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Table of Contents

Table of Figures

Table of Tables

Introduction

Innovation is the precursor to all business. It is a dialectic of two fundamental activities: Exploration of new technological trajectories and the subsequent incremental exploitation thereof (Pandey, S. Sharma, RRK. 2009. p. 49). Models of organizational search have hence been relying on these conceptions for a long time. With the plurality of organizational forms come emergent properties that resemble, promote, or inhibit these efforts differently. When thinking of a centrally controlled organization, we rightfully imagine gray, industrial top-down dictatorships with broken spirits servicing the assembly line. On the other hand, we vicariously celebrate the charismatic CEOs who lead their companies to the future like captains at the steering wheels of innovation. And whilst four eyes for a fact see more than two, the big picture is often lost to the lowest common denominator when bad communication, impediments to goal-conguent search and inefficient coordination skew the search process.

In their paper from 2005, Nicolaj Siggelkow and Jan W. Rivkin built a comprehensive basic model of search among different organizational structural configurations. This paper aims to leverage their groundwork, to examine the different structural configurations' robustness to subjective utilitarian and psychological impediments to goal congruent search. The representative constructs for this examination are the disutility of effort and evaluation apprehension in the context of organizational search.

I will take the following steps:

#1. The concepts of asymmetric information and conflicts of interest will be tackled in more detail with the help of agency theory. They will be put into context with organizational structure to understand where these issues can be expected to appear most and when they are worth the pain.

#2. The exploration-exploitation framework will be lined out. Through the constructs of search-scope and search-depth, comparability between organizational archetypes will be achieved.

#3. Types of impediments to goal congruent search will be categorized. In addition to the objective monetary conflicts of interest discussed by Siggelkow and Rivkin, two classes of subjective search-related decision biases will be lined out, being non-monetary utilitarian expectations of the post-hoc state, and psychological biases that affect situational decisions but don't actually reflect a post-hoc realization of utility. Specifically, the disutility of effort and evaluation apprehension are discussed.

#4. The resulting utility function and the exploration process are implemented as extensions to Siggelkow and Rivkin's agent-based model in an NK-landscape.

#5. The reconstructed model is experimentally validated and critically re-evaluated.

#6. The differences in search performance between different structural configurations must be understood, before introducing new impediments.

a) The adverse effects of information asymmetry and bad coordination are identified and isolated.
b) The exploration and exploitation framework is broken down to search scope and search depth to make fundamental comparisons between different organizational structures possible.

#7. The model is examined under of disutility of effort and evaluation apprehension.

a) The different impacts of those impediments on different structural configurations are examined and explained.
b) Mechanisms that reduce the impact of said impediments are identified, possible alternatives are discussed.

Research Question

How is the search performance of different organizational structures affected by search-related decision biases?

Main Part

a. Theoretical Fundamentals

i. Organizational Structure

Delegation and the Cost of Asymmetric Information

Most organizations coordinate a diversity of tasks, that benefit from specialization and focus. Under certain conditions like organizational size, differentiation of tasks into separate functional departments can be worthwhile. It may also be an unavoidable step to allow for further growth.

One key decision that needs to be made when tasks are delegated is, whether and to which extent decision-making authority should be delegated as well. There is no conclusive answer to this question that holds true for all organizations alike. Delegation of decision-authority comes with advantages and disadvantages, that weigh differently for different business-environments.

The Principal-Agent Framework

Principal-Agent models reduce relationships of delegation to two parties (Laffont, J. Martimort, D. 2009. pp. 28-30.):

The **Principal** is the party, which delegates tasks and decision authority to somebody else. The delegated tasks are meant to serve the Principal's goals.

The **Agent** is the party, which fulfills these tasks and receives the authority. Agents have their own goals which are not usually perfectly aligned with the Principal's goals.

> Illustrative Example, Bakery (pt.1):
>
> The owner of a bakery wants to open a second branch. He can't be present in both branches at the same time. He solves this, by employing his skilled friend in exchange for a monthly salary. The owner has a strong interest to make both branches succeed, as all profits go directly into his pocket. The friend's interest is to sustain the monthly wage and a comfortable life. He will work just hard enough, to avoid getting dismissed.

Issues of agency always arise, when two things coincide (Fischer, T. 2015. pp. 308-315):

1. Conflicts of Interest
2. Asymmetric Information

When interests between the principal and the agent are perfectly aligned, the agent will perform optimally from both parties' perspectives. This will even be the case if the principal asserts no further control. This work will refer to the level of interest-alignment as goal congruency (ibid. p.313).

When the principal knows everything his agent knows, he can immediately identify and penalize inadequate performance. It is arguable though that delegating decision authority is unnecessary if the agent has no information advantage in the first place.

In most situations where authority is delegated, issues of agency result in lower performance for the principal, than under goal congruency or perfect information. This difference in performance has been termed "agency costs" (Jensen, M. Meckling, W. 2009. pp. 286-288).

There are three types of information advantages an agent can exploit:

1. **Hidden Characteristics:** During processes of hiring and delegating authority, agents know their own capabilities better than the principal. They can exploit this to claim positions, for which they are not the best suited candidate.
2. **Hidden Information:** When at work, agents gain access and control over work-related information, that is outside the reach of the principal.
3. **Hidden Action:** Agents have some freedoms of action, that cannot be controlled and sanctioned by the principal. This includes opportunism and shirking.

Minimizing agency costs by improving goal congruency and reducing information-asymmetry are hence key-considerations for any principal, when designing a decision-making structure.

Organizational Archetypes with different delegation of Decision Authority

Greenwood and Hinings have exhaustively isolated two organizational archetypes: The corporate bureaucracy, and the heteronomous professional bureaucracy (1993. pp. 1065-1066). They are categorized as opposing poles on the dimensions "Ratio of Integration to Differentiation " (ibid) and "Criteria of Differentiation" (ibid, see Fig.1).

The **corporate bureaucracy** has a high ratio of integration to differentiation and differentiates responsibilities programmatically. In simplified terms, it is the more **centralized** side of the spectrum.

The **heteronomous professional bureaucracy** has a low ratio of integration to differentiation and differentiates responsibilities professional-functionally. It is hence the more **decentralized** side of the spectrum.

Criteria of Differentiation	Ratio of Integration to Differentiation: Low	Ratio of Integration to Differentiation: High
Program		Corporate Bureaucracy
Professional-Functional	Heteronomous Professional Bureaucracy	

Figure 1. Sampling Matrix after figure 1 in Greenwoods, R. Hinings, C. R. 1993. p. 1066)

Interpreted in the Principal-Agent framework, we can condense these two dimensions into a tradeoff in the one-dimensional authority-delegation space, between the benefits of professional excellence that an organization can leverage by delegating decision authority and the agency costs this would produce (Fig. 2).

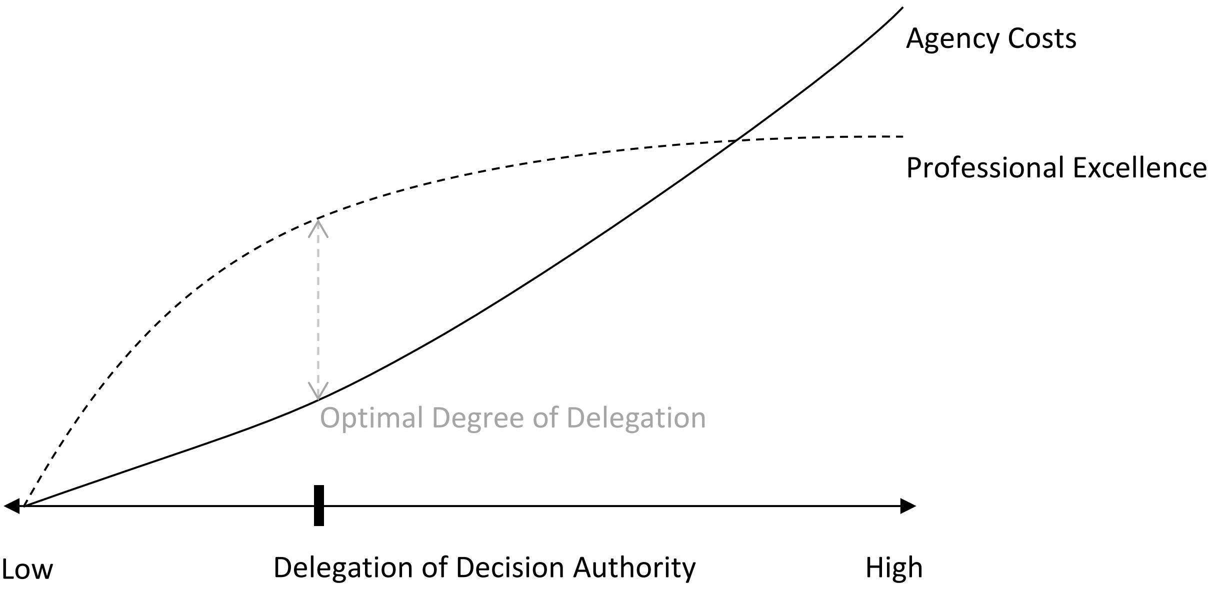

Figure 2. Tradeoff between the Benefits of Professional Excellence and Agency Costs when delegating Decision Authority. The Curves are only meant to illustrate the Idea.

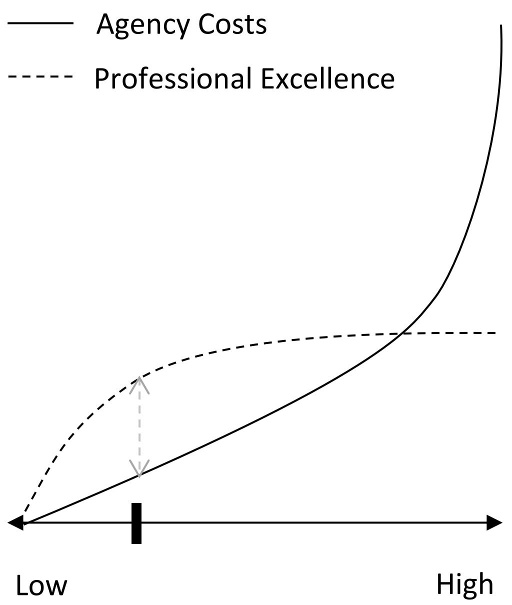

Figure 3. Situation, where less Delegation of Decision Authority would be superior (see Fig. 2)

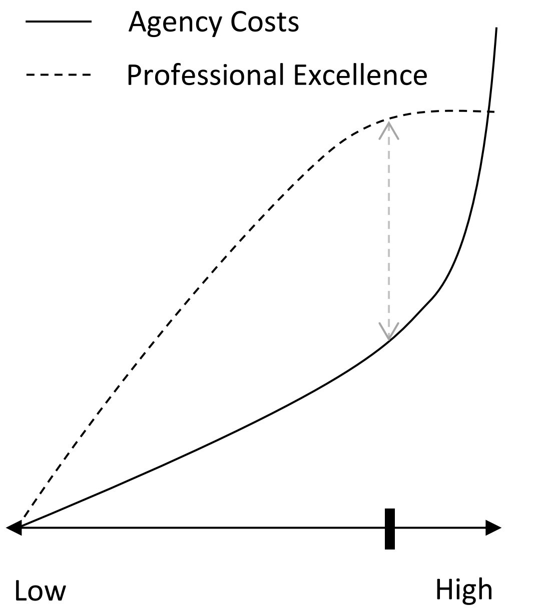

Figure 4. Situation, where more Delegation of Decision Authority would be superior (see Fig. 2)

In an organizational segment, in which performance does not greatly depend on a high degree of differentiation between departments, department heads don't need a great information advantage to the central. The additional benefits of professional excellence would soon be overshadowed by the agency costs (see Fig. 3). The centralized corporate bureaucracy –

archetype would be the better fit. The opposite holds true for organizational segments, where the required flexibility and quality of decisions makes leveraging the agents' information advantage crucial. If post-auditing of decisions and alignment of interests are cheap and reliable, this can also make higher levels of delegation more attractive. Then, the decentralized heteronomous professional bureaucracy – archetype would be the better fit (see Fig.4).

Illustrative Example, Bakery (pt.2):

The employed manager of the second branch was given the responsibility to procure the baking ingredients of his branch himself. He starts buying a cheaper brand of flour without informing the owner. Savings are falsely presented as gains, earning him a bigger bonus.

As the owner notices the decline in quality and customer-satisfaction, he understands, that his friend exploited the decision authority trusted upon him.

His proven recipes are simple to follow anyways, and the weekly demand in both branches is stable. So, he dismisses his friend for a cheaper worker and consolidates orders.

Coordination: Mintzberg's Five Structural Configurations

Henry Mintzberg reduced organizational design to nine universal parameters. He further reduced the contexts in which organizations operate into four basic contingency factors (Mintzberg, H. 1979. p.14). Among the possible combinations of those variables, Mintzberg identified five common patterns, which he called structural configurations (ibid. p.15). They coincide directly with five different coordinating mechanisms.

