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STRATEGIC CONTINGENCIES AND POWER IN NETWORKS OF INTERNATIONALLY DISPERSED R&D FACILITIES

by

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WORKING PAPER NO. 68

August, 1997

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Presented at

The Academy of Management Annual Meeting

Boston, August, 1997

strtcntg.006

Abstract

A model of the organizational structures used to manage networks of internationally dispersed technology units is developed using the strategic contingencies theory of power and Thompson's model of organizational unit interdependence. The new model is used to integrate similar models available in the technology management and international business literatures. The model is also used to resolve several issues in the literature, generate hypotheses that can be empirically tested, and to provide advice to managers.

An important facet of the general trend towards the globalization of business has been the increasing amounts of technical work (research, development and support) being done abroad to tap offshore sources of expertise and to support overseas marketing and manufacturing (Chiesa, 1996a, b; Coughlan & Brady, 1996; Dalton and Serapio, 1995; Gates, 1995; Granstrand, Hakanson and Sjolander, 1992; Pearce & Singh, 1992a, b). Such off-shore work has come to be seen as absolutely essential to competitiveness in a number of industries. Many multinationals now manage networks of technology units which are dispersed across a number of countries and continents (Bartlett & Ghoshal, 1990; Granstrand, Hakanson and Sjolander, 1992; Hakanson, 1990; Kuemmerle, 1997; Malnight, 1995; Ohba, 1996). How to effectively manage such networks is an issue of increasing importance to multinational firms.

For some years now the granting of autonomy to overseas technology units has been seen as crucial to their effectiveness, but no consensus has arisen about how much autonomy is appropriate (Asakawa, 1996; Bartlett & Ghoshal, 1990; Pearce & Singh, 1992a, b; Behrman & Fischer (1980); Brockhoff and Schmaul, 1996; Buckley & Brooke, 1992; Cheng & Bolon, 1993; De Meyer & Mizushima, 1989; Nobel & Birkinshaw, 1996; Stock, Greis and Dibner, 1996). Issues of autonomy and control create a number of tensions in global organizations that hamper organizational effectiveness (Asakawa, 1996). Tension arises around such issues as: How to reconcile the different R&D thrusts aimed at varied overseas markets with corporate wide initiatives; how to adapt to the research and management practices of host countries while maintaining an appropriate level of internal consistency as a corporation; how to take advantage of overseas external research collaborations while protecting your own intellectual property; and how to maintain long term research objectives while responding to the short term pressures of overseas units. The resolution of these and related issues is crucial to the success of mangers charged with responsibility for the technical resources of the firm.

A great deal of excellent field research has been done on these issues but the interpretation of the data has remained primarily at a descriptive level, with little attempt to apply theoretical models. This descriptive approach has left the literature not as well integrated as it might be and has left unresolved a number of apparent contradictions. Theoretical models could give more rigorous guidance to data collection, broader and more rigorous integration of the data collected, and more carefully reasoned advice to practising managers. This paper will show that the strategic contingencies theory of power (Hickson, Hinings, Lee, Schneck & Pennings, 1971; Saunders, 1990), and Thompson's (1967) model of task interdependence, can advance our understanding of networks of globally dispersed technology units and, in particular, of power arrangements in such networks. We begin with a review of the recent literature.

Autonomy in Globally Dispersed Technology Units

Papers concerned with power in networks of globally dispersed technology units have given primacy of place to autonomy. This is because those charged with the management of such units find that control of them is a greater challenge than it is for similar units located in the home country. Many forces press for the granting of greater autonomy to overseas units but it is not clear that such autonomy is always in the best interests of the firm.

Asakawa (1996) studied the effects of the internal and external linkages of Japanese overseas technology units on the amount of autonomy they are given by the home office. He found that when overseas units increase their external linkages (to entities in the host country) they expect more autonomy from the home country. This tendency is countered, to some extent, by more explicit control by the home office, especially in sensitive areas such as intellectual property and research initiatives. On the other hand, when overseas units increase their internal linkages to the home office, control from home increases. In some cases, the comfort which the home country feels with this degree of control leads to the granting of more autonomy to the overseas unit. Asakawa's discussion of these findings, and his description of centre-periphery power tensions, leaves some ambiguity about these situations. For example, how can a centre simultaneously grant more autonomy and have strong control through internal communication linkages? There are undoubtedly resolutions to such apparent paradoxes, and a better theoretical understanding may provide them.

Stock, Greis and Dibner (1996) found that units of Japanese biotechnology companies located in the US were given more autonomy by the home country than were the US units of European biotechs. They attributed this, at least in part, to the fact that the US units of Japanese biotechs had much greater scientific expertise in biotechnology than did their home units, while the US and home units of the European biotechs were much more evenly matched in scientific expertise. Stock *et al* also found more working collaboration between the European home and US units than between the Japanese home and US units. They suggested that more autonomous overseas units have less interaction with the home unit. How does this fit with Asakawa's finding that overseas units with more communication with home were granted more autonomy? Again, our understanding of these issues might be improved by a better theoretical base.

Brockhoff and Schmaul (1996) identified three different kinds of organizational structure for coordinating overseas technology networks; the hub, competence and network models; and found them to involve different degrees of autonomy for their overseas units. In the hub model, the overseas units have the least amount of autonomy. In the network they have the most, and in the competence model they are somewhere in between. Brockhoff and Schmaul described the overseas units of competence models as having more interconnections than do those of network models. How does Brockhoff and Schmaul's finding of intermediate amounts of autonomy for highly interconnected units jibe with the ideas of Asakawa (1996) and Stock *et al* (1996) about the relationship between control and the level of interaction.

Nobel and Birkinshaw (1996) identified three different kinds of overseas technology units and found that they are controlled by headquarters through different mechanisms. One type of unit, "local adaptors", whose mandate is to adapt existing products and processes to local demands, are controlled primarily by formalization, which is the provision of rules and procedures by headquarters. The second kind of unit, "international adaptors", adapt products for global or regional markets, and are controlled primarily through centralization, the retention of decision-making power at headquarters. Finally, "international creators", which are primarily involved in research and development at the international level, are controlled primarily through socialization, which involves frequent interunit visits ands the exchange of personnel. Does distinguishing among different means of control, as done by Nobel and Birkinshaw, provide a way to resolve the apparent contradictions described above? Further, what do we mean by autonomy and control when socialization is the mechanism of control?

Buckley and Brooke (1992) distinguished three kinds of structure for coordinating the activities of overseas technology units. In the "hub model" decision making is centralized at headquarters and the overseas units are assigned subordinate tasks. On the face of it, this is similar to Brockhoff and Schmaul's (1996) hub model. Buckley and Brooke also describe a network model which may correspond to Brockhoff and Schmaul's (1996) network model. If so, does this mean that Buckley and Brooke's third type, the competitive model, corresponds to Brockhoff and Schmaul's third type, the competence model? If so, why do Buckley and Brooke imply that the periphery units in the competitive model have more power than those in the network model, while Brockhoff and Schmaul's empirical data show the periphery units in network models to have more autonomy than those in competence models. Are the network models in these two systems really equivalent?

Buckley and Brooke also discuss two approaches to defining centralization. One is to base it on locus of decision making. In centralized firms, decisions are made at headquarters; in decentralized firms, they are made elsewhere. This approach is clearly that used by Brockhoff and Schmaul (1996) to operationally define autonomy. It is not as clear that other papers are using this definition. The second approach to defining centralization is in terms of influence. Regardless of where a decision is made *formally*, various units, at home and abroad, may have various degrees of influence upon it. In the extreme case, a decision made at home (in a firm which is apparently centralized, considering only locus), may be merely a rubber stamp for the real decision, which was made overseas by influential units with high business and technical expertise. Is this distinction between locus and influence connected to the apparent contradictions described above?

