

The Chief Technology Officer

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The growing recognition of the increasing importance of technology to competitiveness has focused considerable attention on the management of product, production process, and information technologies.¹ It is hardly surprising that these new strategic priorities should influence the organizational design of large manufacturing corporations. In particular, from among the possible organizational design responses, a number of large corporations have created a senior position at the corporate level with broad responsibility across at least two of the three general technology areas—product, process, and information technologies. The person who occupies this position is commonly referred to as the Chief Technology Officer (CTO).

Many companies have Vice-Presidents for Research and Development. The breadth of their responsibilities and authority over technological matters in the corporation is, however, variable and often less than a CTO's.² They often derive their influence from the corporate and divisional R&D laboratories for which they are directly responsible, and they often have a basically functional orientation in their jobs. The growing importance of technology to competitiveness and the growing interdependence of various types of technology—some of which often fall outside the purview of the R&D labs—make a purely functional view of technology increasingly insufficient. This perhaps helps explain why only one CEO in five regards their top technologist as part of their "inner circle."³

But what, more precisely, does this broader, general management view of technology consist of? This article reports the results of a survey of CTOs in *Fortune 100* industrial companies designed to help us understand the tasks and background of the CTO.

Data

For the research reported in this article, we focus on the *Fortune 100* industrial companies in the United States (in 1985). Using the 1985 10K Reports and Standard and Poors Register, we identified the subset of corporations that had corporate officers with explicit technology responsibilities and with titles other than "VP for R&D." While there are certainly cases in which VPs for R&D play the CTO role, we did not have the resources to distinguish those who did from those who did not. We thus assumed provisionally that corporations that had nominated a CTO would exemplify the general issues. A questionnaire was mailed to these 29 executives in the spring of 1986. We received replies from 26; and of these, only one did not have the breadth of responsibility his title had suggested. Of the remaining 25, we conducted follow-up phone interviews with 22.

All the 25 CTOs considered themselves to be the most senior technical officer in the company. Their actual titles were Chief Technical Officer (in 4 companies), Executive (or Senior) Vice President for Technology (11 companies), and Vice President for Science and Technology (10 companies). Of the 25, 19 reported to Presidents, Chairmen, Chief Executive Officers, or Chief Operating Officers; the other six reported to Executive Vice Presidents or Vice Chairmen. In short, the executives in our sample occupied very senior corporate positions.

These executives also met our criterion for breadth of responsibilities. As summarized in Table 1, 3 had direct reports from all the major technology functions and 17 had direct reports in more than just R&D. The remaining 5 had only R&D reporting directly to them, but like their 20 colleagues, they all insisted that direct reporting was not the only medium for their influence. All 25 characterized their responsibilities as encompassing both product and process technology in both centralized labs and business units. (Information support systems was the most common missing element.)

Results

What do these chief technology officers actually do and where do they come from? We put these questions directly to the CTOs in our sample, through the questionnaire and the interviews.

Reporting Relationships—All the 25 CTOs in our sample considered themselves to be the most senior executive responsible for technical matters in the corporation—a responsibility that spans both product and process technologies (and in a few cases information technology), typically at both divisional and corporate levels. The extent of CTOs' formal authority over these areas varied considerably. As one might expect, these relationships were not always clear nor simple. In order to summarize our observations,

Table 1. Breadth of CTO Authority: Direct Reports

N	Breadth of Responsibility	"Who reports directly to you?"
3	very high	R&D, Engineering, Manufacturing Process Technology, Information Systems, Operations Support
10	high	R&D, Engineering, Manufacturing Technology, Operations Support; or R&D, Engineering, Manufacturing Technology; or R&D, Engineering, Information Systems, Operations Support; or R&D, Engineering, Information Systems
7	medium	R&D, Engineering, Operations Support
5	low	R&D

we used a two-parameter framework to capture both "solid line" and "dotted line" relationships: CTOs' solid line relationships were captured through questions about their authority over the business units' technology investment budgets, and CTOs' dotted line relationships through questions about their power to appoint senior technical officers in the business units. Howe and Cashel's analysis of Chief Financial Officers used this framework and found that CFOs typically had both direct channels of influence—solid lines as reflected in budgetary authority—and less direct channels—dotted lines as reflected in the power to approve appointments.⁴

