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# ORGANIZATIONAL PRODUCTIVITY—THE ROLE OF INFORMATION TECHNOLOGY

PAUL A. STRASSMAN
Xerox Corporation
Stamford, Connecticut

Current methods of productivity reporting and analysis rely on changes in unit labor costs. This paper extends the concept of productivity accounting to include the costs of information automation affecting labor costs. Systems design and work structuring consequences arising from the need to improve organization productivity are then specified.

## 1. INTRODUCTION

Peter Drucker [1] correctly points out that making "the knowledge worker" productive becomes the primary task for our information oriented society. Daniel Bell [2] shows how an information-rich culture creates new problems in managing its exploding complexity because decision-making and individual choice becomes more difficult when alternative "information goods" have to be selected. Our society has learned during its history to choose between different items for direct consumption. As knowledge generation and use becomes the predominant form of employment in advanced industrial societies Porat, [3] the question of productivity of resources used by the information sector becomes a vital concern for securing continued favorable economic performance.

Thus emerges the pivotal role of information technology. Are we using office automation properly as a means for advancing economic performance? Are we managing information technology costs using the appropriate techniques? Are we making information technology investments in the right sequence? Do we have the right measurements structures for making investment decisions and then managing on-going expenses towards increased organizational productivity?

In prior papers [4 -6] the author explored some of these related questions. This paper will be devoted to addressing the last question above.

## 2. PRODUCTIVITY MEASUREMENT

### 2.1 Problems in defining productivity

Much of the current thinking about productivity emerges from various government agencies concerned with labor management. [7,8]

Published statistics are labor productivity oriented, keeping track of output per manhour or per manyear for industries such as steel, automobiles, petroleum. The percentage changes of output per unit of input are then discounted by inflation indexes based on unit wage rates to arrive at "real" productivity changes [9] whenever output and input measures are expressed in currency terms rather than in physical units.

This approach may be satisfactory for tracking the effectiveness of producing a homogeneous industrial commodity, using a constant mix of input factors and with the labor factor dominating. If there is a change in technology [10,11] or if the quality of the output product changes materially, a year-to year comparison of input labor expense per unit of output yields an incomplete picture of achievement. For example, as increased social welfare programs increase manpower employed in health, education and welfare occupations, overall productivity indexes decrease. [12] Similarly, large scale automation programs or investments in energy intensive methods will grossly overstate the aggregate productivity achieved in deployment of all resources if the measurements are defined only in labor productivity terms. [13]

Except for cases where information technology has been used to mechanize standardized and isolated operations such as in check handling or in invoice preparation, there are a few documented cases in literature which directly relate computer investments to specific productivity improvements tracked over an extended time period. [14] Payback claims for computer projects are usually made at project initiation. After the fact, monitoring of realized benefits is rare as volume changes, output mix differences, reorganizations in accountability, technology upgrades and qualitative changes in the product specifications create a complex maze which make audit difficult.

### 2.2 Institutional and behavioral influences on productivity measurement

The predominant mode in which knowledge workers are employed is in the overhead or bureaucratic form. This means that it is usually not possible to relate the output of information workers to direct costs for conducting their functions. For productivity of overhead or bureaucratic labor to be enhanced via information technology, the following criteria must be met:

(i) Planning and budgeting

Information technology investment increments must be an integral part of the functional planning and budgeting process. The current practice of justifying information technology projects on a program by program basis, without displaying the long term effect on the aggregate economic performance of related functions, hides the cumulative effect on the overall results. It also makes subsequent tracking difficult, if not impossible.

(ii) Goal setting

Achievement of benefits from the use of information technology must be an integral part of individual or group goals. Ideally, the improvement goals should

be personalized, especially if the information systems allows flexible uses of system features or if it permits variable amounts of computing to accomplish a task.

(iii) Tracking methods

The accounting system should generate productivity indicators as a by-product of routine reporting. For instance, in case of a transaction oriented system, the computer would generate the needed statistics: elapsed time at terminal, unit transaction cost for processing and the amounts of telecommunications used up and so forth. If service indicators such as response time are needed, sensor based systems could be integrated to track pertinent operator variables, including error rates.