Simple Structure – Coordination through Direct Supervision

Organizations with a simple structure have a minimalistic hierarchy, often just composed of one person at the top making all important decisions (ibid. pp. 305-308). Direct supervision means having one accountable person giving instructions to others and controlling for output. This goes hand-in-hand with a low degree of departmental differentiation and specialized expertise. Such organizations are often still young and small, have a primitive technical system and are embedded in a simple but dynamic environment.

Machine Bureaucracy – Coordination through Standardization of Work Processes

The Machine Bureaucracy bears a higher degree of job specialization and functional differentiation (ibid. pp. 314 – 319). It counterbalances the resulting information advantage on the side of the workers with rigid formalization of work processes and communication and strong vertical centralization. This is further confirmed by a pronounced administrative component. Related operating units are usually supervised by a common management. A standardized work process makes supervision very effective. Machine Bureaucracies are usually old and large and are embedded in a simple and stable environment.

Divisionalized Form – Coordination through Standardization of Outputs

Mintzberg calls organizations with heterogeneously structured units "divisionalized" (ibid. pp. 381 – 384). Divisions are assigned to different markets and operate rather independently from each other. Most of the strategic control is however still centralized around the top management and the divisional managers, with a tendency for Machine Bureaucracy configurations in the divisions themselves. Standardized outputs can both relate to products and the divisional performance (ibid. p. 6), making budgeting and post-auditing very effective. Hence, divisional managers exercise control via supervision of work processes, whilst the top management exercises control via budgeting and post-auditing. Divisionalized configurations are usually old and large and embedded in diversified markets.

Professional Bureaucracy – Coordination through Standardization of Skills

From all five structural configurations, the degree of job specialization is the highest in the Professional Bureaucracy (ibid. pp. 348 – 358). Decisions need to be made within the operating core itself, as flexible coordination with clients is necessary, and/or problems are too complex or unpredictable to be coordinated by a central instance. Coordination is still possible, by standardizing the employee himself through training and indoctrination (ibid. pp. 6-7). This narrows the employee's decision-space down to predictable and controllable forms.

Professional Bureaucracies are usually found in complex, stable environments and lack a sophisticated technical system.

Adhocracy – Coordination through Mutual Adjustment

Adhocracies emerge in dynamic and complex environments. This promotes flexible forms of coordination with a low degree of standardization. Human resources are assigned to departments and market-based projects with high horizontal specialization based on their formal training. Liaison devices are the crucial intra- and inter departmental decision-coordination approach (ibid. pp. 431 – 435). Due to the focus on innovation, Adhocracies do not standardize skills as much as Professional Bureaucracies. Mutual adjustment means coordination through informal communication (p. 3). Adhocracies are usually young, relying on a sophisticated technical system.

In the principal-agent framework, these configurations can be arranged by the degree of delegated decision authority (see fig. 5). Agents in an Adhocracy bear the most decision authority, but their actual decision power is limited by the mutual accountability with other agents. Agents in Professional Bureaucracies by design have a narrower decision space but are subject to a much lower amount of control. This effectively leaves them with more power that can be exploited against the principal's interests. The Divisionalized Form and Machine Bureaucracy are very similar in terms of delegation, but budgeting and post-hoc control are easier to exploit than standardized work processes (Gordon et al. 2006. pp. 153 – 156).

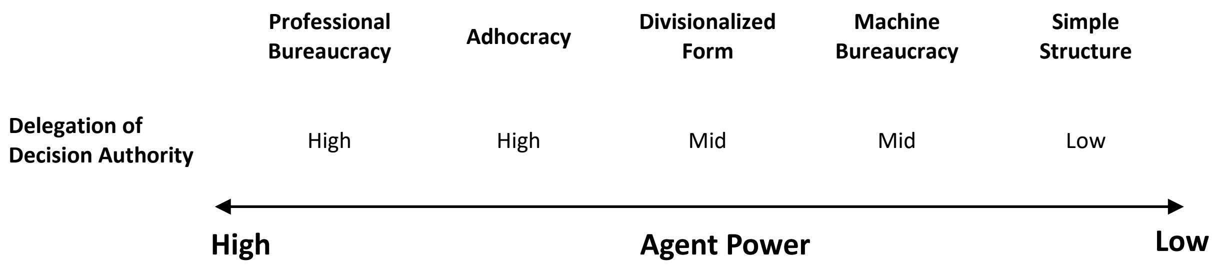

Figure 5. Mintzberg's Five Structural Configurations, arranged by the amount of Agent Power (and therefore Agency Costs).

a. Theoretical Fundamentals

i. Organizational Structure

ii. Exploration in Organizational Search

iii. Subjective Impediments to Search

The Exploration – Exploitation Framework of Innovation

The concept of innovation can be broken down to two general categories of activities (Pandey, S. Sharma, RRK. 2009. pp. 49 – 50):

Exploitation describes activities of incremental adjustments on the existing technological trajectory. It is associated with the refinement and optimization of the current architecture and components that are relevant according to the search-objective. It often implies harvesting the organization's given technological capital by finding new value-added applications. The technological trajectory is an emergent property of the heuristics, routines and the experience anchored in the cultural capital of an organization, that are relevant for problem solving (Laursen, K. 2012. p. 5). In terms of organizational search, exploitation is also referred to as local search.

Exploration describes activities of searching for new solutions on new technological trajectories. It is associated with the augmentation and redesign of the current market portfolio. This often implies investing into new technological capabilities.

What should be considered exploitation and exploration can hence often be a matter of perspective and standards. In any given frame of reference, exploitative activities would however always search closer within the realm of currently active technologies than explorative activities. They would further involve less uncertainty and expenditures. And vice-versa.

Empirical Examination of the Exploration – Exploitation Framework

Fittingly, the degrees of exploration and exploitation have previously been operationalized as ratios rather than binary modes. Katila and Ahuja successfully implemented the metrics of search depth and search scope for this purpose (Katila, R. Ahuja, G. 2002. p. 1187). **Search**

depth measured, how well the organizational memory retained and utilized its gained knowledge[1] over time. Effectively, this served as an indicator for exploitation. **Search Scope** was reflected as the ratio of new knowledge that entered the organizational memory to the total utilized knowledge of that year. This served as an indicator for exploration. The paper found that the number of successfully introduced new products is positively related to both, search depth and search scope, with a positive interaction between the two. The marginal benefit of search depth is decreasing and ultimately hurting innovation. Hence, keeping track of too much old knowledge slows down innovative output. A negative effect on innovation from too much exploration could not be demonstrated with significance.

Hence, exploration and exploitation should not be reduced to being two poles on a one-dimensional innovation scale. They are two distinct activities whose effectiveness is strongly interdependent (ibid. p. 1189). As they compete for the same resources, some tradeoff seems necessary. However, organizations can simultaneously commit to high degree exploration and exploitation at the same time - or do neither. Indeed, the large positive interaction term suggests a convex indifference curve (see Fig.6). As one activity intensifies, the marginal benefit of intensifying the other activity increases as well. When accounting for costs, one-sided search-strategies would be less efficient than balanced strategies.

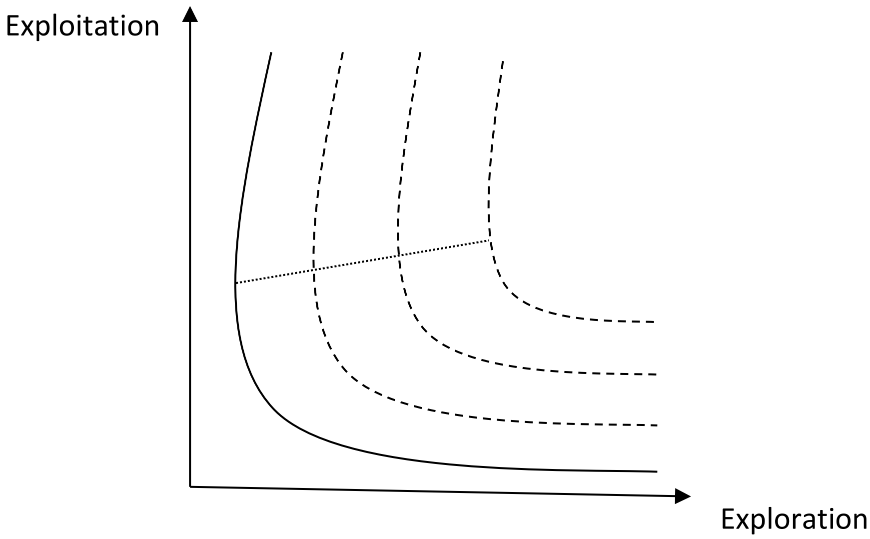

Figure 6. Indifference Curves (before Costs) for Search-Strategies. Strategies above the dotted line are automatically dominated by alternatives underneath assuming costs are positive.

[1] Knowledge was operationalized through citations used in patents.

Both measures were positively correlated with the R&D expenditures with statistical significance. As those are ratios, this is not a tautological statement. It is not just the quantity of search, that is positively correlated with higher expenditures. It is the increased level of effort and quality on the part of the agent.

a. Theoretical Fundamentals

iii. Subjective Impediments to Search

Utility

For this paper, the concept of utility is used to contrast the subjective experience of a decision's desirability from its objective market value.

An agent's experienced desirability of a decision alternative does not merely reflect its objective expected monetary value. It also regards subjectively perceived advantages and disadvantages that affect the propensity towards any decision alternative. The concept of utility has originally been introduced to describe consumers preferences as surjective functions (Pindyck, R. Rubinfeld, D. 2009. p.119). Each combination of decisions (e.g., a market-basket) can be linked to a subjective utility value, allowing for an analysis of preference orders. For a long time, there have been debates whether such a utility function should be cardinal or ordinal (Baccelli, & Mongin, P. 2016. pp. 269-271). Proponents of the ordinal type argue that the substrate through which people mentally represent preference orders is only relational but not extensive. Hence, they assume a mental representation of ordinal preference, but no mental representation of preference-differences (see Fig. 7). Proponents of the cardinal type like Lange and Suppes however consider it useful to assume the preference-space to be extensive (ibid. pp.271-272, see Fig. 8). Agents mentally differentiate the extent of difference between utilities. The ordinal type is an obvious oversimplification, ignorant of learning-effects and neuroplasticity. Given an experienced agent in a repeating decision framework, like in a professional setting, the incentives to refine mental representations of utility-expectations are obvious.

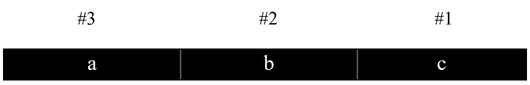

Figure 7. „c“ is preferred over „b” and “b” is preferred over “a”.

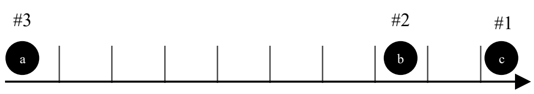

Figure 8. „b“ is preferred over „a” more, than “c” is preferred over “b”.

Due to bounded rationality, the mental representations of decision-settings in the real world are never fully exhaustive. Utility judgements must be ambiguous to some degree. The concept of fuzzy utility takes this into account better than a continuous function (De Wilde, P. 2004. p. 1). For the sake of interpretability, this paper will work with a continuous, cardinal utility function of additive components. Building upon Rivkin and Siggelkow, the starting point is a monetary reward that is directly proportional to the Agent's performance from the Principal's perspective. From this basis, the Agent discounts this reward with the subjective biases and (dis-)utilities he attributes to the individual decisions with regard to how different they are from the current state.

Impediments to Goal Congruent Search – Decision Biases

Empirical evidence exists that the information economist view is not a sufficient explanation for managers' rationales for making decisions and sharing information within organizations (Reitzig, M. Maciejovsky, B. 2015. pp. 1988 – 1990). Contrary to a true homo-economicus, managers do not always propagate outcome-maximizing information. Mere monetary goal-congruency does not automatically imply a utilitarian goal-congruency. Beyond genuine utility expectations, psychological impediments related to the search-setting may further decouple ex-ante utility judgements from the ex-post experienced utility. In terms of the Principal-Agent framework, impediments to goal congruent search can be described as **search-related decision-biases** caused by (1) misaligned monetary interests, (2) subjective experienced utilitarian interests and (3) situational psychological impediments in the presence of information asymmetry.

Monetary interests are misaligned if the assessment basis for the agent's reward promotes actions, which are not in the best interest of the firm as a whole (Fischer, T, M. 2015. pp. 313 – 315). This can happen, if the relevant KPIs are not measuring performance in terms of the truly desired outcome. Rewarding periodical sales can come at the cost of long-term growth and profitability (Kerr, S. 1975. p.775). KPIs can also be easily manipulable, like through intertemporal profit-shifting (Andries, K. Cools, M. Van Uytbergen, S. 2017. p. 531). An issue relevant for cooperative search is, furthermore, KPIs that disregard synergies and opportunity costs between organizational units.