Chiesa (1996a, b) has published two papers recently which address issues surrounding globally dispersed technology units. In the first (Chiesa, 1996a), he describes seven kinds of coordinating structures for overseas technology units. In the second paper (Chiesa, 1996b), three types are described. These three have an intriguing parallel to those of Buckley and Brooke (1992) and Brockhoff and Schmaul (1996) and, although the correspondence is not exact, the promise of integration seems to be there. How do the seven in the first paper correspond to the three in his second paper and to those of Buckley and Brooke and Brockhoff and Schmaul? Chiesa provides rich descriptions of the rationales for the different structural approaches. Are these consistent with the descriptions in the other papers?

The autonomy granted overseas technology units is a core theme in these recent papers concerning power and control in networks of globally dispersed technology units. But we have seen that there are various unresolved issues. The two highlighted here concern the apparently contradictory statements about the relationship between autonomy and the amount of communication with headquarters, and apparent disagreements about the role of autonomy in different structural types. Other considerations include the varied approaches to defining autonomy and to the nature of different kinds of control. These may have a role to play in resolving the issues identified. If the varied approaches to classifying structural types could be integrated into a single system, it might enable a better integration of other aspects of the literature, and provide a way to resolve some of the apparent inconsistencies. There is no doubt that thorough empirical work has been done, and that the results do make substantive contributions to our understanding. But, given the apparent contradictions and the lack of consensus about the different structural types, it seems that some more fundamental level of understanding is needed. Such understanding may be provided by better theory.

The current paper will provide a theoretical integration of much of the work reviewed above. It will develop a model of eight different structural types, then tie those types to the strategic contingencies theory of power (Hickson *et al*, 1971) and Thompson's (1967) model of task interdependence. This new model will be used to integrate structural models already in the literature and to resolve some of the issues described above. In addition, the new structural types (developed by considering structures for globally dispersed technology units) will be shown to be consistent with more general models of international business structures. It will also be shown that the new system can generate rigorous, empirically testable hypotheses and some implications for practising managers.

A Classification of Structural Cells

The first step in building the new model will be to provide standard terms for the different kinds of structures found in networks of globally dispersed technology units. These terms are based upon the concept of a structural cell (Figure 1). A **Structural Cell** is a set of organizational units connected to one lead unit, which acts as the cornerstone of the cell, and will be called the **Centre Unit**. The units connected to the centre unit are called **Periphery Units**. In a firm with globally dispersed technology units, for example, the corporate R&D office in the home country will usually be the centre unit, and the globally dispersed labs will be the periphery units. The terms "centre unit" is intentionally ambiguous so it can encompass a wide range of arrangements, running from those in which the centre unit is clearly superordinate with the periphery units reporting to it, to those in which the lead unit is more "a first among equals", working in collaboration with the periphery units.

Please insert Figure 1 approximately here

Structural cells can be classified on the basis of three of their characteristics; (1) the strategic significance of the work done by their periphery units, (2) the mutual interconnected ness of periphery units with each other, and (3) the interconnectedness of periphery units with the centre unit. **The strategic significance of the work of periphery units** varies along a continuum anchored at the low end by units which do work of only minor significance, such as developing minor product modifications for a particular, small market and; at the high end, by units which do work of great significance to the firm such as managing a world product mandate for a large market. **The mutual interconnectedness of periphery units** runs the gamut from periphery units which have virtually no direct communication with each other to those in which the periphery units engage in deep and frequent communication on complex issues, with or without the centre involved, and often with more than two at a time. **The interconnectedness of periphery units with the centre unit** is the level of communication that the periphery units have with the centre unit, ranging from minimal to systematic and ongoing, perhaps several times a day on a broad range of issues. Structural cells can be classified as low or high on each of these three characteristics, yielding the eight types of structural cell listed in Table 1 and assigned numbers.

Please insert Table 1 approximately here

The complete structure of a firm is a combination of structural cells which are stacked on top of each other. Except for those at the very top and bottom, every unit in an organization is part of two structural cells. As shown in the upper part of Figure 2, the cells in the middle are simultaneously periphery units in an upper cell, and centre units in a lower cell. Structural cells can also be multi-tiered. In the lower part of Figure 2, the cell has two levels of periphery units. The upper tier consists of units reporting to the centre which do work of high strategic importance (large circles), and the lower tier consists of units which do work of low strategic importance (small circles). We will now show how structural cells fit with the strategic contingencies theory of power.

Please insert Figure 2 approximately here

The Strategic Contingencies Theory of Power

The strategic contingencies theory of power explains how organizational units come to have power over other organizational units (Ashar and Shapiro, 1988; Harpaz & Meshoulam, 1997; Hickson *et al*, 1971; Hinings *et al*, 1974; Lachman, 1989; Salancik and Pfeffer, 1974; and Saunders, 1990). It uses a definition of power based upon that of Dahl (1957), who defined power as the ability of a social unit to influence the behaviour of other social units, in the pursuit of its own interests. Strategic contingencies theory has applied this basic concept to a particular kind of social unit, departments in formal organizations.

A good definition for our uses here is that of Harpaz and Meshoulam (1997), "power ... is the capacity of a subunit to influence the behaviour of another subunit" (p. 108). This definition provides for both horizonal and vertical power relationships in organizations. A unit might influence the behaviour of a unit below it in the hierarchy (eg. regional headquarters influences the activities of units located in cities within its territory); a unit might influence the behaviour of a unit above it in the hierarchy (eg. a unit in a particular city might convince its regional headquarters to allow greater price flexibility on a product, given the appearance of a strong competitor in its local market); and a unit might influence the activities of a peer unit (eg. the unit in Dallas might convince the unit in Houston to ship it some product to see it through a period of unexpectedly high sales).

Strategic contingencies theory goes on to propose that organizational units will have power to the extent that they effectively deal with the events and activities that are essential for attaining organizational goals (strategic contingencies). The degree to which a unit does deal with such critical events and activities is based upon a number of factors. Authors vary in their precise definitions of these factors and in the number of separate factors they list. A number of refinements have been suggested to the list of such factors proposed by Hickson *et al* (1971) in their original articulation of the theory. It is beyond the scope of this paper to resolve these issues of definition and concept (see Saunders, 1990; and Ashar and Shapiro 1988; for a discussion of them). The factors listed below have been identified by various authors as aspects of critical contingencies (Ashar and Shapiro, 1988; Hickson *et al*, 1971; Hinings *et al*, 1974; Lachman, 1989; and Salancik and Pfeffer, 1974). Beside each, in brackets, is the term used by Hickson et (1971), in their seminal paper, which is most closely related to the concept as defined here. According to critical contingencies theory, then, an organizational unit will have power over other organizational units on the following bases:

1. **Criticality** (Coping with uncertainty)

   This has to do with how critical to the success of the firm the work of the unit is. In the case of technology units, the question is how closely the work of the unit is to the technology core competencies of the firm. The more critical the work of a unit, the more influence it will have over other units.

2. **Substitutability** (Substitutability)

   This is the degree to which the work of the unit could be done by alternate means (inside or outside the firm) at comparable cost. For example, a very generic technology might easily be out sourced to any one of a number of supplier companies, while the only source in the world for another technology might be one particular lab of the firm. The less substitutable the work of a unit, the more influence it will have.

3. **Pervasiveness** (Centrality)

   This is the degree to which the unit interacts with other units in doing its work. The greater the pervasiveness of a unit, the more influence it will have.

4. **Immediacy** (Centrality)

   This is the time lag between stoppage of work in the unit and the cessation of the work of the firm as a whole. More immediacy gives more influence.

Power Relationships in Structural Cells

The model of structural cells presented above can now be tied to the strategic contingencies theory of power. That model classified structural cells using three of their characteristics; the strategic significance of the work done in the periphery units, the mutual interconnectedness of the periphery units, and the interconnectedness of the periphery units with the centre unit. Eight types of structural cells were identified based upon these characteristics (Table 1).

