Evolving Information Use in Firms, 1850-1920:
Ideology and Information Techniques and Technologies

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Introduction

Today we are constantly reminded that industrial society is in the midst

of a revolution in information technology and in the use of information in

businesses. Often those who study the current information revolution see it

as unique and unprecedented. But just a century ago American firms were in

the midst of another information revolution that transformed the office and

the way firms dealt with information. This information revolution introduced

most of the equipment and techniques that dominated the office in the first

half of the twentieth century (some of which are still with us), from

telephones and typewriters to tabular forms, stencil duplicators, and filing

cabinets. One indicator of the magnitude of this transformation is the growth

(in constant dollars) of total capital in the office equipment industry from

$10 million in 1879 to $455 million in 1929 (Bureau of Census, 1960: 412).

During the two decades between 1890 and 1910, capital in this industry grew at

a much higher rate (194% and 182%) than capital in all U.S. manufacturing,

(67% and 81%) (Beniger, 1986: 398). This revolution was not, however,

characterized solely by the machines it introduced; interlocking "hardware"

and "software," technologies and techniques for handling information, were

part of a complete transformation of information use within firms during this

period.[1] Such techniques included, for example, the use of forms to aid in

gathering and recording data and the use of graphical techniques for displaying information. This earlier information revolution played an important role in the emergence of the modern American firm.

This paper will suggest that the rapid and radical transformation in information technology and techniques that supported revolutionary new business uses of information cannot be fully explained as the purely rational economic response of individual firms to the information demands of firm growth and structural evolution, although Chandler [1977] has shown that such functional explanations are often adequate for explaining the evolution of information techniques and practices in specific highly innovative firms. Neither can it be fully explained by changes in supply--that is, by technological determinism such as that implied when current information technology is portrayed as an independent force determining its own direction of evolution and creating its own demand. While the forces of supply and demand certainly played essential roles, this paper proposes a general model (see Figure 1) in which a third force was also instrumental in the rapid spread of information techniques and technologies: a new managerial ideology.

Before saying anything further about the nature or role of this ideology, I must briefly clarify what I mean--and do not mean--by the often value-laden term **ideology**. I am using the term neither to mean a political program based in propaganda nor to mean the opposite of the economically rational or scientific. Rather, I follow Geertz's lead in using it to refer to a culturally embedded, symbolically expressed system of beliefs or values (Geertz, 1964). Such systems of belief, he argues, provide templates for understanding and acting. They are most useful when existing traditions for guiding behavior have lost force. "When . . . those hallowed opinions and

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rules of life come into question, the search for systematic ideological formulations, either to reinforce them or to replace them, flourishes" (Geertz, 1964: 63). These formulations may differ from the scientific search for objective truth, but are not always in opposition to it.

The systematic management ideology, which had its origins in specific managerial responses to crises of coordination in growing firms, coalesced into an ideology or system of values and beliefs about the nature of management and the place of information in the managerial role. It was then widely diffused among managers and firms by publications, associations, consultants, and contacts, serving as a template for managerial strategy and practice. This ideology encouraged and was encouraged by information technology and technique in a mutually reinforcing dynamic fed by motives and mechanisms including costs, symbolism, and role models. While ideology was certainly not the only factor in the rapid diffusion of the new techniques and technologies within firms, it played a significant contributory role.

The first section of the paper provides a historical narrative of the information revolution that occurred in the late nineteenth and early twentieth centuries, incorporating the emergence and role of managerial ideology. The second section presents my model of firms' adoption of information techniques and technologies, using examples from specific firms and focusing especially on the role of managerial ideology.

THE INFORMATION REVOLUTION OF 1850-1920

Communication and Information in the Early and Mid Nineteenth Century

In the small, owner-managed firms that predominated in American business

up until the mid-nineteenth century, communication and information needs were minimal and easily handled. Market prices and availability were the main sources of external information used in decision making (Johnson and Kaplan, 1987). Correspondence with suppliers, agents, and customers, along with traditional account books, documented interactions with external parties. Virtually no internal, operational information was recorded or collected. Most firms had only three layers in their hierarchies: the owner/manager(s), one or more skilled artisans, and a few unskilled workers. Internal operations were readily managed by direct supervision and oral exchanges. The early nineteenth century textile factories separated ownership from management and began to combine multiple functions in the same facility. At this stage additional internal information became theoretically desirable for efficient coordination. Some of these factory owners created the first, relatively primitive cost accounting systems for monitoring the costs and profits of their operations (Johnson and Kaplan, 1987). Such information systems were still, however, rare, and other aspects of factory life, such as individual jobs and organizational procedures, were still managed primarily by word of mouth.[2]

By the middle of the century, the railroads and the telegraph began to expand local and regional markets into national markets, and in the late nineteenth century, manufacturing firms began adopting new mass production technologies and expanding to serve the larger markets. First the transportation and communication companies themselves and then the manufacturing firms grew in size and organizational complexity, creating new needs for internal coordination. In the 1840s, the railroads' need to assure safety and honesty led to early innovations in using systematic flows of

internal information for coordination. Further developments in the
information system resulted from diseconomies of scale exacerbated in many
cases by increased competition. While the managerial principles articulated
by leading railroad managers were harbingers of the systematic management
ideology that later emerged among manufacturing managers, their direct
influence was limited primarily to the railroad industry.

Systematic Management and the Growth of Internal Communication

Most manufacturing firms only began grappling with these information and
communication issues in the 1880s and 1890s, as they adopted new production
technologies, expanded, and encountered their own crises of coordination.
Initially their growth was unaccompanied by significant changes in the ad hoc
management methods of the past, resulting in confusion and disorder. While
the hierarchy deepened, both vertical and horizontal coordination broke down
(Litterer, 1961b; 1963). Production itself was still generally controlled by
foremen or job contractors who operated relatively autonomously (Nelson,
1978). Middle and upper managers lacked tools for controlling what occurred
on the production floor and for coordinating their own actions to make the
horizontal flow of materials through the production process efficient. Thus
the profits expected from expansion often failed to materialize.

In response to these problems, managers began a "search for order and
integration" that was ultimately to take form in the approach known as
systematic management (Litterer, 1961a; 1961b; 1963).[3] As innovative
managers developed methods for dealing with the new situations they faced,
they began, in Geertz's terms, "the search for systematic ideological
formulations . . . to replace" the old rules of thumb. Captain Henry

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Metcalfe, for example, was one of the earliest innovators in his managerial role at the Army Ordinance Department's Frankford Arsenal. Right around 1880 he was experimenting with new systems for assuring accountability and efficiency in its operation, and by the mid-1880s he had published and presented to the American Society of Mechanical Engineers (among whose ranks many of the first discussions of systematic management principles occurred) descriptions of the system he devised and formulations of its underlying principles (Metcalfe, 1885; 1886). In subsequent years, other figures such as Slater Lewis (1899) and Horace Lucian Arnold (1901) wrote about manufacturing works management, cost accounting, and other specific systems or techniques, while Alexander Hamilton Church (1900; 1913) generalized at a higher level about the nature of management. In the early years of the twentieth century, a new managerial literature containing both specific tactics and broader strategic formulations began to appear in periodicals such as the new System and the renamed Industrial Management, previously Engineering Magazine.

