

On the Optimal Size of Economic Organizations: The Benefits and Costs of Centralization and Decentralization¹

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Abstract

This paper considers the determinants of the optimal size of economic organizations and the benefits and costs of centralization and decentralization. After observing that this question arises with a broad class of organizations including regional and spacial ones, it focuses on an economic organization, the business firm. The paper first asks: why are factors of production, like managers, workers, and capital equipment, integrated into a firm for production? How is the boundary of the firm formed? In short, what is meant by the optimal size of the firm? It then proceeds to argue that the size of the firm is basically determined by the costs of operating it, and different costs of operating the firm are identified. New information technology affects the size of the firm by changing the relative magnitude of the costs. The paper attempts to assess the effects of new information technology on the degree of centralization and decentralization of the firm.

1. Introduction

Economic science deals with organizational issues. When a business enterprise makes decision on the size of its headquarters and branch offices, the benefits and costs of centralization (and decentralization) must be weighed. The problem of regional economic integration is in a sense that of political, economic, and cultural centralization. In fact, organizational issues arise not only in the economic and business arena, but also in other arenas such as engineering. One example is centralized versus distributed computing. This paper considers the issue of centralization and decentralization with a focus on the organization of a business firm.

Thus, the objective of this paper is to consider the determinants of the optimal size of a firm. Why are factors of production, like managers, workers, and capital equipment, are integrated into a firm for production? How is the limit to firm size determined? What kind of economic consideration is made by a manager when deciding whether to employ a worker under a long-term contract or hire him only when the need for his services arises? How is the boundary of a firm formed? In short, what is meant by the optimal size of a firm? These are the questions to be dealt with in this paper.

On the surface, it may appear that the limit of an economic organization such as a firm is determined by, e.g., the history of the firm, the size of its product market, or the characteristics of productive technology of the firm. In the short run, the size of the firm may be determined by such factors. In the long run, however, economic causes should play a dominant role. In this paper, we consider the benefits and costs of forming (and not forming) a firm, and present a model for determining the most economic size, i.e., the optimal size, of a firm.

In section 2, we set forth the methodology which we use to consider the problem. The background of the problem will be explained in section 3. Williamson [1985, ch.6] called it a chronic puzzle in relation to the problem of finding the limit to the advantages of vertical integration. In section

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4, we suggest that the cost of "idle capacity," which necessarily increases from employing any factor of production under a long-term contract, is the major limitation to the expansion of a firm. In this paper this cost will be called the cost of integrating a production unit. In Section 5, two mathematical models will be presented for explaining the point stated in Section 4. A conclusion will be given in Section 6.

2. The Costs of Economic Organization and the Optimal Size of a Firm

We postulate that the optimal size of a firm is determined so as to minimize the long-run cost of forming and operating it. As we know, the foundation of economic activities lies in the division of labor and coordination between economic agents, which is achieved by transactions of goods and services. There are two alternative modes of transactions: market transactions and transactions internal to a firm. In other words, markets and firms are alternative means of economic coordination. (We may consider "no transaction" as still another mode; this is the case if coordination is more costly than self-sufficiency and there is no advantageous division of labor.)

In reality, however, there are many cases in which market transactions cannot be distinguished from internal transactions. For instance, when a large corporation is composed of a number of profit centers, each of which is run independently, transactions between the centers may be regarded as market as well as internal. Economists often consider labor contracts as a means of transacting in an "internal labor market." On the other hand, a corporation may be engaged in transactions with subcontractors over a fixed term for an extended time period; in such a case, the subcontractor may be regarded as a department of that corporation. For simplicity, however, we assume away in this paper such intermediate cases and concentrate on "purely" internal transactions and "purely" market transactions.

Let me first spell out the basic approach of this paper. Consider the production sector of the entire economy. Usually, it is a collection of firms, each of which is composed of a number of factors of production: managers, workers, physical capital, and others. We call a factor of production or a collection of them a production unit and regard it as the "atom" of economic organization. The activity of producing goods and services carried out with a production unit is called a substantive activity. In contrast, activity of organizing and managing production units and that of achieving transactions between production units are called an organizational activity.

