

What defines a great CTO?

by

Jean-Michel Prouillet-Leplat

M.S., Ecole Supérieure en Science Informatique (2004)

Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Engineering and Management

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 2019

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Jean-Michel Prouillet-Leplat
System Design and Management Program
January 16, 2019

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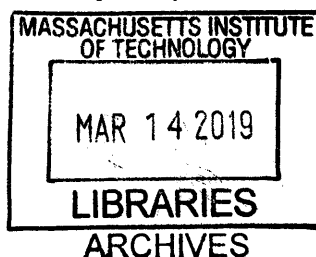
Certified by: _____

Dr. Bruce G. Cameron
Director, System Architecture Lab
Thesis Supervisor

Signature redacted

Accepted by: _____

Joan S. Rubin
Executive Director, System Design & Management Program





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ABSTRACT

The pace of technology development shapes the landscape of almost every industry today. The words innovation, digital transformation, process automation are synonyms of success. The most successful corporations nowadays understand that technology should not be a standalone initiative gated within the IT department, to achieve an impact, technology must become a part of company's DNA along with its brand strategy or culture.

The study examines the role of the CTO, which has been relatively poorly characterized by research to date. This research characterizes how CTOs view their job description, notably how they balance internally-focused attention with external responsibilities. This work draws on a quantitative analysis of 100 CTOs from LinkedIn to understand their tenure duration and career history. We also collected primary data through interviews with 20 CTOs to understand their activities, responsibilities and the context that influences the span of impact. This work posits five Personas of CTOs: The Evangelist, the Anchor, the Coordinator, the Visionary, and the Strategist in various corporate settings. The study further examines the relationship between the career path of the CTO, his/her responsibilities and impacts in current role.

The study indicates that the CTOs' responsibilities align most closely with the Coordinator and the Anchor personas. Both responsibilities and personas showed coherent distribution relative to the company maturity giving the opportunity to draw a CTOs' lifecycle where the Anchor is more likely to be found in early companies and the Coordinator in mature companies. Among the CTOs studied, 10% to 20% do not have a pure technical background, 40% are not involved in product delivery and only 36% had previously served as a CTO in another firm. The data also shows that CTOs would like to be highly collaborative and cross-functional, and desire proximity to the CEO.

Thesis Supervisor: Dr. Bruce G. Cameron

Title: Director, System Architecture Lab

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ACKNOWLEDGMENTS

I would like to thank my thesis advisor Dr. Bruce G. Cameron for his guidance, support and availability throughout this thesis. He made time to discuss about the direction of the thesis, my progress, and suggest where further analysis would have been required. His questions and comments always encouraged me to reformulate questions under different angles. Also, I would like to thank him for suggesting CTOs' interviews as way to collect data which was undoubtedly the funniest part of this thesis.

I am grateful to the CTOs who gave me their time in their busy schedule, to answer my questions and help me to draw what defines a great CTO.

I would like to thank the System Design and Management (SDM) staff and faculty for offering me the opportunity to contribute to the SDM program that bridges Engineering and Management worlds to study and solve complex system problems. In addition to the grounded program, the thesis exercise has been as beneficial as the core curriculum. This exercise gives me the opportunity to work on independent strategic analysis, with hypothesis and to build experiments to prove or disprove those hypotheses. This experience is one of the most valuable experiences in my career and professional life.

Last be not the least, I would like to thank my wife Maria for encouraging me to start this program, and for her confidence, encouragement, and continuous support.

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1 INTRODUCTION

1.1 MOTIVATION

Innovation pace has been accelerating for the past 30 years (Berman & Dorrier, 2016). The diffusion of computational technology into many sectors of the economy, bolstered by increased access to cheaper hardware, software and better internet connectivity, has placed technology as one of the key value drivers for firms (Browning, 2017). To respond to the increased number of technological disruptions and changes in the industrial landscape, businesses established a new role – Chief Technology Officer. The role of the CTO is to focus on technology to develop customer products and grow company’s topline (Zetlin, 2010).

According to Google Book trends, the CTO word really started to be used in the 1990. But we can estimate that the first analog of the CTO role emerged after the Second World War, in the 1950, when companies started expanding the Research and

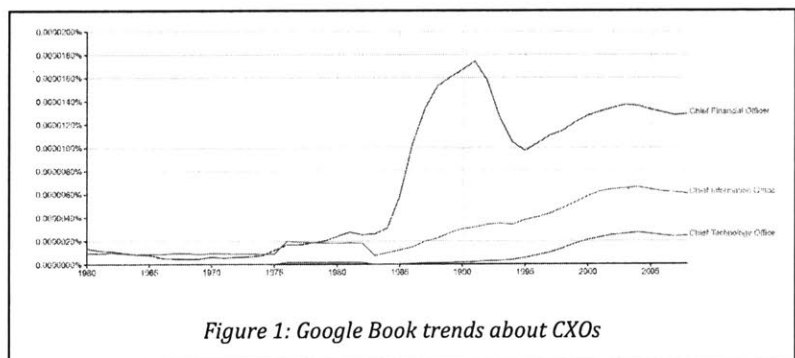


Figure 1: Google Book trends about CXOs

Development activity by building the standalone corporate structures such as laboratories. The Directors, heading these independent structures were not part of the overall business, with the primary focus on hiring best scientists and developing innovative projects. However, if we apply the broad definition of the CTO, we would find multiple examples of CTO-like roles prior to 1950: G. Bell or H. Ford who also used technological innovation to delight customers and grow business.

For more than 30 years, corporations have been mindful of technological progress and created a dedicated role to oversee it – Chief Information Officer. By analyzing the library of Harvard Business Review, we identified that the articles citing CIO's (1841 relevant hits) are focused on the operational side of the business, cost efficiency and how the IT infrastructure is running. Gartner converges that CIO responsibilities are having a focus on internal policies and on the company bottom line. The CTO search returns 650 hits with major focus on customers and topics such as product innovation strategy, business turnaround using technology. The HBR literature does not provide a unified picture

of CTO responsibilities, it does show that CTOs are generally having their focus on topline. Bob Ianucci, the Nokia CTO, Patty McCord tell their experiences of how to build the bridge between the customers and their company's products using technological innovation. As the technology becomes more central to the success of organizations, the CTO position is gaining more recognition and attention. In 2017, over 40% of IBM profits were generated from products and services that were impossible just a few years ago (Burrus, 2013). That reflects the transformative nature of business today as well as the speed of the transformation. The shift in demand patterns caused corporates to re-allocate the resources and dedicate more attention to innovation for customers. Today, Bobby Murphy (Snapchat), Arash Ferdowsi (Dropbox), or Solomon Hykes (Docker), represent the new generation that are drastically changing the perception of this profession. With this new popularity, comes the question of scope definition for the CTO role in a modern world.

The study examines the scope of responsibilities of CTO, and the necessary skills required to be successful at the role.

1.2 GENERAL OBJECTIVES

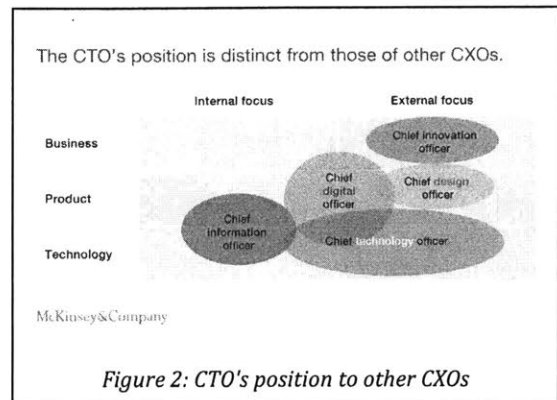
The definition of the CTO role and success criteria for performance assessment are the main objectives of this study. The secondary objective of this thesis is to build definition on the responsibilities of CTOs, their personas and in which context, situation, and organization these personas are most successful.

To achieve these objectives, the thesis will explore the background of 100 CTOs to understand the demographics and the type of company and industry in which they evolve, and will comment the insights from the interview of 20 CTOs to assess their responsibilities and personas.

1.3 LITERATURE REVIEW

Surprisingly, there is a limited number of studies about CTOs. As explained in introduction, Harvard Business Review spends fewer articles about the CTO compared to the CIO, CFO or CEO. The CTO role is not a position often studied (Finkelstein & Hambrick, 1996; Herstatt, Tietze, Nagahira, & Probert, 2007).

As asserted by Borden and her colleagues from McKinsey, the CTO main responsibilities are building the technological vision, grasping both the dangers and opportunities, and sharing it across a company to ensure its success, but also monitoring the external environment for significant and relevant new technologies (Borden, 2018).



They present the role as external, instead of the CIO role which is internal, as shows the graph Figure #2. According to them, CTO's must have the following qualities:

- a deep understanding of customers and, for B2B companies a reputation and networks in the customer space
- a deep understanding of the company's current technology
- the curiosity to learn about potentially relevant new technologies coming on line or in development
- the acuity to see the implications and possible uses of such technologies
- external networks (including with actors such as universities, start-ups, and venture capital)
- a mastery of systems engineering;
- a willingness to challenge the status quo.

Those are qualities which can lead to responsibilities but do not explicitly define the role.

In her article, Zetling defines 4 top-line focus CTO evolving in different types of organization: the IT CTO, the product CTO, the company founder, the CIO in disguise (Zetling, 2010). All of them are defined by working respectively in companies offering nontechnological consumer products, companies offering technology products, startup companies, and companies confounding CTO and CIO. Again, Zetling offers a characterization of the CTO in some circumstances but not a description of the responsibilities.

On the other hand, Cetindamar & Pala identified seven roles/functions fulfilled by the CTO (Cetindamar & Pala, 2011):

- CTOs coordinate of technological efforts among business units and corporate research to ensure synergy and economies of scale (Adler & Ferdows, 1990; Smith, 2003). This task is mainly aimed at avoiding the duplication of technological efforts between business units and

facilitating technology transfer from one to the other. Hence, there will be an increase in the utilization of technologies developed across business units by reducing the technology development costs per unit of products/services. In other words, there will be gains in terms of economies of scale in R&D.

- CTOs represent technology within the top management by providing expert opinion on technological questions, recommending a long-term view of technology, and fostering infant technology development projects (Kor & Mahoney, 2005). As a result, chief executive officers (CEOs) gain reliable information from CTOs about applications of technologies, particularly how they might add value to the firm along the lines of company strategy.
- CTOs should monitor technological advances in order to capture the developments in technology fields that might impact company operations (Adler & Ferdows, 1990). Many companies go bankrupt primarily for not recognizing the disruptive impact of emerging technologies on industries (Christensen, 1997).
- CTOs supervise R&D laboratories and other technology development units (Adler & Ferdows, 1990; Kor & Mahoney, 2005). Therefore, CTOs manage teams participating in research projects. Project management literature clearly shows how the performance of teams increases when senior managers are involved in teams (Burgelman, Maidique, & Wheelwright, 2004).
- CTOs assess technological aspects of major strategic initiatives (Roberts, 2001; Medcof, 2007). This assessment includes the technological implications of proposed acquisitions, joint ventures and strategic alliances (Adler & Ferdows, 1990). CTOs can supply strategic data to the executive board by evaluating the value of technologies in the company that are aimed to be acquired or joint ventured. This additional data contains reliable value for the targeted company as well, as it considers the synergies that those technologies could generate within the company (Smith, 2003).
- CTOs manage the relationship of the company with technological actors in the external technology environment, such as universities and regulatory agencies (Herstatt, Tietze, Nagahira, & Probert, 2007; Smith, 2003). Considering that open innovation is becoming a widely applied strategy in developing technologies, the external involvement of CTOs thus becomes a critical element in acquiring technologies externally. For example, the Procter & Gamble Company expects to receive half of its technologies from external sources (Slowinski, Hummel, Gupta, & Gilmont, 2009).

- CTOs should be included in marketing and media relations (Smith, 2003). Although the marketing department usually pursues media relations, CTOs can communicate with the media to build the image of technological products because these individuals have the most knowledge about the product capabilities and technical features. Marketing efforts will increase the productivity of commercialization activities carried out at firms.

From this definition, we can notice that two or these roles are prescriptive whereas the others are descriptive. Do we have to conclude that these two roles – monitoring technical advances and participation in marketing and media relations – are not always included in the CTO role? Unfortunately, the researchers did not explain this contrast, but the thesis will assess their importance.

Cetindamar and Pala also concluded that CTOs have a positive influence on the company results within a population of companies they studied in Turkey. More precisely, they successfully proved that having a senior executive manager in charge of technology increases company performance (Cetindamar & Pala, 2011). The study also proved that it is the act of assigning the Executive to oversee technology, not the title, that positively affects the performance. If the data shows that a managerial figure in charge of a technology strategy affects positively the company performance, we need to understand why CTOs are still so underemphasized.

The researchers' contribution is significant since they compile several researches to constitute the set of CTOs' roles; however, they do not explore in detail the CTO responsibilities and how CTOs behave. We see an opportunity to understand better the CTO profiles, to deep dive into the CTOs' responsibilities, and to discover which personas are really represented in companies of different maturities.

1.4 THESIS OVERVIEW

Chapter 2 provides a high-level summary of research questions, tangent topics, collected primary and secondary data.

Chapter 3 provides an explanation of the methods for data mining and analysis applied to shed light on the CTOs' background and responsibilities.

Chapter 4 provides the analysis of secondary data gathered from LinkedIn.

Chapter 5 provides the analysis of the primary data (the CTOs insights).

Chapter 6 provides an overview of the next steps to gather more data to be able to achieve statistical significance or explore other questions generated by the current study.

Chapter 7 provides high level summary and concludes the thesis.

2 RESEARCH QUESTIONS

This chapter introduces the research questions about CTOs' behaviors and responsibilities, and factors influencing their role.

2.1 CTOs RESPONSIBILITIES

Starting from the seven aspects of CTOs' responsibilities of Cetindamar and Pala, we envisioned different scenarios (different company size, maturity and organization structure) where CTOs would be involved, and came up of the initial list described below.

This list will be used as boundary options for interviews to allow CTOs to react and assess if they think that these responsibilities are potentially in the CTO scope and if they think that they endorse each responsibility (and to which extent).

Considering the large spectrum of the potential responsibilities, CTOs may be involved in the following responsibilities:

- Internal responsibilities consisting of:
 - managing technology development projects.
 - managing product development.
 - establishing an engineering culture.
 - monitoring technological innovations capable to impact positively or negatively the firm.
 - coordination across business units.
- External responsibilities consisting of:
 - participation in industry groups, conferences, panels.
 - assessment of potential partnerships or acquisitions aligned with the firm's strategy.
 - hiring of technology talent.
 - participation in corporate development, and public relations for product launch or recalls.

In their study, Cetindamar and Pala offered a list of more generic roles that may encompass all these responsibilities. However, they do not explore the real ones in the context where CTO has become a strong popular figure. That is why we decided to break down more the spectrum of responsibilities:

- We separated R&D and Product development management, considering these two related to two different functions in the company.
- We added the responsibility “establishing an engineering culture” considering that this responsibility might be important in all industries today, in a context of strong competition.
- We added “hiring talent” considering that the potential external influence of the new CTO might attract new talents.
- We specified corporate development and public relationship in support of sales and marketing communications.

This new set of responsibilities helped to define personas (see 2.2).

Throughout this thesis, we will catalog a series of hypotheses. We will develop some data to evaluate each. Although the research methods do not permit us to draw strong conclusions for each hypothesis, this represents a useful means of declaring the questions of interest.

H1: The internal and external responsibilities of CTOs are represented in the above set, and the heterogeneity in CTO efforts is a composition of these responsibilities.

2.2 PERSONAS

In their paper, Cetindamar and Pala noted that to replace acting CTOs, proxy CTOs might emerge to take some of the seven responsibilities. The very presence of such role raises the question about the type of CTOs. Do they take some sort of aggregation of technology related responsibilities lacking in the organization or do they have a coherent responsibility set shaping an identifiable behavior?

In order to understand better the responsibilities of CTOs, we will draft personas to help categorize CTOs and understand their behavior. We assume that there are 5 personas of CTOs, to be evaluated during the interviews:

- **The Evangelist:** A public persona well known within the company and beyond. Grows the company's revenue indirectly by leading industry change, or directly by participating in sales. Oversees the new technology adoption for the firm. Substantial time spent externally with partner firms / ecosystem players / industry groups. Plays a significant role in talent acquisition (Ex: Larry Biagini – CTO of Zscaler or Robert Reeves – CTO of Phurnace).
- **The Anchor:** Anchoring the product development organization. Manages product portfolio and steers the strategy for R&D to support company growth in cost friendly way. Anchor is responsible for profitability of existing technology, and decisions on investment in disruptive technologies. Engaged in day-to-day business of developing products (Ex: John Apostolopoulos – CTO of Cisco or Arash Ferdowsi – CTO of Dropbox).
- **The Coordinator:** Corporate role where the divisions host most of the power. In charge of rationalizing approaches across the firm, bringing technology from one division to another, serving as the interface between the CEO and the technology organization. Senior enough to communicate across corporate functions and convince marketing, manufacturing etc. Coordinator oversees the long-term interest of the company as a whole. Stimulates organizations in long lifecycle industries to be excited about technology, stimulates engineers to pick up R&D technology (Ex: John Tracy - CTO of The Boeing Company or Jane Gilmour – CTO of Coca-Cola).
- **The Visionary:** Anticipates future changes in technology that could have a substantial impact on the firm. Part researcher and part futurist. The Visionary protects the firm's competitive position managing capital allocation across diverse technology investments. Guides industry groups and academic groups on potential investments or joint efforts. More accountable than the evangelist (Ex: Werner Vogels – CEO of AWS or Jeremy King – CTO of Walmart).
- **The Strategist:** Takes corporate strategy, technology forecasts and product positioning as inputs, and sets which markets the firm will enter. The Strategist also builds competitive strategy of the firm (potentially with differentiation on technology, or differentiation on cost, or non-CTO areas such as sales, distribution, etc.). Open to external partnerships and plays a role in sourcing or evaluating M&A opportunities from synergy perspective (Ex: Joe Bernik – CTO of McAfee or Brad Peterson – CTO of Nasdaq).

Theses personas tend to encompass the responsibilities defined earlier:

The Evangelist	• participation in industry groups, conferences, panels.
	• hiring of technology talent
	• establishing an engineering culture
The Anchor	• managing technology development projects
	• managing product development
	• establishing an engineering culture
	• hiring of technology talent
The Coordinator	• coordination across business units
	• establishing an engineering culture
	• participation in corporate development, and public relations for product launch or recalls
The Visionary	• monitoring technological innovations capable to impact positively or negatively the firm
	• participation in industry groups, conferences, panels.
The Strategist	• participation in industry groups, conferences, panels
	• assessment of potential partnerships or acquisitions aligned with the firm's strategy

H2: CTOs can be classified as one of these personas, and these personas cover a majority of CTOs. The personas represent the focus of their position even if they may also contribute to other activities.