The loose assemblage of methods and strategies that made up systematic management shared a common focus on efficiency as a central value or goal for businesses. Furthermore, efficiency was to be achieved through system or systematizing. Experts and consultants (such as A.W. Shaw, publisher of System and Factory magazines and lecturer at Harvard Business School; or William Henry Leffingwell, consultant and author on office systematizing), who served as another mechanism for the diffusion of this set of beliefs, were often referred to as systematizers. Systematizing involved two general types of activities:

- Recording and rationalizing knowledge previously only known to the

individual using it, including workers' methods, managerial

processes, and executive knowledge. For example, one systematizer

argued, "As to the form that an order should take, the only

satisfactory form is the written order. . . .If the request is in

writing neither [the sender nor the recipient] is obliged to

depend on his memory" (Griffith, 1905: 19-20). This documentary

process transcended the individual and created an organizational

memory for future as well as current reference.

- Collecting and drawing operating information up the hierarchy and

    using it to evaluate and compare the performance of individuals

    and organizational units. Metcalfe (1894) notes the importance of

    "collecting and classifying the records of the past so that the

    future operations of the art may be more effective." Church

    (quoted in Litterer, 1961a) formulated it thus: "Under rational

    management the accumulation of experience and its systematic use

    and application, form the first fighting line."

Managers attempted to gain control over their businesses by creating systems

for every aspect of their process and products--and to implement and monitor

these systems via flows of written communication and information. In this new

philosophy, management no longer meant standing over workers or foremen and

managing by word of mouth; it meant control through systematic information and

communication. These two principles necessitated increased documentation of

all sorts. The new management periodicals were full of articles on subjects

such as "Advantage of Written Orders" (Burt, 1910) and "Factory Purchasing

System: Methods and Records" (Russell, 1917).

Beginning in the last decade of the nineteenth century and accelerating in the early twentieth century, growing amounts of internal written communication began to flow up, down, and across the firm hierarchy (Yates, 1989). Systems of reports emerged to pull information up the hierarchy. Many of these reports conveyed quantitative operating measures from one level to the next, where they would be compared, analyzed, and consolidated with other data to proceed on up the hierarchy. As managers began to systematize procedures, they needed to communicate them downward in written form both to specify them as unambiguously as possible and to provide a source of reference on the new procedures. The written order to an individual, the circular letter or bulletin addressed to groups, and the more comprehensive and permanent rule book became important new managerial tools. Finally, horizontal flows of internal correspondence emerged to document interactions within and among different departments, even though large firms had widely adopted internal telephone systems beginning in the 1890s, enabling individuals to coordinate their actions orally if they wished. Although the innovators in systematic management did not initially call for documentation of horizontal interactions, the emerging ideology's overall emphasis on internal documentation encouraged this development by analogy.

Developing Information Technologies and Techniques

Given the limited amount of written communication and record keeping before 1850, the supporting techniques and technologies of that era could be relatively primitive. Pen and ink were used to create and copy documents and records and to perform necessary calculations. Accounts were entered (and

consequently stored) in large bound volumes ruled to accommodate traditional,
double-column accounts. Outgoing correspondence was copied by hand into bound
volumes of blank pages, and incoming correspondence was folded into packets
and stored in pigeonholes. Around mid-century, the press copier, which made
impressions of documents in bound volumes called press books, became a common
copying device, and the press book the standard storage device for outgoing
mail. Soon after this innovation was adopted, pigeonhole storage began to be
supplemented or replaced by box files shaped like volumes, which stored
incoming documents flat rather than folded.

As the volume of internal (as well as external) written communication
began to increase under the influence of firm growth and systematization, it
put pressure on the old methods of handling information within firms. During
the period from 1880 to 1920, a variety of techniques and technologies, some
new and some adapted to new uses, were introduced for recording and compiling,
duplicating, storing, analyzing, and presenting the increasing amount of
information. In some cases, inventors or developers were responding
relatively directly to the business market's new information handling needs.
In others, the innovations had been intended for quite different, and often
more limited, markets but when potential business demand evidenced itself,
they were adapted or marketed to it. Office equipment and methods received a
great deal of publicity from systematizers writing in the management and trade
press who portrayed them as ways to improve the efficiency and reduce the cost
of handling the growing amounts of information flowing through firms. Indeed,
such devices and systems came to be seen as visible symbols of the modern
management methods fostered by the systematic management philosophy. By the
early twentieth century, these techniques and technologies were being widely

adopted by manufacturing firms.

Recording and Compilation: The first mass-produced typewriters appeared in
1874, aimed at a target market of court reports, authors, and other
specialized users. Typewriters operated by experienced typists could produce
documents at three times the rate for pen and paper, thus increasing the speed
and lowering the cost of producing them. Beginning in the 1880s and 1890s,
firms adopted the typewriter just in time to slow the already rising costs of
their increased internal and external written communication.

At about the same time, prepared forms, a bureaucratic technique
previously used only occasionally within most firms, were also being widely
adopted to improve the efficiency and uniformity of routinely recording and
compiling standardized data. Forms were adopted by most railroads around mid-
century and by many manufacturing firms at the end of the nineteenth century.
Such standardized forms (initially printed by external printing shops, but
later often duplicated internally) provided all of the information that did
not vary from one reporting period to the next, leaving room for the varying
information to be filled in for each report. They both reduced the time spent
in recording information and encouraged consistency and system in the data
reported. Moreover, because the same information was always in the same place
on forms, they made it easier to extract the data for compilation and analysis
at higher levels. Forms (as well as non-form reports) were often converted to
a tabular format, eliminating figures embedded in text and thus further
simplifying both the recording and the later consolidation of numerical data.
Around the turn of the century, the tab function was developed for typewriters
to aid the typist in typing tables and filling out forms (Leffingwell, 1926).

The managerial journals that emerged at the turn of the century published large numbers of articles, by both managers and systematizers, advocating forms for collecting and compiling data. Some of these described sets of forms for a specific purpose (e.g., "System for Factory Purchases," 1903) while others promoted forms in general and proposed guidelines for designing forms that would be efficient to use (e.g., Barnum, 1925). Forms became an important symbol of system.