The approach of this paper is to treat substantive activities as "parameters" and consider organizational activities as the variable to be determined. In this paper, accordingly, unlike in the case of ordinary economic analysis, substantive activities such as the level of output and cost, are assumed invariant throughout. Rather, the way in which substantive activities are combined and organized is the target of our investigation.

To begin with, we consider two extreme, if unrealistic, forms of organization: complete centralization and complete decentralization. Suppose that all of the production units in the economy are integrated into a giant firm (as in a socialist economy). In this case, by definition, all transactions are done within the firm; market transactions do not exist. All of the production (substantive) activities in this organization are planned and executed by a governing unit (the central planning board: CPB). Coordination is completely centralized.

On the other hand, consider the case in which every production unit is an independent firm having its own management and account. All transactions are market transactions; there are no internal transactions in this case. Coordination is achieved in a completely decentralized way.

Between these two extremes are intermediate cases, each of which may be characterized by the average size of a firm (i.e., the average number of production units comprising a firm). In Figure 1, the left end point D of segment DC indicates a completely decentralized economy and the right end point C the completely centralized economy. An intermediate case is indicated by a point, say P, along this segment. When point P approaches D, the average size of firms decreases, and when P approaches C,

it increases.

Intuitively, it is clear that the polar cases D and C are extremely inefficient. This is because the cost of complete decentralization and the cost of complete centralization are very high.

This is illustrated in Figure 1 by measuring cost along the vertical axis. Let curve C_1 denote the cost of centralization to the economy, and curve C_2 the cost of decentralization. The cost of centralization arises from making internal transactions, i.e., it is the cost of resources needed for organizing and operating a firm; we will call it the firm cost. The cost of decentralization, on the other hand, arises from making market transactions; we will call it the market cost.

As shown in Figure 1, firm cost C_1 increases as point P approaches C, and the market cost C_2 increases as P approaches D. The sum $C = C_1 + C_2$ is the total organization cost to the entire economy; it exhibits a U-shaped curve as shown in Figure 1. Point P, at which total cost C is minimized, gives the optimal degree of centralization (the optimal degree of decentralization); it corresponds to the optimal size of a firm.

The objective of this paper is to identify the components of firm cost C_1 and the components of market cost C_2 . The components of firm cost and those of market cost are summarized in Figure 2. It can be seen that most of these are informational in the sense that they arise from collecting, transmitting, and processing information within or between firms. The only non-informational component of firm cost is the cost of integrating factors of production, which is the major target of investigation in this paper.

3. An Overview of Research on Optimal Firm Size

In this section, we provide a brief survey of research on the problem of optimum firm size in relation to the issue of centralization and decentralization and explain what this paper is intended to contribute. We first consider the neoclassical theory of microeconomics and then the transaction cost economics of Coase and Williamson.

The neoclassical theory of microeconomics points out the informational efficiency of the price mechanism by emphasizing the presence of the cost of centralization C_1 (Hayek [1945], Koopmans [1957], and Hurwicz [1973]). These authors assert that, in order to achieve coordination, one must use information local to each production unit. It is costly to transmit all of the local information from each production unit to CPB. Under the price mechanism, transactions can be adjusted by transmitting information about commodity prices and quantities; coordination is achieved without transmitting all of the local information from a production unit to the firm manager, and consequently a great deal of information cost is saved. This is part of the reason why firm cost C_1 increases as the average firm size is increased by centralizing more and more production units.

Second, neoclassical theory also emphasizes problems arising from the incentives of economic agents. The labor efficiency of a self-employed worker is higher than that of the same worker hired by a firm under a long-term contract. Consequently, firms hiring workers need to spend money on controlling and overseeing workers in order to maintain labor efficiency, and the cost of doing so is part of firm cost C_1 .