Using the strategic contingencies theory of power, we can rank order these eight cell types according to the influence of their periphery units. This is because the three dimensions used to classify the cells can be connected conceptually to the bases of power proposed by strategic contingencies theory. The first dimension, the strategic significance of the work done in the unit, determines the criticality of that unit. Those cells whose periphery units do technology work of high strategic significance will have more influential periphery units (all else being equal) than cells whose periphery units do work of low strategic significance. The second dimension, degree of mutual interconnectedness of periphery units, is related to the strategic contingency factor, pervasiveness. Periphery units with many communications connections among themselves will have more influence than those with few. The third dimension, interconnectedness with the central unit, is also related to pervasiveness. Periphery units with strong ties to the centre will have more influence than those with weak connections. The combination of these three dimensions determines the relative influence of periphery units in different kinds of structural cells. For example, in cell 1 (Table 1), periphery units do work of high strategic significance, have high interconnectedness with each other and with the central unit. They have more influence than periphery units in cell 8, which do work of low strategic significance, have few connections with each other and have little connection with the centre unit. Taking into account all three dimensions, the cell types from 1 to 8, in Table 1, are in descending order of influence for periphery units, as shown in column 2.

Please insert Table 2 approximately here

Three Generic Cell Types

Now that the influence of periphery units in eight different cell types has been specified using strategic contingencies theory, we will identify three generic cell types based upon structural types identified in the literature. This identification will establish the connection between the model proposed here and the empirical observations reported in the literature. The three types proposed here will be based upon the types suggested by Chiesa (1996a, b), Brockhoff and Schmaul (1996) and Buckley and Brooke (1992). Chiesa (1996a, b) presents somewhat different systems for classifying structures in his two papers. At this point we will focus on his second paper (Chiesa, 1996b) since it presents a polished conceptualization of three kinds of structures. The names used here for the generic structural cell types are closest to those of Buckley and Brooke, so we will begin the discussion with them.

The first of Buckley and Brooke's (1992) types is the hub model. In it, decision making is centralized at headquarters which assigns supporting tasks (of small strategic significance) to the overseas units. There is no mention of mutual interaction by periphery units. Brockhoff and Schmaul (1996) provided an empirically based refinement of the hub structure, which also made no mention of interaction at the periphery. They found periphery units in the hub model to have the least autonomy of any of the cells they studied. Chiesa's (1996b) Central Global Labs structure corresponds to the hub model. The structure consists of a home country lab in which the most significant technology resources are concentrated, and globally dispersed small units which feed market information to the centre, and/or adapt products developed at the centre to local markets. The centre lab controls and coordinates. Chiesa does not mention any communications among periphery units. These structures will be called hub cells here.

In **Hub Cells** then, periphery units do work of low strategic significance and have low mutual interconnectedness. The degree of interconnectedness of the periphery units with the centre is unclear. In Table 2, the hub is either a cell 7 or 8, depending upon the interconnectedness with the centre unit. The periphery units in these cells have the lowest levels of influence of any of the eight types. The hub structure can be pictured as shown in Figure 3, which draws on Chiesa's design.

Please insert Figure 3 approximately here

Buckley and Brooke's (1992) second structure is the "network model". In it, overseas technology units take on strategically significant tasks, such as responsibility for entire foreign markets or having world product mandates. Brockhoff and Schmaul (1996) propose that when strategically important work is given to periphery units they will be more successful if they are also charged with coordinating the activities of other periphery units involved in the areas of their mandates. When such coordination responsibility is given to periphery units, Brockhoff and Schmaul call the structure the "competence model". They found that periphery units in this structure have a mid-level of autonomy, when compared to their other two structural types. The network model corresponds to Chiesa's (1996b) Integrated Global Laboratories, in which significant product development capabilities are dispersed globally. Collaboration among these dispersed, high powered units is necessary for the kinds of products these firms develop. These descriptions are vague about the amount of interconnection between the centre and periphery units. These structural arrangements will be called network cells here.

In the **Network Cell** then, periphery units do work of high strategic significance and have high mutual interconnectedness. The degree of interconnectedness with the centre unit is unclear. The network cell is a type 1 or type 2 in Table 2, depending upon the amount of interaction with the centre unit which is assumed or found. According to Table 2, these are the cells with the highest levels of influence in their periphery units. In Brockhoff and Schmaul's empirical study they were found to have a medium level of autonomy, a finding which will be discussed below. Network cells can be pictured as shown in Figure 3.

Buckley and Brooke's (1992) third structure, the "competitive model" has overseas units which are profit centres which "determine their own spectrum of activities (p. 503)". This high level of autonomy is consistent with Brockhoff and Schmaul's category called the "network structure", whose periphery units had the highest degrees of autonomy of any they studied. Brockhoff and Schmaul's networks give strategically significant tasks to periphery units, which may have more technical competence than the centre unit. There is little interconnectedness among periphery units. The Specialized Global Laboratories of Chiesa (1996b) fit here. In this arrangement, the overseas units can have technical operations as important as those of the central laboratories. The periphery units are given considerable autonomy in their specified areas and their areas are made non-overlapping as much as possible, to prevent duplication of effort. For this reason, there is little interaction among the dispersed units. This arrangement will be called here the cluster cell.

In the **Cluster Cell** then, periphery units do work of high strategic significance but have little mutual interconnectedness. They may have relatively little interaction with the headquarters unit as well, but this is ambiguous. This profile places them in cell 3 or 4 in Table 2, with periphery units having less influence than those in network cells. Cluster cells may be pictured as shown in Figure 3.

This completes the identification of three generic structural cell types, based upon the work of Chiesa (1996b), Brockhoff and Schmaul (1996) and Buckley and Brooke (1992). Hub cells have periphery units with little influence since they do work of little strategic significance and have low mutual interconnectedness. Cluster cells have periphery units with medium influence since they do work of high strategic significance with low levels of mutual interconnectedness. Network cells have periphery units with the highest levels of influence since they do work of high strategic importance and have high mutual interconnectedness.

The Interdependence of Units

The next step in model development will be to characterize the three generic structural types using Thompson's (1967) theory of unit interdependence. Thompson proposed three modes of interdependence (pooled, sequential and reciprocal) and that these modes vary in the amount of interdependence they involve.

Pooled Interdependence involves organizational units working with little interdependence with each other. They are connected only in so far as they draw from and contribute to a common pool of resources. They have little need for interaction, consultation or exchange of information or materials. There is little need for coordination. This description is most apt for cluster cells. In those cells, periphery units operate quite independently of each other and their primary communication with the centre is often via financial controls, which specify the amount of money provided to, and expected from, each unit each year.

Sequential Interdependence occurs when the outputs of one unit are necessary inputs to the work of another unit. More coordination is needed here than with pooled interdependence since schedules must be harmonized and inputs and outputs specified and controlled. Units in hub cells have this type of interdependence. Periphery units provide technology inputs to the centre which uses them in its work. The centre unit coordinates those inputs so there is little need for interaction among the periphery units.

Reciprocal Interdependence occurs when unit tasks are dependent upon each other. One unit cannot carry out its activities until it knows what the others are doing. Mutual adjustment among the units converges on a course of action which is effective for all. This is the highest form of interdependence and makes the highest coordination demands. This is the kind of interdependence found in network cells.

We have now identified three generic structural types found among globally dispersed technology units. The characteristics of the three types and their correspondences to the cell types in Table 2 are shown in Table 3. Note that the studies of globally dispersed technology units have not produced reports of structures that correspond to cell types 5 and 6 in Table 2. Cells 5 and 6 have periphery units that do work of low strategic significance and have high interconnectedness. Why such units do not appear is not immediately apparent.

Please insert Table 3 approximately here

The Network Power Paradox

Now that three generic structural types for overseas technology units have been described, we can turn our attention to an apparent anomaly which was identified above, the network power paradox. **The Network Power Paradox** occurs when an organizational unit which has more power than another unit has less autonomy than that other unit. The example of the network power paradox noted above involved the comparison of periphery units in network and cluster cells. On the basis of the strategic importance of the work done by periphery units, and the degree of interconnectedness of periphery units, strategic contingency theory predicts that the periphery units in network cells will have greater influence than periphery units in cluster cells. Contrary to this prediction, Brockhoff and Schmaul's (1996) empirical data showed clearly that periphery units in cluster cells have more autonomy than periphery units in network cells. How can this contradiction be explained?