Duplication: The new dependence on recorded information and written rules and instructions also created a need for better methods of duplicating documents. Disseminating the increasing number of notices, policies, and procedures flowing down the levels of the hierarchy required methods for duplicating documents in quantities from under ten to hundreds or even thousands. Press copying made one or possibly two copies. Multiple copies of a document could be created only by retyping or by sending it out to be printed (both slow and costly). The solution for small numbers of copies lay in carbon paper, a technology available since early in the century but only useful for most business purposes in conjunction with the typewriter. Before the typewriter, carbon paper could only be used with a pencil or a blunt stylus, because the steel- or gold-tipped pens of the era could not apply the requisite pressure without ruining the pen or tearing the paper (Proudfoot, 1972). Thus it could not be used for standard business documents. But with the typewriter, carbon paper was immediately seen to gain new usefulness. Not only could it replace the messy and slow press copying process, but a strong typist using thin paper could make up to ten copies at a single typing. Thus as firms adopted the typewriter in the 1880s and 1890s, they often adopted carbon paper as a way to

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create small numbers of copies quickly, conveniently, and inexpensively.

Rapid and inexpensive methods were still needed for creating larger numbers of copies; two systems for doing so emerged in the last quarter of the century (Proudfoot, 1972). The hectograph method used a gelatin bed to transfer special ink from a master document onto blank sheets of paper, making up to one hundred copies. The second method, stencil copying, used a stencil master with tiny holes which allowed ink to pass through; it could make up to a thousand copies at a time. Various devices for creating the stencil master and the copies were introduced in the U.S. in the late nineteenth century, starting with Thomas Edison's vibrating Electric Pen (a short-lived, relatively unsatisfactory device which left a row of pin holes as the user "wrote" with it) introduced in 1876 for use with a manual duplicating press, and culminating with the A.B. Dick Company's Edison rotary mimeograph introduced in the 1890s. Edison, with his market-oriented approach to invention and development (Millard, 1990), recognized and targeted the potential business market, suggesting its application to internal documents such as notices and forms.[4]

Storage and Retrieval: The flood of new internal communication could only be used for future reference, as demanded by the new managerial ideology, if it were readily accessible. The existing storage system with its bound chronological volumes of press copies for outgoing correspondence, letter boxes or flat files[5] (organized by subject or correspondent) for incoming correspondence, and a variety of miscellaneous systems for internal documents did not permit ready access to all documents on a specific subject. The new copying methods just discussed produced loose copies rather than bound

volumes, thus making it possible to combine documents from all sources in a more comprehensive and accessible system of subject-based storage. While this recombination could have occurred (and very occasionally did) with existing equipment, it generally awaited the introduction of vertical filing to the business world at the 1893 Chicago World's Fair (Chaffee, 1938).

This now-familiar method of filing, initially adapted for the business market by a library supply firm (Library Bureau) from card files designed to index the Dewey Decimal system of library organization, combined equipment (manila folders, dividers, and cabinets) and bureaucratic technique (a system for combining documents from all sources and organizing them by subject, location, or some other indexing scheme appropriate to a firm's or individual's retrieval needs). Like forms, vertical filing systems received considerable attention in management periodicals (e.g., Wilson, 1901) and in textbooks (e.g., Hudders, 1916), becoming closely associated with systematic management methods. Proponents proclaimed it more efficient than the old systems both in retrieval time and in use of space. They also argued the virtues of various indexing and organizing systems, from alphabetical to decimal, agreeing only that files should be centralized. This new storage and retrieval system clearly made the increasing amounts of internal and external documentation in firms more accessible. Some evidence also suggests that such files, which quickly became decentralized in spite of expert recommendations, encouraged the generation of increased horizontal documentation.

A variant of vertical filing, the card file, was also adapted from library to business use to speed retrieval of structured data such as sales or production statistics, or even a firm's central accounts (Morse, 1900; Clark, 1916; Leffingwell, 1926 & 1917). The cards were generally preprinted forms

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(usually tabular) organized by a single scheme (e.g., a customer's name or sales location). They were retrieved by this main information category and other information could then be extracted from the cards. Such card systems were well-suited to combination with recording or analyzing functions. One of the earliest formulators of systematic management techniques and principles, Metcalfe (1896), saw the use of cards for initial recording and for later storing, sorting, and retrieving of information on time and on materials as central to his innovative methods at the Frankford Arsenal at the beginning of the 1880s.

Analysis: In the late nineteenth and early twentieth centuries, a variety of technologies were introduced to speed the analysis of information, including both sorting and calculation. Although many of them were initially developed for use in accounting departments (e.g., bookkeeping machines), as the systematic management philosophy encouraged the widespread use of information throughout firms, the more general devices became more widely used. Vertical card files were developed in ways that allowed more complex sorting and retrieval of data. Metcalfe (1896:22) had pointed the way towards such use in noting the advantage of making "each card a representative unit, capable of combination with others, according to any one or more of their common features; thereby attaining by the mechanical operation of sorting, the results otherwise achieved only by the tardy and laborious processes of book-keeping". Various devices such as notches, metal tabs of different shapes or colors, and punched holes were added in designated positions to signify particular characteristics, thus enabling sorting by multiple characteristics. Beginning in the late 1880s a variety of office adding

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machines and calculating machines were introduced and adopted to speed numerical calculations and by the 1920s, at least 25 different companies manufactured adding machines alone (Leffingwell, 1926; Williams, 1985). Calculating machines, especially the electric ones available by the mid-1920s, multiplied and divided much more rapidly than did adding machines, further speeding calculations.

Tabulating systems, which began to be developed at almost the same time, combined the two analytic functions and handled much larger amounts of data than card files or calculating machines. These systems of electro-mechanical and mechanical devices both sorted data into categories automatically and counted cards or registered quantities encoded on the cards and accumulated totals. Working for the U.S. bureau of the Census, Herman Hollerith developed the first of these systems, the electro-mechanical Hollerith tabulator, specifically to speed up processing of the 1890 Census data (Austrian, 1982). When Hollerith's relationship with the Census Bureau went sour in the 1890s, he looked to large firms as potential customers. In the final years of the century, he worked with a few railroads and other firms to develop systems of machines suited to their information processing needs. By the early decades of the twentieth century, the devices were being widely discussed in the business and trade press (e.g., "Hollerith Tabulating Machinery in the Business Office," Koon, 1913; "Accounting by Tabulating Machines," Shattuck and Kapp, 1926) and interest in and adoption of such tabulating systems grew among large firms in a variety of industries (Austrian, 1982; Norberg, 1990). While the Hollerith machine led the way, other tabulating devices, such as the mechanical Powers tabulator, soon followed.