Thus, we may state that neoclassical theory considers firm cost C_1 only; the implications of the presence of market cost C_2 are often neglected. From consideration of C_1 alone, we would reach the conclusion that, the finer economic activities are divided and the nearer point P is to the completely decentralized state D, the more efficient the organization of the economy as a whole will be, an unacceptable conclusion. Furthermore, neoclassical theory often identifies a firm with a single production function; it does not take into consideration the fact that the firm is composed of many factors and that the way in which it is organized significantly affects the functioning of the firm and also the performance of the economy.

A comprehensive investigation of market cost C_2 was initiated by Coase [1937]. Coase asked

the question of why economic units are integrated into a firm even though they can engage in transactions as independent units. Coase stated that firms are formed to avoid "transaction costs." Transaction costs (market costs) arise when the firm engages in market transactions instead of employing production units under a long-term contract. Transaction costs are composed of, among others, the cost of searching for a desirable party for a transaction, the cost of finding an appropriate price, and the cost of implementing contracts and transferring property ownership. In other words, Coase stated that firms are formed by integrating production units so as to avoid transaction costs. Williamson [1985] expanded upon this point and proposed "transaction cost economics."

There is one problem regarding the limit to firm size in relation to firm cost C_1 (Williamson [1985, ch.6], Marris [1988], and Stiglitz [1991]). Consider two firms engaged in vertical transactions. For example, a large firm A purchases materials or services regularly from a small firm B. We consider the benefits and costs of A's absorbing B to form a larger organization, to be called A*. The size of A* being greater than that of A, the firm cost will be greater in the case of A* than in the case of A. On the other hand, transaction costs to A and B will be less after integration than before. The relative magnitudes of these two costs will determine whether or not integration is advantageous. This aspect will be considered fully later.

It should be noted, however, that the new firm A* has a number of alternative ways to control B. One alternative is for A* to treat B as a new department and allow B to operate in the same way as it did before integration; in other words, this alternative allows A* to simulate the market activities performed by B before integration. A* could control B directly or could let it behave as an independent entity, whichever advantageous. Thus, the resulting combined firm [A*] can do everything that the two autonomous firms [A and B] could do previously and more (Williamson [1985, p.133]). In other words, the integration of B into A would always bring a net benefit without an accompanying loss. If this were true, then it would be efficient to integrate all of the production units in the economy into one giant firm to obtain a completely centralized organization. As we saw previously, this is not true. There must be something wrong with the argument stated above. What is that? It is "the chronic puzzle" on the limit to the firm size.

Since Coase [1937], there have been a number of research works attempting to explain the limit. For the case of horizontal integration, the size of product markets and the level of (substantive) costs are considered to be a limiting element. Penrose [1959] and Uzawa [1969] considered the scarcity of management resources to be a major limit to the growth of a firm. Furthermore, integration will increase the number of levels in the hierarchy of a firm, which in turn will increase the cost of management and control (Williamson [1967], Calve and Wellisz [1978]). In addition, Williamson [1985] pointed out that integration would lessen the work incentive in firm B, thereby increasing the cost to A of controlling B.

We should point out that none of these authors took into account the possibility of firm B's simulating market transactions. Furthermore, we should also state that to seek a limit to firm size in work incentives or increased managerial costs alone may not be consistent with the existence of firms of different size since incentival problems and managerial costs depend on the size of the firm itself and the consequences thereof differ between small firms and giant corporations. We need to seek a limiting factor elsewhere.

4. The Cost of Factor Integration

We now proceed to identify the major cost of centralization, which limits the firm from growing indefinitely by vertical or horizontal integration. By doing so, we shall be able to give an answer to the Williamson puzzle. A distinction will also be made between internal transactions and market transactions, despite the fact that in reality there are many intermediate cases between the two extremes.

Let me begin by considering Coase's notion of forming an organization. A firm is an

organization in which factors like managers, workers, productive equipment, and others are intimately connected. The services of most of these may be available for purchase in the market. The reason that these factors are concentrated in the firm under a long-term contract is that it is advantageous for the firm as a whole to do so. The firm can avoid the cost of going out to the market, that of searching for a factor or service that fits its needs, and that of making a contract by concentrating productive factors within itself that are ready for immediate use. The cost of doing all of these, i.e., the cost of market transactions, can be avoided once these factors are employed by, and concentrated in, the firm.

