

Nonlinear Systems Theory: A More Dynamic Approach to International Strategic Management

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Abstract

The complexity and volatility of the environments in which many multinational corporations operate have lessened the effectiveness of traditional planning techniques. As multinational corporations grapple with the conflicting pressures of globalization and localization, the need to track changes in the countries in which they operate and to devise more effective intervention strategies becomes more pressing.

We propose using a tool of nonlinear systems theory—phase plane analysis—for examining, monitoring, and responding to international strategic challenges. By applying phase plane analysis, we demonstrate how environmental changes within and between countries can be tracked and how management can develop intervention strategies *a priori*. To discuss the application of phase plane analysis within the context of specific international examples, country risk measures (and the two major components of country risk—economic performance and political risk) of two emerging markets, Brazil and Mexico, were used. The benefits of incorporating phase plane analysis into international strategic management are also discussed.

Introduction

The globalization of business has had a major impact on the strategic management of corporations operating internationally. In addition to economic issues, it is clear from the international business literature that strategic managers of multinational corporations (MNCs) must take into account cultural, social, legal, and political issues (Buckley, 1990; Bodewyn and Brewer, 1994; Earley and Singh, 1995). The complex environment of MNCs (brought about by such factors as regulatory changes, intense competition, creation of new industries, rapid changes in technology, and unstable international monetary systems), has rendered traditional planning techniques largely inefficient in steering an MNC's course. A further complication is that MNCs are faced with conflicting pressures as they attempt to reap the benefits of global integration while simultaneously responding to differences in local environments.

A fundamental premise of this article is that a more dynamic way of thinking is needed for examining, monitoring, and responding to international strategic challenges. We argue that nonlinear systems theory can provide such an approach. More specifically, we demonstrate that one tool from nonlinear systems theory, phase plane analysis, can provide a useful way to track the changing dynamics within and between countries. As a consequence, this tool can also provide a useful framework for planning management's response to changing environmental conditions.

MNCs' Strategic Challenges

The highly competitive and unpredictable environments in which MNCs operate, and the often conflicting challenges of globalization and localization, have made the task of managing a company on a worldwide basis increasingly difficult. On the one hand, the rapid globalization of various industries has created intense pressure for MNCs to seek efficiency on a worldwide basis; that is, for companies to prosper internationally, they have to be more efficient than their competitors in reducing costs. Exploiting economies of scale, scope, and experience, standardizing products, and developing worldwide communication networks have become critical factors for achieving global integration and coordination (Bartlett and Ghoshal, 1990; Doz and Prahalad, 1994; Prahalad and Doz, 1987). On the other hand, the need to respond to local differences and rapidly changing conditions throughout the world calls for a company to be more effective than its competitors in satisfying both the needs of differentiated markets and the requirements of host governments while at the same time enhancing its own revenues. Developing an understanding of differing local tastes, industry structures, and distribution systems is considered critical for a sustainable and successful localized strategy (Bartlett and Ghoshal, 1990; Doz and Prahalad, 1994; Prahalad and Doz, 1987).

Since the objectives of globalization and localization are inherently contradictory, conflict is often unavoidable; for example, an MNC's desire to design and produce a product with attributes that meet the needs of specific markets can easily be in conflict with efforts to achieve efficiencies through economies of scale, scope, and experience. Some companies, by the nature of their industries, experience more pressure for global integration than for local responsiveness. The strategic orientation of companies in the consumer electronics and computer industries, for example, has been toward developing global strategies that attempt to take advantage of the benefits of economies of scale, scope, and experience. In contrast, the pressure to respond to local environments has been more important in industries such as apparel and packaged foods. Companies in these industries typically have developed multidomestic strategies; that is, strategies which seek to increase revenues by responding effectively to national differences in tastes, distribution systems, and market structures.

In recent years, however, structural changes have blurred the distinction between global and multidomestic strategies. The computer industry, for instance, is no longer comprised of vertically integrated firms; instead, it is characterized by companies that are outsourcing many segments of their value chains. Furthermore, an increasing number of computer customers are demanding customized products that require flexibility in production. Thus, companies that previously could afford to focus on only one of the two pressures now must address both pressures simultaneously.