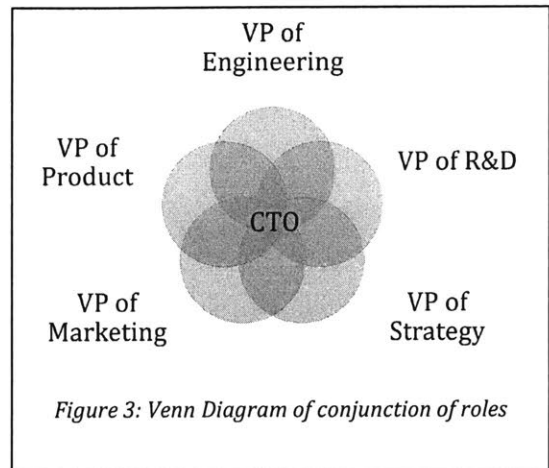
2.3 ROLE DEFINITION

As said earlier, the role is not often well defined, left to the interpretation of the CTO in order to fulfill his/her goals.

In the study, we will focus on the role and responsibilities. Having the title is a strong signal but highly dependent of the organization structure or key people recognition.

Depending of the structure, the CTO role might be a conjunction of a several other roles (Figure #3):

- VP of Engineering
- VP of R&D (Science)
- VP of Product
- VP of Marketing
- VP of Strategy



These roles might already exist in the corporate structure prior to CTO role or be created to delegate

the responsibility. From managerial span, the CTO may have direct reports, or have a functional responsibility for other managers. Since CTO role is loosely defined and is cross-functional, it is challenging to track the performance of its individual contribution. Therefore, many CTOs are supposed to have global performance metrics that are aligned with those of other executives of the company. To succeed, CTOs need to make the other representatives successful.

H3: CTO is a role focusing on cross-functional alignment. To execute their vision, CTOs need to be highly collaborative and connected within the company.

2.4 PERFORMANCE AND ORGANIZATION

2.4.1 Company maturity

Similar to other C-Level members, the CTOs' role might vary depending on maturity of the business and a business cycle the company is in. For a start up at the seed stage, the first need is to prove a business model, deliver fast, develop a minimal viable product that will attract and convince investors, deploying limited resources. In such hectic and dynamic environments, CTOs may serve in multiple roles, such as technical Director, Co-founder or Chief Operation Officer. In a large company, with significant technical debt and complex architectures, the need is more to coordinate the cross-functional architectural coherence and innovation implementation. The role of CTO in such a company is more steered towards creation of architectural transparency, managerial coordination of investment and R&D efforts.

H4: The maturity of the company shapes the CTOs' responsibilities, by making him/her more focus on the company needs

2.4.2 CEO proximity

One of the key roles of the CTO is to bring the technology awareness to the C-level suite and CEO. The proximity of the CTO to C-suite and CEO correlate with the span of his responsibilities, level of responsibilities and influence. In some large organization, we can find many Business Unit CTOs reporting to a Senior General Manager.

H5: The influence of the CTO is defined by its proximity to CEO and Business Unit Presidents.

2.4.3 Performances Metrics

Performance metrics are used by companies to evaluate the productivity of individual employees, track their progress and adjust their compensation. Performance metrics analysis will help us understand where CTOs sit in the hierarchy of the company and how they are evaluated. By analyzing the type of metrics, we will derive the span of the influence and responsibility: financial, business development, program management, productivity, innovation, etc. The incentive structure tied to the metrics will help understand what weight each of the responsibilities plays in the performance assessment and thus help derive the success criteria.

H6: Performance metrics are predictors of CTO responsibilities, by categorizing his/her types of objectives.

2.5 TRAINING AND CAREER EXPERIENCE

2.5.1 Inter-company mobility

CTOs are generally thought to have a broad knowledge of a wide swatch of technology industries. To achieve success in the CTO role, knowledge of the company's history and context is also valuable.

Knowledge of internal organizational structure, architecture, understanding of the company long-term values and strategy are skills that are difficult to match with external hires. The CTOs have often been with the company and have a proven record of accomplishment. At the same time, the unique skillset is a barrier for CTOs to transition across companies and across industries.

H7: CTOs have a lesser horizontal career mobility across companies/industries compared to the other C-Suite executives.

2.5.2 Technology experience

CTOs have a deep understanding of technology, architectures and often possess a hands-on experience in a specific engineering domain. The CTOs acquire this tribal knowledge throughout their career as leaders, managers, but not necessarily as individual technology experts. By comparing the educational background and career path from individual contributor to a global tech influencer, we will be able to understand what drives CTO success: specific expertise vs holistic tribe knowledge acquired from the company.

H8: CTOs have a technical background but do not necessarily have experience as individual contributors/technology experts.

2.5.3 CTO participation in product development

Depending of the company size, CTOs are not expected to actively drive the product development and implementation. CTOs have a birds-eye view of company product portfolio and technical architecture.

H9: CTOs understand product management and development but do not always contribute to product delivery.

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3 RESEARCH METHODS

This chapter introduces the methods used for gathering and interpreting the data from on CTOs' profiles on LinkedIn and CTO interviews.

3.1 QUANTITATIVE APPROACH

The quantitative approach of this thesis relies on simulation of the established corporate players' world and the Silicon Valley startup world. The study explored a set of 100 CTOs from diverse company, industry, experience and education. Such data set allows to explore the points of similarity and points of difference across two company types and build awareness of the associated CTO responsibilities.

To establish the demographics, educational and career patterns, the analysis of primary and secondary data of a population of CTOs was used. We conducted field research of publicly available data about CTO background from LinkedIn to inform the study.

For this purpose, we needed to develop a script to crawl LinkedIn website and extract the relevant data points such as the experiences and the education.

From the list of companies extracted, we sourced public information about the company size and industry, conjointly from The Owlery, Crunchbase, and Orbix.

The table Figure #4 shows the definition of the data extracted from the raw HTML data and the process of data cleaning:

Category	Variable	Description	Information
Profile	id	Profile anonymous identifier	
	inc_profile	Flag if CTOs' profile seems to be incomplete	if declared experiences do not match the max experience
Experience	total_exp	Total declared experience duration	Sum of all the declared experiences
	max_exp	Maximum experience duration	Calculated from the first degree's graduation date
	est_exp	Estimated experience	Calculated from the max between total and max experience fields
Education	degree_first_date	First degree date	or equivalent position (as delegate or responsible)
	degree_last_date	Last degree date	or equivalent position (as delegate or responsible)
	highest_degree	Highest degree obtained	or equivalent position (as delegate or responsible)
	has_business	Flag if the CTO has a business degree	BA or MBA
	has_tech	Flag if the CTO has a technical degree	All technical degree
Companies	total_companies	Number of visited companies	
	company_change_avg_duration	Average duration by visited company	
	company_size_trends	Company size list	Classified in Small Mid Large NA
	fst_cpy_size	First company size	Classified in Small Mid Large NA
	lst_cpy_size	Last company size	Classified in Small Mid Large NA
	large_company_ct	Number of large visited companies	
	mid_company_ct	Number of mid visited companies	
	small_company_ct	Number of small visited companies	
Industries	na_company_ct	Number of NA visited companies	NA: Size unknown or Company not found
	total_industries	Number of visited industries	
	industry_trends	Industry list	Company classified by vertical
Positions	total_positions	Number of undertaken positions	
	lvl_Board	Flag if the CTO undertook a Board position level	
	lvl_C	Flag if the CTO undertook a C position level	
	lvl_VP	Flag if the CTO undertook a VP position level	
	lvl_Director	Flag if the CTO undertook a Director position level	
	lvl_Manager	Flag if the CTO undertook a Manager position level	
	lvl_Lead	Flag if the CTO undertook an Expert position level	
	lvl_Expert	Flag if the CTO undertook a Lead position level	
	lvl_Engineer	Flag if the CTO undertook an Engineering position level	
Activities	lvl_Technician	Flag if the CTO undertook a Technician position level	
	act_Business	Flag if the CTO worked on Business activities	
	act_Management	Flag if the CTO worked on Management activities	
	act_Product	Flag if the CTO worked on Product activities	
	act_R&D	Flag if the CTO worked on Research activities	
CTO	act_Tech	Flag if the CTO worked on Tech activities	
	is_CTO	Flag if the CTO declared a CTO position	
	is_CTO+	Flag if the CTO declared a CTO conjointly with another position	
Raw Data	experiences	Raw data listing the experiences	
	educations	Raw data listing the education degrees	

Figure 4: LinkedIn Data Description

3.2 QUALITATIVE APPROACH

The qualitative approach relies on primary data analysis collected through phone interviews with 20 CTOs across different industries and company sizes. The CTOs were selected from the MIT Alumni Network. We used number of years of active professional experience to form two age groups from 1995 – 2000 and 2010 – 2015 to ensure diverse representation.

A set of 30-minutes interviews were structured as follows:

- Presentation of the objectives of the study from the interviewer.
- Open ended questions about the company context and CTO responsibilities from the CTO.
- Standard questions from a questionnaire (see Appendix I).

- Closing and insights gathering from the CTO.

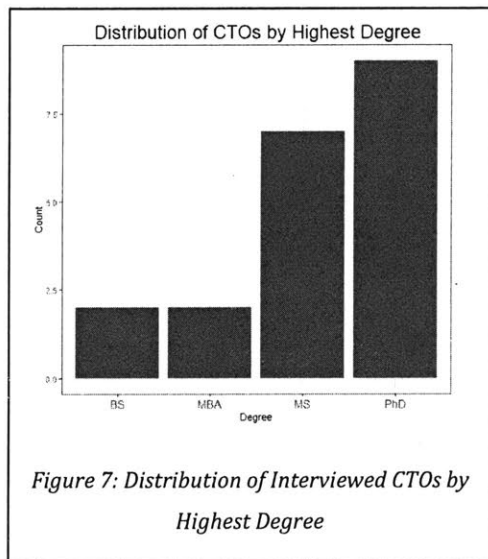
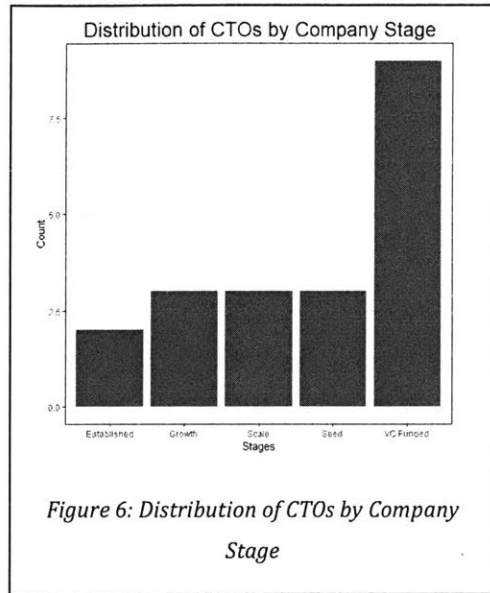
Though the approach is described as qualitative, the author coded the answers in order to have an idea of the data distribution by categorizing the variables. The table Figure #5 shows and explains these variables:

Category	Variable	Description	Information
ID	Identifier	Profile anonymous identifier	
	#Employees	Number of employees in the organization	Rounded figures
Company	Stage	Maturity of the company	Classified in 5 category depending of the number of employees
	Industry	Industry of the company	Classified using the vertical
Shared Responsibilities	S-CEO	Flag if the CTO shares some responsibility with the CEO	or equivalent position (as delegate or responsible)
	S-Eng	Flag if the CTO shares some responsibility with a VP of Engineering	or equivalent position (as delegate or responsible)
	S-Product	Flag if the CTO shares some responsibility with a VP of Product	or equivalent position (as delegate or responsible)
	S-R&D	Flag if the CTO shares some responsibility with a VP of R&D	or equivalent position (as delegate or responsible)
	S-Marketing	Flag if the CTO shares some responsibility with a VP of Marketing	or equivalent position (as delegate or responsible)
Personas	Evangelist	Flag if the CTO identifies himself as ...	see definition of Evangelist
	Anchor	Flag if the CTO identifies himself as ...	see definition of Anchor
	Coordinator	Flag if the CTO identifies himself as ...	see definition of Coordinator
	Visionary	Flag if the CTO identifies himself as ...	see definition of Visionary
	Strategist	Flag if the CTO identifies himself as ...	see definition of Strategist
	Primary Pers	Primary Persona	
	Secondary Pers	Secondary Persona	
Responsibilities	Pers-Flags	Flag for dual Persona	
	R&D	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Product-Dev	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Culture	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Innovation	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Coordination	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Representation	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Strategy	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Hiring	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	CD/PR	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	IP	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Regulatory	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Education	Flag if the CTO identifies the responsibility as his/her	1 0.5 0.25 0 to quantify for yes sometime a little not at all
	Performance metrics	P-Business	Flag if the CTO identifies to be evaluated on performance metrics
P-Product		Flag if the CTO identifies to be evaluated on performance metrics	see examples of metrics in the analysis
P-Program		Flag if the CTO identifies to be evaluated on performance metrics	see examples of metrics in the analysis
P-Research		Flag if the CTO identifies to be evaluated on performance metrics	see examples of metrics in the analysis
P-Eng		Flag if the CTO identifies to be evaluated on performance metrics	see examples of metrics in the analysis
P-Revenues		Flag if the CTO identifies to be evaluated on performance metrics	see examples of metrics in the analysis
Background	CompanyChange	Number of times the CTO changes of company in the last 10 years	
	IndustryChange	Number of times the CTO changes of industry in the last 10 years	
Reporting	R-CEO	Flag if the CTO reports directly to the CEO	
	R-Co-founder	Flag if the CTO is a co-founder	
	R-GM	Flag if the CTO reports directly to a General Manager	
Compensation	C-Equity	Flag if the CTO's compensation encompass an Equity component	
	C-Base	Flag if the CTO's compensation encompass a Base component	
	C-Benefits	Flag if the CTO's compensation encompass Benefits/Perks component	
	C-Bonus	Flag if the CTO's compensation encompass a Bonus component	
	C-Options	Flag if the CTO's compensation encompass an Options component	
	C-Comparable	Flag if the CTO identify to earn a comparable package than other executives	
	C-Lower	Flag if the CTO identify to earn a lower package than other executives	
C-Higher	Flag if the CTO identify to earn a higher package than other executives		

Figure 5: Interview Data Description

Figure #6 describes the business maturity distribution across the population of CTO employers.

We have a large representation of CTOs in the VC Funded stage. This will skew the distribution of responsibility in our analysis.



The graph Figure #7 shows the distribution of CTOs by Highest Degree. Our sample shows a large population of PhD and MS.

We strived to maintain the diverse industry pool and selected 11 industries for the analysis. The sectors where technology is the key success driver such as healthcare, biotech or software development were most popular among CTOs. Figure #8 represents the distribution of Personas across the 11 industries.

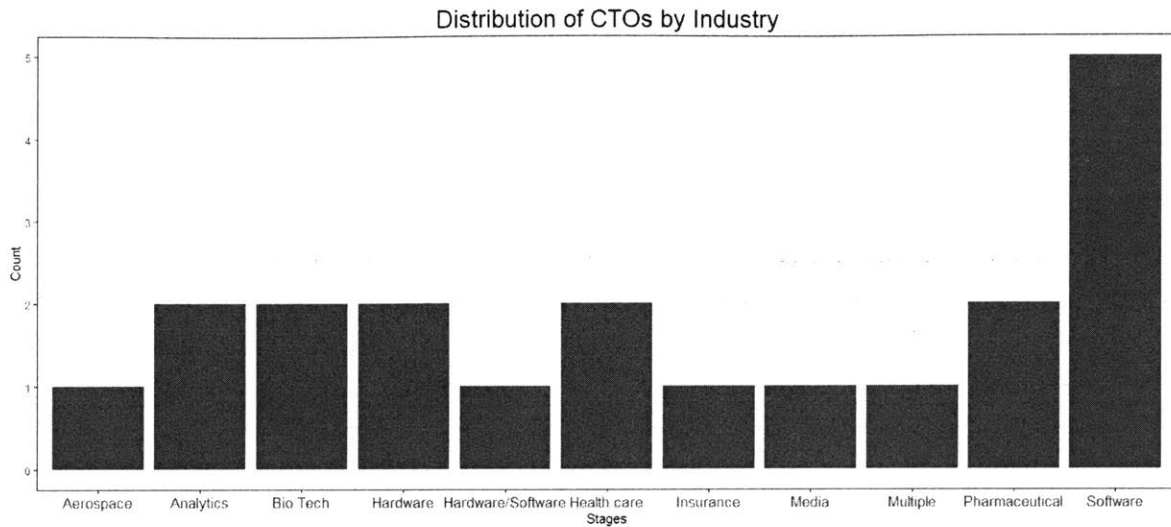


Figure 8: Distribution of Personas by Industry

3.3 BIAS AND LIMITATIONS

We learned that the CTO role is loosely defined in comparison with more established roles driven by narrow organizational specialization such as Chief Financial Officer or Chief Information Officer. This results in the heterogeneity in the pool of CTO profiles. This exploratory study aims to begin to characterize the CTOs, but we recognize that there is a tremendous heterogeneity, and a larger sample size would be necessary to work with the hypothesis cited in this study.

The study acknowledges some limitations in both approaches:

- Quantitative analysis: LinkedIn bios are based on self-declaration. Profiles are known to be “improved” since the information is not confirmed or vetted by a reliable source. In addition, 100 data points may be not enough to reach statistical significance.
- Qualitative analysis: The study acknowledges the bias of self-selection of the CTOs who responded to the call for interviews and the bias of common origin since they are all MIT graduates. Again, with such a large data heterogeneity, 20 data points may not be enough to run regression with a reasonable significance.

However, the fact that the study might not be able to conclude unequivocally on the research questions does not alleviate the interests of the discussion and the potential explanation from the observations.

