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THE RELATIONSHIP BETWEEN SIZE AND THE ADMINISTRATIVE RATIO IN ORGANIZATIONS: THEORETICAL REFLECTIONS ON THE BASELINE MODEL*

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A baseline model is developed to demonstrate that, when other conditions are held constant, Blau's major theoretical propositions on their relationship between the relative size of administrative components and the size of the organizations can be produced by the logical possibilities for differentiation that are generated by different values of size. The relationships specified by theses propositions are illustrated with calculations from a mathematical algorithm that enumerates possible structural forms for each basic size and assigns the same probability of occurrence to each structure. The implications of the results for the relationship between organizational size and administrative ratios can be reduced from the baseline model which provides an analytical framework for which empirical trends can effectively be assessed.

Key Words: *Organizations, Administrative Ratio, Mathematical Sociology*

INTRODUCTION

A long-standing assumption within administrative literature is that sound control and coordination leads to sound efficiency (Bozeman, 1987; Scott, 2002). The weight of administrative components is critical to develop and maintain a system of control for bureaucratic efficiency, since blockages in the control system constitute the serious problems in public administration. While organizational size has the potential to affect efficiency if there is structural differentiation, the organizational slack is used to develop organizational expertise and resources such as the administrative ratio. What are the implications for the structural changes in producing organizational efficiency?

In the public sector, one of the most widely discussed models in recent years is the new public management which focuses on how the efficiency

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of state agencies could be improved (Bernier and Hafsi, 2007 Dent et al., 2004).[1] Organizational size, typically measured as the number of employees, can cut both ways in terms of organizational efficiency. On the one hand, the matter of efficiency becomes more challenging and more difficult in larger, more complex public agencies. On the other hand, larger organizations typically have greater resources such as expertise, personnel, and budget, devoted to efficiency. If larger size translates into more organizational levels such as differentiation, the potential filtering of extra levels of hierarchy has been considered to hinder efficiency. In contrast to the case, the given organization can build expertise in the effective formation and management of networks, which reduces the associated transaction costs and thus increases organizational efficiency. On balance, these effects may offset each other, obscuring the role of organizational size in this relationship.

Blau (1988) has inductively derived and tested two major theoretical propositions relating size and structural differentiation in formal organizations: (1) structural differentiation is an increasing function of size, and (2) the rate of increase in structural differentiation with respect to size is a decreasing function of size. In all cases, the central question is how sizes of organizations influence structural components and outcomes functioned by differentiation. These propositions are of considerable important, because a number of critical and specific theoretical propositions on the relative magnitude of governance in organizations can be derived from them. For example, the minority of administrative component becomes increasingly more powerful and concentrated as size increases. This process can also enhance problems of coordination and communication within organizations, which can be empirically applied to the real world, including elite structure and organizational leadership.

In an effort to disentangle this issue, the present study is to note that Blau's two propositions can be demonstrated by logical possibilities for differentiation that produces by different values of organizational size with the *ceteris paribus* condition, using the baseline model.[2] A baseline model permits us to calculate an expected value in arithmetic average

[1] The ideological basis of public management has moved toward a set of market-centric assumption that the role of the government should be reduced and confined mainly to security and enforcement (Batley and Larbi, 2004).

[2] All propositions in a scientific theory, including mathematical formulation, are *ceteris paribus* statements, and this condition in those propositions is generated by the aim of research design (Skvoretz, 2000).

for some variables such as differentiation whose numerical values appear in each point of the sample space (Mayhew, 1990). Accordingly, the baseline model has two features: (1) a set of background conditions such as boundary variables; and (2) a uniform possibility of density function defined over a sample space whose points include all the configurations that obtain in the background conditions. For example, A is structurally conducive to B, because A measures a structure which, by definition in the model, creates opportunities for B to occur (Edling, 2002).

In confronting the real world with baseline models, it can be assumed that the opportunity for an event to occur is one of the most important determinants of that event's occurrence. The expectation for the baseline model is the object of the present study to account for the relationship between the relative degree of administrative components and organizational size. Some specific models are illustrated to indicate the effect of size and differentiation on the administrative ratio, and theoretical implications of this model are discussed.