Subjectively experienced Utilitarian Interests

Employees sell their time and labor for a wage. As daily waking-hours are a scarce good, and energy and focus are even scarcer, trading them in comes with significant opportunity costs and undesirable feelings. Investing all 24 hours of a day into a singular employment-relationship may well be the most monetarily beneficial use of one's time on paper. It is certainly not the most sustainable lifestyle out there.

Disutility of Effort

The willpower it takes to overcome the increasing self-regulatory fatigue by natural means approaches a limit as brain glycogen levels fall (Evans et al. 2016. p.4). Even pharmacological enhancements cannot overcome the ultimate limit to effort when we inevitably fall asleep or die. Any function projecting disutility on effort would hence necessarily reach a point where the additional share in returns is no longer worth the effort.

Empirical analyses have demonstrated that the expected reward has a significant impact on effort. Whilst attendance may barely be affected by a wage change, employee-productivity will account for a change in reward immediately (Treble, J. 2003. pp. 591-592). The lowered utility of monetary rewards can hence be substituted by a lower disutility of effort.

Ackermann, Tatel & Lyndgard have empirically substantiated by the Bayesian information criterion, that the best model to describe the disutility-function of effort is indeed quadratic (2020. p. 13). It is applicable both on mentally and physically demanding tasks alike. Interestingly, the function is u-shaped and decreasing at first, only increasing after a turning point. The disutility of very low effort is being interpreted as the disutility of boredom, which may possibly play a role in search as well. It is arguable though, that the aversion against boredom is a non-issue in management positions.

Utility of Leisure and Disutility of Labor

Humans like to reap the fruits of their labor and experience a lack of leisure as psychologically painful. Constant Frisch Elasticity is a popular function for projecting utility on leisure. It considers the utility of leisure as equal to the negative disutility of labor (Evans, R, W. Phillips, K, L. 2016. p. 517). The disutility of labor is hence a more generalized construct than the disutility of effort. It considers not only the disutility experienced from performing an activity but depicts the sum of all disutilities associated with work plus the opportunity costs of the missed-out utilities that could have been experienced doing something else. Accordingly, the exponent which determines the marginal disutility is not predetermined, but a value ϵ [1, ∞] that is determined by an empirically derivable coefficient, the Frisch elasticity of labor supply.

Situational Psychological Impediments

There are factors impacting decisions, that don't reflect expected future utilities or disutilities as much as they are emotional or psychological inclinations that occur during the decision-making process. One such construct that bears a long history in decision theory is risk-preference (Egozcue, M. Garcia, L. Wong, W. Zitikis, R. 2011. pp. 188-189). It has little to do with the truly experienced utility at the time of the realization or the ex-ante expectation of it. In a sense, phenomena like this misalign agents' decisions from their own long-term goals. Fearing a superior can realign the agents' decisions with the principal without adequate compensation, but it may as well inhibit the flow of information, ending in a lose-lose situation.

Aversion and Fear

We are not specifically interested in monetary risk-aversion in this paper. However, there are many other risks to personal wellbeing associated with decision making. Social consequences and structural change can be advantageous and disadvantageous to the agent. The existence of mental representations regarding the uncertainty of these consequences and changes, can be safely assumed. Whether these can be as substantial as the representations of monetary risk is less clear. Regardless, differential sensitivities, like fears or desires towards the prospect of different outcomes are well documented. There are five main types of fear that keep employees from taking initiative (Applebaum, S.H. Bregman, M. Moroz, P. 1998, p. 220):

1. **Fear of Failure** makes taking up the responsibility for changes less attractive. Employees who experience this fear will prefer the safety of the status quo and may generally avoid actions which attract too much attention. Even opportunities with favorable expected outcome involve risk. With higher risk, fear increases, making risky opportunities more likely to be rejected.
2. **Fear of Success** relates to the disutilities of being set-apart from others. Taking up the responsibility for change implies responsibility for the fruits of this success. This can come with growth, consequential investments, restructuring of interconnected departments and the hiring of new employees. This increases the moral stakes for the decision maker and the potential humiliation of a deeper fall with all the new attention.
3. **Fear of what others think** makes individuals strongly favor decisions, that they are sure will find approval with colleagues. This leads to a tendency of suggesting obvious, incremental changes. The information-advantage of specialized agents in differentiated principal-agent-hierarchies may get lost for decisions that ponder to the limited understanding of superiors or the less informed majority.
4. **Fear of Uncertainty** comes from a strong preference for the stability of the current job-situation and an aversion from additional or unfamiliar tasks. The fear is caused by the uncertainty of how a decision affects this stability and the current level of control. This fear is not related to failure or success, but with change in general.
5. **Dynamics of group decisions** can produce complex fears, inhibitions, and pressures. Empirically, these group dynamics can lead to both, a more risk-seeking attitude, and a more risk-averse attitude. Vecchio and Applebaum call these phenomena “risky shift” and “cautious shift”, respectively (Vecchio, Applebaum, 1995, p. 419).

Overall, these fears can pose a significant inhibition to creative and foresighted search, making larger changes less attractive. Especially the fear of what others think (3.) and the fear of uncertainty (4.) have little to do with performance. The fear of uncertainty is dependent on the level of change a decision brings. The fear of what others think depends on the asymmetric information between the agent and those affected by his decisions, and on the level of change others will be exposed to.

Evaluation Apprehension

Evaluation apprehension is a special case of the fear of what others think, that has been well examined. Cottrell et al. demonstrated in 1968, that the presence of an audience strongly impacts the behavior of subjects (pp. 257-248). Evaluation apprehension describes phenomena where the awareness of being evaluated affects internal motivations and has the qualities of fear. It can both be a social facilitator and inhibitor (Henchy, T., Glass, D. C. 1968. p. 446).

In the context of organizational search and exploration, it has been shown to have an overall inhibitive effect. These inhibitions have been linked to a pessimistic view on the own competency and credibility and the worry that the knowledge shared would not be appreciated or even worse, result in humiliating criticism (Wang, S. Noe, R.A. 2010. p. 124).

Under evaluation apprehension, the number, diversity, and novelty of ideas generated decreases significantly (Zhou, X. Zhai, H-K. Delidabieke, B. Zeng, H. Cui, Y-X. Cao, X. 2019. pp. 4-5). Evaluation apprehension also decreases the information flow to superiors (Reitzig, M. Maciejovsky, B. 2015. pp. 1993-1995). The number of ideas submitted to superiors is lower under evaluation apprehension, more so, the steeper the organizational hierarchy is.

On the agent level, evaluation apprehension hence biases decisions towards the status-quo. Evaluation apprehension is identified by its effect and not precisely delimited from related constructs like the Dunning-Kruger effect, the Hawthorne-effect, or observer biases. In line with empirical operationalizations, here it shall represent the intersection of compounded, decision-effective phenomena that are caused by the agent's awareness of being evaluated.

Implementation of Decision Biases in the LEN-Model

The best approximation of a disutility of effort function is quadratic (Ackerman, P.L. Tatel, C.E. Lyndgaard, S.F. 2020. p. 13). In this spirit, the commonly used LEN-Model of Principal-Agent Theory has modeled disutility of effort as a convex (see fig. 1) function of effort (Gibbons, R. 1998. pp. 116-117).

The model is composed of

a risky outcome $y = a + \varepsilon$,

a reward contract $w = s + b*y$ and

a utility function $E[U] = E[w] - \frac{1}{2}\alpha Var[w] - \frac{1}{2}\mathbf{c(a)}$ (Mayer, Pfeiffer, Reichel. 2005. p. 16)

which shortens to $E[U] = s + ba - \frac{1}{2}\mathbf{c(a)}$ in absence of risk or under risk-neutrality.

The outcome consists of an effort component “a” that can be influenced by the agent and a component “ε” that is outside the agent’s influence. The reward contract consists of a fixed amount “s”, plus a performance-based amount “b*y”, where “b” is the bonus-coefficient and “y” is the realized outcome. Finally, the utility function subtracts from this reward subjective components that misalign it from the principal (Mayer, Pfeiffer, Reichel. 2005. p. 16):

1.) The **risk-premium**, α Var[w],

which depends on the agent’s risk-attitude "α" and the variance of the reward caused by the risk of the outcome. In the framework of impediments to goal congruent search that were lined out before, this component belongs into the category of **situational psychological impediments**.

2.) The **disutility of effort** c(a),

where c(a) is usually a^2 or $\frac{a^2}{2}$ (see Fig. 9). In the framework of impediments to goal congruent search, this component belongs into the category of **subjective experienced utilitarian interests**.

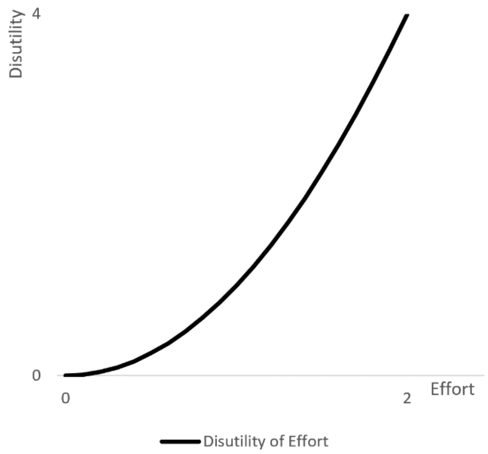

Figure 9. Convex Disutility-Function of Effort

It is hence an established assumption, that any decision-making agent would at least implicitly account for some subjective expected disutility of effort when estimating the expected utility of a decision. Whilst monetary risk is not going to play a role in this paper, having precedent of the category of situational psychological impediments in such a well-established model justifies the analogous implementation of other biases.

b. Methodology

i. The NK-Model

ii. Modeling multi-Agent Organizational Search

iii. Modeling Exploration and its subjective Disutility

The NK-Landscape

This paper follows the work of Nicolaj Siggelkow and Jan W. Rivkin in the examination of Organizational designs with the method of agent-based modeling on an NK-Landscape (Siggelkow, N. Rivkin, J.W. 2005).

NK-Models are named after the parameters "N", standing for the number of binary decisions, and "K", standing for the number of interdependencies between those decisions. Each decision can either have the expression "0" or "1". With "N" possible decisions, the decision-landscape is hence composed of 2^N possible combinations of binary decisions (see Fig. 10).

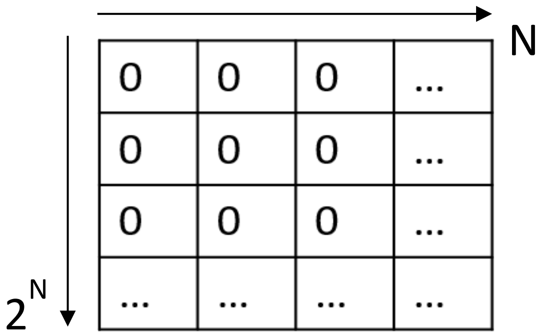

Figure 10. Decision Landscape

Each expression is furthermore linked to a uniform-randomly assigned value - the fitness contribution. The total Fitness *d* of the current state is then the mean or sum of all fitness-contributions C_i from the individual decisions (see Tab. 1).

Table 1. Fitness Landscape with N = 3, the 2^N combinations, the individual fitness-contributions, and the total Fitness.

A	B	C	Contribution A	Contribution B	Contribution C	Ø
0	0	0	0.5	0.8	0.7	0.667
0	0	1	0.6	0.8	0.3	0.567
0	1	0	0.5	0	0.7	0.4
0	1	1	0.6	0	0.3	0.3
1	0	0	0.7	0.4	0.2	0.433
1	0	1	0.5	0.4	0.7	0.533
1	1	0	0.7	0.4	0.2	0.433
1	1	1	0.5	0.4	0.7	0.533

The individual fitness contributions C_i can be interdependent. This can be used to model complexity. If a firm producing smartphone-cases decides to center its sales-strategy around customizability, this may reap more benefits if the implemented production method is 3D-printing, than injection molding. If it bets on standardized mass-production, injection molding would bring more benefits. Analogous to this, the fitness contributions C_i of single decisions modeled in the NK-Model are conditional to K other decisions. The one-way conditionals d_j between decisions are defined in an interaction matrix (see Fig. 11).

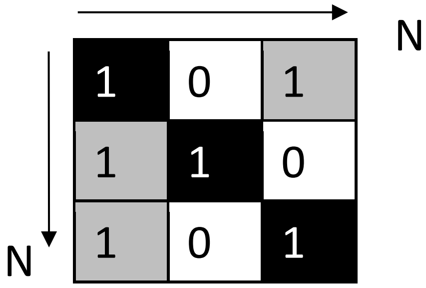

Figure 11. Interaction Matrix. 1 means Interaction

The fitness-contributions then result from the inherent component d_i of the decision itself and the conditional components d_j coming from the interactions with the other decisions (see Fig. 12). The higher K is, the greater is the proportion of these conditional components and thus, the more complex is the resulting fitness-landscape.