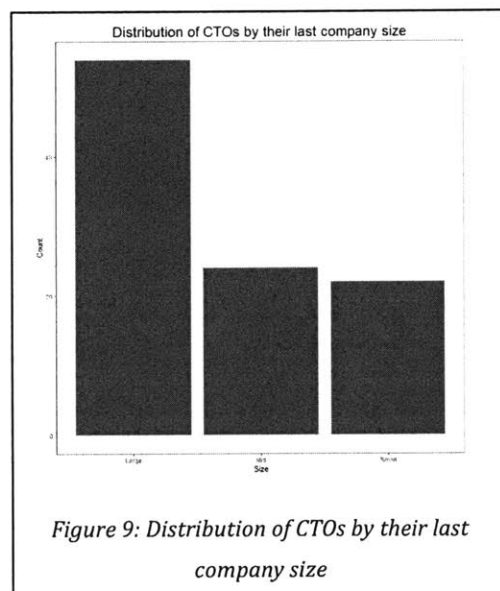
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4 LINKEDIN ANALYSIS

This chapter covers the LinkedIn profile analysis of 100 CTOs. LinkedIn is the website leader for professional networking, giving to users the opportunity to showcase their experience. As such LinkedIn platform provides a great incentive to provide extensive data on education, professional career path and achievements. While we acknowledge that self-generated content provides sometimes inaccurate and selective representation, the reliability and usability of the Linked tool by recruiting community convince that the LinkedIn platform is a reasonably and comparably reliable source of knowledge.

We have selected the panel of diverse industries, both tech intensive and not: Chemistry, Hi-tech, Internet, Finance, Banking, Aero, Oil, Telecom, Automobile, Education, Transport, Robotics, Logistics, Utilities, Consulting, Hospitality, Pharmaceutical, Apparel, Food, Consumer Goods, Retail, Media.

We created a data sample representing diverse sizes of the companies: large established companies, Medium sized businesses and smaller Silicon Valley technology companies. The graph in Figure #9 shows the distribution of CTOs by their last company size categorized by headcount (Small: less than 100, Medium: between 100 to 1000, Large: over than 1000)



4.1 EXPERIENCE

The selected CTOs have a minimum of 8 years of professional experience with an average of 24. Consequently, we can assume that on average, 8 years of experience is the minimum to gather enough technical experience and to build a legitimacy to endorse the role. CTOs are on average 48 years old, which is respectively 3 and 5 years younger than their counterparts CIOs and CFOs (Korn Ferry

Institute, 2017). That can be explained by the over representation of CTOs from Hi-Tech or Internet startups in our population, which is expected to be younger.

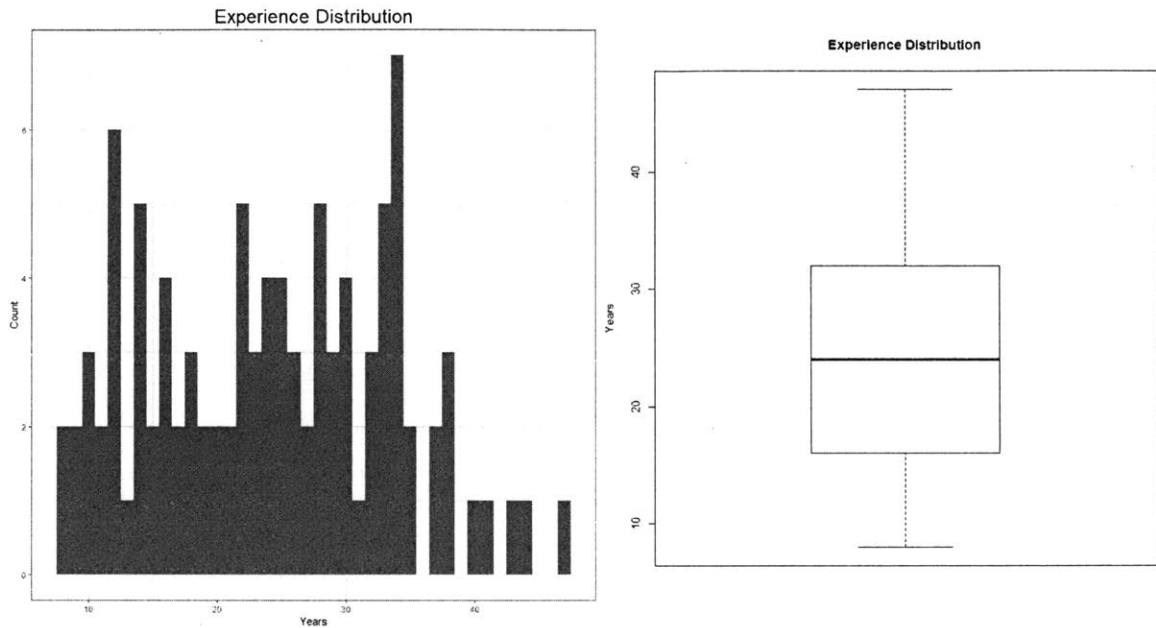


Figure 10: LinkedIn Experience Distribution

4.1.1 Number of Past Companies

The data shows that the CTOs on average switch the employer 5.6 times during their career path. However, this observation has to be taken cautiously since the average does not include exclusively the CTO experiences, but all the experiences over their career. Yet, that might be the sign that CTOs have a rich and diversified experience.

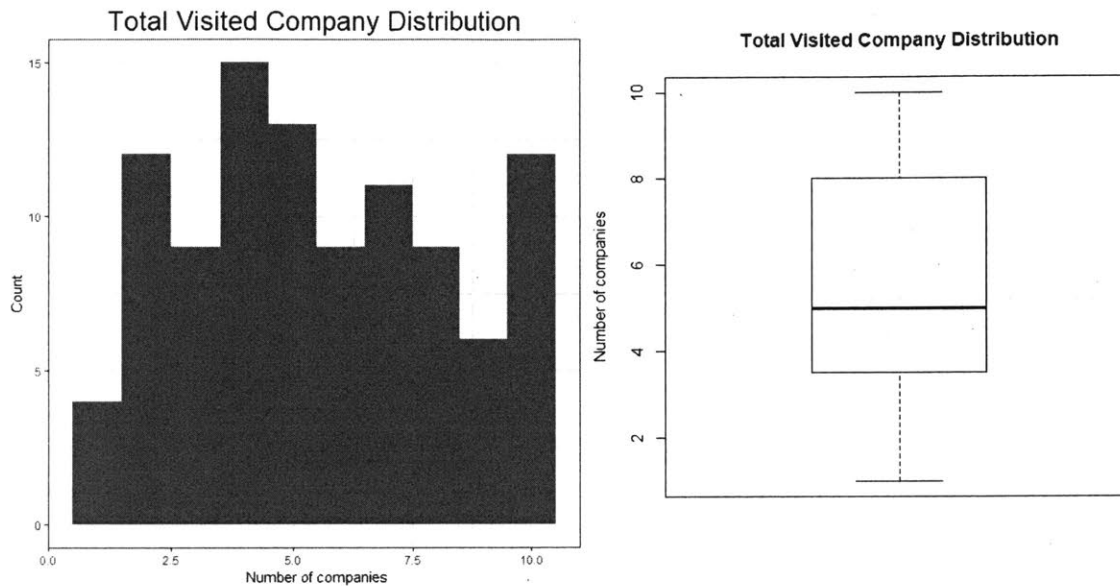


Figure 11: LinkedIn Visited Company Distribution

The average here may not be the best representation, since it should be analyzed along with the overall years of experience of the individual. Thus, the average tenure duration across all jobs might be more interesting to comment:

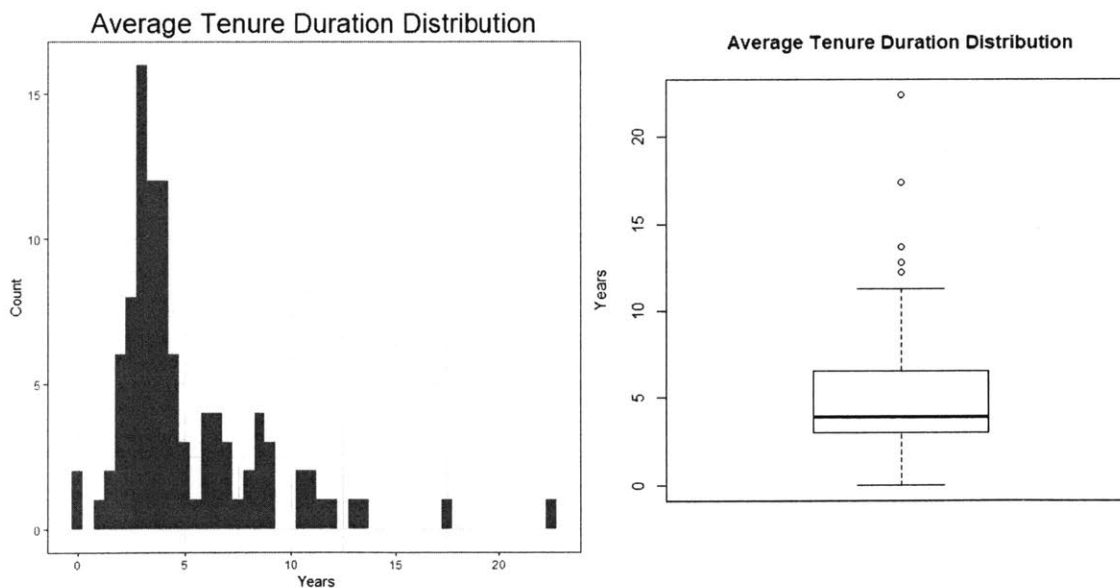


Figure 12: Average Tenure Duration Distribution

Indeed, it turns out that CTOs stay on average 5 years in the same company with a median at 4 years. Interestingly that figure is 18% above the average tenure of 4.2 years provided by the US Bureau of

Labor statistics in 2018 (Economic News Release, 2018). This number also may be affected by the age distribution we selected. Pew Research Center for Social and Demographic trends discovered that workers of 55 years older had a median tenure greater than 10 years, while workers of 25-34 years old stayed only for about 3 years with the same employer (The states of american jobs, 2016).

But the tenure duration might be too average across their experience. Therefore, if we pick only CTOs' experiences we obtain the following distribution.

Our population of CTOs have a tenure duration in a CTO position of around 4 (4.38) years which might not be a long time to implement a technology strategy. However, the graph Figure #13 also shows the tail of very long tenures. In comparison, CIO has an average of 4.3 years and CFOs of 5.1 years (Korn Ferry Institute, 2017).

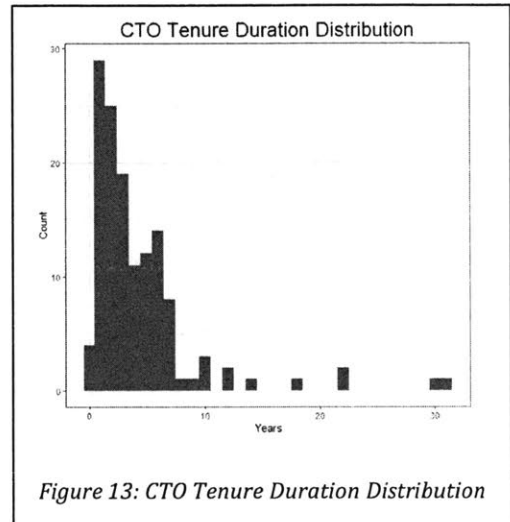


Figure 13: CTO Tenure Duration Distribution

4.1.2 Migration overview

We hypothesized that the career path shapes the CTO experience affecting the roles and responsibilities that they are granted. It is interesting to explore what size of companies they worked in from the beginning of their career to their current position. Figure #14 shows the average of allocation by company size over the CTO career.

Half of the CTOs in this sample worked in Large companies over their career and only 30% built their skills in small companies (categorized by headcount - Small: less than 100, Medium: between 100 to 1000, Large: over than 1000). We may observe this skew toward Large companies since up to early 2000s innovative technology was costly and only large companies had access to high-level engineering resources and hardware. Only in early 2000s the dynamics of the tech industry changed due to engineering innovations, making performant hardware more accessible, globalization, pioneering open-source adoption and increased internet penetration, all together making it possible for relatively small players gain traction in high-tech fields.

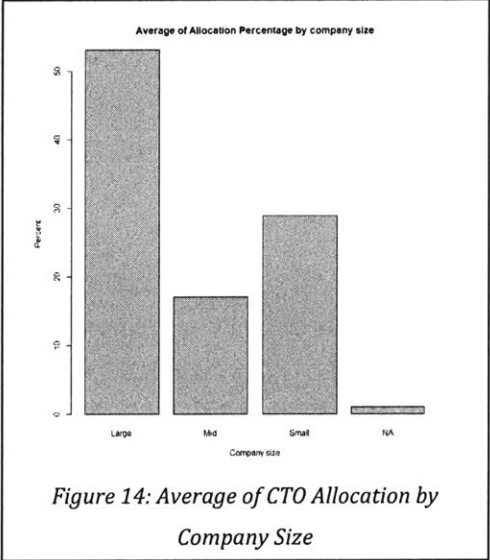


Figure 14: Average of CTO Allocation by Company Size

The data supports that claim. Graph in Figure #15 shows the career trajectory, company size wise, from the first to the current position.

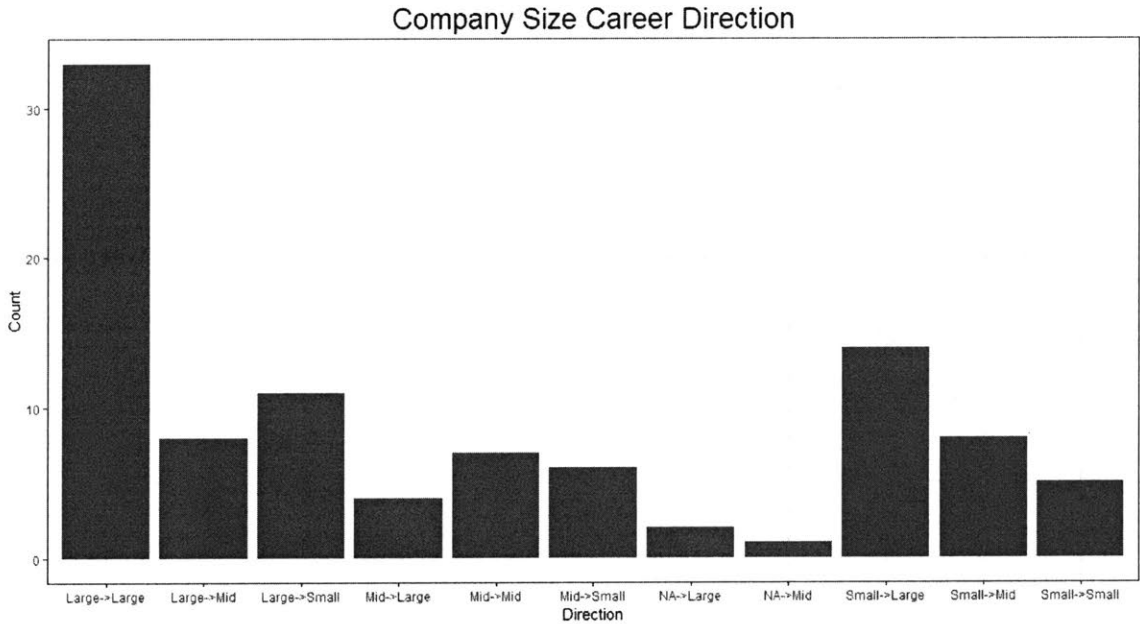


Figure 15: Company Size Career Direction

More than 30% of the CTOs started their first job in a large company, usually as individual contributor, and either stayed or came back to work to a large company after a transition. We can also collect other observations from this chart:

- Around 10% CTOs who started their first job in a large company might switch to a small one, potentially to create a startup or bring a their knowledge to help them grow.
- There is no clear trend for CTOs who started in a mid-sized company. They are equally likely to transition to Small or Medium companies.
- CTOs who started in a small company end most likely in a large company.

4.1.3 Industry Explored

We observed that CTOs role requires extensive industry and business knowledge to be successful. We supposed that CTOs develop expertise that may not be transferable to other industries. Such unique skillset should be a barrier to switching the industries. The data however shows that on average CTOs switch industries 2.8 times over their career. The caveat is the analysis classified the data as business verticals, and in our sample, we have a strong representation of Internet (Software) industry CTOs. One may argue that internet technology knowledge is relevant and transferable to every industry. We also observe that after 4 industry switches, the distribution is skewed, as show the graphs in Figure #16.

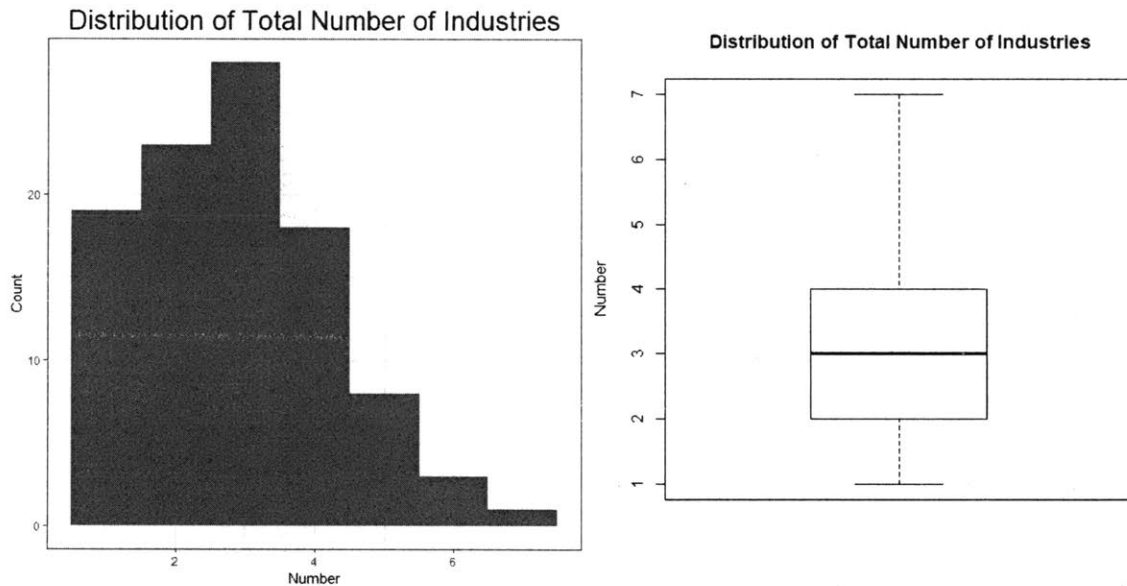


Figure 16: Distribution of Explored Industries

On average, CTOs spend between 5 and 13 years in one industry, with the median of 8 years.