Globalization and localization pressures aggravate the task of strategic planning within environments that are highly complex, varied, and dynamic. The difficulties of managing in these types of environments are highlighted by Lorange and Probst (1990):

The emerging, more complex systems may have special characteristics that we have not yet fully understood. They may be highly interrelated, dynamic, multidimensional....[W]e see that problems and tasks rapidly become outdated—the environment or the context is no longer the same. The multinational corporation is thus in need of

new strategic processes and methods that may allow for more immediate adaptiveness and quicker evolution. (p. 146)

The sources of environmental volatility are many and cover a wide spectrum of economic, political, social, and demographic factors. The uncertainty and unpredictability of developing countries is particularly troublesome for strategic planning (Austin, 1990). Even minor fluctuations in exchange rates, for example, can have a significant impact on the real costs of operations which, in turn, can affect plant location decisions. Environmental volatility also has a major impact on international investment and financing decisions. For example, an increase in the level of political and economic risk in a country (also referred to as country risk) can be a serious problem for a company with assets in that country, since it may affect the cash flow values received from that country. Likewise, country risk can affect a company's decisions concerning local borrowing and foreign debt obligations. This environmental volatility, coupled with greater needs for worldwide integration and coordination, requires flexibility in strategic planning so that risks can be managed and opportunities exploited in a timely fashion (Doz, Prahalad, and Hamel, 1990; Kogut, 1985). It is important to remember that strategic thinking in the context of MNCs not only entails the objectives of coordination, integration, and differentiation of markets but also the coordination, integration, and differentiation of financial activities on a worldwide basis.

Managing the challenges of global efficiency, local effectiveness, and multinational flexibility has become a dynamic, complex process, regardless of the strategy that a company pursues. Thus, many of the strategic concepts and tools of a few decades ago are no longer very useful for competing effectively in today's turbulent environments since they do not adequately address the dynamics of these strategic challenges. It is not surprising, then, to find a low usage among companies of typical strategic management tools such as the Value Chain Analysis and the Five Forces of Competition Analysis (Bain & Company, 1994).

Although the dynamic nature of these shifts is recognized, managerial thinking is still driven primarily by a linear, reductionist, and mechanistic framework. As noted by Istvan (1992), many managers typically conceive of a productive business in terms of a sequence of specialized, individually managed and optimized activities. Similarly, the international value chain of a company is frequently based on linear assumptions; the underlying idea is that if the subparts of the system are optimized, a global optimum can still be achieved. With the exception of a nonlinear approach to the analysis of an international supply chain conducted by Levy (1994), the literature has not adequately addressed the current uncertainty of the environment in a dynamic, multiple-period manner (e.g., Cohen and Lee, 1989; Hodder and Dincer, 1986; Hodder and Jucker, 1985; Kogut, 1985). The literature is equally barren of nonlinear approaches in the assessment of different types of risk related to volatile changes in international environments. Changes in economic risk and political risk can affect both the globalization and localization pressures that confront multinational corporations. At the global level, these risks are an intrusion on the configuration of a company's investments (e.g., location of manufacturing plants and diversification of markets). At the local level, they intrude on the operations of a particular affiliate (e.g., an affiliate's sales level).

MNCs invariably need to assess the political and economic climates of the countries they wish to enter and the countries in which they already have operations. However, rigorous and systematic assessment of the environment tends to be the exception, not the norm

(Kobrin, 1979). Fortunately, recent developments in the application of nonlinear systems provide an alternative approach for conducting environmental assessments in a *dynamic, multi-period, interactive* manner.