The explanation is based upon the distinction between influence and autonomy. Influence, the ability of an organizational unit to affect the activities of other organizational units, is the kind of power most central to strategic contingencies theory. In structural cells, it is the ability of a particular unit in the cell to affect the actions of the other units, and, therefore, of the cell as a whole. We have seen that in hub cells periphery units have little effect on each other because they do work of little strategic significance and have little intercommunication. In contrast, in the network cell, the periphery units have considerable influence on each other, and the centre. This ability of periphery units to influence the actions of other units got little attention in the literature on technology management reviewed above. That literature confined itself primarily to a discussion of autonomy, the ability of a periphery unit to conduct its own affairs without the intervention of others. In the hub cell, for instance, the centre unit has high autonomy since no other unit in the cell can intervene significantly in its actions and decisions.

Although influence and autonomy are not entirely independent, the validity of distinguishing between them can be illustrated by considering the three generic cell types described above. Figure 4 shows their different combinations of influence and autonomy.

Please insert Figure 4 approximately here

In Figure 4, the extremes of influence and autonomy are given by units in hub cells. At one extreme, the centre units in hub cells have high influence and high autonomy. They tell the other units in their cells what to do and conduct their own affairs without interventions by the others. In contrast, the periphery units in hub cells are low in both influence and autonomy. They have no basis upon which to influence the actions of others (work of low significance, little interconnectedness), and must follow the directives of their centre units.

Unlike hub cell units which have extremes of both kinds of power, periphery units of cluster cells have a mix. In cluster cells, periphery units have separate, non-overlapping jurisdictions. They are typically undisputed experts in their own fields, so there is little help or guidance they can give each other. There is little communication among them. Therefore, they have little influence upon each other. Because of the strategic importance of what these periphery units do, and their expertise in their areas, the centre unit is also not well positioned to intervene effectively in their affairs. Consequently, the periphery units in cluster cells have relatively high degrees of autonomy to accompany their relatively low influence.

In network cells, periphery units are also the sole experts in their own fields, which are of high strategic significance. In addition, however, they have high interconnectedness. This gives them high influence on each other, but at a cost. They have attenuated autonomy. Most of what they do is tempered by the inputs of the other units in the cell. Periphery units in network cells have relatively high influence, but they intrude upon each others' autonomy.

These different combinations of influence and autonomy can be explained using strategic contingencies theory and Thompson's (1967) model. The most important concepts here are; that the most fundamental basis for the power of an organizational unit is the strategic importance of what it does (from strategic contingencies theory), and that the work of different units can vary in interdependence (Thompson). Table 4 summarizes the explanation to follow.

Please insert Table 4 approximately here

In Table 4, for purposes of illustration, assume that in a given structural cell the periphery units all do work of roughly equivalent strategic importance. Also simplify by considering the two situations shown as columns in Table 4. In the right hand column, the periphery units do work which is of considerably less importance than the work of the centre unit. In the left, the periphery units do work which is of almost equal importance to the centre unit. On the right, the periphery units have considerably less power than the centre unit. On the left, periphery units have power comparable to that of the centre.

When periphery units have power comparable to that of the centre, they will exercise that power as autonomy or influence, depending upon the interdependence in their work. In Table 4, in the upper row, the work of periphery units is highly interdependent. For it to be done effectively, units must have inputs to each other's work so that all the necessary expertise is brought to bear. The periphery units, therefore, have influence upon each other. But this mutual influence lowers their individual autonomy. So, in the upper left cell of Table 4, the relatively high power of the periphery units is manifest primarily as influence, rather than autonomy. In the lower row, there is little work interdependence, so there is little basis in the task requirements for the units to intervene in each other's work. As a result, they have little influence upon each other, even though they have high power. Their power is manifest primarily as autonomy. They pursue their own affairs with relatively little interference from others. Associated with this is a low level of interconnectedness. So, in the lower left cell in Table 4, the high power of the periphery units is manifest primarily as autonomy.

The right hand column of Table 4 shows situations in which the power is concentrated in the centre unit so the periphery units have little power to exercise as either influence or autonomy. As a result, the degree of interdependence of the work has little effect. Whether their work is interdependent or not, they all follow the directives of the centre, which provides whatever coordination is demanded by the interdependence of the work.

Thus, the network power paradox is resolved using strategic contingencies theory and Thompson's model. The inclusion of these theories in the description of the three generic structural types is shown to be useful for resolving apparent anomalies. We will now move on to demonstrate the scope of the model developed here.

A Review of Chiesa's Structural Types

The work of Chiesa was used above in the development of the model of three generic structural cell types. Chiesa's second (1996b) paper was used for that task because it includes a well refined description of three structural types. However, Chiesa's first paper (Chiesa, 1996a) includes descriptions of seven structural types. If the model developed here is to have credibility, it should be able to encompass the seven types described in the first paper as well as the three in the second. We will now demonstrate this.

Chiesa (1996a) did an extensive field study of geographically dispersed technology units. In order to organize his findings, he classified the organizational structures he found into seven categories. Four of the categories are for product development units (which Chiesa called exploitation R&D) and three categories were for research oriented units (which Chiesa called experimentation R&D). For each of the seven categories he provided a rich description of the kinds of units involved and how they operate. What follows are the mappings of each of his seven categories onto the model developed here.

Isolated Specialization Structure (Development)

In this, the first of the development structures, the centre unit (headquarters in the home country) assigns each foreign lab responsibility for developing a product and/or process, with a global mandate (strategically significant). All the technical and business skills needed by the unit are located at its site so there is little need to interact with other units. So, there is little interconnectedness among periphery units in this structure. The degree of interconnectedness with headquarteres is ambiguous. These units do highly critical work with low mutual interconnectedness. They are, therefore, cluster cells in Table 3.

Supported Specialization Structure

This second category of development structures also has the centre unit assigning separate global responsibilities for important product areas to globally dispersed periphery units. However, each periphery unit is supported by dispersed scanning units which feed market and other information to it. The scanning units are typically small, focused on particular markets or technical areas, and normally just pass on information to the centre unit. They do not have any sizable influence on the strategically significant work done at the centre.

The supported specialization structure, then, is a case of a stacked structural cells, as shown in Figure 2. In the upper cell, the centre unit is the global headquarters of the firm and the periphery units are the labs given global mandates (high strategic significance). There is little interconnectedness among the periphery units in this cell since they have all of what they need themselves, or from their scanning units. This upper cell of the supported specialization structure is, therefore a cluster cell in Table 3. In the lower cells, the global mandate labs serve as centre units, each with a set of periphery scanner units connected to it. The scanning labs do work of minor strategic significance and are not mutually interconnected. The lower cells in the supported specialization structure are, therefore, hub cells in Table 3.

Integrated Local Lab Structure

In this third development structure, the central lab is responsible for developing major new products, which are adapted by periphery units to their local markets, which are differentiated so that a single global product will not do for all. Although the skills of periphery units can be considerable, they are, by and large, specific to their own markets and as adaptors. Their work, therefore, is not of high strategic importance to the firm as a whole. They have little communication with each other since most of their work involves liaisons with the centre unit concerning product adaptations. Sometimes an innovation made in one periphery unit is integrated by the centre into a new product design. However, for the most part, periphery units have relatively little influence upon new product development which is carried out mainly by the centre. The integrated local lab structure is, then, a hub cell in Table 2.

Integrated Global Lab Structure

This is the fourth and last of the development structures. It consists of a number of labs, each with strong skills in important areas of marketing and/or technology, which are all related to some general product area. The labs work collaboratively in coordinated projects which develop global products. They have an active and influential role to play in these innovation activities. The high strategic significance of what the periphery units do, and their high interconnectedness, make this a network cell in Table 3.

Isolated Specialization Structure (Research)

This is the first of Chiesa's research structures. In it, the firm creates a single centre for each of its generic technologies. This gives economies of scale and creates self-contained global centres of excellence for each important area of technology. The centres do not collaborate with each other. Given the high strategic importance of the work, and the low interconnectedness of periphery units, these are cluster cells in Table 3.