To consider the benefit of concentration, the benefit of putting things together, let me cite an example in which objects are concentrated but in which the structure is much simpler than in the case of firms. Take a dictionary, for example. A dictionary assembles the meaning of, and the other information concerning, words in a single volume. By having a dictionary at hand, we can easily look up the meaning of a word. The net benefit from possessing a dictionary is equal to the difference between the cost of obtaining the meaning of a word by some other means and the cost of possessing a dictionary. The same applies to libraries and databases. The advantage of assembling books in a library, or the advantage of assembling information in a database, lies in the fact that they reduce the cost of obtaining books or information. What is assembled in dictionaries, libraries, and databases is information; the advantage of concentration, however, is not limited to information; it holds for other objects as well.

Take, as another example, a household. Households purchase consumer durables and keep them ready at hand so as to be able to use them when needed. The net benefit of possessing them is equal to the difference between the cost of buying the services (i.e., renting them) and the cost of purchasing and possessing them.

The advantage of concentrating productive factors in a firm may be understood similarly. The size of a firm is much greater than the size of a household. The internal structure of a firm is more complicated than that of a dictionary, library, database, or household. In households, the benefit of concentrating consumer durables is received by the household members; the receiver of the benefit is distinct from the objects being concentrated. In the case of a firm, however, the benefit of concentration is enjoyed mutually by the concentrated factors. There is no clear distinction between those who give benefits and those who receive them. In spite of these differences, however, we can attribute the benefit of concentrating productive factors to the fact that concentration makes objects available upon request.

It should be noted that there is a limit to the advantage of concentration. Nobody desires to possess a dictionary too large in size, no community plans to construct a public library too large in size. We do not wish to purchase an excessively large number of furniture items or household appliances even if we are provided with enough space to store them.

Consider the process of concentrating objects in decreasing order of importance. Items which are needed most will be concentrated first, those which are needed less will be obtained later. The difference between the benefit and cost of possessing an item is large in the beginning; as concentration proceeds, the difference becomes smaller. The optimal extent of concentration is reached when this difference becomes zero. The reason that possessing a dictionary of an excessive size is not desirable is that at the margin this difference is negative.

Next let us note that the benefit conferred by a concentrated item is uncertain. In the beginning, we do not know which words in a dictionary or which household appliances are needed. This is for the reason, as all economists know, that the environment is uncertain. Depending upon changes in the state of the world and in our needs, our demand for items to be concentrated will change. Furthermore, it is frequently the case that a concentrated item is used cyclically. There is no item that is utilized 24 hours per day, 365 days per year. The frequency with which an item is used and the probability with which it becomes needed differs greatly for different items. Thus, in a typical household, the dining table is used three times a day, and the beds once a day. A screwdriver may be

used once a month on average but the frequency with which it is used is not known beforehand; it becomes needed when repair work is called for. In short, every concentrated item has some degree of idleness. The presence of idleness, however, does not imply the presence of inefficiency or loss; a large part of idleness is in fact a "calculated loss".

Although the structure of a firm is more complicated and the environment surrounding it more elaborate than in the case of a household, the principle according to which concentrated factors are used is the same. The firm operates over a cycle of time such as a day or a week; both the workers and capital in the firm are used for some period of time and then become idle. The firm is situated in an uncertain environment that is changing dynamically; which factor of the firm becomes needed, and which factor becomes useful, depends upon the actual environment that obtains. When we say that a firm is an organic entity composed of factors, we mean that factors for which a need arises emerge and work smoothly. When it comes to a human worker, his potential usefulness is so great that the firm can often afford to employ him even under extreme uncertainty (for example, even in cases in which the worker becomes useful only once a year or the probability that he contributes to the firm is less than 1 percent). The fact that the usefulness of a factor is cyclical and uncertain does not depend on whether the factor operates at the core of the firm (i.e., close to management) or at its periphery. For example, management consultants are hired at irregular intervals.