Table 2 shows a cross-tabulation of the sample according to the breadth of budgetary and appointment authority (proxies respectively for solid and dotted lines). As the Table shows, five CTOs had full authority over technical budgets and technology appointments in the business units. These five were the most like "line managers" in the sample. In another five cases, the CTOs were in purely "staff" positions in the sense that they had formal authority over neither budgets nor appointments in the business units nor even over corporate research; their influence over technological matters inside the company was more informal—they correspond to Galbraith's integrating roles based on "expert power," with little of the formal decision-making, planning, and budgetary power characteristic of what he calls the managerial linking role.⁵ Between the "line-type" and "staff-type" CTOs, there were others who had formal reporting authority over corporate R&D, and those who in addition to control over corporate R&D had authority over budgets and appointments in the R&D functions within the business units. As one might have expected, however, there is some correlation between authority over budget and authority over appointments, as evidenced by the degree of diagonalization of the matrix in Table 2.

Table 2. Breadth of CTO Formal Authority

Approval authority over appointments of senior technology related positions in:	Budgetary Authority over Technology Expenditures in:				Total
	all business units	all R&D units only	corporate R&D units only	none	
all business units	5	0	2	1	8
all R&D units only	0	3	0	0	3
corporate R&D units only	0	0	3	0	3
none	1	1	2	5	9
Total	6	4	7	6	23

Tasks—Our questionnaire asked CTOs “What are your major responsibilities?” The answers fell into five groups:

- *Coordination among business units' technological efforts to ensure synergy and economies of scale.* The tasks most frequently mentioned were coordination tasks: avoiding duplication of effort in different business units and assisting in the transfer of technology from one unit to another. Some 60% of respondents mentioned among their major responsibilities tasks related to coordination of technology efforts across business units; 20% mentioned getting technology out of R&D; and 12% mentioned responsibility for ensuring synergy between product and process technologies. The common theme among these tasks was coordination—between the business units and corporate research, across the business units, and across functional areas. This corresponds to what Porter calls “horizontal” strategy, in this case, horizontal technology strategy.⁶
- *Representation of technology within the top management team.* Representation was the second-most frequently mentioned group of tasks: 52% of respondents described one of their key tasks as being a voice for technology in the top management team. In contrast to the coordination tasks, the focus of these tasks was within top management and upward towards the Board: pushing for a long-term view of technology, nurturing infant technology development projects, and providing expert opinion on technological questions.
- *Supervision of new technology development.* Besides ensuring technology coordination and representation, some of the CTOs directly supervised technology activities in their company. This task was mentioned by 28% of respondents. As indicated in Table 2, the central corporate and divisional laboratories sometimes reported directly to the CTO; among the tasks of some of these CTOs was the supervision of these organizational units.

- *Assessment of technological aspects of major strategic initiatives.*
Another 28% of respondents mentioned tasks related to the assessment of the technological implications of proposed new acquisitions, joint ventures, strategic alliances, and lines of business. Under this heading respondents also mentioned their responsibilities for assessing the business impact of the long-term trends in the relevant technologies.
- *Management of the external technology environment.* Many CTOs also dealt directly with organizations and individuals outside the corporation. Two external groups were often mentioned: 20% mentioned universities and other outside research organizations, and 20% mentioned relations with regulatory agencies. With the first group, the main tasks were to provide broad guidelines for funded research and to collect signals about important technical developments. With the second group, the main tasks were ensuring that the corporations' products and processes complied with the relevant regulations, identifying trends in regulatory constraints, and orchestrating the corporation's efforts to influence the regulatory process.

Personal Background—All the CTOs in our sample were men. Table 3 describes their prior work-experience in the major functional areas. While 16 had general management experience, all but one CTO had spent a considerable part of their careers in technology functions (R&D or Engineering). Rubenstein suggests that in recent years more CTOs have been recruited from outside R&D;⁷ but our findings suggest that few CTOs have not, at some point in their career, sunk deep roots in the technical community. Another question revealed that 15 of the 25 CTOs had PhDs. An advanced degree may be a vehicle for more rapid advancement within technical management and probably serves as a gage of technical expertise. Only 5 of the 23 CTOs on whom we have this data report experience in Manufacturing, and none report significant experience in Information Systems. Seven CTOs had been recruited to their current position from an R&D management role, while 11 had come via other roles. Four were recruited from outside the company, in most instances because of their extensive experience in Government.⁸

Table 3. "In which functional areas have you had working experience?"