Specialized Contributors Structure

In this research structure, the periphery units work in narrowly specialized areas and transfer the knowledge they develop to the centre unit. The centre coordinates the activities of the periphery units and integrates their work into final technical outcomes. The work of the periphery units is so specialized that it is not usually of high strategic importance. They do not interconnect with each other, although they may work quite closely with the centre unit to ensure the proper inclusion of their contribution. The periphery units have little influence on the central innovation process. They just carry out parts of a plan specified by the centre. With low strategic importance and low mutual interconnectedness, his is a hub cell in Table 3.

Integration Based Structure

This is the third and last category of research structure and, in it, each periphery unit is allowed to undertake its own research initiatives in its own important area of technology. There is continuous interaction among the periphery units which have a relationship of reciprocal interdependence, involving considerable influence upon each other which leads to attenuated autonomy. An organization may have several such networks each with a "network supervisor lab" coordinating its activities. In this case there is a stacking of cells.

In the upper level of the integration based structure the centre unit is the global headquarters of the firm and the periphery units are the individual network supervisor labs. Chiesa implies that there is a high degree of interaction among these supervisor labs and that each is in charge of an area of technology which is of high strategic importance to the firm. This makes the upper level a network cell in Table 3.

In the lower level of the integration based structure, the centre unit is a network supervisor lab and the periphery units are centres of excellence in particular technologies of high strategic importance. These structural cells are, therefore, network cells in Table 3.

This completes the analysis of the seven structural types identified by Chiesa (1996a) and their classification as one of the three generic cell types shown in Table 3. The results of this analysis are summarized in Table 5. This analysis gives considerable support to the new system, showing it to be capable of integration beyond the three studies (Brockhoff & Schmaul, 1996; Buckley & Brooke, 1992; and Chiesa, 1996b) used to develop it. We will now go on to consider further implications of the new model.

Please insert Table 5 approximately here

Implications

Now that the model developed here has been shown to integrate a number of models arising from the study of globally dispersed technology units, and to be able to resolve some of the apparent contradictions in the literature, its further implications can be explored. This will be done by showing its consistency with models of global organizational structure that have been proposed in the general international business literature, not just that which focuses upon technology management. The ability of the model to generate specific, empirically testable hypotheses and advice for practicing managers will also be demonstrated.

Integrating General International Business Models

The models of general international business organization about to be discussed have probably influenced that thinking of those who have focused upon international technology management. It is important to demonstrate clearly that the model developed in the present paper can be applied not only to technology activities but to many others as well.

Bartlett and Ghoshal (1990) have had tremendous impact upon the thinking about how multinational organizations are, and should be, organized. Central to their thinking on these issues has been the articulation of four general approaches to multinational commercial activity and innovation. Each of these four approaches can be classified within the system developed here and shown in Tables 2 and 3.

One approach described by Bartlett and Ghoshal (1990) is the "centre-for-global", in which, "the key assets and capabilities of the company, and key value-adding activities such as product development and manufacturing, are retained at the centre, or are tightly controlled by the centre" (page 251). The overseas subsidiaries are pipelines which deliver centrally made products to their local markets. Communications among periphery units are not mentioned by Bartlett and Ghoshal. Their primary contacts are with the centre whose plans they carry out. A "centralized hub" structure is adopted by organizations taking this approach. As the name suggests, and given the strategic importance of the subsidiaries, their communication networks, and their power relationships to the centre, these are hub cells in Table 3.

Another structure is the "decentralized federation", used with the "local-for-local" approach. Here, the "key assets and capabilities of the multinational are dispersed among the different subsidiaries, each of which is allowed to develop as a self-contained autonomous operation able to respond to local demands and opportunities" (Bartlett and Ghoshal, 1990, page 217). The granting of strategically important mandates to periphery units; the lack of mention of interconnections among periphery units; and the high autonomy of periphery units; are all consistent with classifying the decentralized federation as a cluster cell in Table 3.

In recent years, suggest Bartlett and Ghoshal (1990), some firms have abandoned the two traditional approaches to international business (the centre-for-global and the local-for-local, just described) and have turned to a "globally linked" approach. In it, many different capabilities of the MNC (at both the headquarters and the subsidiary level) are pooled to create and implement innovation, jointly. In one example, the powerful European, Japanese and American subsidiaries of multinationals are described as working in a collaborative manner involving intensive communication among them (coordinated by headquarters) to produce a new product. In this example, there is strategic importance and strong interconnection in the periphery, making it a network cell in Table 3. Bartlett and Ghoshal emphasize that the extremely high coordination costs of this approach are its primary drawback.

Finally, Bartlett and Ghoshal (1990) have identified a fourth approach, the "locally-leveraged". In it, innovations originally developed in national subsidiaries for their local markets are adopted for global exploitation in other markets. The success of this approach, as for the globally linked, depends upon, "an interdependence of resources and responsibilities among organizational units ...[and]... a set of strong cross unit integrating devices" (Bartlett and Ghoshal, 1990, page 233). The strategic significance of their work, and strong interconnectedness among periphery units makes this a network cell in Table 3.

This completes the alignment of the Bartlett and Ghoshal (1990) types with the model proposed here. A clear set of correspondances has been demonstrated. The robustness of the model summarized in Tables 2 and 3 is shown by the fact that even though Bartlett and Ghoshal are talking about multinational organizations at a broader level (including marketing and manufacturing as well as technology) than the studies used to develop the model, the types of approaches described by Bartlett and Ghoshal can be classified by it.

Hakanson (1990) has shown that an earlier version of Bartlett and Ghoshal's model, as described by Bartlett (1986), has correspondances with other earlier models of multinational firms. In Bartlett (1986) the three structural types are called centralized hub, decentralized federation and integrated network. The correspondances between these and the later Bartlett and Ghoshal (1990) types, and the types described here, are obvious. The correspondances between Bartlett (1986) and other earlier models (Franko, 1978; Perlmutter, 1969) are shown by Hakanson in his Figure 10.2 (page 264), and relevant portions of it are shown here in Table 6. These correspondances are not discussed in detail but they do show that the model developed here has strong possibilities of integrating much earlier work as well.

Please insert Table 6 approximately here

Malnight (1996) used a case study of Citibank to demonstrate the transition of a single firm from a structure which he called the "decentralized model" to a structure he called a "network-based model". The decentralized model involves significant organizational resources being decentralized to major national markets outside of the home country and the granting of considerable autonomy to those periphery units. These characteristics indicate that Malnight's decentralized model is an example of a cluster cell in Table 3. Malnight describes his network-based model as having considerable resources located in the periphery, and a high level of communication there as well. This suggests that the network-based model of Malnight is a network cell structure in Table 3. Although Malnight's work is not focused upon the managment of technology, it is important because it adds a rich, descriptive understanding of the processes by which cluster cells can evolve to network cells. That understanding may provide insights useful in understanding how the technology function has made the same evolution, in some firms.

Hedlund and Rolander (1990) describe the heterarchical MNC as the very model of the modern multinational. Its most distinguishing characteristic is its use of a wide range of governance modes and many centres of many different kinds. A given heterarchical firm might use all three, or some subset of, the structural cells shown in Tables 2 and 3. It would use various combinations of them, as appropriate, in meeting the demands of its ever-changing international environment. Coordinating different cell types will clearly be a management challenge, as will be the management of their constant evolution from one form to another. Understanding the essence of each type, as outlined in Tables 2 and 3, should provide some help to managers charged with the management of such eclecticism. More on this below.

This brief survey of a number of important papers from the field of international business should make it clear that the model of structural cell types developed here for technology units have validity in that wider context. It has now been shown that the strategic contingencies theory of power and Thompson's model of unit interdependence apply to the general international business arena. This general applicability of the model bodes well for its ability to integrate, in more detail, a wide body of literature. Now that the scope of these ideas has been demonstrated, we can turn to the development of more specific hypotheses about the technology units of organizations.

Generating testable hypotheses

The model developed here has considerable potential for guiding future research. This will be shown by demonstrating its ability to generate empirically testable hypotheses about power in globally dispersed technology units.