Nonlinear Systems Theory

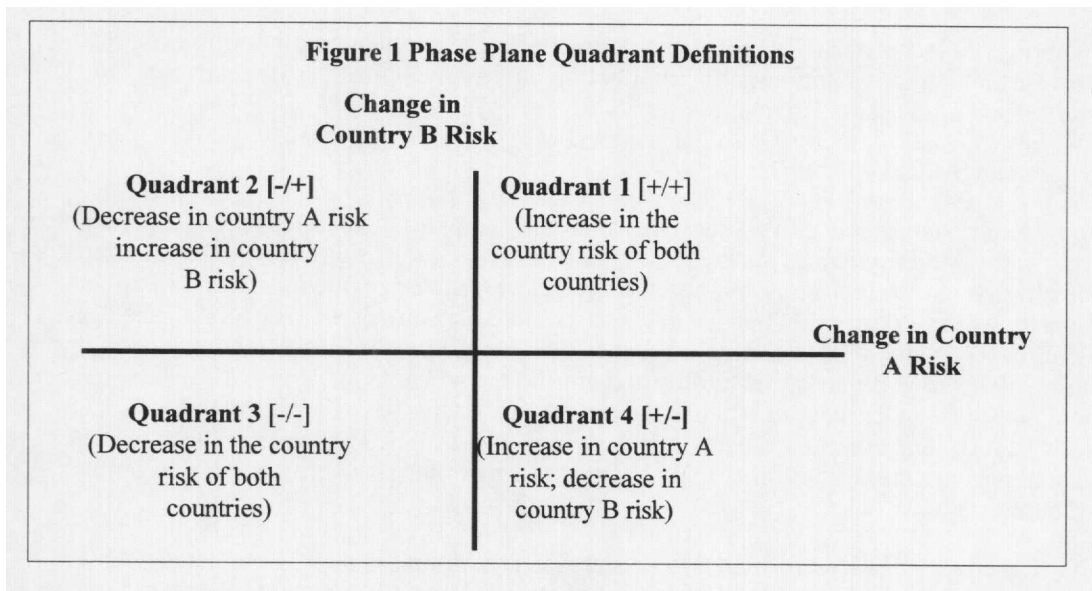
Nonlinear systems theory (also known as chaos and complexity theories) became popularized in the natural sciences during the 1970s, challenging the traditional views held about the physical universe. Chaos and complexity theories have provided alternative explanations for why systems do not behave in linear, predictable ways over time. As stated by Best (1991), these new theories compel us "to reinterpret the universe as being constituted by forces of disorder, diversity, instability and non-linearity" (p. 194). While the outcomes of nonlinear systems are not predictable, these types of systems have the ability to produce orderly patterns that emerge from a few underlying simple rules. Thus, one of the attractions of nonlinear systems is the ability to find patterns of order and structure underlying complex systems (Levy, 1994).

Recent applications of nonlinear systems can be found in such areas as: economics (Arthur, 1990; Kelsey, 1988); international relations (Mayer-Kress and Grossman, 1989); planning (Cartwright, 1991; Priesmeyer and Baik, 1989); international value chain (Levy, 1994); and productivity (Istvan, 1992). Thus, our purpose in this article is not to explain the numerous technical concepts, terms, and methods that have been developed in the field of nonlinear systems. Rather, we will show how this new way of thinking can be used to examine changing environmental factors so that MNC managers can make strategic interventions in an interactive, dynamic, and timely manner.

The Use of Phase Planes in International Environmental Analysis

One analytical method often used in nonlinear analysis employs "phase planes" which describe the evolving *state* of a system. These phase planes can be used as a tool to facilitate international environmental analysis. Specifically, a phase plane describes the changing condition of any system by identifying the "state of the system" on a common two-dimensional Cartesian plane. The two dimensions are simply two selected measures of the system. For instance, *Euromoney's* country risk rankings (which incorporate measures of a country's economic performance as well as political risk) for two countries in which a company has investments can be used to examine the impact of changes in risk on such decisions as resource allocation, budget considerations, and debt location. It is important to realize that phase planes plot *changes* in the two measures underlying the country risk rankings rather than the actual values of the variables. That is, they plot marginal values, the differences between each measure's reported value and its value in the previous reporting period. As a result, changes can be either positive or negative from period to period. The center of the phase plane is coordinate 0,0 representing no change in either measure. Quadrants are traditionally numbered as shown in Figure 1.