Presentation: With more and more information travelling up the narrowing

hierarchy, top managers could easily be inundated with information they lacked

time to absorb. Although tables were efficient for gathering and

consolidating statistics, they required detailed study to yield their

implications. Graphs were widely adopted in the early twentieth century to

make information more accessible and compelling to those using it. While

graphic representations of data had existed for at least a century, they had

been used primarily for government statistics and for experimental data in

science and engineering (Funkhouser, 1937). Advocated by systematizers and

engineers-turned-managers in books and in articles (e.g., Bismer, 1911;

Brinton, 1914), graphs gained considerable popularity as a way to make all of

the information gathered and analyzed available in an efficient and compelling

form so they could readily use it in decision making. As with forms and

vertical filing, systematizers associated graphs with "modern" methods: "In a

modern organization the executive obtains [operating] information through a

system of graphic records, a simplified summary of countless departmental

statistics and itemized reports" (Parsons, 1909: 214-5).

All of these changes in the collection and handling of information were

fairly widely diffused even before World War I, and the volume and efficiency

demands of the war completed the transformation. The office of 1920 looked

quite different from that of 1880. But the change was not simply one of

different equipment adopted to perform the same information and communication

functions. The nature of managerial information use in firms as well as the

techniques and technologies supporting it had both changed profoundly and in

interaction with each other. There was not to be so significant a change in

the information capabilities of the firm again until the adoption of computers and the new telecommunications technologies of recent decades.

TOWARDS A MODEL

Now I would like to step back from the changes just traced and develop a framework or general model for understanding the forces underlying firms' adoption and use of the information techniques and technologies that so increased their information capabilities. In this section I will present the model, as shown in Figure 1, describing and illustrating from the experience of specific companies the relationships indicated by it, focusing especially on the mechanisms by which ideology influenced the rapid adoption.

Size and Structure

The growth and structural evolution of American firms and markets, the profound changes traced by Alfred D. Chandler (1977) in The Visible Hand, affected the adoption of information techniques and technologies directly by increasing demand for information, though in specific cases the effect was not always simple or immediate. The case of the Scovill Manufacturing Company, a Connecticut brass manufacturer tracing its origins to a partnership established in 1802, illustrates the sometimes complex effects of structural change and growth.[6]

Several interlocking partnerships, each of which produced a different product line (buttons, hinges, and photographic plates, as well as semi-finished brass products), were combined when the firm incorporated in 1850. The new company had a work force of over 150 persons and several departments or "rooms" (e.g., the casting room and rolling room) run by skilled workers

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who reported directly to the owners. According to Johnson and Kaplan (1987), this incorporation into a single firm of multiple functions previously coordinated by the market should have triggered the adoption of at least primitive cost accounting techniques based on systematic collection and monitoring of operating information. Such a system, like those developed in a few early nineteenth century textile firms, would have allowed owners to monitor their operations to assure that internal, managerial coordination of multiple functions was as efficient as the market coordination that preceded it. At Scovill, this system did not emerge for another two decades, triggered in part by another structural change, the addition of a new layer of management. Around 1870 the first (relatively primitive) cost accounting system was initiated by a pair of bookkeepers, C.P. Goss and M.L. Sperry, recently promoted to the newly created positions of secretary and treasurer by a company president who did not want to manage the whole operation himself (Bishop, ca. 1950).[7] This system was implemented through a new information technique, a set of forms they created to collect and compile the necessary operating information.

Growth by itself also put increased demands on the existing information system, as Scovill's adoption of the typewriter illustrates. During the 1880s, Scovill's workforce grew from 400 to over 1,000 employees and its assets from $1,225,000 to $1,657,000. This increase in business was reflected in its growing correspondence with customers, suppliers, and its own stores in New York, Boston, and Chicago. In the first years of the decade, the firm's outgoing correspondence filled approximately five 1000-page press books per year. Between 1883 and 1886, however, the total grew rapidly, and from 1886 into the 1890s, it filled nine to ten volumes per year. In 1888 Scovill

adopted the typewriter.[8] At that point, the typewriter had been available

for over a decade, and the systematic management ideology had not yet been

introduced into the firm. Thus the timing strongly suggests that growth was

the primary factor driving the firm's adoption of the technology at that time.

In addition to the direct influence of size and structure on the use of

information techniques and technologies, at this point it is worth briefly

mentioning the reciprocal and mediating forces indicated in Figure 1.

Information techniques and technologies also played a role in the continued

growth and evolution of firms during the early twentieth century. Without the

typewriter, for example, the costs of producing all the written communication

resulting from continued growth and later systematization in firms like

Scovill might have slowed and constrained that development. Finally, firm

size and growth, as indicated in the first half of this paper, created the

conditions that fostered the emergence of the systematic management ideology,

which, as described below, also affected the adoption of techniques and

technologies.

Supply of Information

The supply of available methods and devices for handling information

naturally affected their adoption and use. That is, a firm could not adopt a

device or technique that had not yet been developed (although it might invest

the time and resources to develop one), and was less likely to adopt one that

was obscure or costly. In some cases, the technology or technique existed

considerably before it was widely used in business, indicating that other

factors were more crucial in its adoption than the supply. As described

previously, carbon paper, for example, was available but of limited use in

firms until the typewriter made it convenient to use. Similarly, graphs had
long been used in presenting trade and demographic statistics and in
displaying experimental data in engineering and science, but they were only
applied to managerial data around the turn of the twentieth century, in
conjunction with the period's burgeoning collection of operational statistics.
On the other hand, the first half of this paper demonstrated that the variety
and quantity of new devices and techniques for handling information increased
greatly during the last decade of the nineteenth century and the first few
decades of the twentieth century.

In some cases the supply of techniques and technologies was a critical
constraint on a long-standing or newly emerging need. For example, the
Illinois Central Railroad adopted the Edison Electric Pen within months of its
introduction, in spite of its relatively unsatisfactory performance.[9] They
used it to fill in the names and titles of new managers within divisions in
announcements of personnel changes, thus allowing them to save printing costs
by having very large numbers of generic announcements printed, rather than
relatively small numbers of specific announcements. Few innovations were
perfected technically by the time they were introduced, and their
manufacturers and new competitors responded to existing and new demand by
continued development, as with the typewriter's tab feature, developed to aid
in typing tables or filling in forms. In the case of the Hollerith Tabulator,
for example, Hollerith recognized that large railroads and other businesses,
like the Census Bureau, had extensive information processing needs, and he
worked with potential customers in developing suitable equipment. This
process continued as he improved the various devices in response to
suggestions and complaints from existing customers (Austrian, 1982). Thus the

relationship between supply and adoption of such technologies was reciprocal.