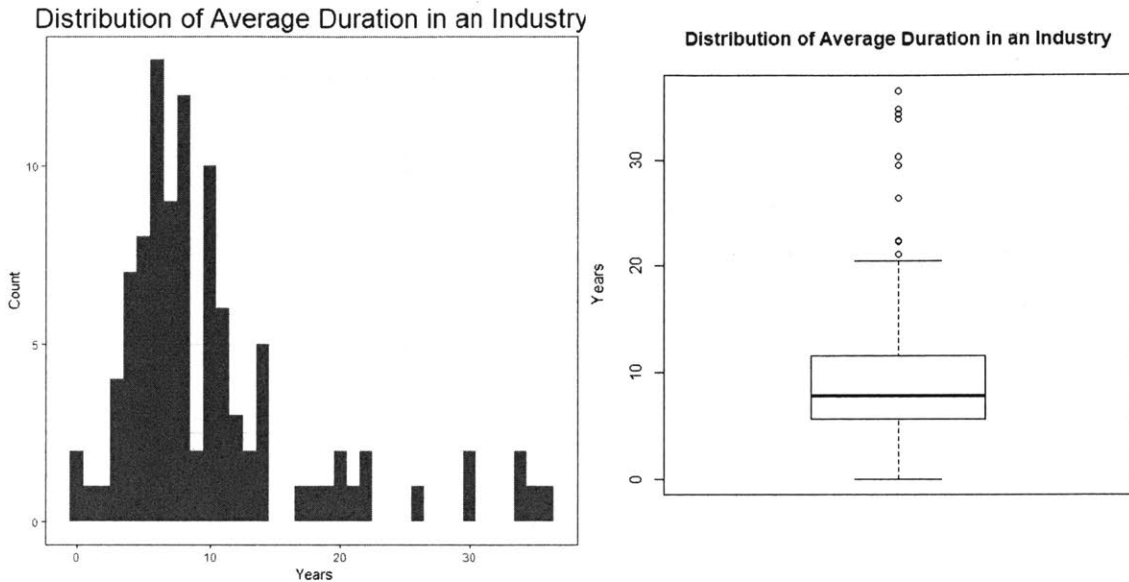


Figure 17: Distribution of Average Duration in an Industry

The observation is consistent with the requirements that we defined for a successful CTO skills that require in-depth understanding of the industry and its dynamics.

4.2 EDUCATION

4.2.1 Highest Degree

After a classification of the CTOs' degrees, we can assert that CTOs do not have always an advanced degree. CTOs with either a PhD or a MS degree represent 48%. The biggest representative degree is the Master's (excluding MBAs) with 33%, followed by the bachelor's degree with 25%.

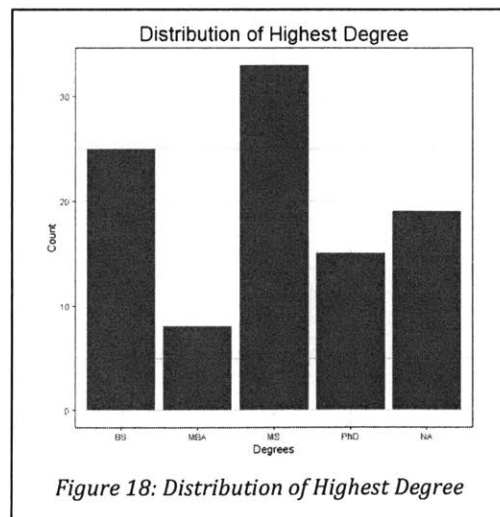
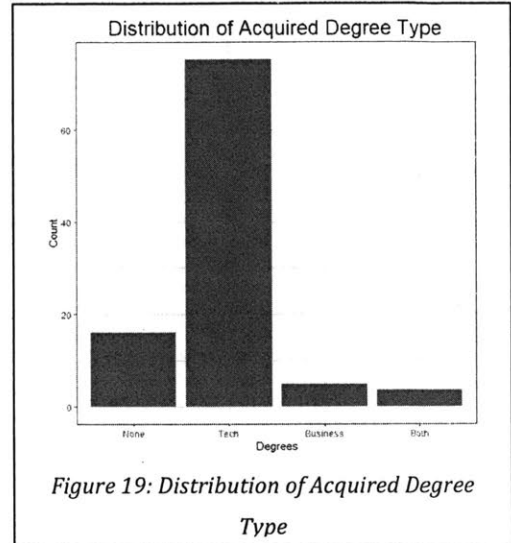


Figure 18: Distribution of Highest Degree

4.2.2 Technical or Business Degree

As expected, most CTOs have a scientific or engineering degree. A small minority of CTOs have a business degree.

Note that 16% of the CTOs do not have either a technical or a business degree. The number is comparatively high considering the degree of specialization required for CTO role.



4.3 CAREER PATH AND JOB TITLES

We used LinkedIn to trace the career path and evolution of job titles of the CTOs. We acknowledge that using self-reported content may flaw our analysis since people may choose not to disclose all of the positions or career transitions.

4.3.1 Job Titles

Over their career, CTOs in our sample transition through a range of 4 to 9 job titles, with an average of 6 (6.7), as shows the graph bellow.

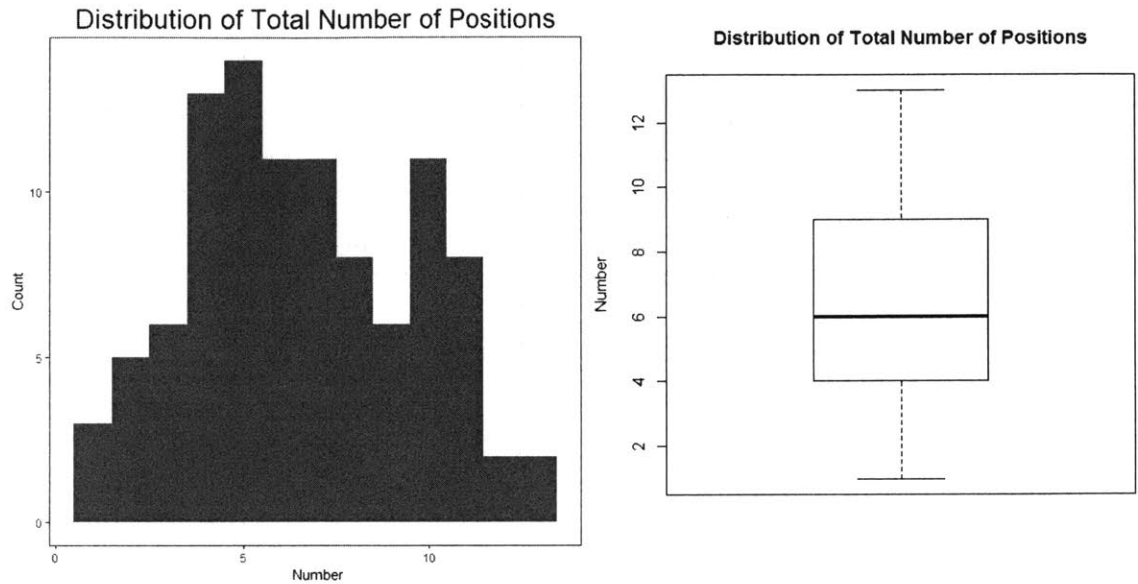


Figure 20: Distribution of Total Number of Positions

On average, we see that CTOs during their career path are most likely to stay between 3 to 5 years in the same position (see Figure #21). Note, that this time, the distribution has a significant number of outliers, confirming that there are exceptions.

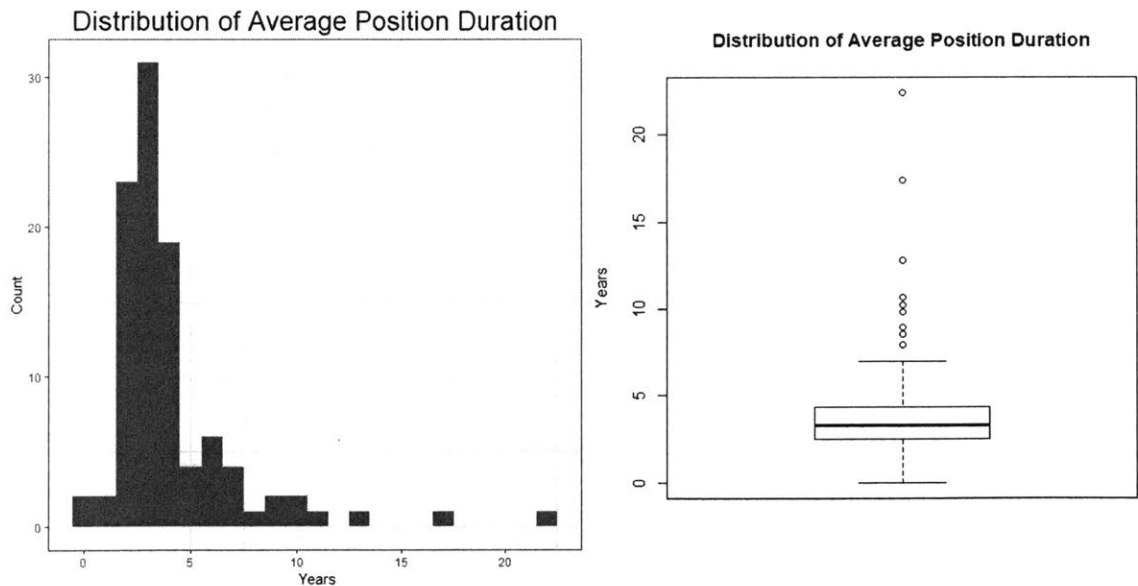


Figure 21: Distribution of Average Position Duration

By classifying the job titles, we can extrapolate either the type of responsibilities and the level of the position.

If we classify the CTOs' positions and flag all the levels, we obtain the following diagram, expressing how many CTOs had at least a position in each level over their career prior their last role of CTO (or in parallel for few of them (ex: Board Member)).

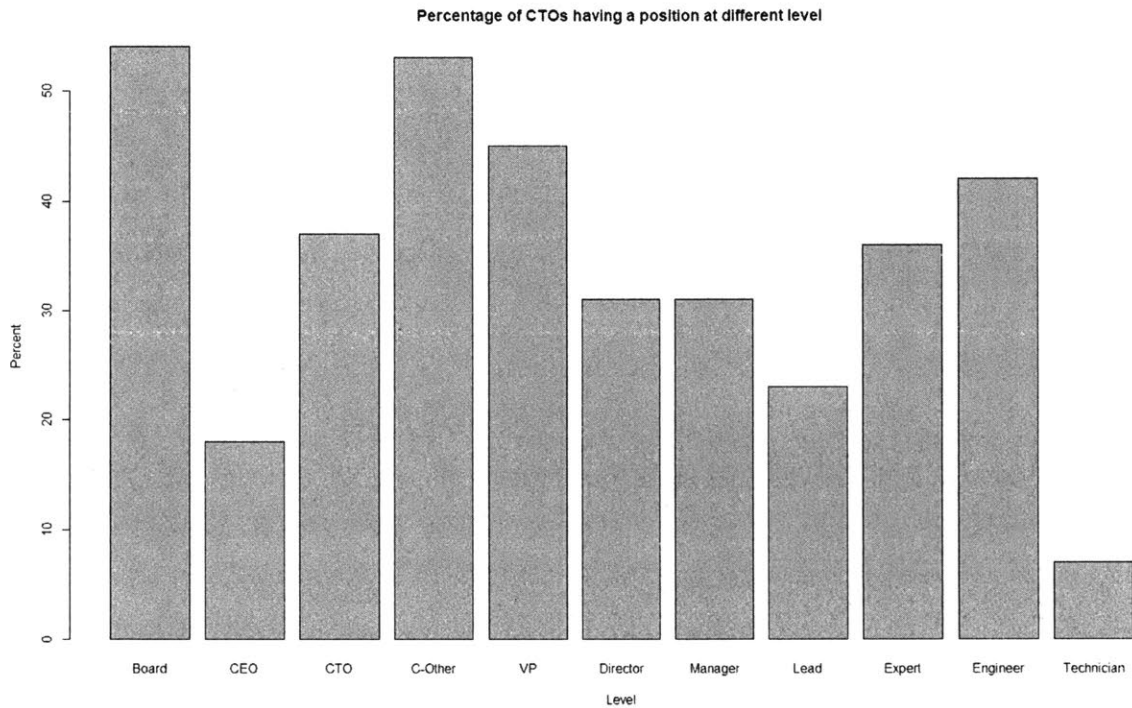


Figure 22: Distribution of Position Level during the career

We observe:

- Almost 55% of the CTOs had a board related position
- 18% had been CEO before their last CTO position
- 36% already had a previous CTO experience
- Almost 55% had at least another C-Level position (CIO, COO, ...)
- More than 45% of them had a VP position
- Around 40% got pure technical positions such as Subject Matter Expertise, Architecture or Engineering.
- More than 30% had a role of people management such as Manager or Director.

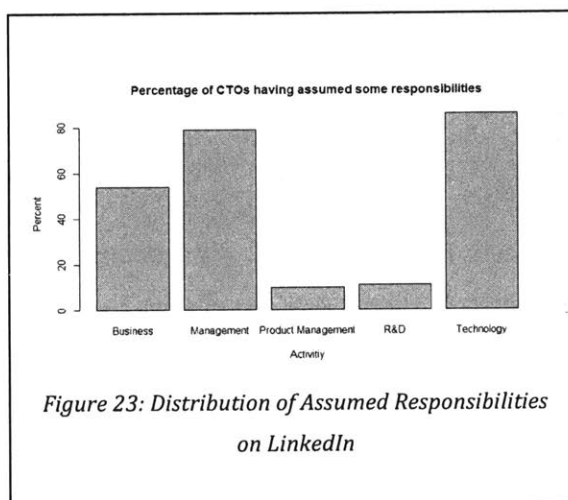
What is interesting here is the fact that not all CTOs have been involved as technical contributors, assuming that their profile reflects their full career.

4.3.2 Responsibilities

Similarly, in classifying the positions by self-reported responsibilities, we obtain the graph of Figure #23 representing the fact that CTOs had at least once each responsibility during their career prior their last CTO position. To classify responsibilities, we matched manually all the declared titles with normalized positions (such as CTO, VP of R&D, Technical Director, Product Manager, Engineer) and encoded responsibilities for each normalized position (for example, a VP of R&D will be associated to Management and R&D, and a Technical Director will be encoded with Management and Technology).

Once again, not surprisingly, CTOs have been all involved in technology matters, even if, as shown earlier with the level, they have not been all individual technical contributors.

Management responsibilities are highly present since around 80% of the CTOs had a management position. The business responsibility is also very represented (55%) brought by the board level positions (see earlier). What is notable is that very few CTOs have been responsible for Product



Management or R&D responsibilities. We would have expected more CTOs for R&D responsibilities, but our method is not flawless since it uses only the title to detect the responsibilities. It could be possible that CTOs do not express the need to qualify their position involving R&D responsibilities and therefore those would be hidden from us. Another explanation is that CTOs responsibilities do not always encompass R&D responsibilities, but most likely product development. Also, the Product Management is usually separated from the product development responsibilities in Hi-Tech or Internet companies.

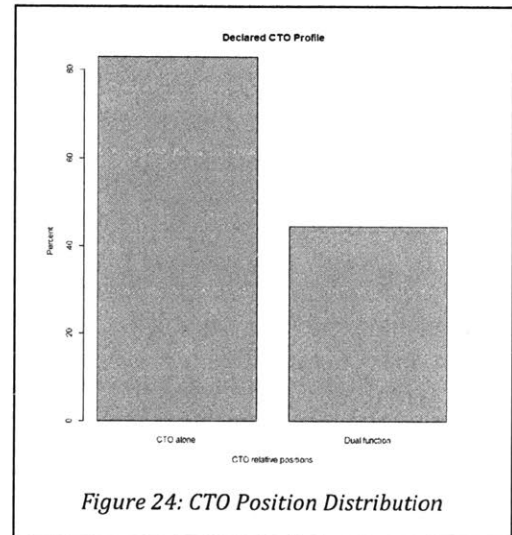
To conclude, CTO are expected to have experience in product development but not always to have developed expertise in R&D or Product Management. These last responsibilities do not seem mandatory for becoming CTO.

4.3.3 CTO: a single position?

The LinkedIn profile analysis required a lot of data matching and categorization since no profile had the same way to declare their functions. One surprising finding is that not all the observed CTO profiles declared only the position of CTO. Instead, those profiles declared the CTO function in addition to another function.

That leads to the graph of Figure #24 showing the percentage of profiles declaring at least a position of CTO, but also the percentage of profiles declaring a second function in addition to the CTO position.

Thus, more than 80% of profiles declare having a CTO position using the position title field. Therefore, least than 20% of CTOs do not declare to be a CTO using a position title field but instead use the global profile description field or the position description field of their profiles in explaining assuming some functions of CTO (such as “acting CTO”).



Interestingly, around 50% of the openly declared CTOs assume another position in addition to their role. Is the CTO position not enough in itself or is it a complement to other positions?

The most represented positions along with the CTO title are:

- Co-Founder or Founder: 39%
- VP: 48%
- CEO/COO/MD/President: 12%
- Distinguished Engineer: 2%

From this representation of executive levels, one can wonder if, for these 50% of CTOs, the title of CTOs is a description of some additional technology-related responsibilities more than a CTO role.

5 INTERVIEW ANALYSIS

This chapter introduces the analysis of data from CTOs' interviews. Interviews are very useful to gather insights allowing to understand and explain some data analysis result.

In overall, our population of CTOs, mainly from companies in early maturity, recognized all the suggested responsibilities as potentially bound to the CTO roles but also that they work more on the internal responsibilities, and showed a strong self-identification to the Anchor and Coordinator personas.

“My responsibilities evolved with the growth of the company. Now, I manage and delegate to managers, reviewing the technology work and setting the milestones.”

- CTO from growing startup in the Software industry.

They also showed that being a CTO is matter of building an engineering team and shed the light of a CTO lifecycle accompanying the company and organization growth.

“There is a friction between short-term and long-term [technology] strategy. It's up to the CTO to build the bridge to inform the CEO decisions.”

- CTO from a large Hardware/Software corporation.

One of the CTOs' challenges is to answer to the short-term needs of the company in building the necessary work to improve the company bottom-line in a time horizon depending to pace of the industry (3 years for Internet industry or 8 years for the Health Care industry).

The last important finding is that 100% of our population of CTOs reports directly to the CEO or a Business Unit Executives. We acknowledge a bias in our distribution because of the presence of 40% of Co-Founders.

In the following, we will deep dive in the transcript of interviews about responsibilities, personas and factors shaping the CTOs' responsibilities.

5.1 RESPONSIBILITIES

As said earlier, all the responsibilities have been recognized as potentially attributed to CTOs, when directly asked.

“Part of my responsibilities is to manage Patents, the IP lawyer relation, and the regulation paper work.”