THEORETICAL BACKGROUND

The overall literature review within administrative and organization theory emphasizes the importance of structural variables such as size, differentiation, and administrative ratio in determining key outcomes in the efficiency of public management (Haque, 2001; Jermier, 1998; Thompson, 2006).[3] The effect of size on organizational structure is the central feature of efficiency measurement and indicators, reflecting a significant shift from controlling inputs and procedures to achieving results. For example, organizational restructuring is primarily about downsizing the public sector which leads to the erosion of public interests and services (Batley and Larbi, 2004).

One of the important characteristics in modern organizations is differentiation, which can be divided into a number of structural components. The central concept of differentiation in organizations must be clearly defined in terms that permit translation into operational measures. A dimension of differentiation is any criterion on the basis of which the numbers of an organization are formally divided into positions. This classification includes, in general, critical elements such

[3] There is an abundance of relevant discussion about the conception of size. But size can be measured, in general, by four dimensions among others, that include physical capacity of organization, financial capacity, amount of input and output, and human dimension (Armandi and Mills, 1982; Suh, 2004).

as horizontal differentiation, vertical differentiation, and division of labor (Price, 1997). A structural component is either a distinct official status such as supervisor line or a subunit in the organization. Accordingly, structural differentiation means the degree of classification about functions in terms of any criterion to attain organizational goals (Glenn and Malott, 2004).

Owing to a variety of the pyramid types in organizations, the criterion demands that it can be applicable to most of organizations, showing the condition of differentiation. From this point, the number of minimum administrative component, namely, the number of unit which has no more sub-unit can be a reasonable criterion. Because the number of the minimum administrative component can be an appropriate indicator of structural differentiation, simultaneously, we can have a grasp of that, in respect of the needs of being administrative component when the function is important in organizations.

In this regard, much has been done about the relations between size and differentiation on the aspect that the administrative components carry out the function of control and coordination in organizational behavior (Kettle, 2002; Meier and Bohte, 2003; Steven, 1995). Those studies assumed that the ratio of administrative can be explained by the relations between size and differentiation ratio in organizations. The basic generalizations about the formal structure of organizations are: (1) large size promotes structural differentiation; (2) large size promotes differentiation along several different lines; and (3) the rate of differentiation declines with expanding size. When state agencies are compared, for example, increases in size are accompanied by initially rapid and subsequently more gradual increases in the number of local branches into which the agency is spatially and functionally differentiated (Kimberly, 1976). Regarding the relations between size and the ratio of administrative, however, there are many different or contradictory views which depend on the difference of the definition and methodological limitations (McKinley, 1992). Although their studies indicate a line of development on the topic, it is necessary to examine the relationships under a specific set of predictions from the baseline model in more detail.[4]

The general hypothesis to be investigated is that administrative ratio increases disproportionately as organizations become complex. The

[4] Reducing the gap between models and empirical analysis would certainly increase the attractiveness of applying mathematics to social problems (Coleman, 1998).

hypothesis is a straightforward deduction from two assumptions: (1) that increases in structural differentiation lead to increases in the issue of control and coordination, and (2) that the administrative component, rather than the production or sales components, is the one primarily concerned with problems of coordination. This hypothesis can be illustrated with the point that the significant factor in the disproportionate growth of administrative ratio is the increase in differentiation rather than the increase in size. Thus, the Blau's two propositions actually consist of three hypotheses, based on the significance of the issue: (1) the size of organization and structural differentiation are directly related; (2) the size of organization and the administrative ratio are inversely related; (3) the administrative ratio and structural differentiation are positively related. If we assume that size and complexity go hand-in-hand, and that differentiation and coordination are related, these hypotheses are understandable.

THE BASELINE MODEL

Following Blau, the present study defines size (S) to be the number of personnel who comprise the organized labor force of the formal organization, and structural differentiation (D) to be the number of system parts in which employees can be assigned formal positions, including roles, authority, departments. Accordingly, D is restricted to the values in the range of $[1 \leq D \leq S]$. The administrative ratio (AD) refers to the ratio of the number of employees who belong to the administrative component versus the number of entire employees.