Finally, there is one other relationship with supply indicated in Figure 1: The increase in the supply of equipment was also fed by the demand created by the new managerial ideology. William Henry Leffingwell, a well known office systematizer, offered the following explanation for the growth of the office machinery industry in the Office Appliance Manual that he compiled and edited for the National Association of Office Appliance Manufacturers:

> When business method was individual and self-centered and business aims narrow and secretive, there was little incentive for inventive genius to burn the midnight oil in the search for business machinery. The demand for mechanical office appliances did not exist because there was no similarity of method. But as similarity of method spread through the exchange of ideas, the possibilities for mass production attracted some of the keenest minds in the country, who turned to making machines and devices that would simplify the mass of problems crowded into the business man's day. As a result, an immense industry has been created-- an industry which produces office machines and devices for the entire world. (Leffingwell, 1926: 18)

The existence of a wide market of businesses all facing similar information-handling tasks made the development and sale of office devices and supplies from tabulators to forms an attractive business prospect. Thus the supply of information techniques and technologies was influenced by the similarity of methods encouraged by the exchange of ideas about systematic management in the managerial literature.

Managerial Ideology

This link between supply and systematic mangement brings us to the third major factor, along with supply and organizational size and structure, in the rapid spread of the bureaucratic and mechanical devices described earlier. Managerial ideology is also a key part of the story. The growth and evolution of firms and the resulting chaos and diseconomies of scale certainly created a demand for better coordination and control, but more than one approach to the problem may have been possible and even functional.[10] Moreover, although systematic management emerged from functional responses to specific situations on the part of innovators like Metcalfe, the ideology formulated in the process of these responses gained a life of its own in this period when, in Geertz's (1964: 63) terms, "those hallowed opinions and rules of life [came] into question." American business's wholehearted embrace of the values, language, and mechanisms of systematic management reflects not just economic rationalism, but also the managerial community's acceptance of a specific ideology of managerial coordination and control.

As the earlier description of systematic management reveals, this ideology involved beliefs both in internal efficiency as the highest goal and in system as the way to achieve efficiency. System in turn depended on written documentation of procedures and of operating information, both for immediate use and for later reference. This ideology became an important factor in the proliferation of information techniques and technologies; at the same time, this proliferation reinforced the ideology. This mutually reinforcing dynamic operated through several (and often interlocking) motives or mechanisms.

Function/Cost: The ideology of systematic management called for uses of information and communication not previously seen as desirable—functions such as recording, analyzing, and reporting extensive internal operating information up the hierarchy or conveying rules and regulations to employees in relatively permanent written forms. In many cases, firms could achieve these functions with existing techniques or technologies but perhaps at great expense. Newer technologies might substantially reduce the cost of doing so. Function or cost is thus one mechanism by which the systematic management ideology can reinforce the acquisition and use of new techniques and technologies; it is also a mechanism by which the new techniques and technologies reinforce the ideology. That is, the new methods of collecting and processing information may be so rapid and inexpensive that they encourage new uses of data not thought of by the original systematizers. The influences thus reinforce each other. While cost or function is a standard economic force if the new uses of information were chosen as the optimal method of coordination within the firm based on grounds of economic rationalism, in many cases they were chosen on ideological grounds, and they might be optimal, suboptimal, or one of several equally good methods.

Let us examine some instances exhibiting this motive. The systematic management ideology called for the systematizing of procedures communicated by a downward flow of written rules and orders. In 1887, when Scovill already employed about 1,000 people in several departments but before the ideology of systematic management had been introduced into it, Scovill's top management opposed on principle any written policies:

We have never had any shop rules printed. There is a general understanding that ten hours constitute a day's work and that the hands

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are expected to do a day's work if they get a day's pay. Each
department is under the direction of a foreman, in whom we trust and who
sees that the hands are industrious and attend to their business. If
they do not do it, he sends them off and gets others. . . . We do not
think printed rules amount to anything unless there is somebody around
constantly to enforce them and if such a person is around printed forms
can be dispensed with. (Bishop, ca. 1950: 205)

But in the early twentieth century John H. Goss, the Yale-educated son of the
firm's president, introduced the modern ideals of systematic management into
the firm. After his schooling, where he was evidently exposed to the new
ideas about management, he returned to the firm first as an apprentice
production worker, then moved into his first lower-level management job. As
he later described his experience, "That was the first time it came to my
attention forcefully that my college education had done me any good, because I
discovered that there was a complete lack of system and I started in to try
and see how I could introduce a little system into at least the immediate area
in which I was working."[11] Although work force growth in the years since the
statement against written orders had been moderate and although he started out
in charge of a single, relatively small department, Goss immediately
instituted a downward flow of general bulletins and specific written orders
within that department, in spite of "at least passive resistance from every
direction." As he moved up to become General Manager a few years later, he
did likewise for the firm as a whole. As his description suggests, he was
motivated less by specific situations than by a learned belief that system was
good.

This shift in managerial ideology created a new communication function,

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thereby creating a need to disseminate the orders and to store them
accessibly. Because the firm lacked duplicating equipment when Goss began to
issue such bulletins, the original was typed with several carbon copies, which
were then circulated around the departments. While additional originals and
carbon copies could have been typed to allow each recipient to keep a copy,
that more expensive procedure was not followed. Soon, however, some of the
foremen receiving copies of the notices decided to have them retyped for local
storage and reference before passing them on. That procedure created the need
for more typing and for additional filing equipment. Both Goss himself and at
least one of the foremen acquired Shannon files, a specialized form of box
files, in which to store their own copies of such orders. In the second
decade of the twentieth century, the firm acquired duplicating equipment to
preclude the need for retyping, and vertical filing equipment for more
accessible storage. Thus when Goss introduced the values of systematic
management into the firm, they spurred the gradual acquisition of new
technologies and techniques to enable the firm to accomplish the new functions
at an acceptable cost.

Scovill's systematization continued through the first two decades of the
new century. By the final days of World War I, which had been a period of
enormous firm growth and increased establishment of upward reporting systems,
a statistician named E.H. Davis was hired to systematize the reporting system
itself and to extend Scovill's statistical analysis of the voluminous data it
was collecting. While the firm's Cost Office used a Hollerith tabulator,
Davis immediately requested a Powers tabulating machine for his new
Statistical Office. He justified his request as follows:

The Powers Machine will open up a large field of statistical

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investigation and presentation. A certain amount of preliminary

experimentation is necessary in handling data susceptible of treatment

in any one of several ways. This machine will make possible a series of

provisional experiments now prohibitive on account of the time and labor

required, and will facilitate actual operation along the lines

eventually adopted.[12]

He acquired the tabulator to perform additional data manipulations that would

have been too costly and time-consuming without it. Having the machinery, of

course, no doubt further reinforced the systematic management ideology by

letting Davis carry information analysis farther than the original

systematizers of the late nineteenth century would have dreamed possible.

Fad/Symbolism: While in the cases discussed above, new techniques and

technologies were adopted to reduce the cost of achieving additional

information functions demanded by systematic management beliefs, in other

cases managers adopted such devices less out of a desire for efficiency than

out of desire to signal that they were modern and up-to-date. Uses of

information, as well as clerical and mechanical devices that evolved to

support these uses, themselves became symbols of modern methods, and were

often adopted (or avoided) on that basis, even when adoption was not

economically justified.