(iv) Understanding

Productivity indicators are best understood if used as direct feedback information to the operator in a computer system. Consequently, the indicators must be in a "real time" relationship to the task being performed and must be directly relevant to the purpose of job design. We must avoid counter-productive behavior caused by improperly conceived measurement methods that are not directly relevant to people who perform the job. In most bureaucratic establishments job performance indicators are too far removed from the job done and statistics is usually gathered as a byproduct of monthly, quarterly or annual reports. Computer technology permits a direct feedback relevancy which can bridge the difficulty between complexity of tasks and the ease of understanding results produced.

(v) Productivity targets

Experience has shown that maximum opportunities for productivity improvement arise when individuals have an opportunity to recombine resources and methods in new ways to achieve a well defined end objective. A major indictment of present bureaucratic forms of organization is their propensity to subdivide tasks towards increased specialization. If jobs are narrowly designed and are only remotely contributing to a measurable end results, there is little room for an imaginative rethinking in methods. Even if work redesign is possible the remoteness of an individual's position from desired results makes for local improvement projects which may make the ultimate situation worse. Therefore, selection of feasible productivity improvement targets should begin with rethinking of the job contents by asking: "What justifies your being on the payroll? What are you accountable for?" Only after we have isolated a meaningful job scope can we stimulate managers to look for productivity improvement by means of a search for new ways of managing resources under their control.

Productivity commitments, especially for information projects, should be set at the lowest organizational level possible and aggregated upwards. Great care must be given to consistency and financial integrity of the productivity objectives. It is relatively easy to show good productivity improvement of one function at the expense of another. Computer automation projects especially when originated from large, technically driven and centrally run organizations are particularly prone to violate this rule by claiming that they have superior knowledge on ways to wrest productivity out of information technology applications. Since information technology inputs rarely exceed 10-20% of the cost of accomplishing any task, information technologists cannot be held accountable for end results. Thus technology investments without productivity commitments by those responsible for deliverable products invariably end up as an economic liability.

(vi) External variables

When designing productivity measures that are appropriate for different levels of organization, care must be taken to remove the effect of cost factors such as: interest rates, taxes, currency fluctuation, price increases and labor inflation to levels where appropriate management can be made accountable. For instance, a year-to-year change in the costs of capital due to higher interest charges should not be included in productivity computations for low level clerical transactions because it would disguise true performance accountability for specific operating results.

## 3. EXAMPLE OF PRODUCTIVITY ANALYSIS APPLICATION IN ADMINISTRATION

### 3.1 General experience

A practical approach to productivity analysis has been underway in Xerox for the past three years. Unit costs for performing discrete administrative processes such as: payroll check preparation, benefit plan administration per employee, etc. have been tracked successfully and used in management objectives setting. From a budgetary planning standpoint this experience has been satisfactory since yearly productivity improvement targets could be set well in advance thus allowing departmental management to work on operating plan expense levels without detailed, item by item scrutiny by higher management.

A similar approach has been used for the past four years in planning prices and resource levels for computer operations. Year-to-year unit cost improvements were established successfully for a number of end-item products generated by the computing center, to become in turn an element of cost to be incorporated into a broader definition of a product and unit cost. One should observe that information technology enters into the unit cost stream at a low level of aggregation and even then its importance as an input factor is relatively low. Only about 20-30% maximum of the total cost for performing information intensive activities such as billing (and much less for labor intensive functions such as credit or order entry) can be identified as information processing expense. Since total information management budgets run only 20-30% for technology (machines and maintenance) and the rest is for supplies and labor, the principal leverage for obtaining maximum productivity increases is not through labor displacement, but through new ways of dealing with information complexity that would improve the quality with which tasks are performed. The focus must, therefore, shift to the excess costs for coordinating a complex process.

### 3.2 Administration example

The work as well as organizational task breakdown structure shown in fig. 1 require a further definition of unit costs (as shown in fig. 2) to make productivity reporting possible. Most significantly, each element of unit costs needs to be also accompanied by a corresponding Service Index (see fig. 3) so that each element of unit cost can be further modified by changes in benefit/cost ratios as the standards for work performance change.

In a practical sense we have found that productivity reporting takes place best if the attention of the organization focuses, in the short term, on achieving planned Service Index targets because these numbers are most easily captured on a weekly or monthly reporting basis. The Service Index targets are in turn obtained from periodic budgetary reviews of benefit/cost relationships.

The reporting of changes in unit cost trends is largely dependent on the extent of automation of a company's transaction accounting system. Where both

volume and resource consumption events are captured as a by-product of business activities, unit cost reporting is relatively simple. The ideal mechanism for achieving unit cost monitoring is by means of integration of a volume recording and resource utilization reporting scheme as an indirect result of system design.