- CTO from a startup in Bio Tech industry

“You’ve forgot coaching and training. I spend lot of time educating partners and internal stakeholders such as Sales or Marketing about our technology”

- CTO from a Software industry

During the interview three new responsibilities had to be added:

- Managing an IP portfolio, communicating with IP lawyer
- Managing regulatory compliance, driving the regulatory documentation
- Educating customers or partners

However, some CTOs did not always express any responsibilities related to these ones during the open-ended question phase, but only after the enumeration of the responsibilities by the interviewer. These are potentially less representative in the CTOs' mind of our sample

Therefore, the list of responsibilities becomes:

- Internal responsibilities consisting of:
 - **R&D:** managing technology development projects.
 - **Product Development:** managing product development.
 - **Culture:** establishing an engineering culture.

- **Innovation:** monitoring technological innovations capable to impact positively or negatively the firm.
- **Coordination:** coordination across business units.
- External responsibilities consisting of:
 - **Representation:** participation in industry groups, conferences, panels.
 - **Strategy:** assessment of potential partnerships or acquisitions aligned with the firm's strategy.
 - **Hiring:** hiring of technology talent.
 - **CD/PR:** participation in corporate development, and public relations for product launch or recalls.
 - **IP:** Managing an IP portfolio, communicating with IP lawyer
 - **Regulatory:** Managing regulatory compliancy, driving the standard documentation
 - **Education:** Educating customers or partners

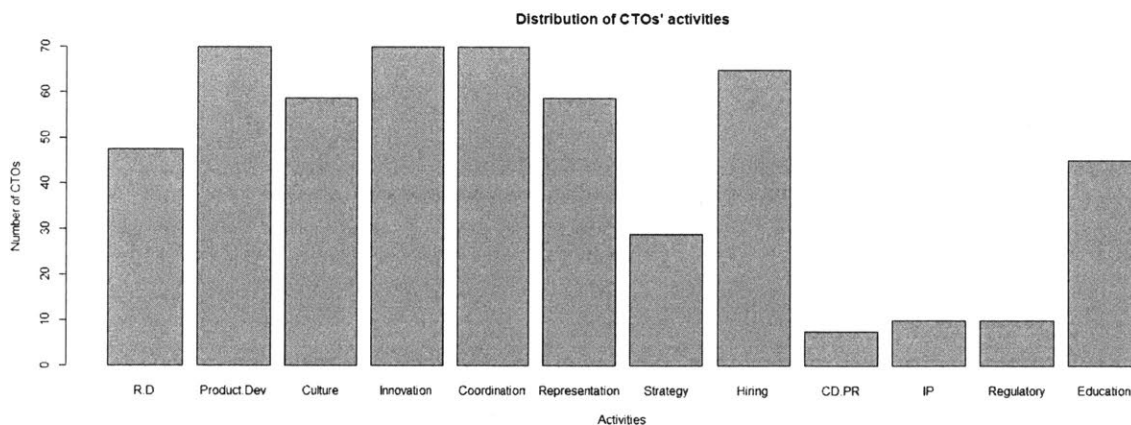


Figure 25: Distribution of CTOs' responsibilities

The graph Figure #25 shows the distribution of the responsibilities among the CTOs, obtained by transcription of their responses. Each activity has been coded by:

- ⇒ 1 if fully assumed (most of their time)
- ⇒ 0.5 if sometimes assumed (not most of their time)
- ⇒ 0.25 if they support others
- ⇒ 0 if not at all

We observe that:

- 70% of the CTOs are involved in Product Development, Innovation, Coordination
- Around 60% of them are involved in Culture, Representation and Hiring
- Less than 50%, in R&D and Education
- 30% of them in Strategy
- 10% of them in Corporate Development/Public Relation, IP and Regulatory

The graph also shows the unbalance between internal responsibilities and external ones. CTOs remain anchored in the technology development.

In addition, 40 % of the interviewed CTOs do not have product delivery responsibilities but 90% of them have either R&D or Product Development responsibilities. Therefore 10% of them do not have R&D and Product Development responsibilities.

Finally, none of the CTOs have the same responsibilities profile (Appendix II) showing the heterogeneity of the CTO responsibilities.

5.1.1 Activity by Company Stages

The previous observations do not break out company maturity, but we might reasonably ask how responsibilities vary with company maturity.

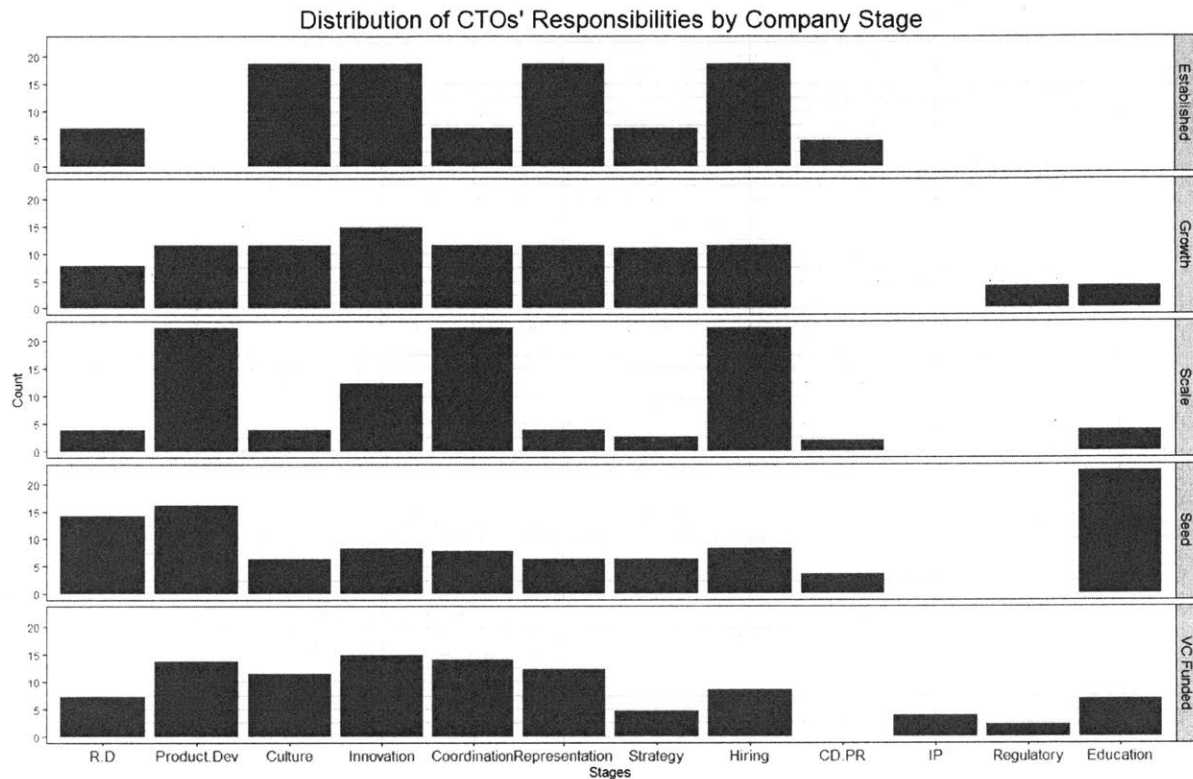


Figure 26: Distribution of CTOs' responsibilities by Company Stage

Retaining only the largest responsibilities in each stage, we can deduce that in:

- Seed stage companies, CTOs are more focused on building a prototype or product and educating the potential customers or partners, as expressed by the R&D, Product Development and Education responsibilities (in the figure #26 line 4). These responsibilities suit well the profile of CTO co-founder looking for early adopters and funding.
- VC Funded stage companies, CTOs are more focus in Product development, Innovation and Coordination (in the figure #26 line 5). They have to be involved in the product definition, the technology differentiation and coordination until the company have enough traction to grow.
- Growth stage companies, CTOs do not have a focus of responsibilities. They seem to have a large spectrum of responsibilities from Product Development to Hiring (in the figure #26 line 2). At this stage, they act at every level to ensure that the company continue to grow.
- Scale stage companies, CTOs are more focus in Product development, Coordination and Hiring (in the figure #26 line 3). At this stage, CTOs must be involved in the development the product portfolio using a lot of coordination among the different departments and hire a lot of talents to sustain the company scaling.

- Established stage companies, CTOs are more focus in Culture, Innovation, Representation and Hiring (in the figure #26 line 1). They are probably more distant from the product development and act as the Technology face of the company.

5.1.2 Influence of the shared responsibilities

“My CEO and co-founder is technical. He is managing all the investor relations and fund raising, advocating for our technology.”

- CTO from a startup in Bio Tech industry

“Before I was involved in developing our product. Since I hired managers and delegate to VPs of Engineering, which report to me.”

- CTO from a scaling company in Analytics industry

One of the hypotheses (H3) states that the organization has an influence on the responsibilities of CTOs. Especially, either CTOs report, collaborate or delegate to other employees within the company, they may adapt their contribution.

In order to understand these relations with other people, CTOs has been asked if they share some technical responsibilities with other people within the organization. There is a bias here since we only have the input of CTOs and not of other roles but it still representative of how they perceive their relations. The graph figure #27 shows the distribution of non-CTOs sharing some technology-based responsibilities.

We notice that 55% CTOs share responsibilities with the CEO, probably because of the over representation of co-founders, but also 30% of them share

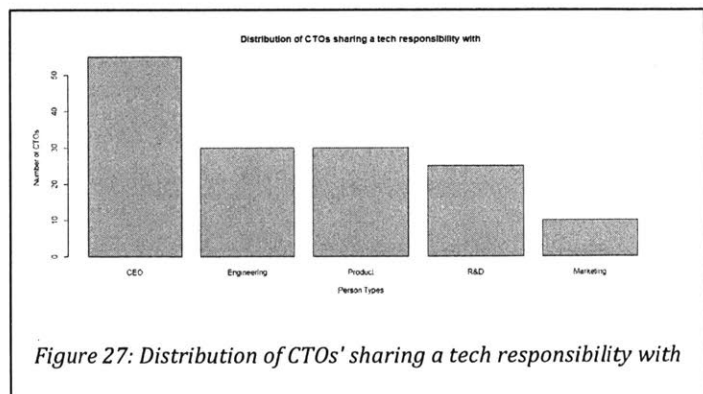


Figure 27: Distribution of CTOs' sharing a tech responsibility with

responsibilities with an Engineering and Product representatives.

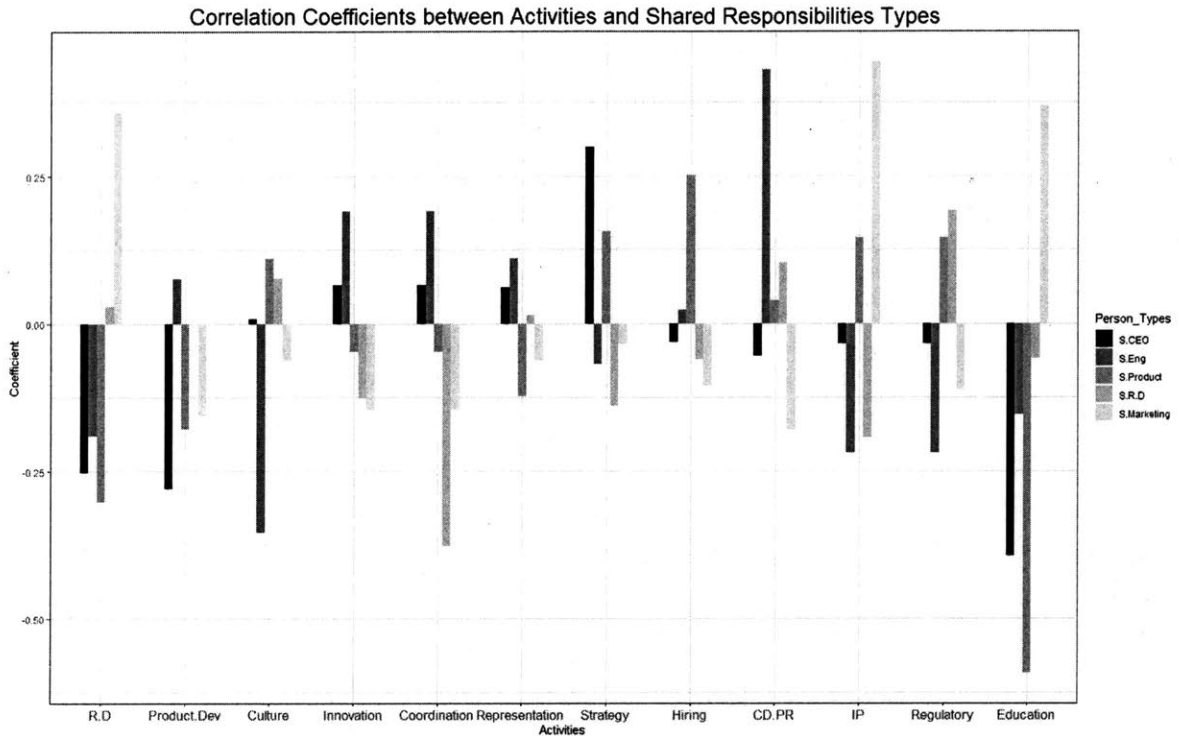


Figure 28: Correlation between Responsibilities and Shared Responsibility Types

The diagram Figure #28 shows the relative correlations between responsibilities and the fact that CTOs shared part of their responsibilities. We can draw some other hypotheses:

- If the CEO is technical, the CTO might be less involved in the R&D (-0.253), Product Development (-0.28) and Technical Education (-0.394) but more involved in Strategy (0.3).
- If the CTO shares Engineering responsibilities, the CTO might be less involved in R&D (-0.19), Culture (-0.354), IP management (-0.218), Regulatory (-0.218) and Technical Education (-0.154) but more in Innovation (0.19), Coordination (0.19) and Corporate Development (0.431).
- If the CTO shares Product responsibilities, the CTO might be less involved in R&D (-0.303), Product Development (-0.178), Representation (-0.122), and Technical Education (-0.592) but more in Culture (0.11), Strategy (0.157), Hiring (0.252), IP (0.145) and Regulatory (0.145).
- If the CTO shares R&D responsibilities, the CTO might be less involved in Innovation, Coordination (-0.126), Strategy (-0.139), and IP (-0.192) but more in Corporate Development (0.103) and Regulatory (0.192).

- If the CTO shares Customer Relationship responsibilities, the CTO might be less involved in Product Development (-0.155), Innovation (-0.145), Coordination (-0.145), Hiring (-0.104), Corporate Development (-0.18) and Regulatory (-0.111) but more in R&D (0.36), IP (0.444) and Technical Education (0.369).

Some of these results are counter intuitive, such as:

- For CTOs sharing Customer Relationship responsibilities, those should have more time for Product Development, Innovation, Coordination and Hiring since these responsibilities are not supposed to be assumed by the Marketing or Sales.
- For CTOs sharing technical responsibilities with the CEO, there is no obvious reason why the CTO would be more involve in Strategy except by creating a better partnership with the CEO.

There are two reasons why we obtain such counter intuitive results:

- The sample is maybe too small for determining a right correlation (especially on R&D and Marketing which represent the skew of the distribution)
- The fact that sharing responsibilities can also amplify other responsibilities since the CTO has more time to work on these responsibilities.

5.2 PERSONAS

The personas section of the questionnaire has been interesting because it raised some comments from CTOs:

What is the difference between Visionary and Strategist again?

It seems that the Visionary and Strategist were not separated in some CTOs' perspectives since the Visionary has to anticipate and the Strategist has to determine the strategy to take advantage of the technology forecast. For some CTOs, that should be the same person.

"It's very difficult to pick only one"

"I think ... I am a little bit of all of them"

Originally, the question about personas expected only one persona, in order to force CTOs to pick the most important behavior. The question turned out to be a real challenge because CTO didn't have the impression to be described uniquely. This response reinforces the hypothesis that the CTO role is diffuse.

CTOs were asked to choose two among the five proposed personas. If a CTO picked only one, the persona has been counted in double to balance the weight.

The chart of Figure #29 shows the distribution of the personas.

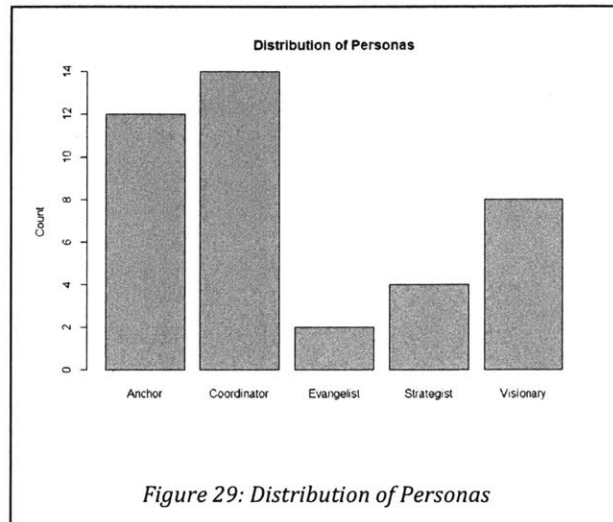


Figure 29: Distribution of Personas

We notice that the Anchor and the Coordinator are the most prevalent in our sample, followed by the Visionary.

5.2.1 Relation with the responsibilities:

As these personas have been picked by the CTOs on the self-positioning basis, it is interesting to explore if we have some correlations with their declared responsibilities.