The evolving "state of the system" is plotted as a trajectory on the phase plane. That is, as the values for each measure change over time, those changes are plotted on the phase plane. The trajectory is provided by extending a line from each plotted position to the next position so that an observer can see the evolution of the system. For example, if the horizontal axis represents changes in Country Risk for Country A and the vertical axis represents changes in Country Risk for Country B, then an increase in both of these measures



(+/+) will be plotted at some specific point in quadrant 1 (upper right) reflecting the positive marginal values for both measures. If, during the second reporting period, both country risk measures decline (-/-) from their previous levels, the decreases in both measures would relate to a specific point in quadrant 3 (lower left). Extending a line from the first point to the second point provides one leg of the trajectory which traces the evolution of the system over time.

If several periods of data are available, the transitions in the data are presented as evolving trajectories on the phase plane. Rather than having to evaluate a series of one-dimensional measures, the phase plane image focuses attention on relative changes which might otherwise escape notice. It graphically depicts the changes in the two measures exposing subtle transitions in the data which are masked by the sheer size of the actual measures. Most often there is an obvious structure and pattern to the changes and that structure is dramatically displayed in the trajectories of interactive changes plotted on a phase plane. The patterns can be classified and used to suggest a variety of other forms of analysis. Most importantly, the phase plane is an appropriate tool for examining the dynamics of international markets in that it provides for examination of changes in multiple, interrelated dimensions over time.

The real merit in this type of analysis lies in the ability to relate positions on the phase plane to specific managerial recommendations. Because positions on the phase plane relate to specific combinations of changes in the system being monitored, it follows that there are unique interpretations for each quadrant and, often, appropriate generic prescriptions can be provided for any position on the plane. The ability to translate changes in data into written interpretations means that analysts applying this technique can generate a series of interpretative statements describing appropriate interventions for virtually any combination of interacting environmental variables.

The phase plane captures the interaction of the changes in the two measures thereby defining the "state of the system." That "state" or condition can then be reported and an appropriate intervention strategy developed. Again, it is important to realize that these condi-

tions relate to the incremental evolution of the system; hence, the interpretations and prescriptions are on the margin. They provide insight into changes which would probably not be noted otherwise and, therefore, they allow management to respond in a more timely manner.

Using country risk assessment as an example, Table 1 provides a description of the changes represented by the quadrants on the phase plane, possible explanations for these changes, and suggestions for intervention strategies that managers could use for protecting or improving their company's position in the countries.

Example of Phase Plane Analysis: Country Risk Ratings of Two Countries

Table 2 provides country risk, economic performance, and political risk ratings for two emerging markets that may be of strategic importance to an international company: Brazil and Mexico.

The versatility and value of phase plane analysis as a planning tool can be seen by plotting this raw data in several ways. For example, we can examine the changes in the relationships between the country risk ratings of two countries or the economic and political measures of a particular country. To illustrate the usefulness of this approach for determining appropriate intervention strategies, the country risk ratings of Brazil and Mexico are plotted in Figure 2.

Assume that a company has made investments in Brazil and Mexico in position 1 (1993, represented by the center of the phase plane). The change in position 2 (1994) indicates that country risk increased in Mexico but remained the same in Brazil. At this point corporate managers may want to seek ways of increasing the ROI on its Mexican investments to compensate for the increase in risk, or they may want to consider actively engaging in specific political strategies (e.g., engaging in a joint venture with a local company). In contrast, the decrease in the country risk of both countries in position 3 (1995) probably warrants a lowering of ROI requirements for each country. As another option, managers may want to simply continue to monitor the situation without changing their strategy and focus their attention elsewhere. This quadrant is the most desirable since it tends to indicate a healthier economic and/or political situation in both countries.

The changes in position 4 (1996) show that country risk has increased in both countries, a situation which signals problems. Corporate managers may want to reassess the investments in these two countries and seek ways of diversifying or mitigating the company's risks. Divestment may be an option if the situation warrants it, the ultimate approach used depending on the underlying causes of the shifts and the specific needs of the company. For example, if the underlying cause is political risk and the country is of considerable importance to the company, then a strategy of increasing investments in that country may be the most appropriate one (see, e.g., Poynter, 1986). Finally, in position 5 (1997), country risk decreased considerably in Mexico. As a response to this situation, corporate managers may find it advisable to shift investments between the two countries or make changes in the budget allocation, again, depending on the causes of the shift and the specific needs of the company.