The ability of the model to contribute in this way is based upon its clear specification of the fundamental characteristics of organizational structures. Although a variety of different characteristics of structures have been broached by previous studies, there has been no specification of which are the most fundamental and which should be the defining attributes of the various types. The model developed here defines structural types on the basis of the strategic importance of what they do, the interconnectedness of periphery units, and the interconnectedness of periphery units with the centre. These dimensions are then conceptually linked to strategic contingencies theory and Thompson's model of unit interdependence. Thus, a theoretical foundation has been put in place. Further, with these theory-based dimensions, the structural cell types described here can be identified in a number of other descriptions of organizational structures in international contexts, not just those involving technology management. In short, the model has a robust, theory-based way of defining structural types that should be widely applicable and can provide a starting point for empirical work.

Given that structural cells can be defined with three dimensions and, given their basis in strategic contingencies theory, it is possible to formulate hypotheses about the structures and the power arrangements found in them. For example, on the basis of the earlier discussion concerning autonomy and influence, the following hypotheses can be proposed:

Hypothesis 1 Periphery units in network cells have less autonomy than periphery units in cluster cells.

Hypothesis 2 Periphery units in network cells have more influence than periphery units in cluster cells.

These hypotheses could be tested in research which identifies the types of structural cell by measuring strategic importance and interconnectedness using questionnaires. That of Nobel and Birkinshaw (1996) might be used to measure interconnectedness (communication). The dependent variables could also be measured by questionnaire. Brockhoff and Schmaul's (1996) instrument for measuring autonomy might be used and a new questionnaire devised for measuring influence. The literature on strategic contingencies theory might be a ready source of other appropriate instruments. In any case, original questionnaires could be developed for all of these variables.

Alternately, these hypotheses might be tested using Chiesa's (1996a) data. The rich interview data he collected might allow a test of the above two hypotheses when restated using his structural types, as follow:

Hypothesis 3 Periphery units in integrated global lab structures have less autonomy than periphery units in isolated specialization structures.

Hypothesis 4 Periphery units in integrated global lab structures have more influence than periphery units in isolated specialization structures.

Variants of these hypotheses can be generated using Table 5 as a basis for the correspondences between Chiesa's seven structural types and the structural types shown in Tables 2 and 3.

Using this general approach, most of the characteristics attributed to generic structural cell types, as shown in Table 3, could be and should be subjected to empirical test.

Assisting Managerial Thinking

Managers involved in transnational technology management are faced with complex issues as they attempt to cope with the highly uncertain global economy. Significant among the issues with which they must deal are those having to do with control, autonomy and influence in the structures they manage (Asakawa, 1996). The literature reviewed above makes it clear that the decisions (good and bad) which they make about these issues are influenced by a great many conflicting factors which pull managers in many directions. Sorting out which factors are most important is a considerable task and there is no ultimately "right" answer.

The model developed here provides one basis for deciding what is most fundamental. Strategic contingencies theory and Thompson's model of organizational unit interdependence are two sets of ideas used here which have wide legitimation in the field of organizational studies. They suggest that the manager should take two factors as fundamental in their thinking about power in structural cells, the strategic importance of what organizational units do and the interconnectedness of the work of different organizational units. Other factors included in those theories can also be considered, but these two are the most important.

When managers must decide how much power and/or influence should be accorded to particular organizational units, they should remember that the power motives of the managers of those units are not the only considerations suggesting that more power is better. More than empire-building may be going on. Yes, there may be empire building, but in addition there may be the elemental forces associated with the strategic significance of what a particular unit does. The repeated demonstration of the role of strategic significance in accruing power to an organizational unit, reflected in strategic contingency theory, should cause managers to consider seriously the appropriate method for the granting and managing such power, rather than thinking of ways to resist the devolution of power.

A similar set of considerations applies to interconnectedness. Task interconnectedness is a reality which must be effectively handled. Handling it demands communication and the necessary level of communication depends upon the degree of interconnectedness. But that communication can act as a conduit for organizational influence, which, when combined with strategic importance, may constitute a force for the decentralization of power that is interfered with only at the manager's risk. This reality must inform the thinking of managers.

For example, managers who have strong needs to enhance his own feelings of self-efficacy, and who are in organizations with cultures which value centralized control, may be hesitant to adopt network cell structures even when the realities of their businesses suggest that they are the most appropriate form. However, the understanding of the fundamentals of the operations of such forms, given by strategic contingencies theory and Thompson's model, might provide a basis for effective decision-making. An understanding of such fundamentals should be of help to all managers who face these kinds of issues, not just those who are blind-sided by contextual factors or their own personal attributes.

Conclusions

This paper has used the strategic contingencies theory of power and Thompson's model of organizational unit interdependence to develop a model of the structures used to manage networks of internationally dispersed technology units. The broad, integrative power of this theory-based model has been demonstrated by using it to integrate similar models available in the technology management literature (which are based primarily upon observation), and similar models in the international business literature. The model was also able to resolve some apparent inconsistencies and contradictions in the literature by applying theoretical concepts of power, autonomy and influence. These theoretical clarifications were then used to develop specific hypotheses about power in globally dispersed technology units: hypotheses that are very amenable to empirical test. The pursuit of such theory-driven hypothesis testing holds the promise of changing this field of study from its current state of domination by descriptive (albeit, well executed) empirical studies, to one pursued with more rigour and attention to fundamental theoretical ideas. The potential of this approach for providing advice to managers was also demonstrated. In short, the model developed here has considerable promise as a vehicle for advancing our theoretical and practical understanding of the management of globally dispersed technology units.

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Table 1

Eight Types of Structural Cells

Cell Types	Cell Characteristics		
	Strategic Significance	Mutual Interconnect	Centre Interconnect
1.	high	high	high
2.	high	high	low
3.	high	low	high
4.	high	low	low
5.	low	high	high
6.	low	high	low
7.	low	low	high
8.	low	low	low

Notes. Strategic Significance - strategic significance of the work done by the periphery unit. Mutual Interconnect - the level of communication among the periphery units in the structural cell. Centre Interconnect - the level of communication between the periphery units and the centre unit of the cell.

Table 2

Peripheral Unit Influence in Different Structural Cell Types

Types	Influence Levels	Cell Characteristics		
		Strategic Significance	Mutual Interconnect	Centre Interconnect
1.	highest influence	high	high	high
2.		high	high	low
3.		high	low	high
4.		high	low	low
5.		low	high	high
6.		low	high	low
7.		low	low	high
8.	lowest influence	low	low	low

Notes. Strategic Significance - strategic significance of the work done by the periphery unit. Mutual Interconnect - the level of mutual communication among the periphery units in the structural cell. Centre Interconnect - the level of communication between the periphery units and the centre unit of the cell. Influence Level - the amount of influence held by periphery units in the cell.

Table 3

Characteristics of Three Generic Structural Types

	State of Characteristics in the Different Cell Types		
Characteristics	Network	Cluster	Hub
Cell types in Table 2	1 and 2	3 and 4	7 and 8
Significance of work of periphery units	high	high	low
Interconnectedness, among periphery units	high	low	low
Interconnectedness, centre to periphery units	high/low	high/low	high/low
Type of work interdependence	reciprocal	pooled	sequential
Amount of work coordination needed	high	low	medium
Power of periphery units	high	high	low
Influence of periphery units	high	low	low
Autonomy of periphery units	low	high	low

Table 4

The Bases for Influence and Autonomy

		Importance (power) differential	
		low	high
work interdependence	high	Influence Higher than Autonomy	Low Influence and Autonomy
	low	Autonomy Higher than Influence	Low Influence and Autonomy

Table 5

The Chiesa Categories Classified by Structural Cell Types

Network Cells (Structural Cell Types 1 or 2)	
	Integrated Global Lab Structure
	Integration Based Structure (upper)
	Integration Based Structure (lower)
Cluster Cells (Structural Cell Types 3 or 4)	
	Isolated Specialization Structure (Dev.)
	Supported Specialization Structure (upper)
	Isolated Specialization Structure (Res.)
Hub Cells (Structural Cell Types 7 or 8)	
	Specialist Contributor Structure (Type 7 only)
	Supported Specialization Structure (lower)
	Integrated Local Lab Structure