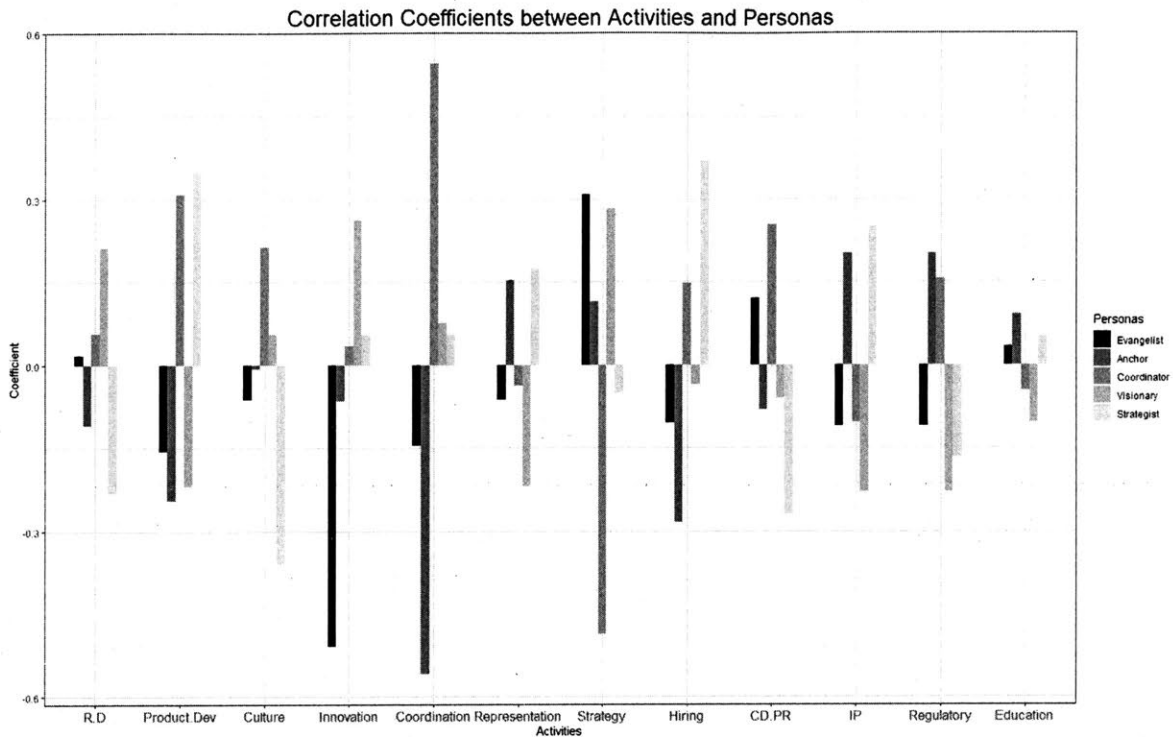


Figure 30: Correlation between Responsibilities and Personas

The graph Figure #30 shows the correlation between responsibilities and personas. Some of correlations have been expected, such as:

- The Evangelist: correlates negatively the Innovation (-0.509) and positively the Strategy (0.309)
- The Coordinator: correlates positively the Culture (0.212), Coordination (0.545), and Corporate Development (0.252) but negatively the Strategy (-0.487)
- The Visionary: correlates positively the R&D (0.211), Innovation (0.262) and Strategy (0.282), negatively the Product Development (-0.219), IP (-0.229) and Regulation (-0.229)
- The Strategist: correlates positively IP (0.25) and negatively R&D (-0.231) and Culture (0.359)

However, others remain very strange:

- The Anchor: correlates negatively the Product Development (-0.25), Coordination (-0.559), Hiring (-0.284)
- The Coordinator: correlates positively Product Development (-0.386)
- The Visionary: correlates negatively the Representation (-0.219)

- The Strategist: correlates positively the Product Development (0.349) and Hiring (0.367), negatively the Corporate Development (-0.269)

Unfortunately, we do not have strong signals highlighting the main responsibilities for each persona. We may have flaws between the CTOs' declarations since responsibilities and personas are very subjective. However, we can try a clustering analysis to group the CTOs, recognized some differences and find out if the CTOs responsibilities lead to some personas.

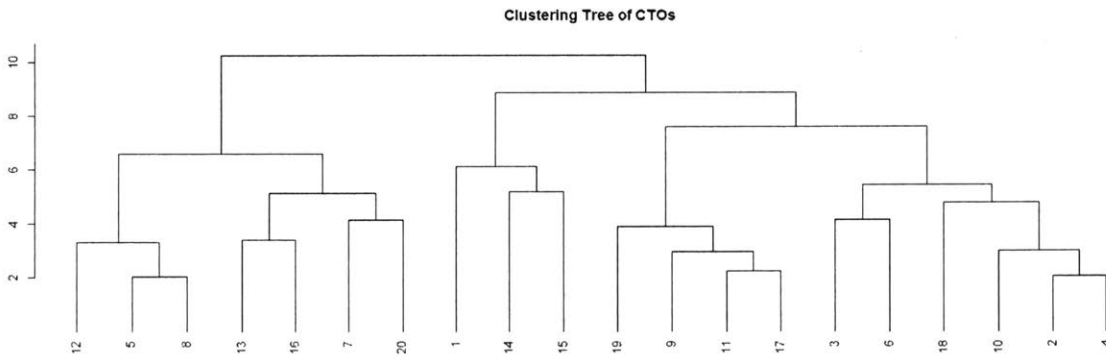


Figure 31: Clustering Tree of CTOs on responsibilities

The chart Figure #31 shows the Clustering tree. However, we need to choose how many groups are the best representative of the CTOs' activity (See in Appendix V the different trials from 2 to 5).

Unfortunately, the clustering algorithm confirms that there is no obvious relation between personas and responsibilities. The summary table of Figure #32 shows the result of grouping responsibilities between 2 to 5 groups (first 4 columns, figures representing the group number) and the declared personas (Pers-Flag columns).

However, if each of the personas are represented by one or two main responsibilities, we can assign these responsibilities to personas as following:

- Evangelist: Education, Hiring

2 Groups	3 Groups	4 Groups	5 Groups	Pers-Flags
1	1	1	1	Anchor
1	1	1	1	Anchor Coordinator
1	1	1	1	Coordinator Visionary
1	1	1	2	Anchor Coordinator
1	1	1	2	Visionary
1	1	1	2	Evangelist Anchor
1	1	1	2	Anchor Visionary
2	2	2	3	Anchor Strategist
2	2	2	3	Anchor Coordinator
2	2	2	3	Anchor Coordinator
2	3	3	4	Anchor
2	3	3	4	Visionary Strategist
2	3	3	4	Evangelist Coordinator
2	3	3	4	Coordinator Strategist
2	3	4	5	Anchor Visionary
2	3	4	5	Coordinator Visionary
2	3	4	5	Coordinator
2	3	4	5	Coordinator Strategist
2	3	4	5	Coordinator Visionary
2	3	4	5	Coordinator

Figure 32: Table of Cluster Groups associated to Declared Personas

- Anchor: Product Development, R&D
- Coordinator: Coordination, Culture
- Visionary: Innovation, Representation
- Strategist: Strategy, Corporate Development

Therefore, on the 2 cluster groups, we can reasonably discern 2 types of CTOs:

- Group 1: The Visionary Strategist (in red dashed line)
- Group 2: The Anchor Coordinator Evangelist (full dark line)

The figure #33 shows two groups of responsibilities from our CTO population, the group one less involved in internal responsibilities. The clustering algorithm shows also the proximity of the Visionary and Strategist personas, as discussed at the beginning of this chapter.

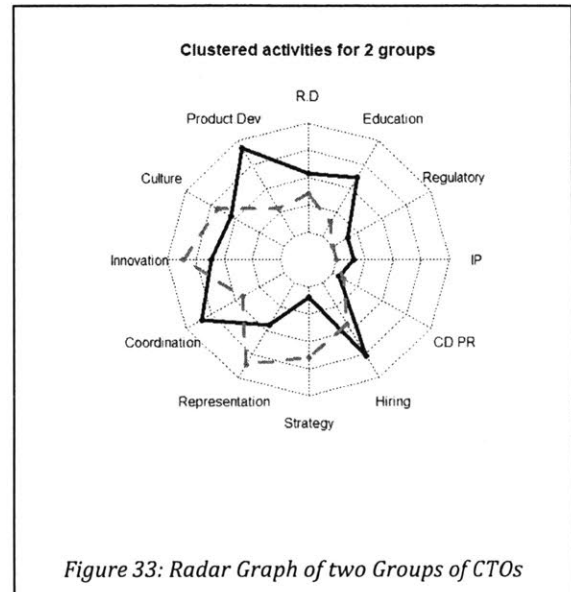


Figure 33: Radar Graph of two Groups of CTOs

5.2.2 Distribution across company maturities

The company maturity may have an influence on the type of CTO personas. The graph Figure #34 presents the distribution of the personas in function of the company stage.

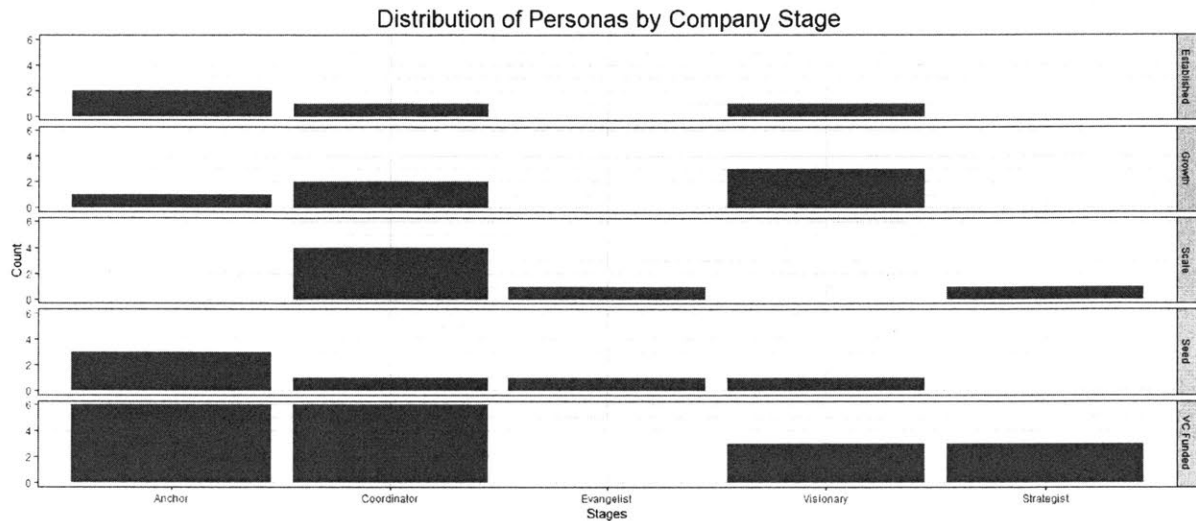


Figure 34: Distribution of Personas by Company Stage

We can observe that on each stage:

- Seed: This stage seems to require an Anchor CTO to build prototypes.
- VC Funded: This stage required an Anchor and Coordinator to build the first products.
- Growth: Visionary and Coordinator, the CTO needs to study technologies and make it integrated in the product lines.
- Scale: This stage needs a CTO Coordinator to be able to develop technology programs across the company.
- Established: it is difficult to conclude based on what we have. We would have expected more a Coordinator, Visionary or Strategist, but the results are widely spread.

5.3 PERFORMANCE

The question about the performance has been the most difficult of the questionnaire leading to answers particularly variable. Since CTOs have a diffuse role in the organization, it may be difficult to measure their performance.

Some of the CTOs from Software, Analytics, Biotech and Pharmaceutical startups use the OKR (Objective Key Result) framework to drive the performance management and tends to be evaluated more from quarter to semester.

There are a lot of metrics to evaluate and review performances, so we decided to categorize them into metrics relevant for the diverse functions related to CTOs:

- Business (Revenues, Cost efficiency, ...)
- Product (Customer Acquisition, #features, ...)
- Research (# IP patents, # of tech integration, ...)
- Program (Gates, Milestones, # of projects, ...)
- Engineering (# of hiring, productivity, # bugs, ...)

The distribution of performance metrics (Figure #35) shows that most of 70% of CTOs are evaluated on Business metrics, followed by almost 60% on Engineering metrics

Coming back on the definition of the CTO role, the fact that the CTO is so highly evaluated on the Business metrics can also be seen as the fact that CTO bring values to the

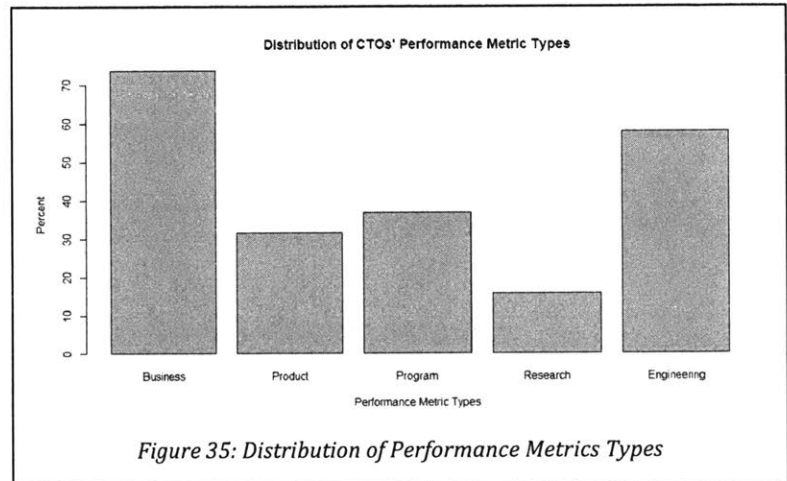


Figure 35: Distribution of Performance Metrics Types

company, but the CEO does not know how to use him/her to make him/her perform. The easiest way is to make his/her work in alignment with the company's goals. In that way, the CTO must find the best way to contribute to the success of others through technology advancement.

The graph Figure #36 shows the correlations between responsibilities and the performance metric types:

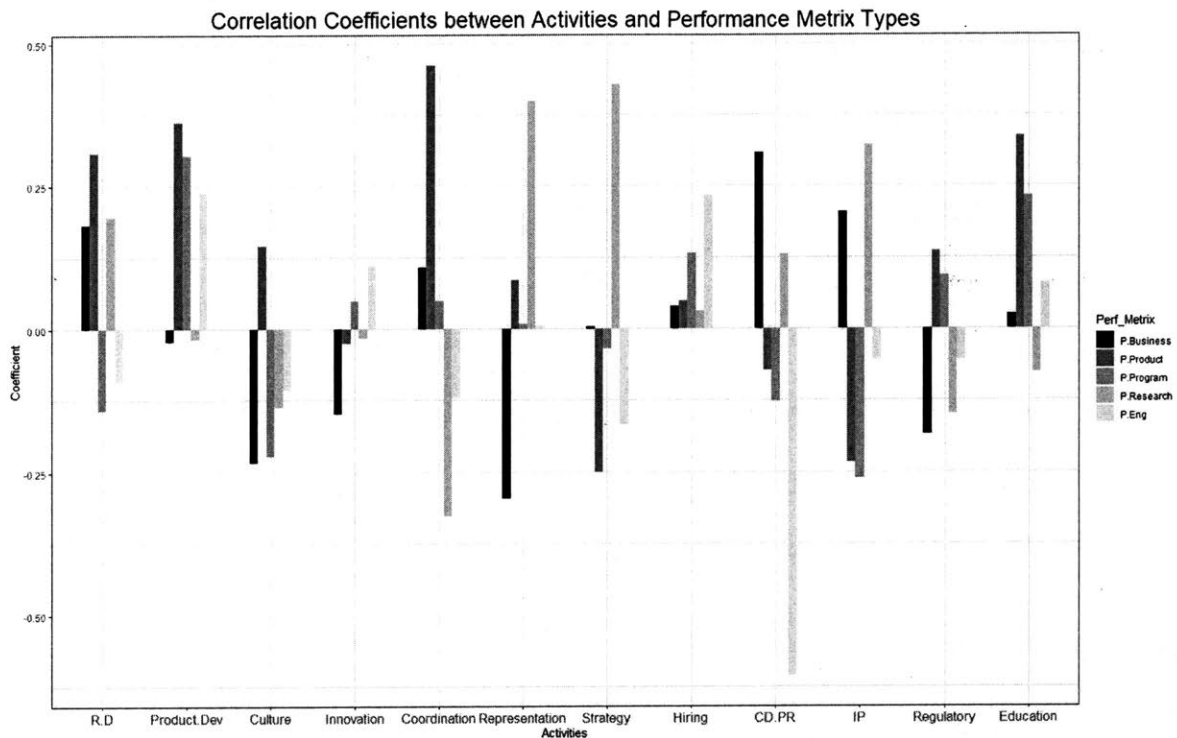


Figure 36: Correlation between Responsibilities and Performance Metric Types

If we retain only the correlation close to 0.20 and over, or close to -0.20 and under as cut off, we can observe:

- Business metrics correlate positively the Corporate Development (0.309).
- Product metrics correlate positively R&D (0.308), Product Development (0.363), Coordination (0.462) and Education (0.338) but negatively the Strategy (-0.251).
- Program metrics correlate positively Product Development (0.303) but negatively IP (-0.262).
- Research metrics correlate positively Representation (0.398), Strategy (0.428) and IP (0.322) but negatively the Coordination (-0.327).
- Engineering metrics correlate positively Product Development (0.238) and Hiring (0.233) but negatively Corporate Development (-0.606).

Most of the correlation are expected, but we can comment some results:

- Business metrics should be more correlated to the Strategy, since their goals are to improve the company performance.
- Product metrics should not negatively impact the strategy, since CTOs evaluated on these metrics should do some part of Product Strategy.

- Program metrics should be correlated to the Coordination, since they encompass project management and planning responsibilities.

Overall, we can reasonably assert that the performance metrics reflects CTOs responsibilities. This needs to be contrasted to the fact that the question about the metrics was particularly difficult to answer for some CTOs (except for the business metrics), emphasizing the blurry definition of the CTO role.

5.4 COMPENSATION

Most of the CTOs are incentivized on Equity, as shows the following distribution of compensation type (the compensation types may be cumulated).

80% of the CTOs have some equities and 60% have a base salary.

In order to check the consistency of the responses, it is interesting to break down

by company maturity and if the CTO is a Co-Founder. The nature of the latter can influence greatly the distribution.