Size and Differentiation

A formal organization of size can be structurally differentiated in exactly as many ways as there are integer sequences that sum to the size. The starting point, however, is that structural differentiation, symbolized as D, means the number of basic unit which has no more sub-units, including the number of department, and S is the size of group. Let N indicate the number of structure, defined by the way of assigning the relationship to the positions, which can occur under the random process. For a specified value of S, we can construct a model which permits us to calculate the expected value of D when each of the N structures is assigned the same probability of occurrence. So we can define this as follows:

$$P(i) = \frac{1}{N}$$

Let D denote the degree of structural differentiation and E(D) the expected value of that. The equation for the expected value of differentiation, for any given S, can be stated as follows:

$$E(D) = \sum_{s=1}^{N} D \times P(i) = (\sum_{s=1}^{N} D) / N$$

This equation defines a baseline model of structural differentiation for any given size, a model which holds constant all factors that may be expected to affect structural differentiation except S, and it permits S to affect D only through the number of structural forms logically generated by S. That is, the above equation also produces a baseline model for size, since it can give the expected value under assumption of random structural possibilities. Each of the above equations is a *ceteris paribus* proposition that other things being equal or in the absence of other considerations. This baseline model can be illustrated as is shown in Table 1.

In the first sum, three individuals or elements are equally distributed in three systems parts so that D = 3. In the second sum, three individuals are distributed in two parts, with one individual in one part and two individuals in the other, so that D = 2. In the third sum, all three

TABLE 1. THE BASIC SAMPLE FOR SIZE AND DIFFERENTIATION

Size = 3		Size = 4		Size = 5	
Case	D	Case	D	Case	D
1, 1, 1	3	1, 1, 1	4	1, 1, 1, 1, 1	5
2, 1	2	2, 1, 1	3	2, 1, 1, 1,	4
3	1	2, 2	2	2, 2, 1	3
		3, 1	2	3, 1, 1	3
		4	1	3, 2	2
				4, 1	2
				5	1
N = 3	≥ 6	N = 5	≥ 12	N = 7	≥ 20
E(HD) = 6/3 = 2.00		E(HD) = 12/5 = 2.40		E(HD) = 20/7 = 2.85	

TABLE 2. THE EXPECTED VALUE OF DIFFERENTIATION FOR EACH SIZE

Size	E(D)	Size	E(D)	Size	E(D)
1	1.00	8	3.91	15	6.07
2	1.50	9	4.27	16	6.33
3	2.00	10		17	6.62
4	2.40	11	4.91	18	6.87
5	2.85	12	5.18	19	7.14
6	3.18	13	5.50	20	7.38
7	3.60	14	5.78	…	…

individuals are in one part, so that D = 1. For S > 3, the number of such sequence structures rapidly increases, as illustrated in Table 1 for S = 4 and S = 5.

The expected values of differentiation obtained from this calculation for each size are as is shown in Table 2.

Thus, the baseline model for size and differentiation illustrates the proposition: (1) structural differentiation is an increase-function of size; (2) the rate of increase in structural differentiation with respect to size is a decrease-function of size. Consequently, it means that the increasing size of organizations produces structural differentiation with decelerating rates, as indicated by the curve linear line with a positive direction.

Size and Administrative Ratio

We can define a measure of administrative components, symbolized AD, as $[1 < AD < \frac{S}{2}]$, where S is the size of group ($S > 1$) and $\frac{1}{2}$ represents the proportionally maximum value for the function of administration along an authority dimension in organizations. Let AR denote the ratio of AD for size, symbolized as $[\frac{AD}{S}]$. So we can express this as follows:

$$\frac{1}{S} < \frac{AD}{S} < \frac{1}{2}$$

This means that the relative size of AD is 1/2 (maximum value) and less than 1/2 for all sizes. Let MAD be the magnitude of AD, and E(AD) the expected value of AD. E(AR) refers to the expected value of AR. So we define this as follows:

$$E(AD) = \sum_{s=2}^{N} MAD \times P(i) = (\sum_{s=2}^{N} MAD) \; / \; N$$

The equation for the expected value of AR can be stated as follows:

$$E(AR) = \frac{E(AD)}{S}$$

The basic sample for these equations can be illustrated as shown in Table 3.