## 4. ACHIEVING PRODUCTIVITY INCREASES

### 4.1 Productivity optimization vs. productivity suboptimization

The fundamental fallacy of figs. 1 through 5 lies in their emphasis on improving the productivity of each component individually, without consideration of the behavior of the entire administrative process.

If, through specialization, we have achieved a high degree of efficiency in performing individual job tasks, we will find the inter-task coordination problems quickly escalating. A symptom of this occurring can be detected through flow charting communications within and without the organization. I have seen several cases where a single transaction with the external world will generate 10-25 intra-organizational documents notifying others of sub-task completion or, sub-task errors. This amplification in communication occurs especially if the system is subject to a good deal of unpredicability and change. In such situations informal communications schemes will be overlaid on top of the existing formal procedures. Even though the hybrid procedure will work reasonably well, the gradual increase in informality will generate large amount of redundancy in intra-organizational messages.

When similar intra-system information overloads occur in related computer applications, the solution prescribed is usually the creation of a data base management environment, which assures us that basic information will be entered and vadlidated only once so that all components of the system can then share common overhead support. Individual application tasks then find it more economical to extract standard data elements out of a common data base pool.

When we observe clerical and administrative specialists, each working on their small elements of a much larger task, experiencing large intra-system communication overloads we are led to wonder whether there are organizational analogues to data base management systems.

Is it possible to simplify the work designs and relationships of people who must deal with increasing administrative complexity? How can we be sure that through unit costing and quality indexing of administration subtasks we assure the achievement of productivity when examined from the standpoint of the overall organization?

Steiner in his pioneering book [16] tells us that if administrative tasks are divisible, but inter-related, the breakdown of jobs into finer and more detailed areas of specialization will create unneeded complexity, unresponsiveness and increased levels of frustration. As the system grows in rigidity and formalism as a means of protecting the integrity of its own specialized role both the administrators as well as the customers will find the performance of the organization deteriorating unless major infusions of resources take place.

Steiner's insights tells us that in addition to instituting measurements for recording the productivity of individual tasks, we must also focus on the structure of potentially counter-productive relationships which excessive specialization and functional isolation will produce at the next level of organizational aggregation. In other words, efficiency of individual components may be bought at the expense of costly ineffectiveness of the system as a whole, as pointed out by White. [17]

### 4.2 Designing jobs around productivity objectives

The question how to structure organizations to seek maximum productivity brings us back full circle to the definition of the quantity and quality of output. As administrative processes increase in complexity and thus involve more and more specialists, the relationship between tangible output and the contribution of any individual becomes more remote and artificial until it vanishes so that end results do not matter at all to the individual. Measurements lose relevance. When this occurs, administrative activity becomes the end instead of the means, and achieves the ultimate state of counter-productive perfection.

To illustrate how easily this can happen, we go back to fundamental concepts of productivity. A lack of productivity is readily seen as long as the enterprise is reasonably small and/or stable and insofar as the external competition will provide rapid feedback on organizational performance. As soon as we need indirect means as a way of measuring organizational productivity, we quickly run into the difficulty of having to modify simple productivity definitions by means of measures relating to the quality of results delivered. This is why large organizations rarely go through the trouble of explicitly computing resource allocations and rely rather on committees, auditors, boards, task forces, control bureaus, planning departments and many layers of coordinating management to achieve an acceptable level of productive deployment of costs.

Perhaps the best way to describe this situation is by means of the diagram on fig. 4. It shows how administrative resources (1,2,3,...) organized on a specialized basis and integrated by coordinative resources (I,II ....) to deal with their customer clientele (A,B,C,D ....). The division of labor among the administrative resources is essential because of unique skills needed to accomplish jobs requiring increasing amounts of specially skilled and trained personnel. In the evolution of the administrative bureauracy a point is reached when the benefits of specialized skills are overwhelmed by the cost of coordination. Costs are also increased by the time consuming requirement of processing several tasks sequentially through pockets of functional expertise and by the increased sense of counter-productive alienation of functional groups several layers removed from the real world they are trying to serve. We will most likely see a stagnant condition approaching, when each component of the functional bureaucracy is able to claim outstanding performance, while the aggregate unit costs rise and customer perceived performance deteriorates.