General Management and Technology (R&D &/or Engineering) and Manufacturing	4
General Management and Technology (R&D &/or Engineering)	11
Technology (R&D &/or Engineering) and Manufacturing	1
Technology (R&D &/or Engineering)	6
General Management	1

Business-Unit-Level Technology Directors—Our research's premise was that technology has become a more important competitive factor and that there is an increasingly large potential for synergy between product, process, and information technologies. We were therefore interested in examining the effect of this trend not only at the corporate level but also at the divisional level: Do the business units have positions with broad responsibility for more than one technology domain?

Nine companies reported such business-unit-level "technology director" positions. Of these 9 companies, 5 were distinctive in that they were dominated by continuous-process operations, rather than discrete-parts fabrication/assembly operations. Petro-chemical and paper products companies were particularly well-represented, and discussions with their CTOs confirmed that the linkage of product and process technologies is so tight in these industries that broader technology management roles were taken for granted. In the remaining four companies with business-unit-level technology directors, discussions with the CTOs revealed that competitive pressures and growing synergy opportunities across product/process/information technologies were encouraging a growing number of their divisions to revamp their organizational structure to bring product, process and sometimes information organizations into closer alignment.

Motivations in Creating CTO Positions—In several cases, the telephone interviews suggested that the creation of the CTO position had been triggered by the availability of the right individual. Our interviews also suggested some performance factors that prompted the creation of a CTO position. Broadly speaking, the motivations differed depending on whether the corporation had a central R&D organization. When we asked CTOs from corporations with central R&D organizations why their firm had created a CTO position, responses highlighted the need to foster greater "responsiveness" on the part of central R&D and greater "receptiveness" on the part of the business units. For those without central R&D facilities, the driving concern was more often the need to "avoid duplication of businesses' R&D efforts," to ensure the "cross-fertilization" of businesses' technology efforts, and to "exercise overall leadership" in order to maintain the technological base of the company, in particular, by serving as a "window to outside technologies."

Discussion

A skeptic might argue that CTO positions are a fad or fashion. The creation of CTO positions might reflect a "mimetic" process—it may not be motivated by any rational calculation of the expected contribution to profitability or to growth so much as by the desire to imitate what they see other successful companies doing.

While there is probably an element of truth to that hypothesis, our survey suggests an alternative hypothesis: that the CTO plays an integrating role made increasingly necessary by the peculiar dynamics of technological evolution. As technological change accelerates, it both diversifies the range of technological opportunities—such as with the emergence of new composite materials—and creates new intersection zones among those technology opportunities—such as when mechanical and electronic sub-systems are integrated into “mechatronic” systems or when new composite materials facilitate changes in product designs. As a result of the technological diversification process, the corporation’s technology players—internal and external, centralized and divisionalized, product and process, research and development—are naturally pulled in different directions: the expanding universe of technological opportunities leads each player to adopt an increasingly differentiated agenda. But in tandem with this differentiation, the opportunities represented by both the new technology intersection zones and the broader business logic of technology synergies are simultaneously increasing. The combined effect of technological diversification and multiplying synergy opportunities puts under increasing strain the established coordination mechanisms that link the corporation’s technology players: divisional autonomy makes it difficult to avoid redundancy of effort, to ensure adequate coverage of emergent technologies, and to ensure adequate exploitation of potential synergies, while the traditional division of labor between central R&D and the operating divisions exacerbates difficulties in technology transfer and in appropriately linking the central R&D organization’s agenda with the divisions’ needs.

Corporations that are experiencing these types of coordination problems might be expected to lag their more effectively integrated competitors in their ability to develop and deploy new technologies. While there are many factors that contribute to the corporation’s ability to derive competitive advantage from technology, a CTO can contribute to that ability by facilitating the process of tapping opportunities emerging among technology suppliers, developing products and processes that capitalize on new technological opportunities, and marshalling the complementary skills and resources needed to effectively exploit these innovations. As one element of a broad range of organizational responses to the acceleration of technological change, Chief Technology Officers are thus likely to become an increasing common figure in top management teams.

References

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