	A	Contribution	B	Contribution	C	Contribution
A	0	0.7	0		0	-0.2
	0	0.7	1		1	-0.1
	1	0.4	0		0	0.3
	1	0.4	1		1	0.1
B	0	0.6	0	0.2	0	
	1	0.2	0	0.2	1	
	0	-0.3	1	0.3	0	
	1	0.1	1	0.3	1	
C	0	0.1	0		0	0.6
	1	-0.4	1		0	0.6
	0	0.1	0		1	0.2
	1	0.5	1		1	0.2

	A	Contribution	C	Contribution	B	Contribution
A	0	0.7	0	-0.2	0	
			1	-0.1	1	
	1	0.4	0	0.3	0	
			1	0.1	1	

	B	Contribution	A	Contribution	C	Contribution
B	0	0.2	0	0.6	0	
			1	0.2	1	
	1	0.3	0	-0.3	0	
			1	0.1	1	

	C	Contribution	A	Contribution	B	Contribution
C	0	0.6	0	0.1	0	
			1	-0.4	1	
	1	0.2	0	0.1	0	
			1	0.5	1	

Figure 12. Conditional Contributions with N = 3 and K = 1.

b. Methodology

Search on the NK-Landscape

As the number of possible combinations grows exponentially with the number of decisions, landscapes can reach a large size quickly. With 10 decisions, the number of combinations would already be 1024. An agent who wants to achieve good results quickly would not exhaustively check all 1024 combinations before making a choice. He starts at some state S_0 where S_0 is part of the set of possible combinations. From this state, he may first examine similar alternatives, where only one decision is changed. With N decisions, there would hence be N alternatives in the immediate "neighborhood" (Levinthal, D.A. 1997. p. 937). This is referred to as "local search". If he is more open minded, he may also consider some more distant alternatives if they strike his mind. Due to constraints of time and bounded rationality, he would however only be able to examine a limited number of alternatives before making a decision. Once the decision is due, if at least one of those alternatives is preferable to the current state, he would be inclined to choose implementing this new alternative. The examination of further alternatives would be deferred to the next period. These would then be measured by the fitness of the new current state, S_1. Fitness levels are values between 0 and 1.

The core of these NK-Models is hence iterative improvement under rationality constraints. This allows us to examine emergent properties of these dynamic, implicitly learning systems. One of the most prominent properties is the trap of local optima. Whilst in a perfectly simple landscape with K = 0, even local search would eventually lead agents to the optimal alternative, agents in complex landscapes may often find themselves in situations, where all the alternatives in the neighbourhood are worse. The agent will assume to have reached the optimal solution already, when in fact there are better alternatives out there (see Fig. 13).

A	B	C	ø	Distance
0	0	0	**0.667**	3
0	0	1	0.567	2
0	1	0	0.4	2
1	0	0	0.433	2
0	1	1	0.3	1
1	0	1	0.533	1
1	1	0	0.433	1
1	1	1	0.533	0

global Maximum

too far away

Fitness ≤ Current State

local Maximum (Current State)

Figure 13. When the current state is [1, 1, 1], and no neighbouring state is better, the Agent is stuck in a local optimum and will never reach the optimal state [0, 0, 0] under local search.

More complex environments have a significantly higher number of local optima. A fitting metaphor for this is that of a mountain range, a rugged surface with peaks which are topologically separated by valleys. Reaching another peak would require the agent to first descend downwards to a lower fitness level or to jump over to another mountain. In the literature, this is called a “long jump” (Levinthal, D.A. 1997. p. 938).

The following graphs illustrate the relationship between the complexity of a landscape expressed by “K” and the number of local optima (see Fig. 14). In a perfectly simple landscape without interactions, there can always only be one peak. With 6 decisions, the average number of peaks for K = 1 is 2. For K = 5 it is already 9 peaks on average. The probability of reaching the global maximum under local search falls from 100% to only 11% .

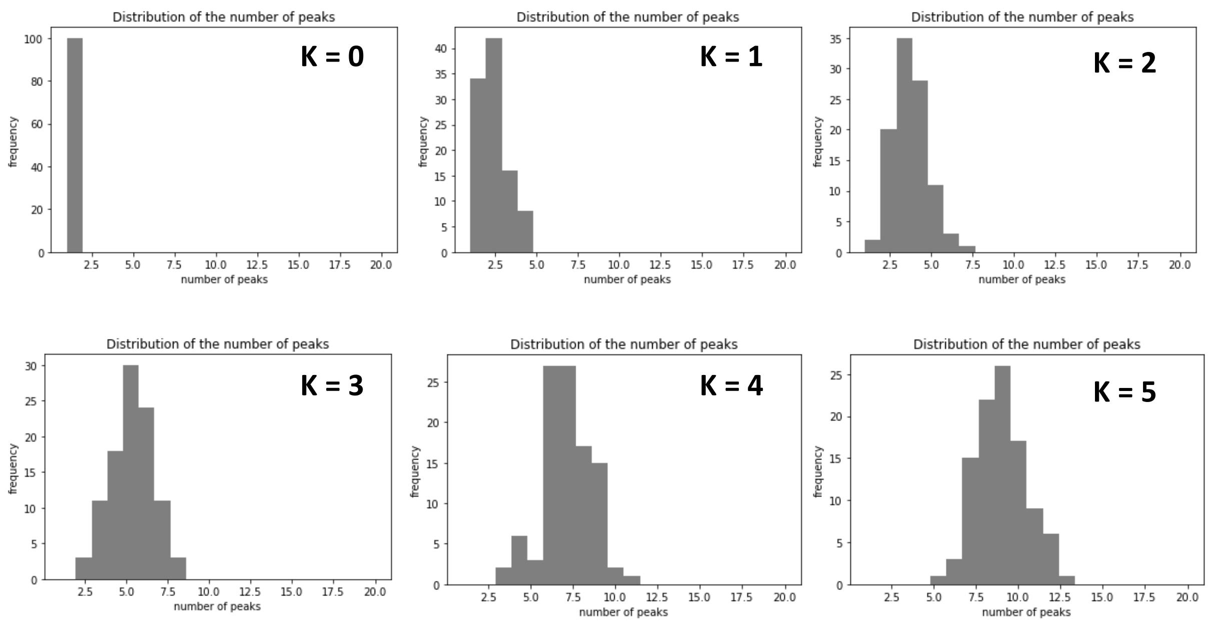

Figure 14. Number of peaks by Complexity for N = 6 for 100 randomly generated Fitness Landscapes

Multi-Agent Search

When multiple Agents are searching together on their principal's behalf, they are acting in the same environment as him. One could conceive of many kinds of cooperative search, whether agents are searching simultaneously or alternately, whether they focus on a designated number of decisions or have partial or complete overlap between them.

This work is concerned with agents, that represent organizational departments with designated responsibilities. Hence, in the basic alternative-finding process, each department is responsible for finding improvements to its own set of decisions. These departments are searching simultaneously and deliver proposals simultaneously. Alternating search may be a beneficial option for hierarchical organizational forms, as coordination would improve, and search could be more targeted. As Siggelkow and Rivkin did not account for this possibility (2005), this work too will avoid convoluting the model more than necessary.

The cooperative search-process is modeled by up to three steps (see Fig. 15):

1.) Agents search for and evaluate alternatives of their designated decisions.
2.) Agents propose a number of their most preferred alternatives.
3.) The principal or the group chooses the combination of alternatives to implement.

This is then repeated for a predefined number of *t* periods.

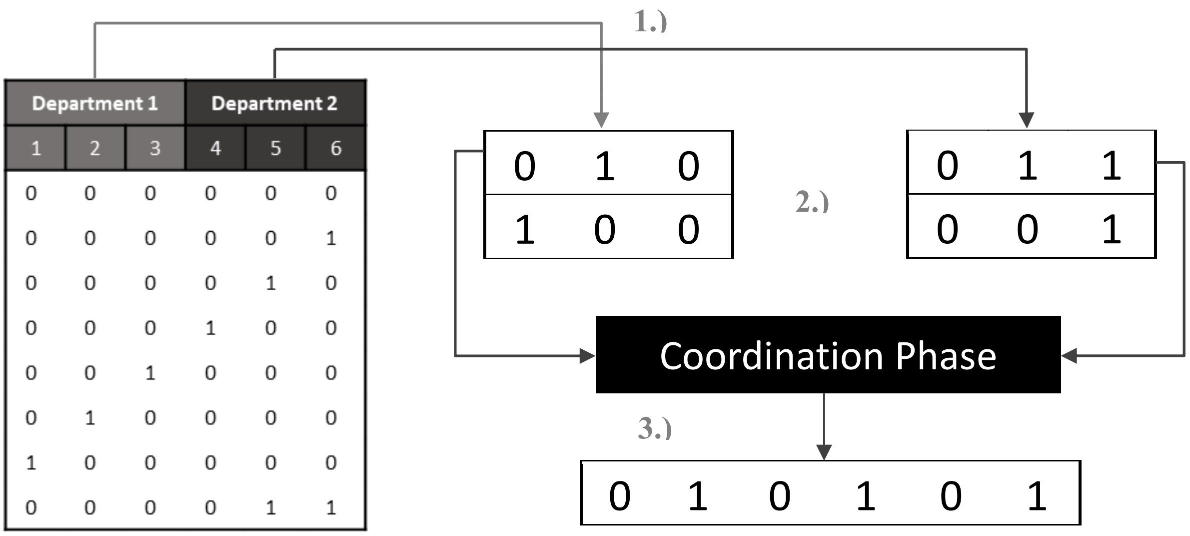

Figure 15. Flow Chart of the cooperative Search-Process

Design-Elements

Siggelkow and Rivkin's model consists of several environmental and organizational design elements. They are chosen in the spirit of keeping the model no more complex than it needs to be to answer the underlying questions (ibid. p. 103). We already touched on the environmental parameters N and K. In line with their implementation from 2005, N is set to be 6 binary decisions *d* in this work. K is a value between 0 and the maximum number of interactions N-1. The interaction matrices are then generated randomly by uniform distribution, such that each decision is interacting with K of the other decisions. Direct fitness contributions d_i as well are taken from a uniform distribution and range from 0-1 and then summed up with the K contributions d_j from interactions and averaged to C_i as described in the previous chapter. Each of two departments is responsible for 3 of those decisions (see Fig. 15).

Reward Function

INCENT is a binary parameter to differentiate, whether agent's payoff depends only on the success associated with their own decisions (I = 0), or on the firms total success (I = 1). The basic reward guiding agent's actions is hence

$$P(d) = \frac{\left[C_{self1} + C_{self2} + C_{self3}\right] + INCENT * \ \left[C_{other1} + C_{other2} + C_{other3}\right]}{6}$$

The fitness that guides the principal's evaluations is analogously the mean of all contributions. In the previously outlined classification of impediments to goal-congruent search, the INCENT variable controls a type of misaligned monetary interests. They are misaligned, if INCENT = 0. Under firmwide incentives, the monetary interests are perfectly aligned. In this work, agents evaluate alternatives given a utility function $U(d) = P(d) - C(\Delta d)$, where $C(\Delta d)$ is the total decision bias caused by the alternative's distance to the status quo. The effect of subjective goal-congruency impediments responsible for this bias will be discussed in the next chapter.

Information Processing

ALT controls how many different alternatives each agent searches and evaluates in step 1 of the cooperative search-process. It represents the departmental processing power (ibid. p. 108).

PROP controls how many of those alternatives are proposed to the final evaluating round in step 2. It represents the richness of information flow.

COMP controls how many combinations of the proposed alternatives are being evaluated in step 3. It represents the coordinative processing power.

Not all organizational archetypes include all three of these variables, and they can have slightly different interpretations.

Modeling Organizational Archetypes

To secure the integrity and comparability of the model, the archetypes modeled in this work are recreations of the five organizational archetypes used by Siggelkow and Rivkin (2005). They are based on the five structural configurations by Mintzberg (1979) and arranged by the degree of Agent-Power, like the two organizational archetypes identified by Greenwood and Hinings (1993. p. 1066). As the divisional form and the machine bureaucracy are nearly equivalent for abstract modeling purposes, they are summed up as the "Hierarchy" – archetype. Instead, they model two plausible structural implementations of Mintzberg's "Adhocracy": the "Liaison Archetype" (ibid.) and the "Lateral Communication Archetype" (ibid). Both achieve coordination through mutual adjustment but with two different underlying mechanisms.