Table 6

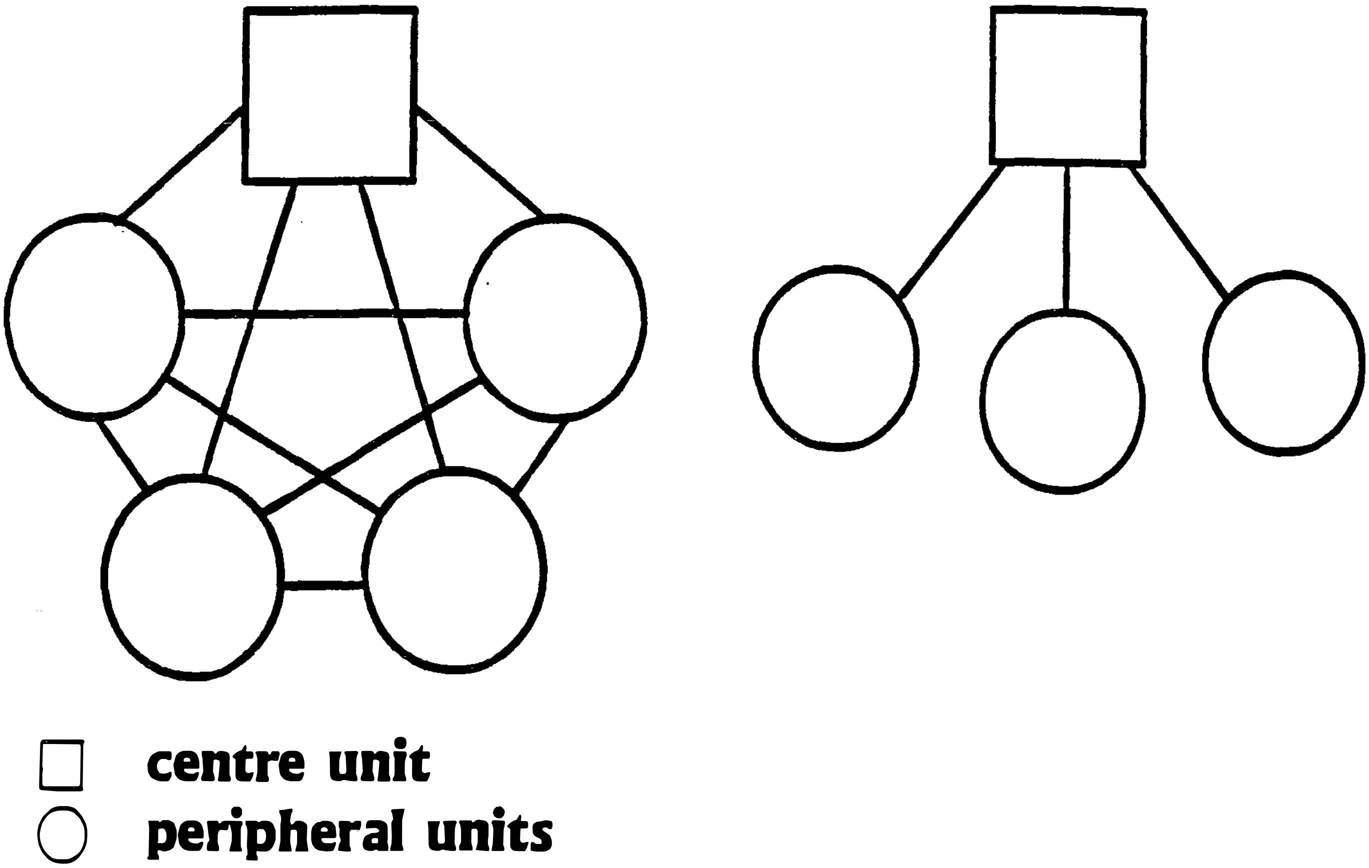
Correspondences among Classifications of Organizational Structures

	Generic cell types from Table 3, above		
Classification sources	Network	Cluster	Hub
Brockhoff & Schmaul (1996)	Competence model	Network model	Hub model
Chiesa (1996a)	Integrated global	Isolated spec. (dev)	Spec. Contrib.
	Integration based	Supported special.	Supp. Spc.
		Isolated spec. (res.)	Integr. Local
Chiesa (1996b)	Global integrated	Global specialized	Global central
Malnight (1996)	Network-Based	Decentralized	--
Buckley & Brooke (1992)	Network model	Competitive model	Hub model
Bartlett & Ghoshal (1990)	Globally linked	Local-for-local	Global-for-local
Bartlett (1986)	Integrated network	Decentralized federation	Centralized hub
Franko (1978)	Global structure	Mother/ daughter	International division
Perlmutter (1969)	Geocentric	Polycentric	Ethnocentric

Note. The classifications for Franko (1978) and Perlmutter (1969) are based upon Hakanson (1990).

Figure 1

Structural Cells

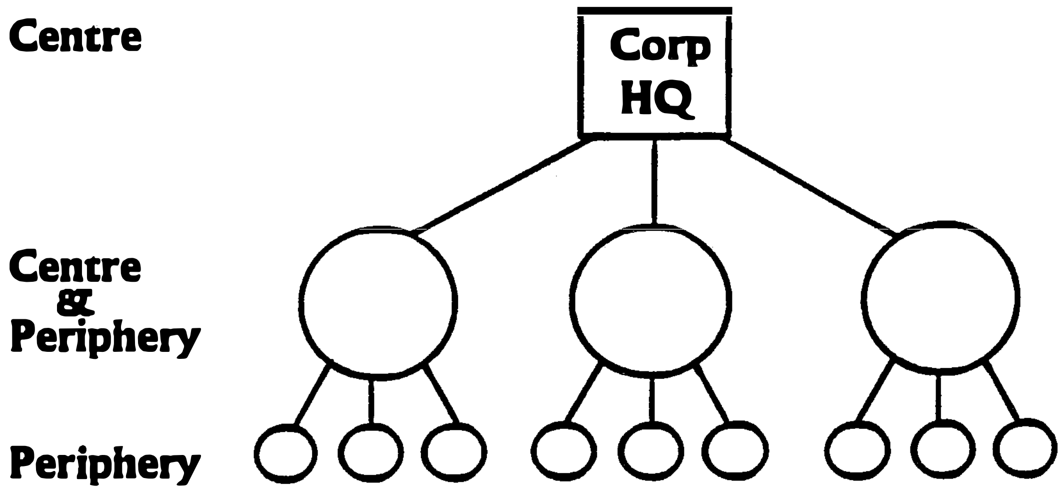


A **Structural Cell** is a set of organizational units connected to one lead unit, which acts as the cornerstone of the cell, and which is called the **Centre Unit**. The units connected to the centre unit are called **Periphery Units.**