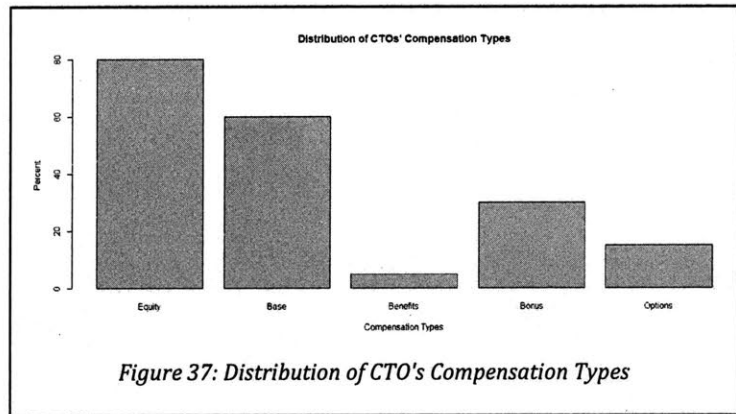


Figure 37: Distribution of CTO's Compensation Types

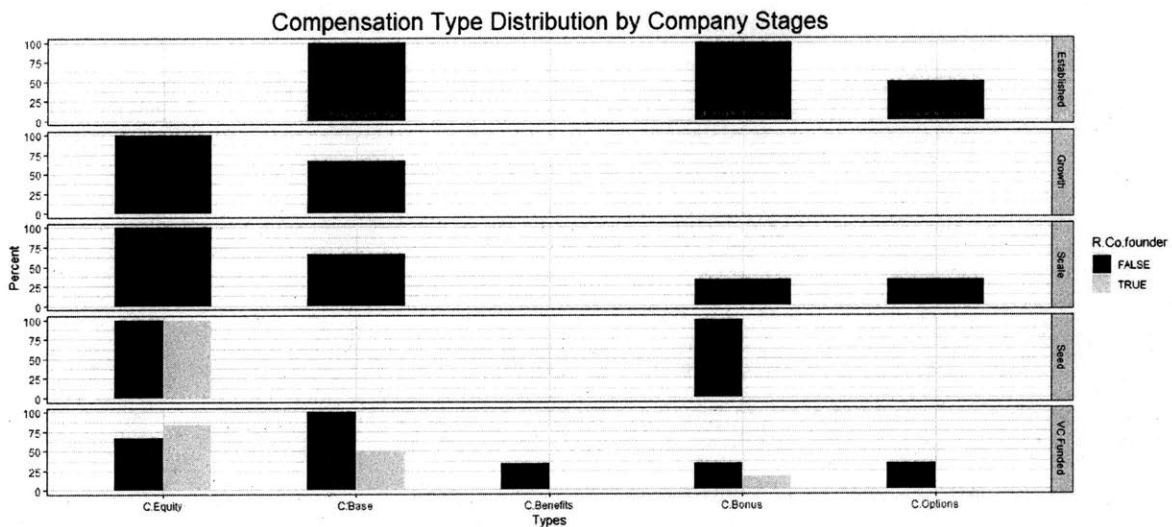


Figure 38: Distribution of Compensation Types by Company Stage

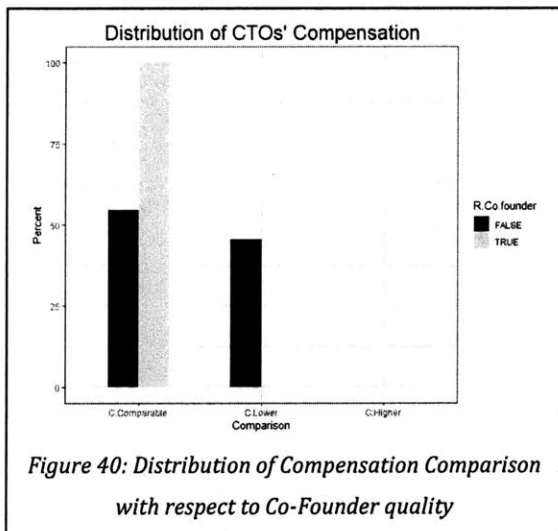
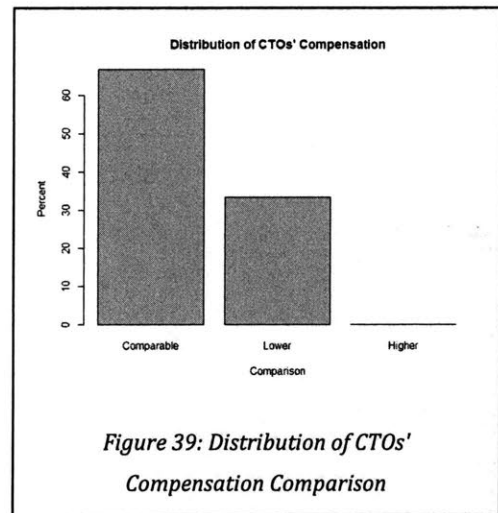
The graph Figure #38 shows distribution of compensation type by company maturity and by population of CTO co-founder or not.

On this graph, we can see:

- The CTO cofounders are only present in Seed and VC Funded Company.
- The CTOs from growth and scale companies still have equity incentives.
- The CTOs from established companies have a different compensation structure with Base, Bonus and Options.

To the question about how comparable the CTO compensation with respect to the other executives is, more than 65% of the CTOs estimate earning a comparable compensation and the remaining 35% estimate earning lower (Figure #39).

None of them estimate earning more.



Once again, Co-Founder CTOs require to be separated from the rest of the population. In the following graph, 100% of the co-founder CTOs estimate to have comparable compensation. However, only 55% of the CTOs non-co-founder estimate having the same envelop, with the rest of them estimating earning less.

5.5 TRAINING AND CAREER EXPERIENCE

Almost all the interviewees come with a technical background which was expected since they have been selected from the MIT Alumni Network.

In average, CTOs switched of companies twice and one of industry in the last 10 years, as show the different graphs Figure #41:

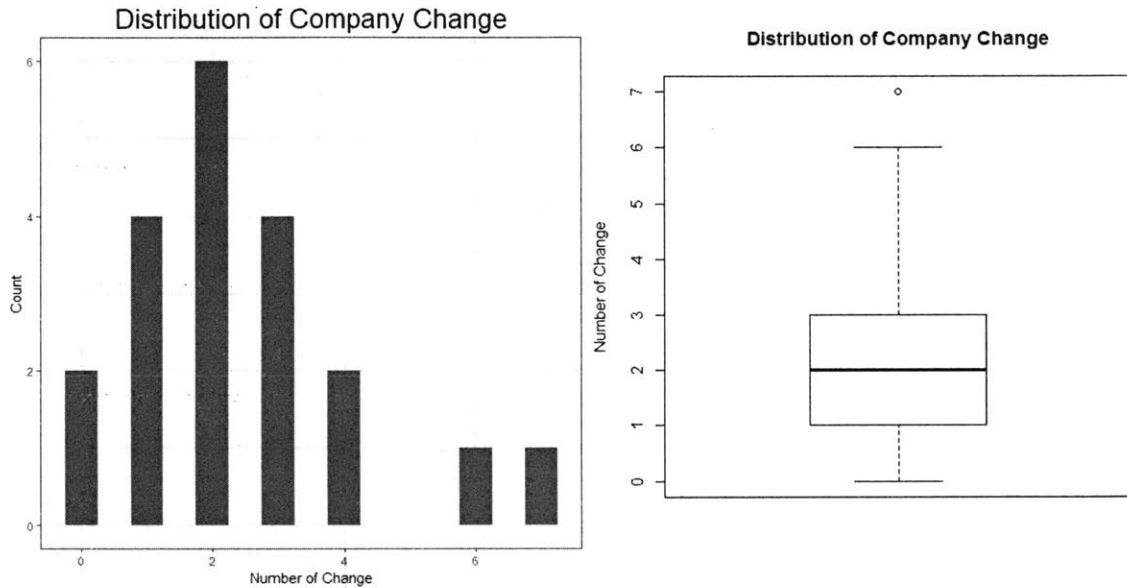


Figure 41: Distribution of Company Change from Interviews

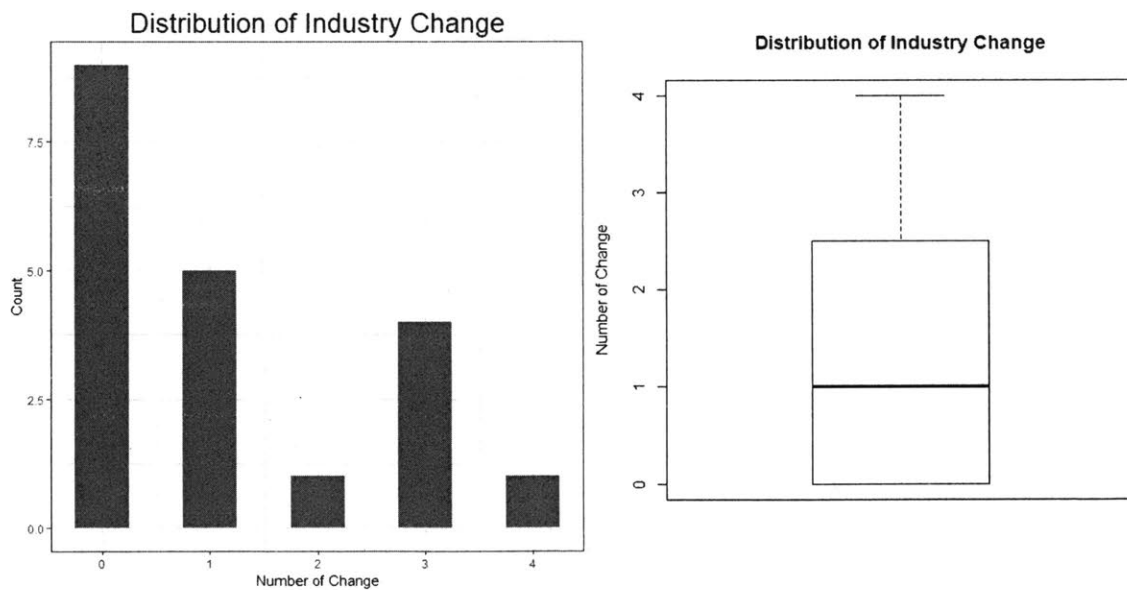


Figure 42: Distribution of Industry Change from Interviews

We can consider that CTOs are relatively mobile in their position. More volatile, some CTOs from the Software industry says that their industry transitions were not problematic, leveraging their technology expertise in each experience.

5.6 OTHER THEMES FROM CTOs

5.6.1 Innovation and Communication

During the interviews, some CTOs really emphasized the importance of technology savviness and communication in the success in the role. Whatever the position or function, CTOs are the only one in a company structure whose role it is to spread the word and advocate for organization changes and process rationalization through technology. CTOs must share their passion and adapt their discourse to convince others beyond revenue/cost considerations.

One of their biggest challenge is to manage and allocate their time to the different influencers and teams. Unfortunately, there is no clear solution solving this need yet, so CTOs resort to their judgement.

5.6.2 Performance and Time horizon

The impact of the CTO influence is more relevant to be measured on a 3 years period more than a quarter, which is the case for the other executive roles, such as the CEO. All the benefits of the fundamental work to organize and improve the company technology are more likely to be seen in this time period. Therefore, there is a friction between both short-term goals and long-term goals. The role of the CTO is to serve both in the same time.

5.6.3 Another way to see the CTO Role

Instead of segmenting the responsibilities of the CTO, one CTO from a scaling company in Analytics industry describes another way to explain the CTO role, using a stakeholder segmentation:

- Development management (Engineering): hiring, product management

- System Architecture (Architecture): holistic view, breath Vs Depth
- Technology ownership (CEO, Board): vision, business
- Communication (internal, external): alignment, advocacy, investor relation

This view is not completely different than the one proposed in this report but has the advantage to show the high-level technology ownership and the communication channels more explicitly.

5.6.4 Global CTOs

In the context of large technology corporate, a CTO drew the picture of five Business Units with each one CTO reporting to a General Manager. There is not any Global CTO in this structure. This is interesting in the way that:

- A global technology mentor may not be necessary as close as the board to influence the organization.
- As soon as the CTO works closely with a Global manager, CEO or Business Unit Senior Executives, the duo can still deliver result.

6 NEXT STEPS

The two analysis bring some data about who are CTOs and what expect from them. Clues have been provided showing relations between their responsibilities and the company maturity, and the relationship with other executives, especially the CEO.

To perform CTO must bring technical skills and insights often comping from their previous experience but also need to bring and communicate the technology vision. This last skill is mandatory to convince the CEO or General Manager to invest in technology, but also to convey the general guidance to the teams.

This study is a start for a better understanding of the CTOs' role but also raises other questions that merit further researches.

These are the potential next steps.

6.1 REACH THE SIGNIFICANCE

The study gathered 20 interviews and 100 backgrounds of CTOs. It is enough to identify trends or patterns for opening discussion and accessing to new questions but no enough to conclude formally.

A future study should reach out more CTOs from other origins than MIT and maybe targeting also CTOs without technical degree to understand how they deal without fundamentally technical expertise.

6.2 COMPOSITION OF PERSONAS

An interesting information would be to study how the previous positions influence the type of CTOs and the responsibilities they endorse. To illustrate the relationship, we can imagine that a CTO from technical product marketing background could be more oriented to do some responsibilities such as educate customer, strategy, public relationship or sales enablement (corporate development). On the contrary, a CTO from a developer experience could be more a hands-on CTO, particularly involve in product development and architecture.

In the same idea, as having only one persona or two is not enough to describe the extend of CTO flavors, a study could poll CTOs to go deeper in understanding the allocation time among the personas. CTOs might be a composition more complex of personas.

6.3 ORGANIZATION

During the study, it appears that relationships are very important for the CTO's mission. Especially, the CEO must understand the CTO value in driving the technology implementation within the company. To feel the empowerment in his/her mission and perform, the CTO has to be recognized by his manager. In a future study, it would be interesting to estimate the level of empowerment of the CTO.

Also, another proxy would be to know if the CTO knows for long the CEO, and whether he/she has been present for developing the company.

Finally, a researcher may want to explore the nature of the relationship with the key people of the organization. The influence of the CTO may be increased or decreased if VPs report to him/her, work as the same level, or delegate the technical ownership.

7 SUMMARY AND CONCLUSION

This chapter reviews all the assumptions and discusses them at the light of the two analysis.

7.1 CTO ROLE

H1: The internal and external responsibilities of CTOs are represented in the above set, and the heterogeneity in CTO efforts is a composition of these responsibilities.

100% of the CTOs recognized all the supposed responsibilities as potentially in the CTO scope. Primary research shows that the presented list of responsibilities was not exhaustive, the following responsibilities were missing: managing an IP Portfolio, managing regulatory compliance and customer/partner awareness ownership. There was no combination pattern among the 20 interviewed participants. That supports the hypothesis that CTO responsibilities are highly individualistic. The heterogeneity of CTO responsibilities is probably the main reason of confusion about what CTOs do.

H2: CTOs can be classified as one of these personas, and these personas cover a majority of CTOs. The personas represent the focus of their position even if they tend to contribute to other responsibilities.

Most of the CTOs were uncomfortable to pick only one persona that disproves the first part of the hypothesis. However, the data shows that all personas have been picked with a prevalence for Anchor and Coordinator and an infrequency of Evangelist and Strategist. CTOs ended to pick two personas, enough to characterize their main behavior. The study shows that there are no strong correlations between the CTO responsibilities within the company and its persona. The data supports our initial hypothesis that CTOs do not have homogenous set of responsibilities. Yet, personas show similar patterns of responsibilities across CTOs who are within the same company life cycle (seed start-up, established business etc.) revealing a certain focus of their position.

H3: CTO is a role focusing on cross-functional alignment. To execute the vision, CTO's need to be highly collaborative and connected within the company.

The data from the study shows that CTOs are driving cross-functional alignment across the company through collaborative resource sharing or ceding the responsibility to a VP of a department. 55% of the CTO population share technical responsibilities with the CEO, 30% with representatives of Engineering or Product and around 25% with representatives of R&D. That supports the hypothesis that CTOs are needed to be highly connected within the company to achieve their vision. That finding is applicable to CTOs irrespective of the industry, company size or stage the business is in. However, our study does not show in which extend there are sharing their responsibility.

The study also reveals that 50% CTOs have another title within the company - Co-Founder, VP or another C-level position - anchoring them in a well-defined function identifiable by others. This dual position may help them to influence the organization.

7.2 ORGANIZATION

H4: The maturity of company shapes the CTOs' responsibilities, by making him/her more focus on the company needs

The data from the interviews supports the hypothesis. CTOs roles evolve with the business maturity of the company (see 5.1.1). The responsibilities start with a focus on delivery, product development to evolving to coordination. CTOs often are responsible for hiring the middle management to delegate the product related tasks and focus on strategic initiatives. The CTOs' concerns shift gradually from the pure technical contribution to pure technical leadership. In the middle, the Growth Stage is the transition where CTOs have the largest spectrum of responsibilities.

The table Figure #43 shows a potential suggestion of the main CTO responsibilities with respect to the company needs:

Company Stage	Company Needs	Main CTO Responsibilities
Seed	Technology Differentiation, Prototyping, Investors pitching	R&D, Education
VC Funded	MVP, Team building, Early adopters acquisition	Product Development, Culture, Hiring
Growth	Activity development, Positive cashflow quest, Branding	Product Development, Innovation, Representation
Scale	Processes rationalization, Develop teams	Coordination, Hiring
Established	Technology demonstration, New technologies acquisition	Innovation, Representation, Strategy

Figure 43: Table of CTO Lifecycle

H5: The influence of the CTO is defined by its proximity to the CEO and Business Unit Presidents.

The study shows that 100% of the CTOs report directly to the CEO or Business Unit President and 55% of them shared technological related responsibility with them, emphasizing the importance of this partnership. Also, the compensation structure analysis shows that 80% of the CTOs are incentivized on equity like the other C-Level which is a clue of proximity. However, as discussed at the Chapter 6, the study failed to prove the immediate impact of the CTO proximity to CEO on its performance. Other researches will be necessary to assert that the more the CTO is close to the CEO or Business Unit Presidents, the more influent is the CTO and the more impactful is his/her contribution.

7.3 PERFORMANCE

H6: Performance metrics are predictors of CTO responsibilities, by categorizing his/her types of objectives.

The study offered to categorize the metrics in five types – Business, Product Management, Program, Research and Engineering – since these types classify the output of the responsibilities. We found a good correlation between the metrics types and responsibilities meaning that Performance Metrics are decent predictors.

In addition, 73% of CTOs in the study reported that the topline/bottom line improvement as a personal objective in the annual performance evaluation. Topline and bottom line are business metrics driven by multiple inputs. Inclusion of such complicated metrics shows that CTOs have to be responsible for coordination of multiple outputs.

The compensation structure also shows that they are most likely incentivized on business metrics like the other C-Levels but without always having a direct accountability on these metrics.

Also, the fact that the distribution of CTOs incentivized on different the metrics types (Business 73%, Product 31%, Program 38%, Research 16%, Engineering 58%) is uneven demonstrates once again that CTOs have a heterogeneity of responsibilities.

7.4 TRAINING AND CAREER EXPERIENCE

H7: CTOs have a lesser horizontal career mobility across companies/industries compared to the other C-Suite executives.

The data does not support the hypothesis. From the study of their LinkedIn profiles, CTOs tend to switch companies 6(5.6) times on average and switch industries 3(2.8) times on average over their career with an average tenure as CTO of 4 years which is lower than the CFO or the CEO. This is relatively coherent with the data from the 20 interviewed CTOs who switch 2 times of companies in average and 1 times of industry for the last 10 years. The study shows that CTOs are more mobile than expected. The interviewed CTOs explain that they can transfer their technical skills and leadership in the same technological domain no matter the vertical, even in industries such as Healthcare, where the product development lifecycle is very particular because highly regulated. However, both of our population have an over representation of the Software industry where skills are supposed to be more transferable that can lower the mobility statistics.

H8: CTOs have technical background but do not necessarily have experience as individual contributors/technology experts.

The LinkedIn data study demonstrates that CTOs do not have always a technical background with only 79% of the CTOs having a technical degree, no matter the highest education level with a surprisingly high percentage of the bachelor's degree (25%) and a low percentage of PhD degree (15%). In addition, 80 to 90% of CTOs have technology or R&D related experience. The study also shows that CTOs do not have always an experience as individual contributors in their past, since only a range of 13% to 57% of CTOs may not have such kind of experience in their past. However, this

result lies on the assumption that all LinkedIn profiles represents all the CTOs' career which might not be the case.