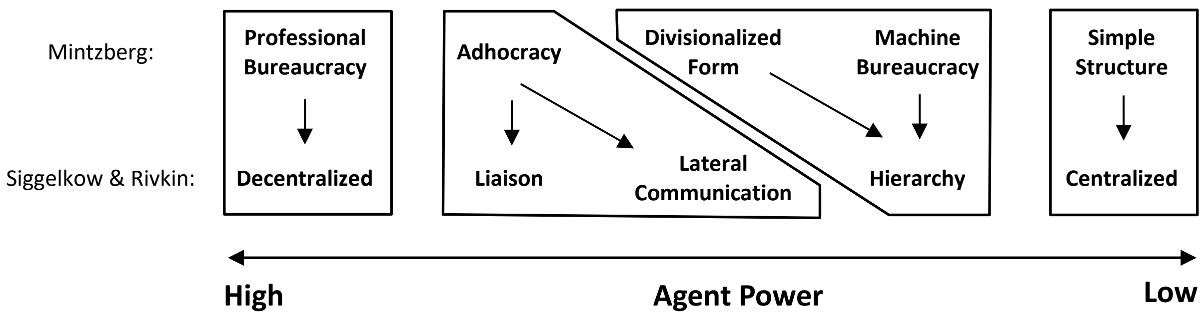

Figure 15. How the Archetypes are based on Mintzberg's structural configurations

Decentralized Archetype

The decentralized archetype models Mintzberg's professional bureaucracy (1979. pp. 348 – 358). Full decision authority is granted to the department heads without a coordination phase. They query and evaluate ALT different alternatives plus the status-quo, given their utility-function and finalize the decision by themselves. As decisions are made simultaneously, departments evaluate the utility of their own decisions ceteris paribus – no change by the other department is anticipated.

Instruments of Power: Complete Autonomy

Systems of Coordination: Firmwide Incentives

Liaison Archetype

The liaison archetype is one of the two implementations of Mintzberg's adhocracy (1970. pp. 431 – 435). Department heads randomly query ALT different alternatives plus the status-quo and evaluate them ceteris paribus. They then rank them by utility and carry PROP of those alternatives to the coordination phase. In the coordination phase, the ranked alternatives from all departments are combined and arranged by the rank sum in the following way:

Joint Rank	Rank Sum	Department 1 Alternative Rank	Department 2 Alternative Rank
1	2	1	1
2	3	1	2
2	3	2	1
4	4	1	3
4	4	2	2

Table 2. Arrangement of Alternative-Combinations by Rank-Sum

The order of combinations with equal rank sum is chosen randomly. In the resulting order, both departments evaluate those combinations separately. The first combination that is preferable or equivalent to the status quo for both departments is chosen.

Instruments of Power: Pre-Screening, Agenda Setting, Veto

Systems of Coordination: Firmwide Incentives, Veto,

Lateral Communication Archetype

The lateral communication archetype is the other implementation of Mintzberg's adhocracy. Instead of a sophisticated pre-screening phase, departments skip the first step and directly bring PROP randomly selected alternatives plus the status quo to the coordination phase. From those alternatives, COMP random combinations are constructed and evaluated. The combination that is acceptable for both departments and best for the firm is selected. Otherwise, it reverts back to the status quo.

Instruments of Power: Veto

Systems of Coordination: Firmwide Incentives, Veto, Neutral Selection at a Draw

Hierarchy Archetype

The hierarchy archetype models Mintzberg's machine bureaucracy and divisionalized form. It introduces the central as an agent in the third step of the search-process. Agents pre-screen ALT different alternatives and forward their PROP favorite alternatives plus the status quo to the central. Then, the central evaluates COMP random combinations of these alternatives and chooses the best option.

Instruments of Power: Pre-Screening

Systems of Coordination: Firmwide Incentives, Central Authorization

Centralized Archetype

The centralized archetype models Mintzberg's simple structure. No decision authority is delegated. Instead, the central searches and evaluates alternatives on its own. This omits issues of coordination and issues of misaligned monetary interests. The downside is that, ceteris paribus, only a fraction of the decisions can be addressed at once. The central searches analogous to the departments.

Instruments of Power: None

Systems of Coordination: Complete Centralization

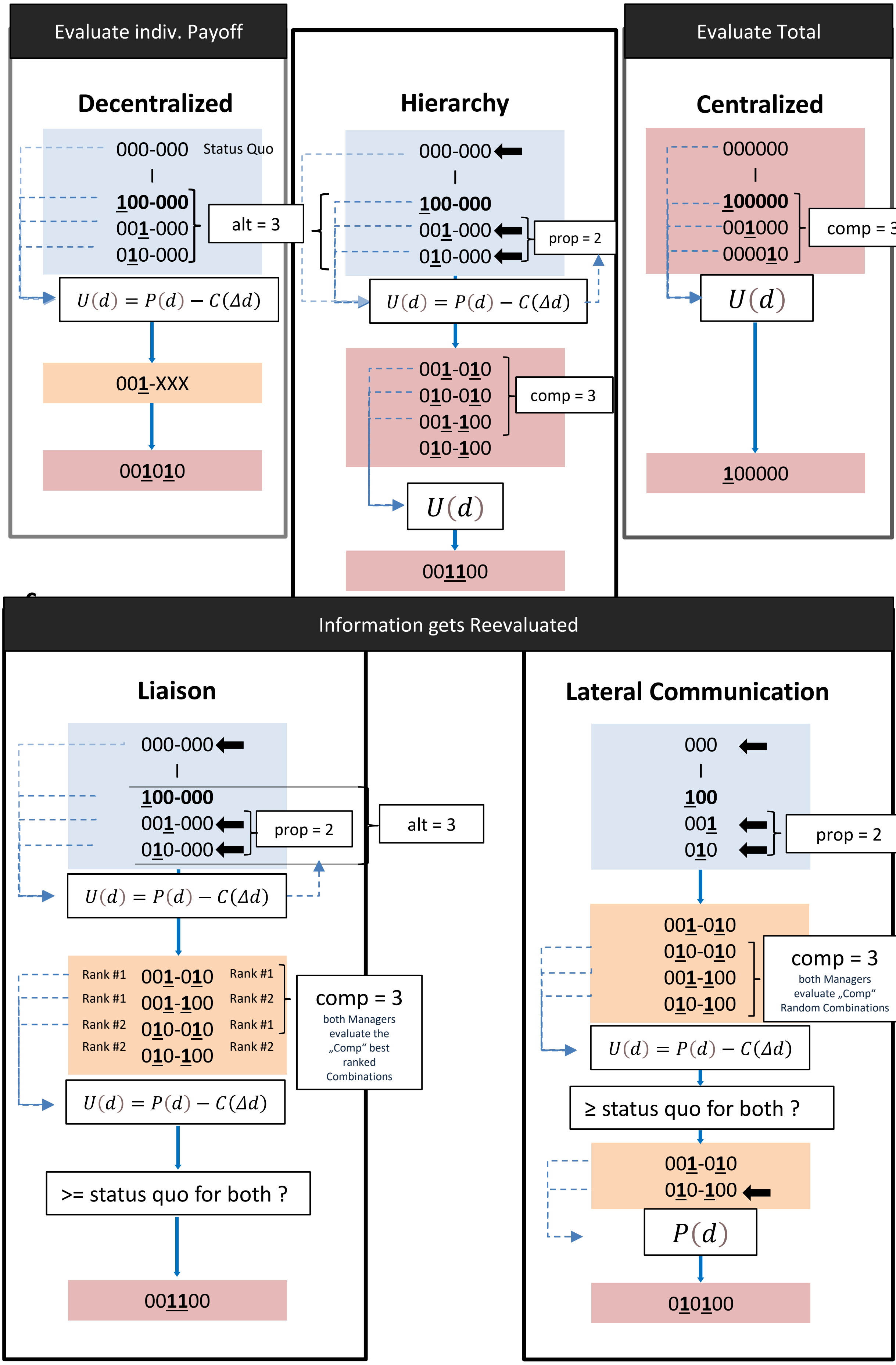

Figure 16. Flow Charts of the five Archetypes

b. Methodology

iii. Modeling Exploration and Decision Biases of Search

Exploration among Departments

This work seeks to examine the benefits and costs of innovativeness for different organizational forms. It was already lined out that innovation is described as two distinct but strongly interdependent activities – exploitation and exploration. The level of exploitation is reflected in the retention of knowledge from previous search (Katila, R. Ahuja, G. 2002. p. 1187). The level of exploration is reflected by how much new knowledge enters the organizational memory. Siggelkow and Rivkin kept both activities fixed in their paper. In fact, explicit information is only ever retained period-wise and destroyed after every decision. In a different model, James G. March has implemented information retention in terms of a social learning and opinion-building process (1991. p. 74). This could be an interesting extension on the sub-departmental level but would unnecessarily convolute this paper. Instead, as in other applications of local search on the NK-model, the activity of exploitation is also seen implicitly in choice-proximity and as a trade-off with exploration (Billinger, S. Stieglitz, N. Schumacher, T.R. 2014. p. 95).

Choice-proximity on a binary decision landscape shall mean the hamming distance from the status quo – the sum of absolute differences between each individual decision. For status quo [1, 0, 0], the hamming distance to the new alternative [0, 0, 1] is $\Sigma[1, 0, 1] = 2$.

The level of exploration of any given alternative is analogously implicit in the choice-distance – in this common trade-off paradigm, the level of exploitation is equivalent to the level of non-exploration.

On the departmental level, exploration is modeled through the maximum hamming-distance an agent is taking into consideration. It is parametrized as *search distance*. Given three binary decisions, the maximum possible search distance is three. Devoid of any prejudice, the probability for finding any alternative equal or smaller than this specified *search distance* is defined as equal. For every three-decision status quo, there are three alternatives with search distance 1 or 2 each, and one alternative with search distance 3.

The exploration takes place in the initial step of the search process. First, all possible binary combinations are generated. Then, the hamming-distance to the status quo of the department is calculated for each of those alternatives. From all alternatives with hamming distance ≤ *search distance* and hamming distance > 0 (the status quo), the current search-period's initial draw of alternatives is taken (see Fig. 17). The number of those alternatives corresponds to the coefficient of the initial draw. For Decentralized, Liaison and Hierarchy this is ALT, for lateral communication this is PROP and for centralized this is COMP (see Fig. 16).

A	B	C	Hamming Distance
0	0	0	3
0	0	1	2
0	1	0	2
1	0	0	2
0	1	1	1
1	0	1	1
1	1	0	1
1	1	1	0

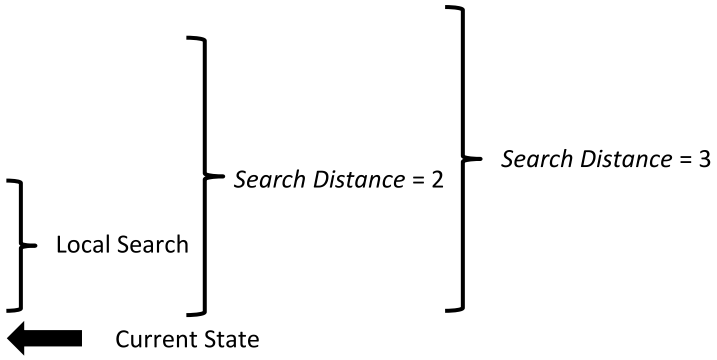

Figure 17. Effect of the Search Distance Parameter

Search-related Decision-Biases

In the previous chapter, three types of decision-biases that impede goal-congruent search were lined out:

(1) misaligned monetary interests

(2) subjective experienced utilitarian interests

(3) situational psychological impediments

The original model by Siggelkow and Rivkin accounted for a misaligned monetary interest that was caused by parochial incentives (2005. p. 106). This work shall examine how the organizational effectiveness of the different archetypes is affected if the agents' evaluation processes account for subjective decision-biases caused by (2) and (3).

For easier explanation and interpretation, this work will stick with consistent examples of such biases, being the disutility of effort for (2) and evaluation apprehension for (3). Moreover, due to the better empirical backing of the disutility of effort – functions and its presumably dominant effect, the focus will be there. It shall be explicitly noted though, that many analogues or amalgams of analogues of the type (2) or (3) can be interpreted interchangeably. Running the simulations with various formulas for the decision bias has shown the overall direction of the impact on the outcomes to be robust to variations for exponents between 1 and 3, regarding the relationship between the *search distance* and the extent of the bias. This gives confidence in the generalizability of the results for analog constructs and amalgamations of such constructs. That is, if a negative relationship between these constructs and the level of exploration can be assumed. Further, this makes a separate treatment of (2) and (3) in the model unnecessary.

For keeping it as closely grounded in empirical research as possible, the bias is modeled as a quadratic function of the hamming distance. This mirrors the findings of Ackermann, Tatel & Lyndgard, who have shown that by the Bayesian information criterion, the best model to describe the disutility-function of effort is quadratic, although a cubic exponent would still be a good fit (2020. p. 13). Agents are assumed to expect an amount of effort *a* that is proportional to the number of decisions Δd their department must implement in the given period. The same can be assumed for the fears lined out in *a. iii.*, as with more extensive change, uncertainty about the future work-environment increases, and the comprehension and approval of less involved stakeholders such as the agent's confidence in his own competence under evaluation decreases. The decisive factor determining the bias in the model is hence the hamming distance Δd between the evaluated alternative and the status quo of the department.