Accordingly, the expected results of administrative ratio which ranged from even to odd numbers obtained from this calculation for each size are as follows:

In Table 4, we can now see a kind of regularity in which each pair of the size has the same expected value of AD. So we can divide this regularity into two categories in terms of even and odd numbers. Also, we can see the increase of E(AD), and the decrease of E(AR) as a function of size. It means that the absolute value of AD increases, and the relative value of AD for all size decreases. And we also can see the decreasing rate of E(AR) as a function of size. These results illustrate the relationship

TABLE 3. THE BASIC SAMPLE FOR SIZE AND ADMINISTRATIVE RATIO

Size = 3		Size = 4		Size = 5	
Case	MAD	Case	MAD	Case	MAD
1,2	1	1, 3	1	1, 4	1
2, 1	2	2,2	3	2, 3	2
N = 1	≥ 1	N = 2	≥ 2	N = 3	≥ 3
E(AD) = 1/1 = 1.00		E(AD) = 3/2 = 1.50		E(AD) = 3/2 = 1.50	

TABLE 4. THE EXPECTED VALUE OF ADMINISTRATIVE RATIO FOR EACH SIZE

Size	E(D)	E(AR): even	E(AR): odd
2, 3	1.00	.5000	.3333
4, 5	1.50	.3750	.3000
6, 7	2.00	.3333	.2857
8, 9	2.50	.3125	.2777
10, 11	3.00	.3000	.2727
12, 13	3.50	.2916	.2692
14, 15	4.00	.2857	.2666
16, 17	4.50	.2812	.2647
18, 19	5.00	.2777	.2631
20, ⋯	5.50	.2750	⋯

that the administrative ratio is a decrease-function of size, and the decreasing rate of administrative ratio (AR) decrease as a function of size.

Therefore, we can formularize the relationship between size and structural differentiation (D), and that of size and administrative ratio (AR) as follows:

$$X = f(S)$$

$$f(S)=(K \times S) + C$$

So, $\frac{dx}{ds} = K$

X: variables such as D and AR
S: size of group
K: parameter for direction and rate
C: constant which is related to the ceteris paribus conditions

If X denotes structural differentiation (D), the value of K will be a positive direction. And if X denotes administrative ratio (AR), the value of K will be a negative value as shown in the figures.

Differentiation and Administrative Ratio

With regard to size, we can set up a baseline model for the relationship between differentiation and the administrative ratio. In the model, we assume structural differentiation (D) and equal division level in D, as shown in Table 5.

TABLE 5. THE BASIC SAMPLE FOR DIFFERENTIATION AND ADMINISTRATIVE RATIO

D	Size = 7	MAD	D	Size = 10	MAD
1	7	2.00	1	10	3.00
2	3, 4	2.50	2	5, 5	3.00
3	2, 2, 3	3.00	3	3, 3, 4	3.50
			4		4.00
			5		5.00
N = 3	P(i) = 1/3	> 7.50	N = 5	P(i) = 1/5	> 18.50
E(AD) = 1/3 * 7.50 = 2.50			E(AD) = 1/5* 18.50 = 3.70		
E(AR) = 2.50/7 = .3571			E(AR) = 3.70/710 = .3700		

TABLE 6. THE EXPECTED VALUE OF ADMINISTRATIVE RATIO FOR DIFFERENTIATION

Size [P(i)]	> MAD	E(AD)	E(AR)	Size [P(i)]	> MAD	E(AD)	E(AR)
1	-		-	11[1/5]	19.50	3.900	.3545
2[1/1]	1.00	1.000	.5000	12[1/6]	27.00	4.500	.3750
3[1/1]	1.00	1.000	.3333	13[1/6]	27.50	4.583	.3525
4[1/2]	3.50	1.750	.4375	14[1/7]	35.50	5.071	.3622
5[1/2]	3.50	1.750	.3500	15[1/7]	36.50	5.214	.3476
6[1/3]	7.00	2.333	.3888	16[1/8]	47.00	5.875	.3671
7[1/3]	7.50	2.500	.3571	17[1/8]	48.00	6.000	.3529
8[1/4]	12.50	3.125	.3906	18[1/9]	58.50	6.500	.3611
9[1/4]	12.50	3.125	.3472	19[1/9]	60.00	6.666	.3508
10[1/5]	18.50	3.700	.3700	20[1/10]	72.00	7.200	.3600

