "effective" exchange rate is a weighted average of the exchange rates against other currencies, where the weights may reflect bilateral trade flows or other measures of the strength of bilateral competition. A "real" exchange rate is one that is corrected for differential inflation. The index used in the figure is a composite of indices based on unit labor costs and wholesale prices.
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11. The author gratefully acknowledges comments on a previous draft by C. F. Bergsten, S. Islam, M. Miller, M. Noland, R. Solow, and two anonymous referees.

Scientific Basis of Modern Weather Prediction

JOSEPH J. TRIBBIA AND RICHARD A. ANTHES

A review of the scientific principles and computational methods used in modern weather prediction is presented. The history of research in this area shows that researchers attempting to improve weather prediction have advanced all of meteorology. The numerical models developed for weather prediction are today an integral component of meteorological data analysis and are used in simulating past and present climates and in assessing the potential for future climate changes. Related disciplines, such as oceanography, computational fluid dynamics, and mathematics, have also reaped benefits from this effort, which is currently being extended to studies at smaller spatial and longer temporal scales.

THE FOUNDATIONS OF QUANTITATIVE WEATHER PREDICTION, as currently practiced at a number of centers around the world, are the same fundamental laws by which modern science predicts nearly every event within the realm of everyday experience: the tides of the sea, the motions of the planets, or the flight of a rocket. These are the Newtonian laws of motion, the conservation of mass, the laws of classical thermodynamics, and the laws of transfer of electromagnetic radiation and its interaction with matter. The formulation of the problem of weather forecasting in such a manner is a direct outgrowth of the 19th-century deterministic philosophy that led Laplace to believe that the future of the cosmos could be determined from complete specification of the present state of the universe and the laws of Newtonian mechanics. The history of the successes and failures of the deterministic method in meteorology has led to the interaction of this science, already broadly interdisciplinary, with numerous other disciplines to their mutual benefit, including computational mathematics, oceanography, astronomy, biology, and chemistry. Even the philosophy of determinism has been affected by scientists grappling with the problems of weather prediction.

Historical Development

The present method of weather prediction has its origin in the scientific vision of three men: Vilhelm Bjerknes (1862–1951), Lewis Fry Richardson (1881–1953), and John von Neumann (1903–1957). Bjerknes's contributions to the atmospheric sciences and the dynamics of rotating, stratified fluids are manifold, including an extension of Lord Kelvin's circulation theorem and the polar front theory of cyclone development. In a seminal paper, published in 1904 (*1*), Bjerknes made two major contributions to modern weather prediction. First, he mathematically stated the problem of weather forecasting as a proper initial-value problem, pulling together the Newtonian dynamical equations for an ideal compressible gas in the form given by Navier and Stokes, the equation for the continuity of mass, the ideal gas law, and the first law of thermodynamics as stated by Helmholtz. Thus he demonstrated the principle that future values of the three-dimensional wind field, the temperature, the pressure, and the density of the atmosphere could be determined from the current values of these variables. Bjerknes's second contribution was his statement, influenced by the deterministic scientific philosophy of Heinrich Hertz (1857–1894), that the central problem of the science of meteorology is the prediction of future weather (*1*).

The system of equations set down by Bjerknes included only the barest representation of the complexity of atmospheric processes

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