We are now able to state the determinants of the optimal size of a firm. It is determined by the degree to which productive factors are concentrated into the firm. The optimal degree of concentration is obtained when the difference between the benefit and cost of integration is equal to the cost of hiring the factor on the outside when it is needed. In the following section, we shall present two mathematical models which make this more explicit.

Following this reasoning, it is possible to distinguish market transactions from internal transactions. That is, when the services of factor B are purchased by firm A on a continuous basis regardless of whether A needs them or not, we say that B belongs to A and that transactions between them are internal to the integrated firm A*. On the other hand, when the services of B are purchased by A only when the need arises, we say that B is not integrated into A and that transactions between them are market transactions.

This also gives an answer to the Williamson puzzle. The mere fact that A integrates B as one of its departments does not determine whether B is inside or outside of A. If, before integration, B dealt only with A and filled every order of A over a fixed term (i.e., immediately and without challenging the content of the order), we say that B is already a part of A. The relationship between a large Japanese corporation and its subcontractors, known as "shita-uke," is an example of this.

On the other hand, suppose that, before integration, transactions between A and B were variable and that B dealt with other customers as well. This means that transactions between A and B were market transactions before integration. The state of A and B after integration depends on the way transactions are conducted. If, after integration, transactions between them are still variable and B is allowed to deal with customers other than A, then we should say that B is, in effect, outside of A and that B is not actually integrated into A. On the other hand, if, after integration, B deals only with A over a fixed term, then transactions between them should be regarded as internal to A*.

In short, whether firm A effectively integrates firm B depends on whether A employs B under a long-term contract. If B dealt with customers other than A before integration, A has to pay more to B after integration than before. However, A can save on transaction costs by integration. On the other hand, B will lose some of its customers after integration but will, at the same time, save on transaction costs. Whether the integration is beneficial to A and B jointly depends on the transaction costs savings enjoyed by A and B and on the loss arising from the decrease in the intensity of operation of B.

Thus, we have arrived at the conclusion that the integration of B by A will always lower the intensity of operation of B, leading to some idleness in the capacity of B. We call the cost arising from increased idle capacity the cost of factor integration. It is an important limit to the size of a firm.

It should be noted that "idle capacity" exists with almost every item. Very few factors, human or other wise, operate continuously 24 hours per day. The contribution of the present paper lies not in pointing out the presence of "idle capacity" but in pointing out that the "idle capacity" of an item is increased when it is integrated into a firm.

Unlike other organizational costs, the cost of factor integration is not informational, as shown in Table 1. Inasmuch as it arises from the unused capacity of a firm, it resembles the idle capacity caused by a recession. However, we do not regard the cost of factor integration as being associated with substantive, as distinct from organizational, activities, because this cost will disappear and will be replaced by transaction costs when the mode of organization is changed from firm to market. Furthermore, it should be noted that when the marginal factor is moved from inside to outside of the firm, or the other way around, the social cost of organization remains unchanged since, at the margin, firm cost and market cost are equal.

5. Mathematical Model

In this section we present two mathematical models of what was stated in the preceding section. We do not intend to add anything new in this section; all we intend to do is to clarify the points made in the preceding section. Model I gives a condition which shows when it is advantageous for production unit B, which is located in the periphery of firm A, to be integrated into A. Model II considers two production units and gives a condition which shows when it is advantageous for the two units to form a firm, transact in the market, or not transact at all.

Model I:

We use the following notations:

- (1) w = the wage rate of B,
 c = the transaction cost to A of purchasing the services of B in the market,
 p = the probability with which A needs the services of B ($0 < p < 1$),
 C_1 = the cost to A of integrating B,
 C_2 = the cost to A of purchasing the services of B when the need arises.

We assume that A's need for the services of B arises stochastically and that once it arises it is inelastic regardless of the supply price of B.