The agents' utility function $U(d) = P(d) - C(\Delta d)$ takes the expected reward of an alternative $P(d)$ and subtracts the bias $C(\Delta d)$ from it. Other than the monetary reward $P(d)$, $C(\Delta d)$ does not depend on parameter *I*. The bias is primarily concerned with what the own department does. The extent of the bias is controlled through the variable *sensitivity*, as it represents the individual sensitivity to the impedimental construct. It is calculated the following way:

$$C(\Delta d) = 0.05 * (sensitivity * (\Delta d)^2)$$

The factor 0.05 was added, so that the relevant range of expressions of the *sensitivity* is between 0 and 1. When *sensitivity = 1*, the bias at $\Delta d = 3$ is 0.45 and hence just small enough to warrant the chance for the maximum degree of exploration at the average fitness level of 0.5. It must be considered, that if *1-current Fitness* < $C(\Delta d)$, the alternative will always be rejected. This leads to certain cutoff-values for which degree of exploration still has a theoretical chance of being applied at any given fitness level (see Tab. 3).

Hamming Distance	*Sensitivity*	*Bias*	*Max. Cutoff Fitness*
1	0.5	0.025	0.975
	1	0.05	0.95
2	0.5	0.1	0.9
	1	0.2	0.8
3	0.5	0.225	0.775
	1	0.45	0.55

Table 3. Cutoff Fitness Values for different Degrees of Exploration, expressed through the Hamming Distance

At a Fitness greater than 0.55 and a *sensitivity* of 1, there is no alternative left that could deliver an improvement great enough to overcome the bias of 0.45. Only alternatives with a hamming distance of 2 or less could still be acceptable. Search would, in theory, be more efficient if exploration would be reduced according to those cutoff values. As agents are assumed to be ignorant about the global maximum and the upward potential from the current state, an exploration-policy that changes with the progression of fitness is not a necessary result of this.

Search related Decision-Biases in the Central

The role of the central makes a huge difference for the interpretation. In the classic agency literature, the central is equivalent to the principal and follows different interests than the agent, usually the maximization of value. In reality, decision-makers in the central can be subject to the same types of impediments. More change may expose a CEO to just as much additional effort and fear as it does the department heads.

In the model, this affects the hierarchy archetype and the centralized archetype. In the hierarchy archetype, the central evaluates what departments had proposed before. It can be a rational strategy for the central to consider the utility-function of its managers: Empirical studies have shown that employees automatically compensate lower utility through lowered effort (Treble, J. 2003. pp. 591-592). Even a highly bureaucratized central would have to anticipate type (2) biases. If the bonus coefficients of the reward function are already assumed to be incentive-optimal, enforcing alternatives that are not acceptable to the agent at the current reward-level would require the central to compensate the agent for the excessive disutility. Type (3) biases like evaluation apprehension cause no ex-post disutilities and can hence be completely overcome under symmetric information. Modeling all of this in one cost-function would, however, require some additional assumptions that inhibit the model's generalizability. For simplicity, the central is modeled to follow the same utility function $U(d)$ as the departments by default. Central agents hence consider the same type (2) bias and experience the same kind of type (3) bias. Additionally, a version of the central is modeled, that follows only $P(d)$, to see the upwards potential in a bureaucratized value-maximizing central or for phenomena like evaluation apprehension that may not affect the central. The same is applied for the centralized archetype.

c. Results

i. Experiment

ii. Discussion

The Effects of Decision Biases on Search in different organizational Structures

The model was reconstructed as described in part b., with consistent results to Siggelkow and Rivkin's paper from 2005 throughout all their experiments. The issue of turbulent environments was not considered. Search speed is a good enough indicator for performance under turbulence and is considered instead. As the exact landscape-creation method of the original paper was not fully explained, the absolute values in my landscapes are slightly different. The relative values between archetypes are consistent without exception, relative values and ordinal rankings are fully comparable to the original paper.

Reconstruction of the Original Experiment

Siggelkow and Rivkin demonstrated, that with equal processing power, two archetypes would be dominant in stable but complex environments due to their diversity of search (Siggelkow, N. Rivkin, J.W. 2005. pp. 115):

1. hierarchical organizations with limited departmental pre-screening power but a high informational flow to the central
2. organizations with a spontaneous, lateral communication and shared incentives

For simple, stable environments, organizational structure doesn't make much of a difference to the thoroughness of search. It nevertheless has a clear impact on the speed of search and along with it to the performance in turbulent environments.

Equal processing power shall mean, the same number of evaluation-steps in total. If two departments are evaluating alternatives, these evaluations count as two separate evaluations. If the central makes an evaluation, it only counts as one evaluation. All archetypes were equalized to a processing power of 4. The same strategy was followed in this work. In the experiment, the same 6 different organizational settings are simulated under firmwide incentives.

I1 - Decentralized represents the decentralized archetype with ALT = 2. Two departments make two evaluations each in every period.

I2 - Liaison represents the liaison archetype with ALT = 1, PROP = 2 and COMP = 2. The departments look at one new alternative in every period and then propose it along with the status quo in a ranked fashion. Together with the other department, they evaluate the two best of the four possible alternative combinations.

I3 – Lateral Communication represents the lateral communication archetype with PROP = 2 and COMP = 4. Both departments propose two random ideas plus the status quo, then they evaluate four of the nine possible combinations together and choose the best of all acceptable ones.

Siggelkow and Rivkin found it useful to compare two different forms of the Hierarchical archetype:

I4 – Hierarchy with full departmental pre-screening power represents a version of the hierarchy where agents evaluate one random new alternative per period and send either this new alternative or the old alternative to the central. The central then receives the combination of the alternatives from both departments and compares it to the status quo. Hence, it is a version of the hierarchy where departments have **total pre-screening power**.

I5 – Hierarchy with full central control differs from I4, in that departments always propose the new alternative and the old alternative. The level of vertical information flow is maximal, which undermines all of the department's screening power.

I6 – Centralized represents the centralized archetype with COMP = 4. The central finds four random ideas, evaluates them and chooses the best.

The replication of the original experiment shows that the relative performances are equivalent to the results of Siggelkow and Rivkin (see Table 4). In a simple environment (K = 0), all archetypes reach the maximum Fitness within 200 periods. In a complex environment (K = 5), the archetypes get stuck earlier. Running the experiment over 500 landscapes like the original experiment, the t-test shows no significant difference between the two top performers. Running the experiment over 10.000 landscapes the one-sided t-test shows, that the mean performance of the lateral communication archetype is slightly higher than the mean performance of the hierarchy with full central control (α = 0.99). Due to their proximity compared to the other archetypes, this slight difference does not justify a different ranking. The performance of decentralized is not significantly different from centralized. The performance of Liaison is not significantly different from the hierarchy with full departmental pre-screening power.

Table 4.

Performance Comparisons of Different Archetypes with Equal Processing Power – Comparison to the Original

Archetype	Decentralized	Liaison	Lateral communication	Hierarchical	Hierarchical	Centralized
Firm	I1	I2	I3	I4	I5	I6
ALT	2	1		1	1	
PROP		2	2	1	2	
COMP		2	4	2	2	4
Simple Environment						
This Work	1.000	1.000	1.000	1.000	1.000	1.000
Siggelkow & Rivkin	1.000	1.000	1.000	1.000	1.000	1.000
Complex Environment						
This Work	0.848	0.833	0.916	0.832	0.913	0.849
Siggelkow & Rivkin	0.893	0.884	0.940	0.883	0.939	0.892

Notes. Own values report the performance in period 200 averaged over 10000 landscapes. The values from Siggelkow and Rivkin are taken from table 7 of their 2005 paper. Incent = 1 for all firms.

Critical Evaluation of the Original Experiment

The decision by Siggelkow and Rivkin to make the evaluations in the mutual adjustment - process of I2 and I3 count as one single process rather than two separate processes has to be criticized: Despite having two departments evaluate each combination separately, they only count as one. Hence, the authors granted this archetype eight separate evaluations (COMP = 4) where the decentralized archetype only received four (ALT = 2) and the liaison archetype only received six (ALT = 1, COMP = 2). In terms of working-hours spent, this is not plausible. It should be irrelevant, that the evaluations are imagined as happening simultaneously or in the same room in real-life. Simulating the lateral communication archetype with 12 combinations of the parameters PROP between 1 and 3 and COMP between 1 and 4 showed a significant positive impact of the processing power COMP on the final fitness after 200 rounds, it was however miniscule (see Tab. 5). Hence, eventually they all get stuck around the same fitness level. The impact on speed is however very large. At the presumably fairer processing-power of 2, the average improvement per round nearly halved.

Table 5.

Impact of Parameters on Performance for the Lateral Communication Archetype (OLS)

VARIABLES	(1) Impact on Final Fitness	(2) Impact on Speed
Number of Proposed Alternatives (PROP)	0.00188	0.01400***
	(0.00141)	(0.00360)
Processing Power of the Mutual Adjustment Phase (COMP)	0.00385***	0.04572***
	(0.00103)	(0.00358)
Constant	0.90594***	0.03907***
	(0.00400)	(0.01013)
Observations	12	12
R-squared	0.635	0.973

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes. Values report the performance in period 200 averaged over 300 landscapes. Incent = 1. K = 5.

Even more, undermining departments screening power makes I5 inefficient, as the information input by the departments is not used . Regardless of their evaluations, the central will always consider both alternatives anyways. Hence, departments may as well skip the evaluations and propose random alternatives to the central analogous to the lateral communication archetype. The hierarchy with full central control may hence deserve a higher processing power of COMP = 4. The higher parameter improved the average performance only slightly in a control-simulation of n = 10.000. This improvement was not significant, therefore the inefficient I5 will be maintained.

Overall, it has become clear that the benefit of processing power is limited by other factors. Further, it is not clear whether the costs of this processing power are truly comparable between archetypes, making a cost-benefit comparison less attractive. Hence, a comparison at equal processing power may not be the optimal solution. Comparing the best-performing parameter-settings within a reasonable range may be more useful for organizational design. Control-experiments for the complex environment were conducted to check for the performances of a wider range of parameter-settings. Luckily, comparing the best performing parameter settings of the archetypes among each other produced the same relative ranking as the ranking with equal processing power. Further, it showed, that increasing the processing power of the decentralized archetype beyond 2 significantly decreased the average performance as sticking points are reached much earlier due to the increased information asymmetry between departments. On the other hand, the performance of the centralized archetype scales indefinitely with increasing processing power – for obvious reasons. The same holds true for the processing power of the central in the hierarchy archetype and the processing power of the mutual adjustment phase in the lateral communication archetype.

At last, Siggelkow and Rivkin did the decentralized archetype, the liaison archetype, and the hierarchy with departmental pre-screening power a disservice, by assuming uniformly distributed interactions between all decisions throughout departments. Pre-screening and agenda setting through ranked proposals would provide more benefit if decisions had stronger interdependencies within departments than between departments. Under uniform complexity, agents may introduce more bias than goal-congruent information into the search process. This assumption is backed by an OLS-regression on the sample of 16 parameter combinations of the liaison archetype: The number of evaluated alternatives ALT by the departments has a significant negative impact on the average final fitness after period 200. Presumably, this issue would only get worse under the increased information asymmetry of exploration. The issue of departmental specialization cannot be addressed sufficiently in a uniformly complex or perfectly simple environment, making the issue of coordination ultimately unnecessary. The simulation was run in an environment with stronger interactions within departments than between departments (see Fig. 18) to check for this.

		Department 1			Department 2		
	d	1	2	3	4	5	6
Department 1	1	1	1	1	1	0	0
	2	1	1	1	0	1	0
	3	1	1	1	0	0	1
Department 2	4	0	0	1	1	1	1
	5	0	1	0	1	1	1
	6	1	0	0	1	1	1

Figure 18. Interaction Matrix for organizations with stronger intra-departmental complexity

Under these circumstances, I1, I2 and I4 indeed have higher performance gains than the other archetypes. However, this only changes the rank-orders of archetype-performance after introducing exploration and decision biases of type 2 and 3. The mechanism of the liaison archetype is however strongly dominated by the lateral communication archetype both in speed and final fitness, in simple environments (K=0), environments with stronger intra-departmental complexity (see Fig. 18) and fully complex environments (K=5) under all circumstances.

The Effect of Exploration and Exploitation

The general hypothesis of this work is, that accounting for the possibility of exploration and the impact of decision biases of the type (2) and (3) would change the relative search-performance of different organizational structures.

We begin with the trivial assumption that in complex environments, a more explorative search within departments would benefit all organizational archetypes in the thoroughness of search.

HYPOTHESIS 1. *At a higher level of exploration within departments, all organizational archetypes reach a higher final fitness.*

With intra-departmental exploration at the maximal *search-distance* of 3, the maximal achievable distance is equal to the number of decisions. Under firmwide incentives there should in theory no longer be any sticking points for all but the centralized archetype (I6). The only issue that could still cause organizational search to get stuck, is departments' (pre-)selections under asymmetric information. In the decentralized, liaison and hierarchical archetype, some evaluation-steps utilize the other departments' choice of the previous period. With a low information flow, even a subsequent coordination mechanism will not be able to overcome sticking points. The proposed issue hence requires both asymmetric information among departments and with the central for the hierarchical archetype (I4 , I5).