The solution to such a condition is to find new ways for arranging specialized support functions to deal with their customers by means of a different architecture for handling the organizational information flows.

### 4.3 Creating a market mechanism for administration

The issue of the organization of work as an efficient productive process is as old as human society. [18] For instance, production of shoes used to be handled personally by a shoemaker who initially made all of the materials needed for making footwear and dealt directly with each customer on an individual basis. As division of labor became increasingly attractive more and more of the components for making shoes were purchased from specialized and more efficient suppliers until the process of shoe production was industralized in its entirety. At the same time, the consumers' desire for increased variety made it attractive to exercise greater choice through selection of alternative patterns, sizes and qualities

from several makers of shoes. The most viable solution to the problem of reconciling the need for diversity and adaptability while preserving the economies of specialization was through the creation of a demand market for shoes; several new additional layers of middlemen who bridged the gap between production organized by functional resource specialization and consumption segmented by need or geography.

A similar process seems to be evolving with regard to large administrative bureaucracies that are unable to serve the needs of their customer constituencies because of increased intra-organizational complexity. We need information middlemen who can package information products and responses to administrative needs by eliminating the inefficiency when individuals have to deal with separate agencies or departments of the same organization.

Diagrammatically, this concept is best expressed by fig. 5 which shows that information middlemen X and Y are specialists in integrating overall needs of their customers and are expert in knowing where to go in the complex functional bureaucracy for assuring the system's maximum responsiveness to their clientele.

The measurement of the productivity of information middlemen X and Y becomes vastly simplified because the satisfactory delivery of output services is clearly identifiable. The cost of providing services to customers - the input variable - is relatively unambiguous because the middlemen are also qualified purchasers of support from the various specialized functions. Depending on the capabilities of the information middlemen, on their error rates, on their knack for eliminating unnecessary follow-ups, or their capacity to accommodate to non-standard conditions it will be indeed possible to observe a wide range of productivities to get a job accomplished.

The cost reductions that will accrue to an administrative bureaucracy will be two-fold. First, through decentralization of the information middlemen to serve the customers directly, the information load on the overall system will be decreased because the bureaucracies will be able to organize the middlemen according to the needs of their external constituencies. A form of a market driven responsiveness will thus become possible. Especially under conditions of change this customer orientation should be much more responsive as well as less costly than information processing organizations that are exclusively process or function oriented.

Where specialization of skills requires the economies of consolidation the presence of middlemen will further simplify information handling because the centralized groups will be able to concentrate on their dedicated areas of excellence instead of devoting much of their energies to seeing to it that they do not mishandle a problem by insufficient coordination with others. In this way the productivity of central support groups of experts and specialists lends itself to better tracking because relationships with middlemen can be discrete, specific and standardized.

### 4.4 Implications for information technology

In the same way as the supplying of footwear proceeded from the hands of local cobblers to a global market of ready made shoes supplied in infinite variety through an increasing network of middlemen, so will the evolution of the method for delivering information progress from its current specialized forms to greater simplification by means of a structure that will imitate a market economy. The driving force behind this tendency will be the increasing need to increase the productivity of the information resource.

For example, the pace of progress from the local shoemaker to the ready availability throughout the world of Japanese rubber boots, was set not only by the increased sophistication in manufacturing machinery but also by development in reliable transport, through improved techniques in foreign trade and finance as well as in more aggressive entrepreneurial capabilities. Similarly, the role of information technology in improving the productivity of the information sectors of our advanced economy is dominant, but certainly not isolated from other factors that will have to be present before information processes will be viewed more like a purchased commodity rather than a bureaucratic possession. As we evolve toward advanced stages of our information-rich post-industrial society information will have to lose the connotation of exclusive possession through power and make it a purchasable factor of production like any other merchandise. Apart from socio-cultural limits, which indeed may be the sole inhibition on the ultimate rate of change possible, the next constraint in this evolution will come from the availability of inexpensive telecommunications. The major improvements in productivity for the bureaucracies will be made possible if the information middlemen, essentially satisfying the need for local responsiveness could access via telecommunications specialized services that would be free to organize on a national or international basis. Much of the labor contents of local, regional and even national bureaucracies is now necessary because the trade-offs between local responsiveness and central specialization cannot be made well.