Once production unit B is integrated into A, A obtains the services of B whenever the need arises. Therefore, the firm cost is equal to the cost of employing B continuously:

- (2) $C_1 = w.$

On the other hand, when production unit B is not employed, firm A purchases the services of B in the open market by paying transaction cost c and wage w . Therefore, the total market cost is

- (3) $C_2 = p(w + c).$

In other words, the opportunity cost to A of integrating B is

- (4) $C_1 - C_2 = (1-p)w - pc,$

which is the difference between the cost of not using a part of B's capacity after integration (i.e., the cost of factor integration) $(1-p)w$ and the expected transaction cost pc . If, for some reason, the

transaction cost c is lowered, it becomes more advantageous to purchase the services of production unit B in the market only when the need arises than to hire it under a long term contract. For example, because of the recent advancement of information technology, transaction costs, of which a large part is informational costs, decreased dramatically and many services which had previously been provided within firms have become external.

Model II:

In this model, we consider two production units (to be indexed by $i = 1, 2$) and three modes of production (to be indexed by k). We use the following notations:

- (5) k = C : within-firm transaction,
 D : market transaction,
 0 : no transaction.
 y_i = the returns to i without coordination ($y = y_1 + y_2$),
 y^* = the joint returns to 1 and 2 with coordination,
 w_i = the wage of i ,
 c_i = the cost to i of market transactions ($c_D = c_1 + c_2$),
 c_C = the joint cost to 1 and 2 of firm administration,
 p = the probability with which coordination becomes effective,
 X_k = the joint net return to 1 and 2 under mode k .

When the two units form a firm and engage in internal transactions, the expected joint net return is

$$(6) \quad X_C = py^* - c_C - (w_1 + w_2).$$

Second, when each of the two units becomes a firm and engages in market transactions with the other firm, the expected joint net return to them is

$$(7) \quad X_D = py^* + (1 - p)(y_1 + y_2) - p(c_1 + c_2) - (w_1 + w_2).$$

Finally, when no transactions are conducted, the joint net return is

$$(8) \quad X_0 = (y_1 + y_2) - (w_1 + w_2).$$

By combining equations (6)-(8), we can deduce the conditions that show the relative advantages of the three modes of organization:

$$(9) \quad X_C > X_D \text{ if and only if } (1-p)y + c_C < pc_D,$$

$$(10) \quad X_C > X_0 \text{ if and only if } py^* - c_C > y,$$

$$(11) \quad X_D > X_0 \text{ if and only if } y^* - c_D > y.$$

It is noted that equation (9) gives essentially the same outcome as model I; the relative advantage of centralization and decentralization is determined by comparing the sum of the cost of factor integration and the cost of management and control to the cost of market transactions. On the other hand, the two options of centralization and decentralization are compared to the no-transaction option in equations (10) and (11). It is noted that in all of these comparisons, the wage rates of units 1

and 2 play no role at all. Furthermore, the condition under which decentralization is advantageous to no transaction does not depend on the probability with which coordination becomes effective. This is because market transactions allow each production unit to go in the open market and engage in transactions only when the need arises and to stay at home and do nothing when the need does not arise.

6. Conclusion

The objective of this paper was to point out the importance of the cost of factor integration. It arises from the fact that whenever a production unit is employed by a firm under a long-term contract, the rate of operation of that unit will necessarily be lower after integration than before; integration generates idle capacity. Centralization is always wasteful in this sense. As explained in the main body of the text, this fact holds not only in the case of economic firms but also in almost every case in which a concentration of objects takes place.

In the past, the problem of the optimal size of a firm was discussed from the standpoint of managerial and control costs before and after integration. Examples are the increase in management costs due to the increase in the number of levels of the hierarchy after integration and the cost of monitoring workers that arises due to the loss of work incentives after integration. Management and monitoring costs are of course important and interesting topics in the theory of the firm. However, these costs should be considered after the boundary of the firm has been determined; they are questions "internal" to the firm although they influence the determination of the location of the firm's boundary. On the other hand, the cost of factor integration is responsible for the determination of the location of the firm's boundary; it is the single most important limitation to the expansion of firm size.