Additionally, even if communication might be key for CTOs since the role implies influence and business knowledge to bridge the gap between technology and business, MBA or other business degrees do not seem mandatory for the success

7.5 SKILLS

H9: CTOs understand product management and development but do not always contribute to product delivery.

The study reveals that 40 % of the interviewed CTOs do not have product delivery responsibilities but 90% of them have either R&D or Product Development responsibilities. Therefore 10% of them do not have R&D and Product Development responsibilities. These ones are more coordinators.

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APPENDIX

I. INTERVIEW QUESTIONNAIRE

CTO Responsibilities:

Would you tell me what are the main activities in your position and roughly what percentage of your time is allocated to each of these activities?

Do you think that your role is more inwardly focused or externally focused?

#Match with the other activities

- Internal responsibilities consisting of:
 - managing technology development projects
 - managing product development
 - establishing an engineering culture
 - monitoring technological innovations capable to impact positively or negatively the firm
 - coordination across business units.
- External responsibilities consisting of:
 - participation in industry groups
 - assessment of potential partnerships or acquisitions aligned with the firm's strategy
 - hiring of technology talent
 - participation in corporate development, and public relations for product launch or recalls.

What do you think of the other potential activities?

Shared Responsibilities

Do you think that these set of activities are incumbent on the CTO? Who are the other people within the organization who share part of the responsibilities?

Do you feel empower to fulfil your position?

CTO Personas:

Do you consider yourself more as:

- ⇒ The Evangelist: the one who converts the talents, practitioners, or technical customers
- ⇒ The Anchor: the one who manages and develops products
- ⇒ The Coordinator: the one who supports every departments to deliver products
- ⇒ The Forecaster, or the Visionary: the one who anticipates the future changes in technologies
- ⇒ The Strategist: the one who knows what strategy the companies needs to pick

CTO Performances:

Performance metrics:

How do fix your goals? How your performance is evaluated?

Do you think that it is aligned to your prerogatives?

Influence:

How do you measure your influence within the board/company?

CTO Background:

Company change:

- ⇒ **How many times have you changed of companies for the last 10 years?**
- ⇒ **Have you ever changed of industry?**

Position information:

- ⇒ **To whom do you report in the company?**

Compensation scheme:

⇒ Without divulging any figures, what is your compensation scheme? Have you a form of equity compensation? And if yes, from your best guest, do you think it is equivalent to the other executives?

Closure:

Do I miss anything?

II. CTO RESPONSIBILITIES' PROFILE

R&D	Product-Dev	Culture	Innovation	Coordination	Representation	Strategy	Hiring	CD/PR	IP	Regulatory	Education
0.5	0.5	1	1			0.5	1				
1	1	1	1	1	0.25		1				
1	1	1	1	1	0.5		1				1
1	1	1	1	1	1		1	0.5			1
1	1	1		1	1		1			1	1
1	1			1				0.25			1
1	1				1	0.5	1		1		1
1		1	1	1	1	1	1	0.25			
1		1	1	1							1
1		1			1	1		0.25			1
	0.5		1	1	1	1					
	1	0.25	1	1	1	0.5					
	1	1	1	1	1		1				1
	1	1			1				1	1	
	1		1	1	1	0.5	1				
	1		1	1			1				1
	1				1		1				1
		0.5	1	1	1	0.5					
		1	1		1		1	0.25			

III. CORRELATION MATRIX RESPONSIBILITIES VS SHARED RESPONSIBILITIES

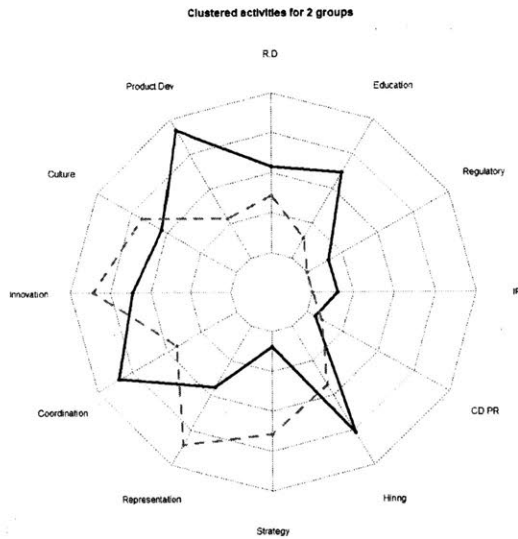
	R.D	Product.Dev	Culture	Innovation	Coordination	Representati	Strategy	Hiring	CD.PR	IP	Regulatory	Education
R.D	1	-0.0955398	0.4198124	-0.2578093	0.0784637	0.03692161	0.00528247	0.07000081	0.3967053	0.01712218	0.01712218	0.56271604
Product.Dev	-0.0955398	1	-0.3651763	-0.2029385	0.1775712	-0.2413878	-0.48616	0.34120978	-0.2505443	0.23249528	0.23249528	0.16356658
Culture	0.4198124	-0.3651763	1	0.12199615	0.06390275	0.13536499	-0.1469256	0.08093079	0.28210297	-0.0621174	0.29283918	0.1525084
Innovation	-0.2578093	-0.2029385	0.12199615	1	0.04761905	0.12199615	-0.0074804	0.20587905	-0.0391931	-0.5091751	-0.5091751	-0.2851124
Coordination	0.0784637	0.1775712	0.06390275	0.04761905	1	-0.1103775	-0.2318928	-0.0228755	-0.0391931	-0.1454786	0.21821789	-0.0657952
Representati	0.03692161	-0.2413878	0.13536499	0.12199615	-0.1103775	1	0.47362986	0.02511645	0.28210297	-0.0621174	-0.0621174	0.04548496
Strategy	0.00528247	-0.48616	-0.1469256	-0.0074804	-0.2318928	0.47362986	1	-0.2838845	0.0677247	-0.0342796	-0.2628099	-0.2997346
Hiring	0.07000081	0.34120978	0.08093079	0.20587905	-0.0228755	0.02511645	-0.2838845	1	0.01882775	-0.1048285	-0.1048285	0.03160698
CD.PR	0.3967053	-0.2505443	0.28210297	-0.0391931	-0.0391931	0.28210297	0.0677247	0.01882775	1	-0.1796053	-0.1796053	0.23466316
IP	0.01712218	0.23249528	-0.0621174	-0.5091751	-0.1454786	-0.0621174	-0.0342796	-0.1048285	-0.1796053	1	0.44444444	0.03350126
Regulatory	0.01712218	0.23249528	0.29283918	-0.5091751	0.21821789	-0.0621174	-0.2628099	-0.1048285	-0.1796053	0.44444444	1	0.03350126
Education	0.56271604	0.16356658	0.1525084	-0.2851124	-0.0657952	0.04548496	-0.2997346	0.03160698	0.23466316	0.03350126	0.03350126	1
S.CEO	-0.2529641	-0.2803999	0.00802676	0.06579517	0.06579517	0.06153848	0.2997346	-0.031607	-0.054153	-0.0335013	-0.0335013	-0.3939394
S.Eng	-0.1905547	0.07610194	-0.3543698	0.19047619	0.19047619	0.11037747	-0.0673237	0.02287545	0.43112399	-0.2182179	-0.2182179	-0.1535221
S.Product	-0.3026457	-0.1775712	0.11037747	-0.047619	-0.047619	-0.1219962	0.15708867	0.25162996	0.03919309	0.14547859	0.14547859	-0.5921565
S.R.D	0.02965649	0	0.07685035	-0.1259882	-0.3779645	0.01537007	-0.1385392	-0.0605228	0.10369517	-0.1924501	0.19245009	-0.0580259
S.Marketing	0.35956585	-0.1549969	-0.0621174	-0.1454786	-0.1454786	-0.0621174	-0.0342796	-0.1048285	-0.1796053	0.44444444	-0.11111111	0.36851387

IV. CORRELATION MATRIX RESPONSIBILITIES VS PERSONAS

V. RESPONSIBILITY CLUSTERING

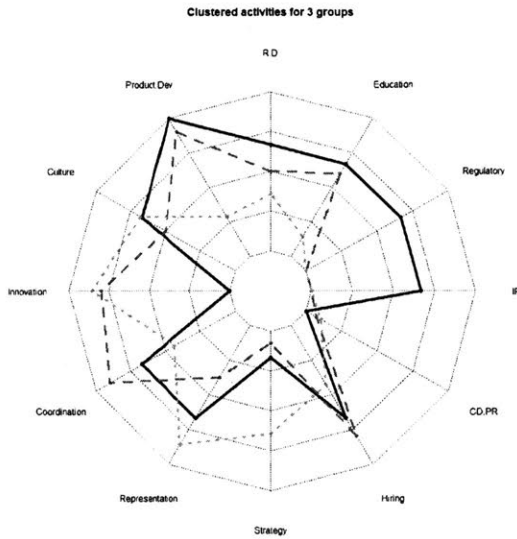
2 Groups

memb	R.D	Product.Dev	Culture	Innovation	Coordination	Representation	Strategy	Hiring	CD.PR	IP	Regulatory	Education
1	0.5384615	0.9230769	0.5384615	0.6153846	0.8461538	0.4423077	0.09615385	0.7692308	0.05769231	0.1538462	0.1538462	0.6153846
2	0.3571429	0.2857143	0.6785714	0.8571429	0.4285714	0.8571429	0.64285714	0.4285714	0.10714286	0.0000000	0.0000000	0.1428571



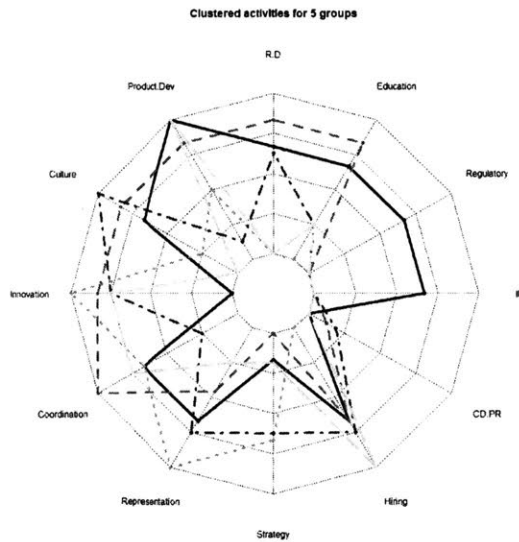
3 Groups

memb	R.D	Product.Dev	Culture	Innovation	Coordination	Representation	Strategy	Hiring	CD.PR	IP	Regulatory	Education
1	0.6666667	1.0000000	0.6666667	0.0000000	0.6666667	0.6666667	0.1666667	0.6666667	0.0000000	0.6666667	0.6666667	0.6666667
2	0.5000000	0.9000000	0.5000000	0.8000000	0.9000000	0.3750000	0.0750000	0.8000000	0.0750000	0.0000000	0.0000000	0.6000000
3	0.3571429	0.2857143	0.6785714	0.8571429	0.4285714	0.8571429	0.6428571	0.4285714	0.1071429	0.0000000	0.0000000	0.1428571



4 Groups

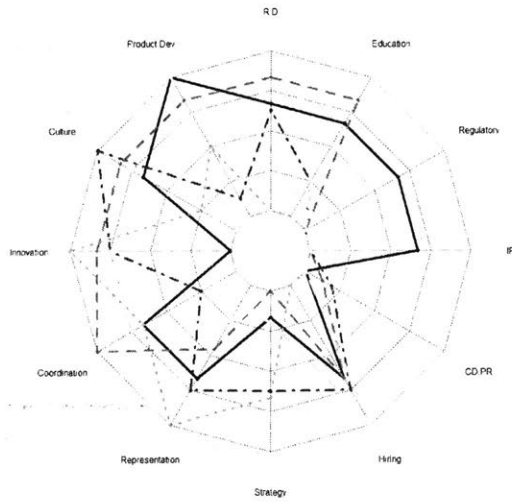
memb	R.D	Product.Dev	Culture	Innovation	Coordination	Representation	Strategy	Hiring	CD.PR	IP	Regulatory	Education
1	0.6666667	1.0000000	0.6666667	0.0000000	0.6666667	0.6666667	0.1666667	0.6666667	0.0000000	0.6666667	0.6666667	0.6666667
2	0.8333333	0.8333333	0.8333333	0.8333333	1.0000000	0.4583333	0.0000000	0.6666667	0.1250000	0.0000000	0.0000000	0.8333333
3	0.3571429	0.2857143	0.6785714	0.8571429	0.4285714	0.8571429	0.6428571	0.4285714	0.1071429	0.0000000	0.0000000	0.1428571
4	0.0000000	1.0000000	0.0000000	0.7500000	0.7500000	0.2500000	0.1875000	1.0000000	0.0000000	0.0000000	0.0000000	0.2500000



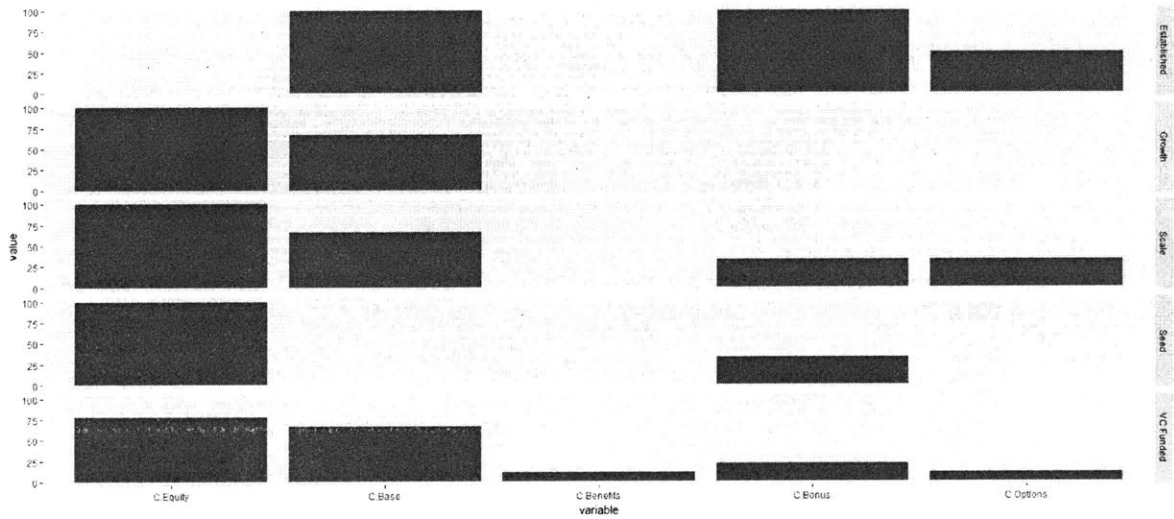
5 Groups

memb	R.D	Product.Dev	Culture	Innovation	Coordination	Representation	Strategy	Hiring	CD.PR	IP	Regulatory	Education
1	0.6666667	1.0000000	0.6666667	0.0000000	0.6666667	0.6666667	0.1666667	0.6666667	0.0000	0.6666667	0.6666667	0.6666667
2	0.8333333	0.8333333	0.8333333	0.8333333	1.0000000	0.4583333	0.0000000	0.6666667	0.1250	0.0000000	0.0000000	0.8333333
3	0.0000000	0.5000000	0.2500000	1.0000000	0.6666667	1.0000000	0.6666667	0.0000000	0.0000	0.0000000	0.0000000	0.0000000
4	0.6250000	0.1250000	1.0000000	0.7500000	0.2500000	0.7500000	0.6250000	0.7500000	0.1875	0.0000000	0.0000000	0.2500000
5	0.0000000	1.0000000	0.0000000	0.7500000	0.7500000	0.2500000	0.1875000	1.0000000	0.0000	0.0000000	0.0000000	0.2500000

Clustered activities for 5 groups



VI. GRAPH OF THE COMPENSATION STRUCTURE BY COMPANY MATURITY



VII. CORRELATION MATRIX RESPONSIBILITIES VS COMPENSATION STRUCTURE

	R.D	Product.Dev	Culture	Innovation	Coordination	Representati	Strategy	Hiring	CD.PR	IP	Regulatory	Education	C.Equity	C.Base	C.Benefits	C.Bonus	C.Options
R.D	1																
Product.Dev	-0.0955398	1															
Culture	0.4198124	-0.3651763	1														
Innovation	-0.2378093	-0.2020385	0.12199615	1													
Coordination	0.0784637	0.1775712	0.06390275	0.04761905	1												
Representati	0.03692161	-0.2413878	0.1836499	0.12199615	-0.1103775	1											
Strategy	0.00528247	-0.48616	-0.1469256	-0.0074804	-0.2318928	0.47362986	1										
Hiring	0.07000081	0.34120978	0.08093079	0.0587905	-0.0228755	0.02511645	-0.2838845	1									
CD.PR	0.3967053	-0.2505443	0.28210297	-0.0391931	-0.0391931	0.28210297	0.0677247	0.01882775	1								
IP	0.01712218	0.23249528	-0.0621174	-0.5091751	-0.1454786	-0.0621174	-0.0342796	-0.1048285	-0.1796053	1							
Regulatory	0.01712218	0.23249528	0.29289918	-0.5091751	0.21821789	-0.0621174	-0.2528099	-0.1048285	-0.1796053	0.44444444	1						
Education	0.56271604	0.16356658	0.1525084	-0.2851124	-0.0657952	0.04548496	-0.2987946	0.03160698	0.23466316	0.03350126	0.03350126	1					
C.Equity	-0.0256833	0.52311437	-0.2395957	-0.3273268	0.21821789	-0.1730413	-0.1199785	0.15724273	-0.1796053	0.16666667	0.16666667	0.20100756	1				
C.Base	-0.2516437	-0.3322053	0.15215594	0.57906602	0.13363062	0.09781453	0.15394028	-0.1711842	0.0732356	-0.0680414	-0.0680414	-0.492366	-0.4082483	1			
C.Benefits	0.24747019	-0.3733665	0.20154574	0.15018785	0.15018785	-0.28705	-0.1808782	-0.3126409	-0.1236128	-0.0764719	0.25362864	-0.4588315	0.18731716	0.18731716	1		
C.Bonus	-0.1905547	-0.0507346	-0.0639027	-0.047619	-0.047619	-0.1219962	-0.0673237	-0.2058791	0.23515854	0.14547859	0.14547859	-0.3728993	-0.4909903	0.31180478	-0.1501879	1	
C.Options	0.16543338	-0.3581144	0.21993959	0.27500955	0.27500955	0.36905118	0.24480501	0.01467892	0.52814523	-0.140028	-0.140028	-0.0985134	-0.140028	0.34299717	-0.0963739	0.03055662	1