Figure 2

Stacked and Multi-Tiered Structural Cells

Stacked Structural Cells



Multi-Tiered Structural Cell

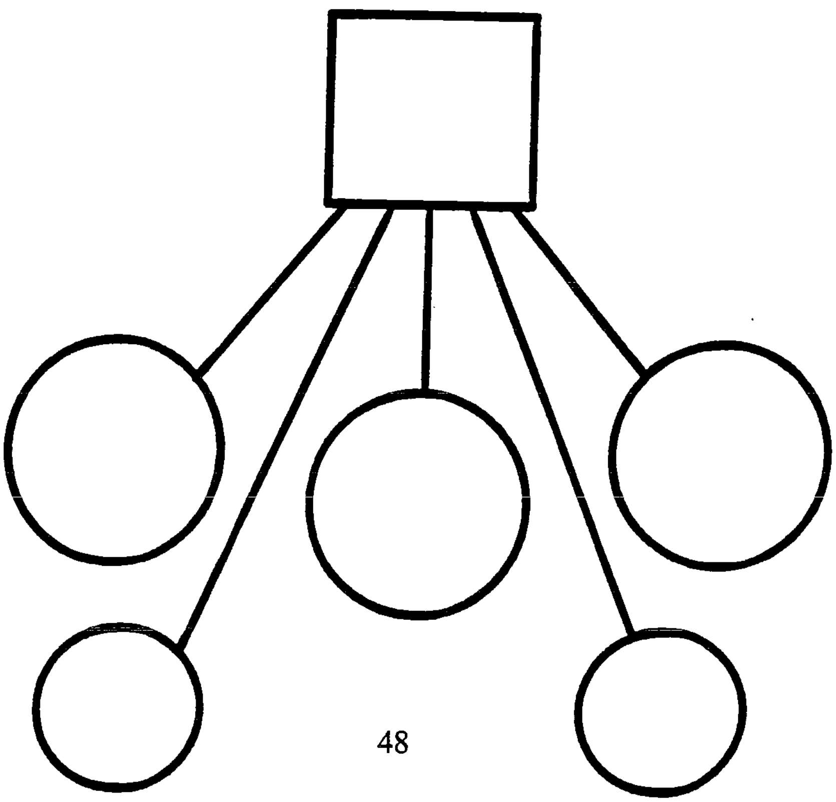


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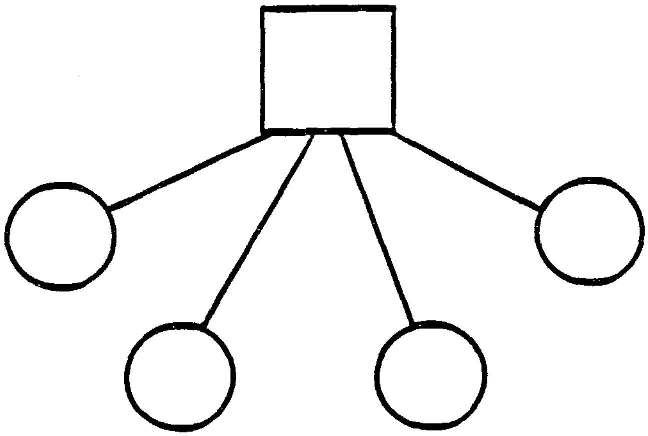
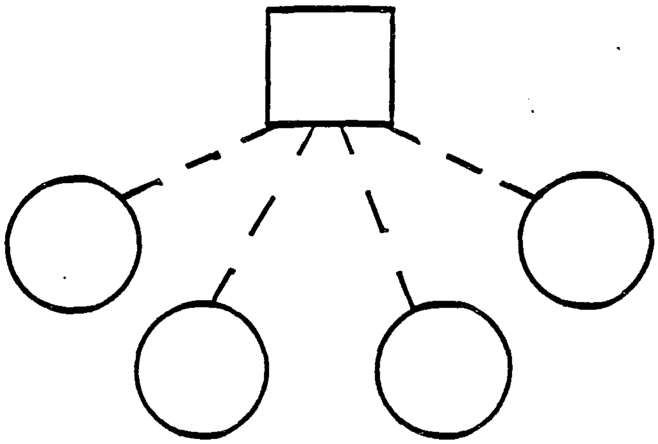
Figure 3

Three Generic Structural Types

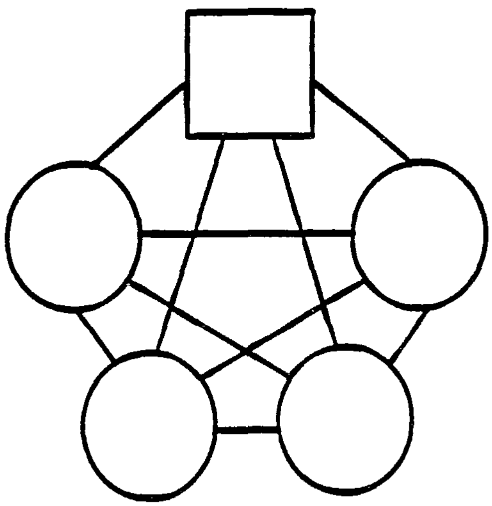
Hub Cell



Cluster Cell



Network Cell



Graphics after Chiesa (1996b)

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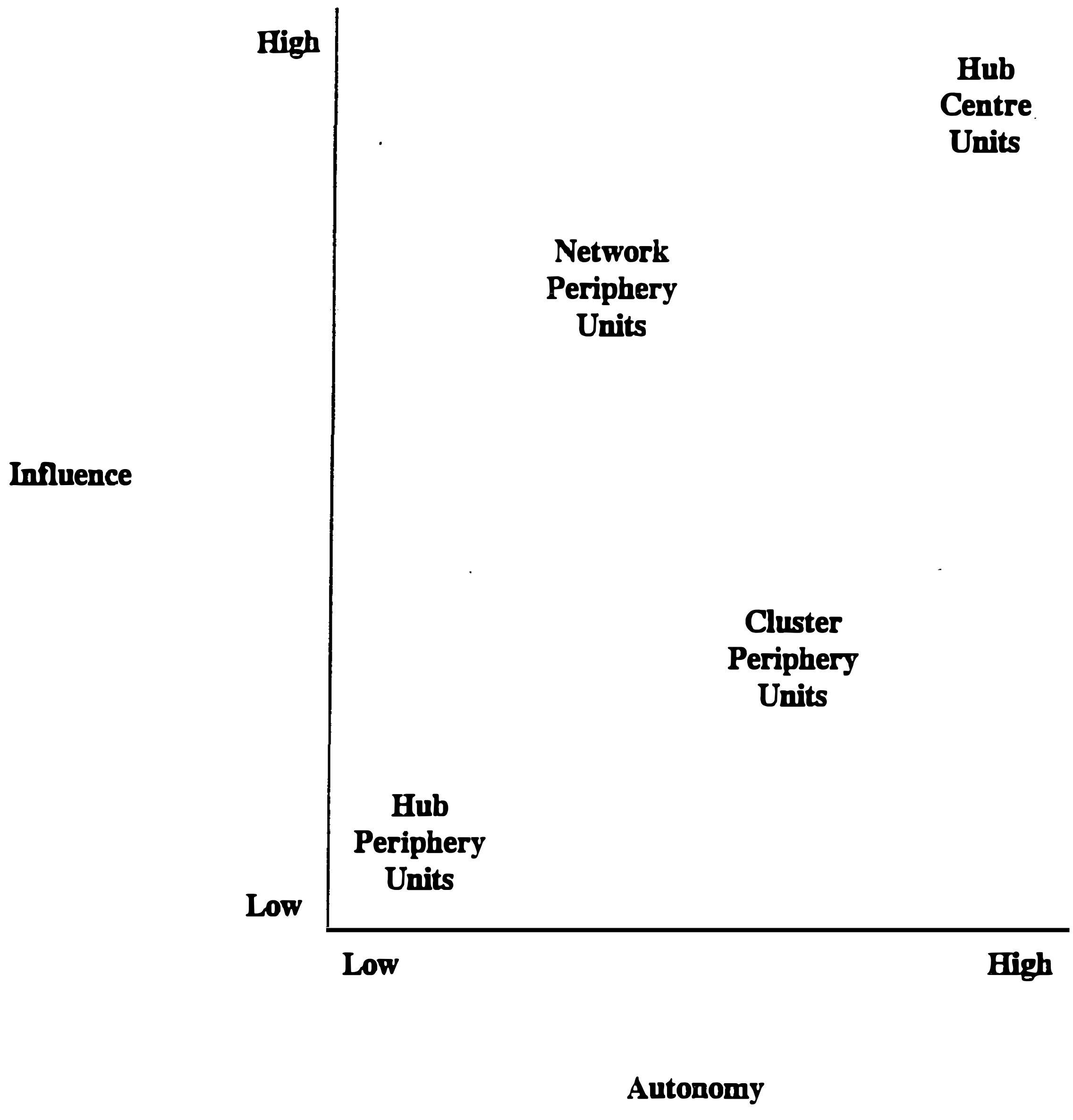
Figure 4

The Influence and Autonomy of Units in Various Structural Cell Types



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