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Figure 1: Firm Cost (C_1) and Market Cost (C_2)

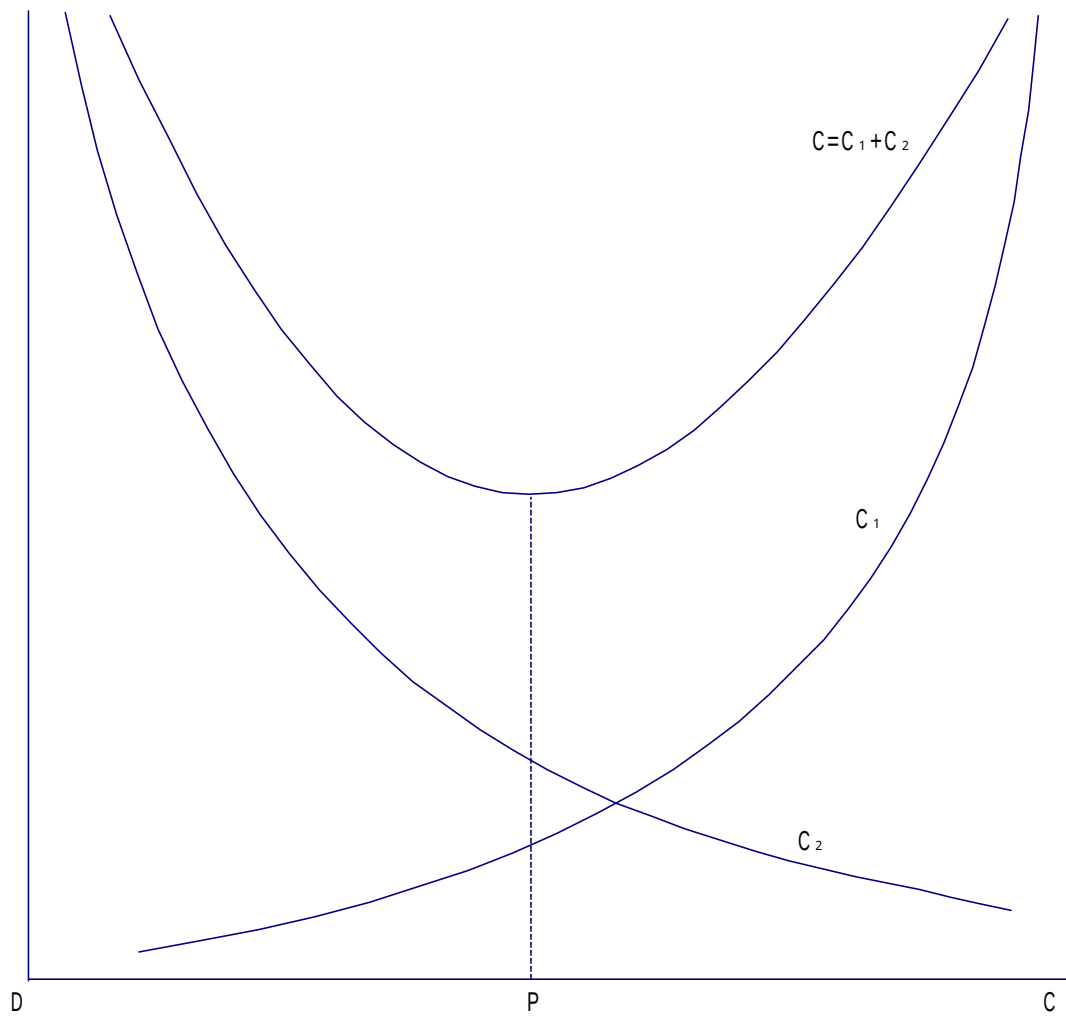


Table 1: The Components of Organizational Costs

	Noninformational	Informational
Firm Cost (C_1)	Cost of factor integration	Cost of management and control Cost of internal communication
Market Cost (C_2)		Cost of search Cost of collecting market information Cost of negotiation Cost of contract formation

"On the Optimal Size of Economic Organization: The Benefits and the Costs of Centralization and Decentralization," *Studies in Regional Science*, Vol.21, No.2, December 1991, pp.9-23.