Again, let us look at examples of this effect. In the late nineteenth

century, Du Pont was still run by an extremely conservative older generation--

so conservative that firm head General Henry du Pont insisted on using a quill

pen for his own correspondence long after the more efficient and cost-

effective steel or gold-tipped pens had replaced quills for standard business

use.[13] Only a secret plot by his clerks in the 1880s finally succeeded in getting a typewriter into the office. At this stage, ideological symbolism retarded changes justified by function and cost. In contrast, Francis G. du Pont, of the next generation of the family, eagerly adopted the typewriter and all of the duplicating and filing equipment becoming popular in the 1880s and 1890s. He obviously wanted to be seen as an up-to-date, modern manager. His management methods, however, were shoddy and erratic, showing none of the system suggested by his adoption of such devices. He used the typewriter himself, for example, rather than gaining its real efficiency by hiring a trained typist. In fact, his unsystematic management of the Carney's Point smokeless powder factory and experimental laboratory was a factor in driving his nephew Pierre du Pont, to leave the firm (Chandler and Salsbury, 1971). Only when Pierre, along with two cousins of his own generation, returned to take over the firm in 1902 did the firm really modernize and systematize its management methods. Thus Francis G. du Pont's use of new information technologies. like General Henry's avoidance of them, was driven primarily by symbolism or fad, rather than by a desire to reduce the cost of achieving new information functions.

The influence of the fad for systematization is also evident in a tendency for firms to institute too many systems of forms and reports initially, then to retrench after further examination. E.H. Davis, the Scovill statistician who obtained the Powers tabulator, initially attempted to make his office a "clearing house of reference," compiling lists and copies of all the routine reports (many of them on standardized forms) that were supposed to be sent to the General Superintendent's office.[14] In doing so, he discovered several superfluous reports, some of which had already been

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silently discontinued. Many of these routine form reports had been established over a decade earlier when J.H. Goss was most intent on systematizing the firm. In the process, Goss had evidently requested some reports that either were never really functionally necessary to his job as General Superintendent or no longer served a useful purpose. When Davis brought them to his attention, Goss eliminated them, noting, "I am giving up certain reports that do not seem to me worth while to continue further in view of the labor required to compile them."[15] Thus Davis's efforts revealed that the use of form reports had exceeded the level justified by cost, probably driven by their symbolic value. Moreover, this unnecessarily increased level of reporting may well have further spurred the adoption and use of other devices and techniques to reduce the time and cost of storing and analyzing it.

Role Models: Another type of mechanism driving the mutually reinforcing relationship between managerial ideology and information techniques and technologies was the increasing availability of role models--individuals or firms that had adopted the ideology or some particular technology and consequently could be role models for others who had not yet done so. This mechanism could operate in conjunction with either of the motives just discussed. For example, a role model could illustrate how a particular technique or device was a cost-effective aid for achieving some goal of systematic management, or how, once a particular technology had been adopted, it could be used to achieve further systematization. On the other hand, managers could imitate role models using a particular technology for symbolic reasons, without clear functional needs of their own. The role model

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mechanism contributed to the self-reinforcing cycle, since every adopter of a technique or ideology increased the number of potential role models available to others.

Let us look at the case of Scovill adoption of vertical filing in the second decade of the twentieth century. In 1911, Scovill took the necessary first step of giving up press copying into bound volumes in favor of carbon copying, which produced loose copies. This change was evidently aimed at facilitating duplication, not storage and retrieval, for the firm initially proceeded to bind the loose carbon copies into volumes separate from incoming documents. Within a year, however, the firm had begun to look to role models for guidance in storage and retrieval systems. It investigated filing practices at a similar brass company, resulting in a report entitled "Vertical Letter Filing; as practiced by the Bridgeport Brass Co."[16] This detailed report described the organization, principles, equipment, and procedures used by Bridgeport, noting especially Bridgeport's total dependence on carbon copying and its combining of all correspondence (internal and external, received or sent) about each customer in a single file. One year after this report, Scovill announced to its New York store the firm's own impending conversion to a comparable system of vertical filing.[17] Although this example clearly involves a role model effect, it is hard to tell whether the role modeling is reinforcing function or fad. Immediately before the new system was instituted (but almost a year after the investigation of filing at Bridgeport Brass), a letter from headquarters to the New York store revealed a failure to locate a document in the old system: "Replying to yours of the 24th regarding terms to Jos. L. Porter & Co., we are sorry that our record for 1908 is quite as inaccessible as yours seem to be, and, unless you consider the

matter of enough importance, you will let the matter pass."[18] This breakdown

in the information retrieval system might suggest that the role modeling was

working in conjunction with functional needs. However, the incident occurred

well after the initial investigation and too close to the final conversion to

vertical files to have played a direct role in it. Thus, in the absence of

other such evidence, the possibility remains that the incident may have been

an isolated one, and that Scovill imitated Bridgeport Brass for more symbolic

reasons. In either case, the adoption again reinforced both the growing

business use of such technologies and, by making retrieval easier, the

ideology's emphasis on documentation for future reference.

CONCLUSION

The virtual explosion of information and communication technologies and

techniques within firms during the decades surrounding the turn of the century

transformed the American office and the role of information in business. By

1920, this transformation was virtually complete, and changes came more slowly

and incrementally in the subsequent three decades. It was not until the

introduction of the computer into post-World War II businesses that a

comparably rapid period of change began. As I have tried to illustrate,

neither the supply of technological innovations nor changes in the size and

structure of firms alone or together account for the full extent of this

revolution. The systematic management ideology, with the premium it placed on

managing through flows of written information, reinforced the adoption of new

devices and techniques, which in turn reinforced the ideology by reducing the

cost and increasing the attractiveness of following it.

This look at events beginning over a century ago suggests some questions

to ask about contemporary developments. Is the current computer revolution driven solely by technological breakthroughs that have radically increased the supply of information technology? Now, in the midst of the transformation, supply often seems to dominate. But this modeling of factors in an earlier information revolution suggests that we might look for other contributing factors. There is certainly evidence of fad playing a role in the adoption of information technology. Individuals and firms often upgrade their computers before they really need additional power, wanting to remain visibly up to date in their equipment. If we look closely enough, we will probably see evidence of the other factors and mechanisms today, as well, though their relative magnitudes and roles may vary. One function of historical analysis is to allow us to observe such dynamics unclouded by our own role in them, and then to use them in formulating questions about what is occurring around us today.

1. Many aspects of this transformation are traced and documented in detail in Yates, 1989. Material in this paper not otherwise cited is from that source.