Table 1 Interpretation of Country Risk Changes in Phase Planes

Quad-rant	Description	Interpretation	Intervention Strategies
1 Upper Right	Increase in the country risk of both countries	<ul style="list-style-type: none"> - May indicate an underlying relationship in the risk. changes of the two countries. - Underlying causes in each country need to be analyzed (whether mainly economic, political, or both). 	<ul style="list-style-type: none"> - May require seeking higher ROI, engaging in political strategies, or divesting. - Actions taken may differ for the two countries, depending on the underlying causes for the increase in risk.
2 Upper Left	Decrease in country A risk; increase in country B risk	<ul style="list-style-type: none"> - May suggest that country risks in the two countries are not related. - Managers may be able to focus their efforts on examining the negative changes in one country. - The underlying causes for the changes in both countries need to be examined. 	<ul style="list-style-type: none"> - May require the movement of assets, personnel, and other resources from one country to another. - Identify new opportunities in country A. Seek to mitigate risks in country B. - Specific actions taken will depend on the underlying causes for the change in risk in the two countries.
3 Lower Left	Decrease in country risk of both countries	<ul style="list-style-type: none"> - May signify a healthier outlook for the two countries at this point in time. - The underlying causes for the positive change in both countries should be examined. 	<ul style="list-style-type: none"> - May suggest a “wait and see” approach, an increase in resource allocation in the two countries, or a focus on achieving or surpassing the stated objectives of the company. - Specific actions taken will depend on the underlying causes for the change in risk in each country.
4 Lower Right	Increase in country A risk; decrease in country B risk	Similar interpretation as for Quadrant 2, except the change in risk in the two countries is reversed.	<ul style="list-style-type: none"> - May require movement of assets, personnel, and other resources from country A to B. - Identify new opportunities in country B. Seek to mitigate new risks in country A.

Table 2 Risk and Macroeconomic Measures for Brazil and Mexico

Country/ Year	Country Risk Rating ¹	Economic Performance Rating ²	Political Risk Rating ²
Brazil:			
1993	39.05%	9.15%	14.63%
1994	39.38%	11.32%	14.15%
1995	31.02%	13.95%	14.12%
1996	33.71%	14.49%	14.34%
1997	33.89%	14.07%	13.12%
Mexico:			
1993	27.22%	16.15%	8.52%
1994	28.75%	13.22%	10.15%
1995	27.81%	12.81%	13.37%
1996	29.78%	15.74%	13.36%
1997	28.33%	16.24%	11.98%

¹Country risk ratings were obtained from *Euromoney*. The *Euromoney* rankings are weighted scores comprised of the following categories: economic performance (25%), political risk (25%), debt indicators (10%), debt in default or rescheduled (10%), credit ratings (10%), access to bank finance (5%), access to short-term finance (5%), access to international bond and syndicated loan markets (5%), access to and discount on forfeiting (5%). The weighted scores are calculated as follows: the highest score in each category receives the full mark for the weighting; the lowest receives zero. In between, figures are calculated using the following formula: final score = [weighting/(maximum score - minimum score) X (score - minimum scores)]. The rankings show only the final scores after weighting. For the phase plane analysis, these rankings were converted into percentages by dividing the ranking of each country by the number of countries ranked in each particular year.

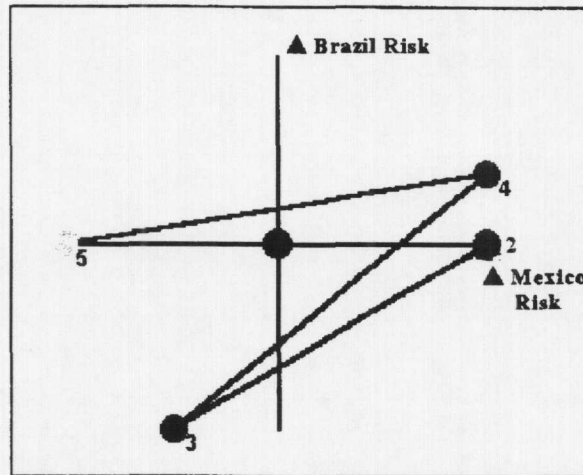
²Economic performance and political risk ratings were obtained from *Euromoney*. They are the two major components used by *Euromoney* in determining the holistic measure of country risk, as indicated in note 1. The political risk measures were inverted so that a higher number indicates a higher risk (conversion: 25% - political risk of each country).