TABLE 7. THE VALUE OF E(AD) AND E(AR) FOR EACH DIFFERENTIATION

Size	D = 3		D = 4			D = 5		
	E(AD)	E(AR)	Size	E(AD)	E(AR)	Size	E(AD)	E(AR)
6	3.00	.5000	-	-	-	-	-	-
7	3.00	.4280	-	-	-	-	-	-
8	3.00	.3750	8	4.00	.5000	-	-	-
9	3.00	.3333	9	4.00	.4444	-	-	-
10	3.50	.3500	10	4.00	.4000	10	5.00	.5000
11	4.00	.3636	11	4.00	.3636	11	5.00	.4545
12	4.50	.3750	12	4.00	.3333	12	5.00	.4166
13	4.50	.3461	13	4.50	.3461	13	5.00	.3846
14	4.50	.3214	14	5.00	.3571	14	5.00	.3571
15	4.50	.3000	15	5.50	.3666	15	5.00	.3333
16	5.00	.3125	16	6.00	.3750	16	5.50	.3666
17	5.50	.3235	17	6.00	.3529	17	6.00	.3529
18	6.00	.3333	18	6.00	.3333	18	6.50	.3611

So the results obtained from this calculation for each size are as follows:

In Table 6, we can see the increase of E(AD), and the fluctuation of

E(AR) as a function of size through structural differentiation (D). And [P(i)]implies, indirectly, the increase of D as a function of size. It means that the absolute value of AD increases and the ratio of AD fluctuates within the range of 30%~50% in proportions. So increasing organizational size generates structural differentiation (D), and this increased D enlarges the administrative components. On the other hand, this D let AR that is the ratio of AD be in the range of 30%~50%. We can also find that E(AR) converges into 35%.

In sum, if we assume that D is a constant, the relationship between AR and size can be illustrated as follows:

Figure 1 shows that if the degree of structural differentiation is 3, 4, 5, the administrative ratio decreases and the decreasing rate of AR also decreases as a function of size.

This means that if structural differentiation is a constant like [D = X], in other words, if D is the same level for each size, the administrative ratio (AR) decreases with decelerating rates as a function of size, including some fluctuation between the decreasing lines. Compared with the case of [D = 3], we can see the decrease of AR with some fluctuation as a function of size when the values of D are 4 and 5.

More increases the degree of D, the decreasing rate of AR more decreases and AR less fluctuates, in other words, the intervals between fluctuating [±] point enlarges. It can be interpreted that, higher is the degree of D, the effect of D on AR decreases. It can be also related to the stability of organizations with a constant AR as a function of D. By

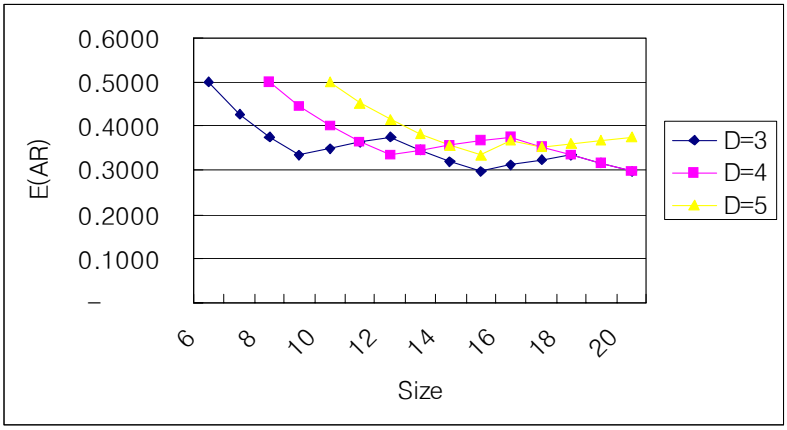

FIGURE 1. THE RELATIONSHIP BETWEEN SIZE AND ADMINISTRATIVE RATIO (D = Constant)

the same token, if an organization has a certain structure through D, that structure proceeds toward a stability rather than mobility.

CONCLUSION AND REFLECTION

Weber, an early observer of bureaucracies, was concerned with what the rationalization of modern organizations would do to the value of individualism (Camic et al., 2005). This approach has been criticized for being dehumanizing and fatalistic because it ignores the feelings of individual members and presumes that behavior is predetermined by social norms. On the other hand, Blau argues that knowledge of the intentions or actions of individuals is not required to explain the conditions of social organization (Marsden, 2005). Viewed this way, his theory offers to explicate how social structure influences the social relations and associations people have with one another.

In organizations, we may predict the administrative ratio through the knowledge of the size and differentiation as demonstrated in the present study. As size increases, the relative ratio of administrative components decreases in surviving organizations. For the relationship between size and administrative ratio, it is meaningful that the structural basis of AD as a whole has some implications for system governance and survival. For example, the administrative ratio can be explored in detail by the result of the baseline model to understand the issue of power distribution in organizations.