2. Some factories had printed lists of rules, made up by the owners or factory managers and posted throughout the factory; however, as Daniel Nelson (1974: 44) has noted, even in these cases, "the shop rules were largely what the foreman made them."

3. The broad but amorphous systematic management movement should not be confused with the more narrowly focused scientific management movement which emerged around the turn of the century and which assumed that many of the basic principles and practices of systematic management were already in place. While Frederick Taylor and his followers focused on very specific techniques for improving efficiency on the shop floor, the broader movement was concerned with systematizing operations at all levels from the top to the bottom of the firm. For discussion of the relationship of these two movements, see Nelson, 1974 and 1980; Kendall, 1912.

4. See "Edison's Electrical Pen and Duplicating Press," 1876 advertising circular, in the Edison National Historic Site in Menlo Park, New Jersey; and "Catalogue of Telegraph Instruments and Supplies," Western Electric Company, 1883, Trade Catalogues, Hagley Museum and Library.

5. By the 1870s and 1880s, flat filing cabinets, in which papers were stored lying flat in shallow drawers, were also available.

6. The evolution of information and communication at Scovill is traced and documented in Yates, 1989, Chapter 6. Scovill's records are housed in Baker Library, Harvard Business School. Much of the early background on the firm comes from an unpublished manuscript history of the firm (Bishop, ca. 1950) found in Scovill Collection 2, Case 59 (hereafter Scovill 2/59).

7. An ideological component may also enter into this timing, in that their training as bookkeepers may have made Goss and Sperry more prone to believe in the value of figures. In addition, it may have exposed them to railroad or early factory cost accounting, though it was not yet widely publicized outside of those industries.

8. Scovill 1/315. Since most letters were one page long, the shift from handwriting to typing did not radically alter the capacity of a single press volume.

9. The evolution of communication and information at the Illinois Central Railroad is traced and documented in Yates, 1989, Chapters 4-5. The records of the Illinois Central Railroad are housed at the Newberry Library in Chicago.

10. For example, one response would be to return some of the coordination to the market by returning to smaller, single function firms. Another would be to adopt oral and consultative approaches similar to those adopted somewhat later by Japanese firms. The more general, cultural ideology of the time, however, was shifting from communual towards bureaucratic and hierarchical approaches to achieving order (Wiebe, 1967). This underlying ideology also helps explain similarities in the approaches of the railroad managers and the manufacturing managers to similar problems, even though there is no evidence that the former influenced the latter.

11. This quote comes from the manuscript of a talk on "The Place of the White Collar and Professional Worker" at Wesleyan University, December 5, 1935, in Scovill 2/58, Chronological miscellany.

12. From a November 8, 1918 report, Scovill 2/34.

13. The developments in information and communication at Du Pont are traced and documented in Yates, 1989, Chapter 7. The records of the Du Pont Company are housed in the Hagley Museum and Library, Wilmington, Delaware.

14. The quoted passage is from a report from Davis to R.S. Sperry, August 13, 1918, in Scovill 2/26.

15. April 25, 1921, J.H. Goss to Miss M. Murnane, Scovill 2/34.

16. December 12, 1912, Scovill 2/26.

17. Headquarters to the New York store, December 27, 1913, Scovill 1/558.

18. Headquarters to the New York Store, December 26, 1913, Scovill 1/558.

REFERENCES

Austrian, G.D. (1982) Herman Hollerith: Forgotten Giant of Information Processing, New York: Columbia University Press.

Barnum, C.L. (1925) "The Layout and Arrangement of Printed Forms", The Office Manager 1 (April): 75-76.

Beniger, J.R. (1986) The Control Revolution: Technological and Economic Origins of the Information Society, Cambridge, MA: Harvard University Press.

Bishop, P. W. (ca. 1950) Unpublished manuscript history of the Scovill Manufacturing Company, Scovill Collection 2, Case 59, in Baker Library, Harvard Business School.

Bismer, J. (1911) "Graphs: Charts that Illustrate the Comparative Value of Figures; How They Are Made up and How They Are Used as Time-Savers and Danger Signals," System 20: 270-276.

Brinton, W.C. (1914) Graphic Methods for Presenting Facts, New York: Engineering Magazine Co.

Burt, C.A. (1910) "Advantage of Written Orders", in P. W. Lennen et al., Business Correspondence, Vol. 2 of the Businessmen's Library, Chicago: System Co.

Chaffee, A. (1938) How to File Business Papers and Records, New York: McGraw-Hill Book Co.

Chandler, A.D., Jr. (1977) The Visible Hand: The Managerial Revolution in American Business, Cambridge, MA: Harvard University Press.

_____ and S. Salsbury (1971) Pierre S. du Pont and the Making of the Modern Corporation, New York, Harper & Row.

Church, A. H. (1900) "The Meaning of Commercial Organization," Engineering Magazine 20: 391-398.

_____ (1913) "Practical Principles of Rational Management," Engineering Magazine 45: 673-680.

Clark, E.A. (1916) "How We Keep Costs in our 75-man Plant," Factory 17: 405-408.

David, P.A. (1985) "Clio and the Economics of QWERTY", American Economic Review 75: 332-37.

Funkhouser, H.G. (1937) "Historical Development of the Graphical Representation of Statistical Data", Osiris 3: 281-342.

Geertz, C. (1964) "Ideology as a Cultural System", in D. Apter (ed.) Ideology and Discontent, New York: Free Press.

33

Griffith, J.B., ed. (1905) <u>Systematizing</u>, 2 Vols., published by The International Accountants' Society, Inc., Detroit: The Book-keeper Press.

Hudders, E.R.(1916) <u>Indexing and Filing: A Manual of Standard Practice</u>, New York: The Ronald Press Company.

Johnson, T.H. and Kaplan, R.S. (1987) <u>Relevance Lost: The Rise and Fall of Management Accounting</u>, Boston: Harvard Business School Press.

Kendall, H. P. (1912) "Types of Management: Unsystematized, Systematized and Scientific", in Dartmouth College Conferences, <u>Addresses and Discussions at the Conference on Scientific Management Held Oct. 12, 13, 14, 1911</u>, Hanover: 112-141.

Leffingwell, W.H. ed. (1926) <u>The Office Appliance Manual</u>, National Association of Office Appliance Manufacturers.

_____, (1917) <u>Scientific Office Management</u>, New York: A.W. Shaw Co.

Lewis,, S. (1899) "Works Management for the Maximum of Production: 1) Organization as a Factor of Output," <u>Engineering Magazine</u> 18: 59-68.

Library Bureau, Statistical Service Division (1924) <u>Recorded Experience</u>, New York: Library Bureau.

Litterer, J. (1963) "Systematic Management: Design for Organizational Recoupling in American Manufacturing Firms", <u>Business History Review</u> 37: 369-391.