Example of Phase Plane Analysis: Economic and Political Measures of a Country

The phase plane can also provide insight into economic, political, or social changes within a country. For example, a manager can examine the relationship between a nation's economic performance and its political risk and relate the various states to recommended strategic or policy changes. The relationship is particularly important in developing economies where the level of political risk often may be more volatile and higher than in developed economies; in such cases, the level of political risk can significantly affect a country's economic performance.

Figure 3 provides the phase plane for the relationship between political risk and economic performance in Mexico and it offers an excellent illustration of how these conditions

Figure 2
Country Risk: Mexico vs. Brazil



evolve dynamically over time. In this image, position 2 represents the changes in the two factors between 1993 and 1994; hence, it specifically reflects the changes which occurred during 1994. It reveals that economic performance declined and political risk increased during this period, suggesting a business climate that is more unstable. The increase in political risk, with a concurrent decline in economic performance, is likely related to the turbulent elections which occurred in that year. Position 3, which represents the changing conditions of 1995 is, technically, the same condition although political risk has increased considerably while economic performance declined only slightly. The increase in political risk was possibly a reflection of the uncertainty caused by the elections and the continued devaluation of the Mexican peso. Position 4 (1996) on the phase plane could easily be misinterpreted. While it is clear that economic performance has increased, this position should not be interpreted as a decrease in political risk. Rather, it represents no change in political risk since it is on the horizontal axis. Finally, position 5 (representing the changes in 1997) shows a continuation of the increase in economic performance with a decline in political risk, suggesting a more stable political and economic climate.

This evolving set of conditions for Mexico also provides an opportunity to characterize the four quadrants on the phase plane. Quadrants 1 and 3 (upper right and lower left respectively) reflect conditions in which the two variables move together directly whereas quadrants 2 and 4 (upper left and lower right respectively) are states associated with an inverse relationship. Over time, the evolving trajectory will often reveal a propensity toward a direct or inverse oscillating pattern which allows a manager to generalize as to the nature of the relationship. Regardless of whether such patterns develop, the current state of the system is explicitly reported by the current position of the trajectory on the phase plane.

Figure 3
Economic Performance and Political Risk: Mexico

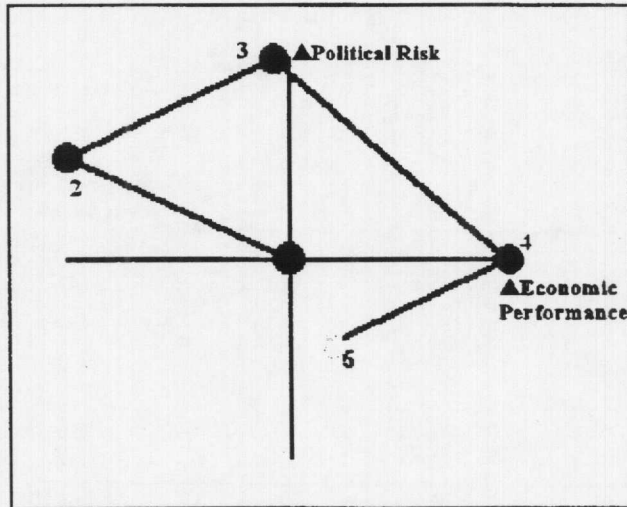
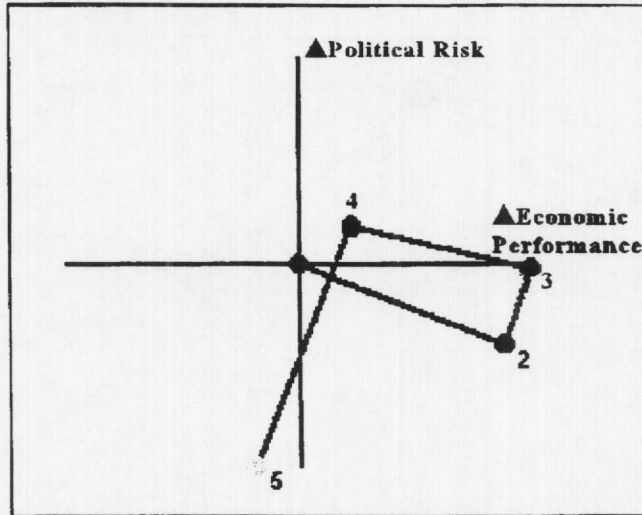