HYPOTHESIS 1.a. *Without any decision biases, exploration at the maximal search-distance is still limited by asymmetric information.*

To tackle these questions, the 6 organizational settings with equal processing power are examined (see Tab. 6). Under local search, the lateral communication archetype (I3) and the hierarchical archetype with a high flow of information (I5 with PROP = 2) reach the highest fitness level among the settings. Allowing for exploration with *search-distance* = 3 even allows I3 to reach the maximum. As predicted, I1, I2 and I4 all get stuck the earliest. As INCENT = 1, this cannot be due to misaligned monetary interests, but must be the consequence of information asymmetry. Apparently, the pre-screening of I1 and I4 leads to the same sticking points as the agenda setting of I2. The key difference these organizations have to I3, I5 and I6, is the effective information asymmetry through department-centric pre-screening of alternatives and in case of I2 and I4 a narrow set of proposals forwarded to the subsequent coordination mechanism. Potentially better solutions will never even reach the table for discussions, as department heads don't anticipate future possibilities in the other departments. The lateral communication archetype overcomes this by the means of random pre-selection. Departments only get to make choices once the synergetic possibilities with the other department are fully understood. The hierarchy with full central control gets access to all proposals the departments know, fully overcoming their screening powers. This however comes at the cost of a cripplingly slow search. Still, a higher *search distance* benefits all archetypes. They all reach higher final fitness values. Speed in simple environments increases and stays the same in complex environments.

Table 6.

Performance Comparisons of Different Archetypes with Equal Processing Power – Effect of Exploration

Archetype	Decentralized	Liaison	Lateral communication	Hierarchical	Hierarchical	Centralized
Firm	I1	I2	I3	I4	I5	I6
ALT	2	1		1	1	
PROP		2	2	1	2	
COMP		2	4	2	2	4
No Exploration	0.848	0.833	**0.916**	0.832	**0.913**	0.849
With Exploration	0.910	0.907	**1.000**	0.907	0.980	0.982

Notes. Fitness in period 200 averaged over 10000 landscapes. K = 5. Incent = 1 for all firms. The *search-distance* for exploration is set at 3.

Whilst in theory I5 should reach the maximum fitness, after 200 periods it only achieved a final fitness of 0.982. Looking at the graphs shows that the matching fitness with I6 is only coincidental (Fig. 19). The centralized organization reaches its maximum much earlier, whilst the hierarchy with full central control is just cripplingly slow. Running it for 500 periods results in an average final fitness of 0.995, which indicates, that the fitness eventually converges with 1. This opens more questions about the reasons for the different efficiencies of search.

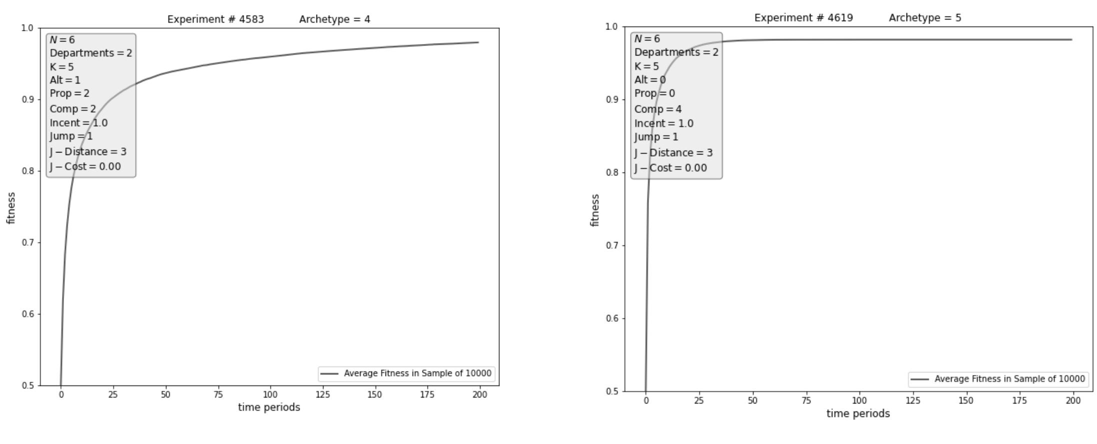

Figure 19. Average Fitness for each period of I5 (left) and I6 (right).

Siggelkow and Rivkin supported the widely held intuition, that a higher coordinative processing power generally improves the speed of improvement under local search (2005. p.112). This still holds true with greater search distances. When comparing the search speed under exploration, the innovative central actually outperforms all other archetypes. The first-round improvement of I6 (0.259) is more than twice as high as the first-round improvement of I5 (0.118). Apparently, the responsible differences between these three archetypes without information asymmetry, occur during the coordination phase (which is the only phase of I6). The coordinative processing power COMP cannot be the sole explanation for this.

Empirical research has shown that too much exploitation is detrimental to the pace of innovation, if the level of exploration does not match it accordingly (Katila, R. Ahuja, G. 2002. p. 1189). On the decision-level, the level of exploitation and exploration is equal for all archetypes, as it has been defined for the *search-distance* parameter. The relative levels of exploitation and exploration still differ significantly between organizations due to their structural differences and parameters. The emergent differences in exploitation can be operationalized as *search depth*, as the ratio of old knowledge re-used to the knowledge used in total (ibid. 1187). The search scope measure for exploration is the ratio of new knowledge to the knowledge used in total. Looking only one period into the past, these measures sum up to 1. Together with the parameter COMP, we can derive our hypothesis for the speed differences:

HYPOTHESIS 2. *Without information asymmetry and without decision biases, the differences in performance between organizations can be condensed to Search Scope, Search Depth and Coordinative Processing Power in the decision phase.*

Assuming a *search distance* of 1: For I3, each department proposes 2 new alternatives plus the status quo. Out of the 3 x 3 = 9 combinations, four contain 1 status quo proposal and one contains 2 status quo proposals with 3 old decisions each, plus the 2 redundant decisions in the new alternatives. 4 of the 9 combinations are being picked randomly from all possible new combinations of the defined *search distance*, containing 2x2 old decisions each. The search depth of I3 is therefore (4x5 + 1x6 + 4x2x2) / (6x9) = 0.78. For a *search disctance* of 3, the average number of new decisions in one department with 2^3-1 possible new combinations is 1.7. For the central with 41 possible new combinations, it is 2.3. When comparing the three organizations without pre-screening, one can easily guess which of these setups will perform worst (see Tab. 7). I5 has the highest average search depth in all settings, but the lowest search scope. With COMP = 2, it only has half the coordinative processing power of I3 and I6.

Table 7. Comparisons of Search Depth and Search Scope during the Coordination-Phase for Organizations that can overcome Information Asymmetry. Search Distance = 3

I3		Number of new Decisions	
Department 1	**Department 2**	**Average**	**Maximum**
old (benchmark)	*old (benchmark)*	*0*	*0*
old	old	0	0
old	new 1	1.7	3
old	new 2	1.7	3
new 1	old	1.7	3
new 2	old	1.7	3
new 1	new 1	3.43	6
new 1	new 2	3.43	6
new 2	new 1	3.43	6
new 2	new 2	3.43	6
Search Scope		0.34	1
Search Depth (1 Period)		0.66	1
Coord. Processing Power	4		

I5		Number of new Decisions	
Department 1	**Department 2**	**Average**	**Maximum**
old (benchmark)	*old (benchmark)*	*0*	*0*
old	old	0	0
old	new 1	1.7	3
new 1	old	1.7	3
new 1	new 1	3.43	6
Search Scope		0.23	1
Search Depth (1 Period)		0.77	1
Coord. Processing Power	2		

I6		Number of new Decisions	
Central		**Average**	**Maximum**
old (benchmark)		0	0
new 1		2.3	3
new 2		2.3	3
new 3		2.3	3
new 4		2.3	3
Search Scope		0.36	0.5
Search Depth (1 Period)		0.64	1
Coord. Processing Power	4		

Some additional regression analysis showed that a higher coordinative processing power strictly increases the search speed for all archetypes without information asymmetry. Doubling the processing power of the hierarchy with full central control (I5) increases the search speed in complex environments from 0.118 to 0.176 (*search distance = 3)*. The structurally nearly equivalent lateral communication archetype (I3) with coordinative processing power 4 is still faster at a search speed of 0.245. Coincidentally, search scope and search depth are a lot more balanced for the lateral communication archetype (I3) than for the hierarchy with full central control (I5). The centralized archetype (I6) further has the advantage of never wasting capacity on a redundant status-quo choice. Just like the other archetypes, it stores the status quo as a benchmark for evaluation, but never runs the risk of re-evaluating it through random selection. This gives it an even better balance than the lateral communication archetype (I3) which results in a higher speed of 0.259. A better balance of search scope and search depth coincides with more efficient search. The final fitness, on the other hand, is ultimately determined by the maximal achievable search scope. As the centralized archetype can only ever address half of the 6 decisions at once, it can still end up getting stuck in local maxima. The other archetypes can, by random chance, even address all the decisions at once, guaranteeing an eventual progression to the global maximum. Hence, an innovative central (*search distance = 3)* should outperform all other archetypes under local search (search distance = 1) due to its superior processing power, search scope and the lack of information asymmetry or decision biases.

A look at table 6 shows, that I6 with exploration (search distance =3) indeed outperforms all other archetypes without exploration (search distance = 1) in complex environments. This is another strong indicator for H2. In simple environments, it beats all other archetypes in terms of speed except the decentralized one (I1). This can again be explained by the higher search scope of I1.

The Effect of Search Related Decision Biases

Equipped with the knowledge about how search performance is determined when there are no issues of misalignment, we can now introduce our decision biases of type (2) and (3). Effectively, they work as threshold-values. If the value added of an alternative is not greater than the bias, it will be rejected. As the bias is a function of the hamming-distance, the expected effects on performance are primarily mediated through the reduction of the maximum number of new decisions over time due to cutoff-finesses (see Tab. 3) and the resulting imbalance of search scope and search depth. Secondarily, the effective processing power will go down quicker, as a high percentage of distant alternatives becomes ineligible but still fills up the processing-capacities. These mediated effects of decision biases of type (2) and (3) should go in the same direction as the effects of the type (1) bias as far as they are related to the agents' pre-selection process. The narrowed, biased selection will prevent any value added of consecutive evaluations. For simplicity, "No Bias" shall mean a *sensitivity* of 0, and "Strong Bias" shall mean a *sensitivity* of 1 throughout the following experiments.

The Effect of Disutility of Effort

It is primarily the organizations without information asymmetry (I3), (I5) and (I6), where interesting differences are to be expected. The simplifying assumption for utilitarian interests related to search distance is, that they are experienced by the central and agents equally.

Besides the lateral communication archetype, only the liaison archetype has a coordination-mechanism with the potential to scatter utilitarian interests. However, as explored in the previous part, the agenda-setting mechanism may be too powerful and preserve too much agency-information. This includes disutility of effort. Value-maximizing shareholders who want to squeeze more commitment out of their central and departments, may want to overcome this. It must be noted, that all commitments nevertheless still add utility ≥ 0 to all agents involved. This follows the assumption, that net-utility losses cannot be enforced sustainably (see Treble, J. 2003).

The results show that the lateral communication archetype deals with disutility of effort better than any other archetype. Given disutility of effort, lateral communication (I3) dominates the hierarchy with full central control (I5) under local search and under exploration, in both simple and complex environments (see Tab. 8). Even when accounting for the slow search-speed of I5 by letting it run for 1800 more periods, it never matches the performance of lateral communication (I3). The most likely explanation for this is the selection by maximum utility for I5, rather than the maximum Fitness at just acceptable utility for I3. Lateral communication (I3) contains a mechanism which limits the effects of agents' biases on preference orders. By only signaling binary preferences (acceptable, not acceptable), no acceptable alternative is rejected illegitimately (see Fig. 20).

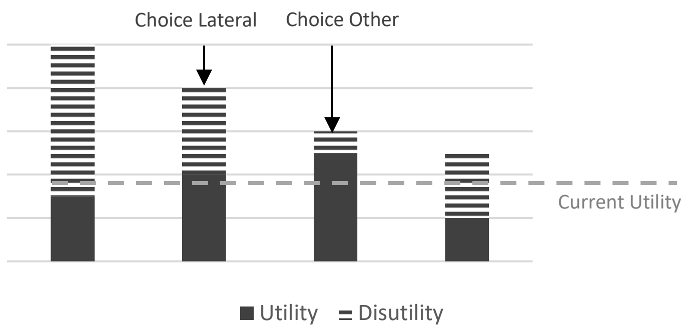

Figure 20. The lateral archetype limits subjective preference biases to the utility-threshold. No acceptable alternative is rejected.

An alternative explanation could be, that the lateral communication archetype is modeled to make an objective selection in case of a tie. If more than one combination is acceptable to all departments, the value maximizing combination is chosen. To control for this, a version of I3 is modeled, that selects randomly in case of a tie. With a random tiebreaker, the fitness performance of lateral communication is just barely lower than with a value maximizing tiebreaker. It is still delivering the best fitness-performance by a large margin. Due to the less efficient coordinative processing, speed decreases noticeably. Nevertheless, I3 still overcomes biases the most effectively. Even in the simple environment, all other archetypes converge on the same fitness level.