Popular accounts often assume that the function of administrative components in organizations is a capacity to coordinate and control. If the number of administrative components within organizations is small, it shows that the power is concentrated in the upper. If the administrative ratio is low, the lower who cannot participate in the power block attempt easily to have an effect on their organizations by a way of legal sabotage or protests. On the contrary, if this ratio is high, the power in organizations is spread widely in the upper. And for the lower employees who cannot participate in the power block, if mobility line to the upper is not opened, they can feel some alienation relatively. In short, the span of power or control structures the relationships between leaders and subordinates in organization.

Equally important, the impression can be derived from the present model that has applicability only to the very small systems, because relatively little decline in AR occurs beyond large size. However, an understanding of the way in which administrative control systems in

economic firms or political communities are structured mitigates this impression. Large system, such as states and firms, are made up of smaller units. If the system is sufficiently large, it will be comprised of relatively small sub-units nested within larger sub-units which will in turn be nested within still larger sub-units, telescoping the number of sub-systems within sub-systems as size increases. Because the large organizations are comprised of smaller ones, the rates of decline in administrative ratio need to be nothing more than the result of the systems' internal composition of smaller units, for which the model holds, indicating a very small negative slope in large organizations.

Consequently, the most important point to be made here is that any theory of the effects of size and differentiation on the relative ratio of administrative components must be complex, because the effects themselves are complex. The issue concerning the effects of size and differentiation on administrative ratio is meaningful in that the direct effect of size and administrative ratio cannot significantly offset the indirect effect of the two variables via structural differentiation. The findings in the present study can be explained by the interpretation that the coordinative and control issues generated by size and differentiation are qualitatively different in terms of organizational efficiency. For example, with an increase in organizational size and the span of control, the frequency and intensity of contact from the administrative components in day-to-day activities decreases while larger organizational size leads to more mechanistic organization as the coordination burden overwhelms communication efficiency.

Although it is of great theoretical meaning to recognize the above, this paper is still sketchy and leaves some problems unanswered. For the baseline models, more detailed and extended studies, especially, with respect to structural differentiation, are required. To develop a more broad perspective, knowledge is needed about many types of organizations. People who are occupied with only one type of organization may miss the breadth of perspective that comes from a comparative scope. Sometimes the solutions that have been found in one type of organization can be adapted to others. Accordingly, the use of a baseline model such as the one proposed here requires cautious selection of the social systems to which it is intended to apply. The effect of administrative ratio, for example, has different meanings that depend on the level of organizational size and differentiation analyzed. If we want to see how far some empirical system departs from the baseline model's predictions, it is appropriate to know that the unit of analysis

in research is in fact at the level of organization where structural differentiation processes occur.

Nevertheless, the present model provides a gauge against which it will be possible to compare empirical trends in order to determine whether variables other than size affect the relative size of administrative components, or whether size itself has an effect in excess of that provided by the model. These comparisons can be possibly made by constructing a new variable expressing the difference between observed values and expected values of the relative size in organizations (Stinchcombe, 2005). By the same token, structures are often determined not by size, but by cultural factors such as belief systems, laws and norms, as well as pressures to conform to existing modal models. Thus, size arguments must compete with a variety of alternative explanations. If observed values not only depart from the random expectation, but are also significantly correlated with other variables posited by a substantive theory, the baseline has served its initial purpose of permitting us to determine how much variation can be explained by a substantive theory alone, above and beyond variation due to chance.

This line of inquiry makes the implications for some general dynamic properties of organizations. At the present time it appears that two theoretical propositions central to Blau's point of view can be valid by continuing random process over the range of size in organizations. In mathematical terms, the influence of size on administrative overhead is indicated by a polynomial with a negative main and a positive mediated term by differentiation at a decelerating rate. Analysis of the relationships between these constructs and theoretically related constructs provides preliminary clue for their value in the analysis of complex organizations. Computational and analytical results suggest how to address the dynamics of structural relationships when administrative overhead of complex organizations is prima facie evidence of their relative efficiency. They pervade organizational design and restructuring where administrative ratio is thought to coordinate action well, reap economies of scale and scope, and compensate for bureaucracies. This idea yields measures that can be used to diagnose current organizational structures and to change bureaucratic systems such as centrality and formalization. In this way, choice may be applied to overcome barriers and move to the type of fit that the baseline model advocates in periods of organizational decline.

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