Figure 4 provides a comparable image of the relationship between political risk and economic performance for Brazil. It differs considerably from that of Mexico which is in line with our experience that indicates each country will provide its own unique evolving trajectory. Positions 2 and 3 each represent the same state as they are both in quadrant 4. During these periods (1994 and 1995) political risk decreased concurrent with increases in economic performance. It was during those years that Brazil was recovering from an environment of hyper-inflation. In 1996 both political risk and economic performance increased (position 4) before both declined in 1997 (position 5). However, the decrease in political risk was substantial while the decrease in economic performance was only slight. The significant decline in political risk may be related to the successes that President Cardoso had in stabilizing Brazil's economy.

When analyzing phase plane images it is also sometimes useful to take note of which conditions (states) did *not* occur. In Mexico, there never was a period between 1994 and 1997 when both political risk and economic performance declined (quadrant 3). In Brazil, there was never a period over this time when economic performance declined while political risk increased. The lack of these two conditions possibly reflects the inverse relationship between political risk and economic performance. Of course, it is possible that either of these conditions could occur in the future. At such time, a manager could already have considered an appropriate response. It is precisely this ability to anticipate what to do without knowing what will happen which characterizes nonlinear analysis. In nonlinear systems, behavior is so complex that it cannot be forecasted. Nonlinear analysis, however,

Figure 4
Economic Performance and Political Risk: Brazil



allows the set of all possible behaviors to be identified in advance and thereby appropriate interventions can be considered for any condition.

Conclusions

Several advantages of using the phase planes for this type of analysis need to be mentioned. First, the moves from one quadrant to another indicate the *magnitude* of the change in the risk of each country in a chronological order, thus helping managers determine the type of strategic intervention that is most appropriate for the specific situation. In this particular case, phase plane analysis shows that the moves in the country risks of both countries are frequent and considerable, yet the extent of these changes is not readily apparent in the raw data used for the ratings. Second, phase plane analysis reveals *changes* in the country risk rather than just the current state, which allows managers to detect the onset of problematic country conditions in a timely manner. Third, phase plane analysis alerts managers to the need to examine underlying causes for the shifts, which can lead to more judicious strategic interventions. Finally, phase plane analysis depicts the *interaction* of two measures over multiple time periods. The two-country-risk phase plane analysis is an example of how a dynamic, multidimensional approach can assist managers in making resource allocation decisions, as well as in providing a way for assessing competing requests for resources from affiliates in those countries.

Perhaps most importantly, this simple analytical tool can be universally applied to examine the dynamic behavior of any financial, operational, or economic measures. Hence, it can be used to reexamine existing company data to gain a new perspective on markets, risks, and performance. Measures such as sales, profitability, and market share within any



given country are potential candidates for analysis. While this technique and our discussion are limited to analysis of two variables in interaction, the underlying principles of this approach apply equally when analyzing more than two measures concurrently. Despite the simplicity of the methods described here, we have found this type analysis to be highly useful as a framework for discussing intervention strategies *a priori*. Additionally, the ability to see the dynamic history of any two-measure interaction provides a perspective which one cannot obtain from any traditional linear method of analysis.

Endnote

1. For a more extensive discussion of the application of chaos theory to business and administration data, see Priesmeyer, H. R. (1992) *Organizations and Chaos: Defining the Methods of Nonlinear Management* (Westport, CT: Quorum Books).

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