From the standpoint of the local information middleman the most important enabling technology will be the personal computer which will make it possible for the local customer contact to aggregate, coordinate and generate the final outputs needed to satisfy total customer needs. The logic of the local processor will be similar to that contained in a comprehensive set of procedure manuals which nowadays decorate the shelves of most administrative bureaus. The local processor will make it possible to relieve the information middleman of the minutiae of information validation and records accumulation. Most significantly, the local processor will be endowed with the necessary logic for accessing the computers of various specialized support staffs in procedurally correct ways.

This architecture of information processing will offer new opportunities for decreasing the total information processing workload on all central units because integration of functions will not be done monolithically by the functional bureaucracy trying to accomodate all conceivable contingencies, but by the local information middlemen whose jobs will be designed to remain within limits that can be grasped by a single human being.

From the standpoint of productivity, the enabling technology needed to support the local information middlemen would have to be modular software which the middleman would purchase from central development staffs on a job function basis. In this manner the concept of job enlargement or job scope would become synonymous with the transfer and training checkout of newly arrived software modules. If software is handled in this manner the attendant problems of security, job training and performance logging for self paced productivity recording would give an individual a much larger sense of job identity and a feeling of personal accomplishment than is possible today.

For the information middleman to be fully effective his personal computer would ultimately have to evolve to handle all relevant customer communications including voice conversations, letters, forms, data, picture records and miscellaneous graphics. The reason why bureaucracies are so highly specialized and process oriented is amplified by existing office automation practices which accentuate narrow concentration on mechanizing small elements within the overall information flow sequence, one at a time. The local information middleman serving the total needs of a welfare

case or of a rental customer or of a user of financial services would not be able to deal with his clientele competitively if all of the forms, statements and specialized records would be generated as isolated entries. The middleman's personal computer will have to be optimized to tie together all of the coordination, record keeping and history recall which are necessary for processing individual cases. These new attributes will certainly push the limits of presently available technology if they are to become available at an affordable expense.

## 5. SUMMARY

The role of information technology in enhancing organizational productivity is seen from the standpoint of applying measurements to a process that presently is handled mostly through bureaucratic and administrative methods. To achieve improved productivity in the information sector of the economy the information generation tasks must be subjected to a discipline of unit costing and performance measurement such as has been previously applied to the industralized sectors of the economy.

In contrast with manufacturing disciplines, the information processes are characterized by simultaneity (rather than sequential handling) and require frequent changes in methods. Consequently, optimization of individual information processing functions towards increased productivity of the isolated activity increases the need for coordination. As specialized functions drive their respective unit costs down there is a danger that savings will not be realized for the organization as a whole. Under pressure for cost reductions, especially when complexity increases due to tighter inter-dependencies, the hard to quantify quantitative performance will invariably suffer and the ultimate customer of the bureaucracy will be frustrated. Excessive emphasis on unit cost performance will also tend to give rise to extreme functional specialization which leads to behaviorally counter-productive reactions by office workers because their job contents becomes ever more removed from personal accountability for tangible results.

The suggested solution advanced in this paper seeks a compromise between the advantages of specialization by function as contrasted with the generalists' needs to serve total human needs more effectively. The concepts of an information middleman is thus advanced as having the desired attributes of a viable structure for designing productive jobs serving in an environment where information handling and administration are dominant tasks for an enterprise.

For the new structure of information middlemen to emerge, information technology needs to produce further advances especially in telecommunications, in software and in multi-media processing.

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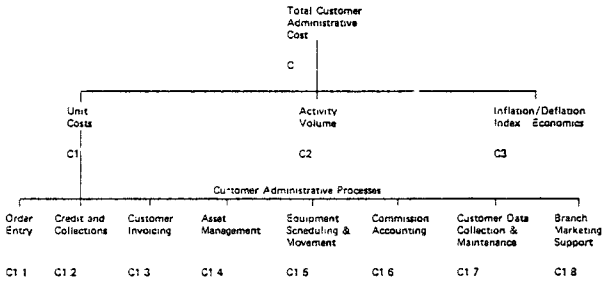