_____ (1961a) "Alexander Hamilton Church and the Development of Modern Management", <u>Business History Review</u> 35: 211-235.

_____ (1961b) "Systematic Management: The Search for Order and Integration", <u>Business History Review</u> 35: 461-476.

Metcalfe, Capt. H. (1894) <u>The Cost of Manufactures and the Administration of Workshops, Public and Private</u>, 3rd ed., New York: John Wiley and Sons. First ed. in 1885.

_____ (1986) "The Shop-Order System of Accounts", <u>Transactions of the American Society of Mechanical Engineers</u> 7:440.

Millard, A. (1990) <u>Edison and the Business of Innovation</u>, Baltimore: The Johns Hopkins University Press.

Morse, F.C. (1900) "Keeping Accounts without Books", <u>System</u> 1:September, n.p.

Nelson, D. (1980) <u>Frederick W. Taylor and the Rise of Scientific Management</u>, Madison, WI: University of Wisconsin Press.

_____ (1978) <u>Managers and Workers: Origins of the New Factory System in the United States, 1880-1920</u>, Madison: University of Wisconsin Press.

_____ (1974) "Scientific Management, Systematic Management, and Labor, 1880-1915", Business History Review 48: 479-500.

Norberg, A.L. (1990) "High-Technology Calculation in the Early 20th Century: Punched Card Machinery in Business and Government", Technology and Culture 31:753-779.

Parsons, C. (1909) Business Administration, New York: System Co.

Proudfoot, W.B. (1972) The Origin of Stencil Duplicating, London: Hutchinson and Co.

Russell, H.S. (1917) "Factory Purchasing System--Methods and Records", Industrial Management 53: 694.

"System for Factory Purchases" (1903) System 3: January, n.p..

U.S. Bureau of the Census (1960) Historical Statistics of the United States, Colonial Times to 1957, Washington, D.C.: U. S. Government Printing Office [???].

Williams, M.R. (1985) A History of Computing Technology, Englewood Cliffs, N.J.: Prentice-Hall.

Wilson, C.E. (1901) "Filing Correspondence", System 1 (8): n.p.

Yates, J. (1989) Control through Communication: The Rise of System in American Management, Baltimore: Johns Hopkins University Press.

----- (1982) "From Press book and Pigeonhole . . .

_____ (1985) "Graphs as a Managerial Tool: A Case Study of Du Pont's Use of Graphs in the Early Twentieth Century", Journal of Business Communication 22: 5-33.

_____ (1991) "Investing in Information: Supply and Demand Forces in the Use of Information in American Firms, 1850-1920," in P. Temin (ed.), Inside the Business Enterprise (edited proceedings of conference sponsored by the National Bureau of Economic Research, October, 1990), Chicago, IL: University of Chicago Press.

Zelizer, V. A. R. (1979) Morals and Markets: The Development of Life Insurance in the United States, New York: Columbia University Press.
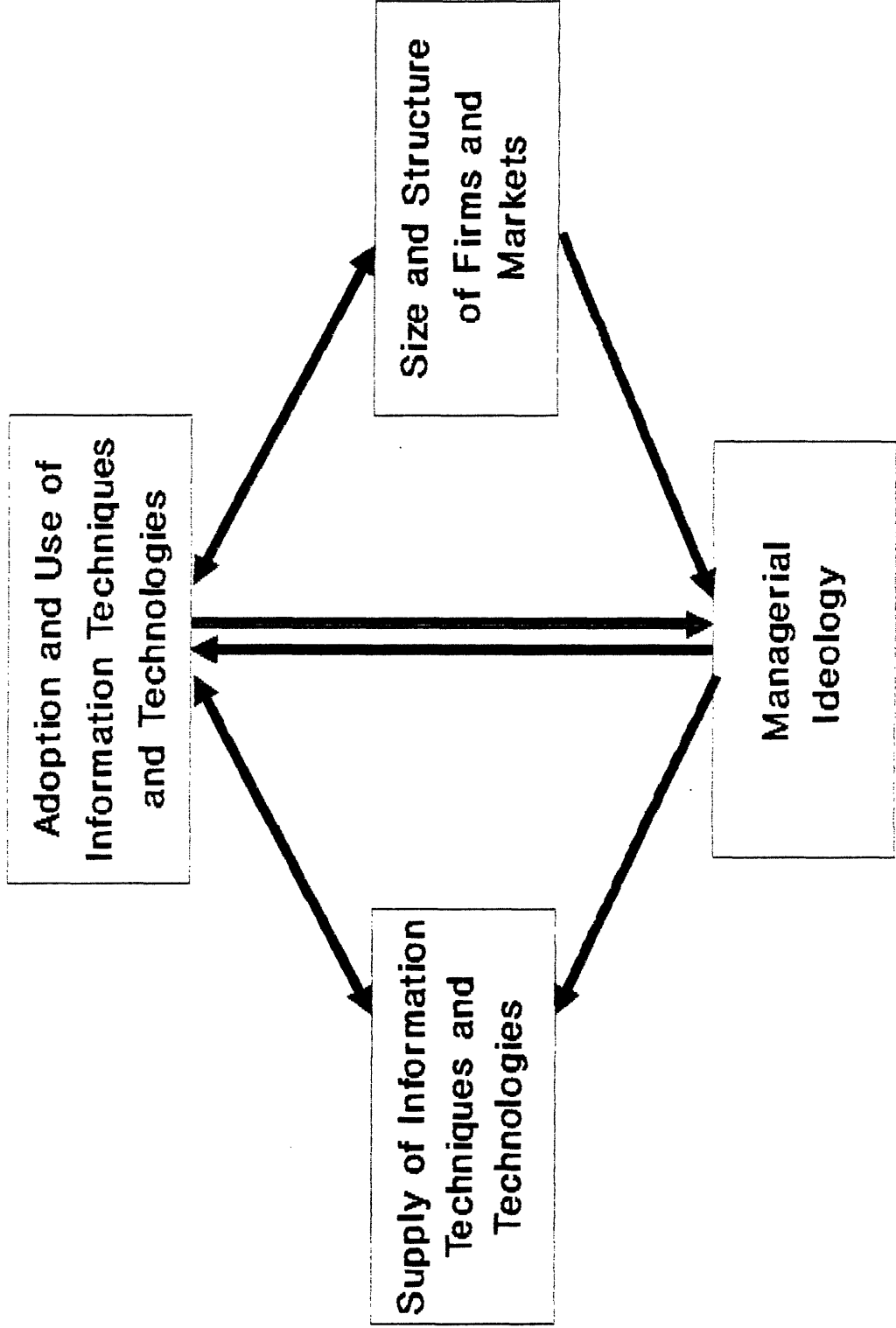
Figure 1. Factors influencing the adoption and use of
information techniques and technologies