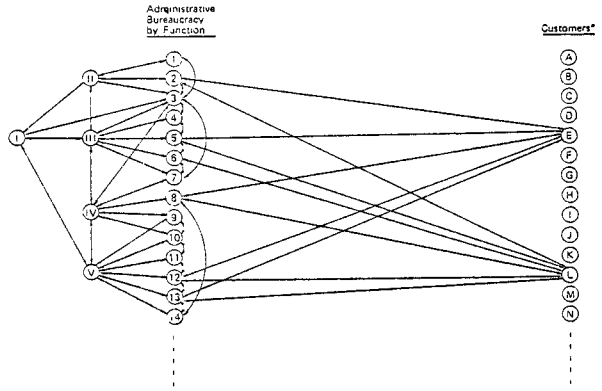

Fig. 1. Breakdown structure for cost productivity measurement

| | | |
|---|---|---|
| C1 | Unit Cost = | Total customer administrative cost per machine installed in field ( $/MIF ) |
| C1 1 | Unit Cost = | Total C/A cost for order processing per customer order ( $/Gross Order ) |
| C1 2 | Unit Cost = | Total C/A cost for credit & collection activities per machine installed in field ( $/MIF ) |
| C1 21 | Unit Cost = | Total branch customer admin cost for credit and collection activities per machine installed in field ( $/MIF ) |
| C1 211 | Unit Cost = | Total branch customer admin cost for accounts receivables activities per machine installed in field ( $/MIF ) |
| C1 212 | Unit Cost = | Total branch customer admin cost for credit investigations activities per machine installed in field ( $/MIF ) |
| C1 213 | Unit Cost = | Total branch customer admin cost for collection activities per machine installed in field ( $/MIF ) |
| C1 214 | Unit Cost = | Total branch customer admin cost for bad debt/write off control activities per machine installed in field ( $/MIF ) |
| C1 3 | Unit Cost = | Total C/A cost for customer invoicing per machine installed in field ( $/MIF ) |
| C1 4 | Unit Cost = | Total C/A cost for asset management per machine installed in field ( $/MIF ) |
| C1 5 | Unit Cost = | Total C/A cost for equipment scheduling & movements per customer machine move ( $/IR CR ) |
| C1 6 | Unit Cost = | Total C/A cost for commissions accounting per salesperson ( $/Salesperson ) |
| C1 7 | Unit Cost = | Total C/A cost for customer data collection & maintenance per customer order ( $/Gross Order ) |
| C1 8 | Unit Cost = | Total C/A cost for branch marketing support per salesperson ( $/Salesperson ) |

Fig. 2. Measurement definitions

| | |
|---|---|
| S | Service index = Process performance index X weighted factor X economics |
| S1 | Process performance index = Total customer admin process cost per cash generated ( $/Sales ) |
| S1 1 | Service support index = Total equipment scheduling/moves admin cost per machine installed in field ( $/MIF ) |
| S1 2 | Service support index = Total credit and collections cost per days sales outstanding ( $/DSO ) |
| S1 3 | Service support index = Total commissions accounting cost per salesperson in field ( $/Salesperson ) |
| S1 4 | Service support index = Total customer data collection/maintenance cost per machine installed in field ( $/MIF ) |
| S1 5 | Service support index = Total branch marketing support per branch sales and service staff ( $/Sales and service person ) |
| S1 23 | Service support index = Total branch credit & collections function cost per days sales outstanding ( $/DSO ) |
| S1 231 | Service support index = Total A/R adjustment activity cost per cash generated ( $/Sales ) |
| S1 232 | Service support index = Total credit investigation activity cost per cash generated ( $/Sales ) |
| S1 233 | Service support index = Total collection activities cost per cash generated ( $/Sales ) |
| S1 234 | Service support index = Total bad debt/write off control activities cost per cash generated ( $/Sales ) |

Fig. 3. Breakdown structure for service quality measurement




* For sake of simplicity only relationships with customers' E and L show

Fig. 4. Schematic of information flows between "administrative bureaucracy" and its "customers"

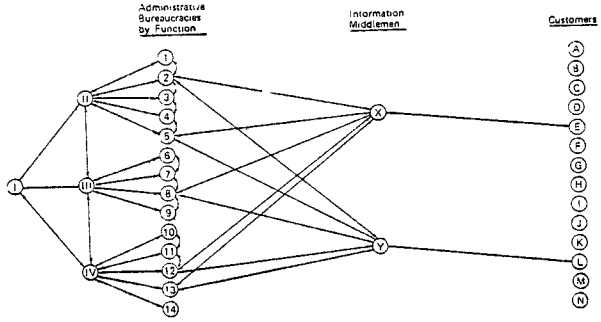



Fig. 5. Schematic of information flows between "administration bureaucracy" information middlemen and two customers