Overall, disutility of effort is detrimental to search. One boundary condition to this generalization could be settings, where the more careful selection caused by the higher decision-threshold could reduce the costs of adverse selection or pre-screening under asymmetric information. If the number of interactions is high, making self-focused decisions for small gains can result in a net loss.

Table 8. Final Fitness Rankings

Ranking of Different Archetypes with Equal Processing Power - No Exploration

Archetype	Decentralized	Liaison	Lateral communication	Hierarchical	Hierarchical	Centralized
Firm	I1	I2	I3	I4	I5	I6
ALT	2	1		1	1	
PROP		2	2	1	2	
COMP		2	4	2	2	4
Simple Environment						
No Bias	1	1	1	1	1	1
Strong Bias	2	2	**1**	2	2	2
Complex Environment						
No Bias	3	5	**1**	5	**1**	3
Strong Bias	2	5	**1**	5	2	2

Notes. The table reports the relative ordinal Ranking of the Archetypes' fitness in period 200 averaged over 10.000 landscapes. The CEO is Subjuect to the same subjective cost-function as the departments. Shared ranks are not significantly different (2-sided T-Test, alpha 0.95)

Ranking of Different Archetypes with Equal Processing Power - With Exploration

Archetype	Decentralized	Liaison	Lateral communication	Hierarchical	Hierarchical	Centralized
Firm	I1	I2	I3	I4	I5	I6
ALT	2	1		1	1	
PROP		2	2	1	2	
COMP		2	4	2	2	4
Simple Environment						
No Bias	1	1	1	1	1	1
Strong Bias	2	2	**1**	2	2	2
Complex Environment						
No Bias	4	5	**1**	5	2	2
Strong Bias	4	5	**1**	5	3	2

Notes. The table reports the relative ordinal Ranking of the Archetypes' fitness in period 200 averaged over 10.000 landscapes. The CEO is Subjuect to the same subjective cost-function as the departments. Shared ranks are not significantly different (2-sided T-Test, alpha 0.95)

A desirable effect is noticeable in the archetypes with the highest agent power (see Tab. 9). For all other archetypes, disutility of effort results in a reduction of speed. Under exploration, the opportunity costs of ineligible combinations seem to outweigh this effect for the liaison archetype (I3). The effective processing power goes down as the search-process is convoluted with more ineligible combinations. When increasing the pre-screening power of the agent such as the coordinative processing power (I7), this effect becomes more pronounced again. Due to the dominant effect of the threshold-value-related sticking-points, this may become less noticeable in the search speed of more advanced periods. Taking risks only at great expected gains serves as a coordinative force between departments that don't communicate.

Table 9.

Speed Comparisons of Different Archetypes with Equal Processing Power

		Complex Environment		
Archetype		Decentralized	Liaison	Liaison
Firm		I1	I2	I7
ALT		2	1	3
PROP			2	3
COMP			2	3
No Exploration				
	No Bias	0.119	0.156	0.186
	Strong Bias	0.147	0.162	0.209
With Exploration				
	No Bias	0.119	0.157	0.178
	Strong Bias	0.146	0.121	0.215

Notes. The table reports the first-round improvement-speed averaged over 10000 landscapes. Incent = 1 for all firms. Search Distance = 3 for all firms. The central is subject to the same subjective cost-function as the departments.

The Effect of Evaluation Apprehension

Evaluation apprehension is a situational psychological impediment to search, and more specifically, a type of fear. Evaluation apprehension has an overall inhibitive effect on organizational search. These inhibitions have been linked to a pessimistic view on the own competency and credibility and the worry that the knowledge shared would not be appreciated or even worse, result in humiliating criticism (Wang, S. Noe, R.A. 2010. p. 124). Evaluation apprehension has been shown to decrease the information flow to superiors in hierarchically structured organizations (Reitzig, M. Maciejovsky, B. 2015. pp. 1993-1995). This effect gets worse, the steeper the hierarchy is. Among organizational archetypes, it would affect all departmental evaluation processes that involve other agents simultaneously or subsequently. Hence, the complete liaison archetype, the lateral communication archetype and the departmental evaluations in the hierarchical archetype are affected by evaluation apprehension. After accounting for these asymmetries, the final-fitness ranking changes accordingly (see Tab. 10). One obvious but nevertheless interesting observation is, that hierarchies with a large enough flow of information can fully overcome departments' evaluation apprehension. As explored before, this comes at the cost of a superfluous evaluation-process by the departments.

Table 10. Comparison under Evaluation Apprehension

Performance Comparisons of Different Archetypes with Equal Processing Power - With Exploration

Archetype	Decentralized	Liaison	Lateral communication	Hierarchical	Hierarchical	Centralized
Firm	I1	I2	I3	I4a	I5a	I6a
ALT	2	1		1	1	
PROP		2	2	1	2	
COMP		2	4	2	2	4
Simple Environment						
Strong Bias	**1**	5	4	5	**1**	**1**
Complex Environment						
Strong Bias	3	6	3	5	**1**	**1**

Notes. The table reports the relative ordinal Ranking of the Archetypes' fitness in period 200 averaged over 10.000 landscapes. The Central and the decentralized Archetype are not subjected to the bias. Shared ranks are not significantly different (2-sided T-Test, alpha 0.95)

c. Results

i. Experiment

ii. Discussion

Lessons from Information Theory: Bias Cancellation through Redundancy with pair-wise attribute noise detection algorithms (PANDA) and Crowd-Wisdom

At this level of abstraction, the potential insights of modeling organizational search may have lots of parallels with those in unsupervised deep neural networks and information theory. It is likely, that many valuable and more sophisticated insights exist in these fields that could find direct applications in organizational search. Concepts like the principle of maximum information preservation (Linsker, R. 1988. pp. 112-114) are directly applicable to organizational search. One exemplary lesson we can take from this principle, is that bias and noise, which is only weakly correlated between nodes, can be reduced through redundancy among the nodes. This is intuitive in the homolog example of organizational search:

- We want to maximize the preserved fitness-information that reaches the decision phase.

- We have bias or noise terms that get introduced by decision-biases that impede goal congruent search. These are not correlated between agents as they are a function of their individual hamming-distances.
- Through firmwide incentives, both departments take in redundant fitness-information.

In information-theory terms, such biases can be treated as attribute noise and could hence be reduced more effectively by a pair-wise attribute noise detection algorithm (Van Hulse, J. Khoshgoftaar, T. M. Huang, H. 2006. p. 171). It compares pairs of instances that are very similar in one attribute but differ suspiciously in another and ranks them by a noise-factor.

For an organization with firm-wide incentives, this is even more plain: Both departments evaluate the same alternatives with the same expected monetary reward. But these alternatives are nevertheless paired with different evaluations – the difference of which must hence be caused by the bias. Assuming only negative biases, the higher of both evaluations must be closer to the true value. This way, the bias can be cancelled up to the smaller of the two.

Even if negative biases are not dominant and no exclusion criterion can be applied, pair-wise attribute noise detection algorithms like this give organizational designers more control over decision biases that impede goal congruent search. They offer a promising alternative to the binary preference mechanism in the lateral communication archetype.

With increasing complexity of larger organizations, more departments, more polycausal noise-terms, this simple rule of thumb is necessarily converging more and more with actual complex analogs of this noise detection algorithm like crowd-wisdom aggregators. The degree of redundancy and variation of departmental pairings allows for targeted control over maximizing the extraction of goal-congruent information and the cancellation of as much of the misaligned component as possible. A comprehensive summary of practically applicable crowd-wisdom aggregators for reducing noise and biases in the framework of the bias-information-noise (BIN) model with an examination of their respective performances is provided in a recent paper (Satopää, V. A. Salikhov, M, Tetlock, P.E. and Mellers, B. 2022. pp. 4-7). More than PANDAs, crowd-wisdom aggregators can even aggregate partial information into complete information. In more realistic situations where asymmetric information cannot be fully avoided, prediction markets and supervised aggregators reduce its impact significantly (ibid. pp. 11-12).

Conclusion

Investigating organizational search under the lens of agency has proven to be fruitful. The basic issues of coordination modeled in the organizational archetypes based on Mintzberg's five structural configurations can be broken down to information asymmetry and conflicts of interest. The differences in search performance between archetypes then are the result of how they handle these issues of coordination, the resulting search-scope and search-depth that reach the final decision phase such as the coordinative processing power at the final decision phase.

In line with the literature, a more balanced ratio between search-scope and search-depth has shown to be desirable. Firstly, a higher degree of exploration has benefited all archetypes in search. Secondly, archetypes with a more balanced structurally implicit ratio between search scope and search-depth clearly outperform other archetypes.

Thankfully, these principles were seamlessly applicable to subjective experienced utilitarian interests and situational psychological impediments. At their core, they are homologous to monetary conflicts of interest as they work as attractors, repellers or, in more general terms, as a noise term. The category "conflicts of interest" itself was extended to "impediments to goal congruent search", to account for the interest-ambiguity of situational psychological impediments like evaluation apprehension. Tying such costs to the hamming-distance of search has desirable effects to uncoordinated search-phases under information asymmetry: In complex environments, the extent of mistakes is tendentially higher when changes are made without coordination. For a small expected gain, much could be lost. Disutility of effort effectively sets a minimum expected value-added that needs to be covered. This improves the speed of more decentralized archetypes, which suggests a better performance in turbulent environments. The more relevant insight of this work is with regards to the adverse effects of said impediments to goal congruent search. In most setups, a reduction of these biases is a crucial factor for achieving a competitive search performance. The adverse effects of utilitarian interests which affect the central as well as the departments, like the disutility of effort, can't be reduced by central agents effectively. If central agents themselves act utility-maximizing or are short-sighted about compensating their agents' disutility, they will reject some of the superior proposals with positive added utility for inferior proposals with a higher utility. The binary preference-signaling, as Siggelkow and Rivkin have modeled it for one of their interpretations of Mintzberg's Adhocracy, only checks whether an option has a positive added utility to all agents but does not save the agents' preference order. This reduces the effect of the bias to the minimum – assuming that enforcing net-utility losses to individual agents is unsustainable (see Treble, J. 2003). Adverse effects of situational psychological impediments, like evaluation apprehension, which don't affect the central, can be fully overcome in hierarchical structures with a rich vertical information flow. However, an innovative CEO or central in a fully centralized organization not only achieves the same search-results, it vastly outperforms hierarchies and even lateral communication in terms of speed.

An alternative mechanism for reducing the adverse effects of biases to goal congruent search utilizes the redundant information within the multi-agent setting. For settings with few agents, pair-wise attribute noise detection algorithms (PANDA) known from information theory are a promising approach. As redundant fitness information is processed by multiple departments under firm-wide incentives, the differences in stated preferences and utility-claims are caused by those biases. Assuming the predominance of negative biases like the disutility of effort and fears like evaluation apprehension, the agent claiming the higher utility will be closer to the true fitness value. Following the same principles, in more complex, practical applications with more agents, crowd-wisdom aggregators in the framework of the bias-information-noise (BIN) model (Satopää, V. A. Salikhov, M, Tetlock, P.E. Mellers, B. 2022. pp. 4-7) can reduce noise and biases that are detrimental to search.

Bibliography

Siggelkow, & Rivkin, J. W. (2005). Speed and Search: Designing Organizations for Turbulence and Complexity. *Organization Science (Providence, R.I.)*, *16*(2), 101–122.

Appelbaum, S.H., Bregman, M. and Moroz, P. (1998). "Fear as a strategy: effects and impact within the organization", *Journal of European Industrial Training*, Vol. 22 No. 3, pp. 113-127.

Gibbons, R. (1998). “Incentives in Organizations,” Journal of Economic Perspectives 12: 115-132

Mayer, B. Pfeiffer, T. and Reichel, A.(2005). „Zu Anforderungen und Ausgestaltungsprinzipien von Anreizsystemen aus agencytheoretischer Sicht“, BFuP - Betriebswirtschaftliche Forschung und Praxis, Vol. 57 No.1, pp. 12-29.

Greenwood, & Hinings, C. (1993). Understanding Strategic Change: The Contribution of Archetypes. *Academy of Management Journal*, *36*(5), 1052–1081.

Treble, J. G. (2003). Intertemporal Substitution of Effort: Some Empirical Evidence. *Economica*, *70*(280), 579–595.

Ackerman, P.L., Tatel, C.E. & Lyndgaard, S.F. (2020). Subjective (dis)utility of effort: mentally and physically demanding tasks. *Cogn. Research* 5, 26

Pindyck, R. Rubinfeld, D. (2009). “Mikroökonomie”. Pearson

De Wilde P. (2004). Fuzzy utility and equilibria. *IEEE transactions on systems, man, and cybernetics. Part B, Cybernetics : a publication of the IEEE Systems, Man, and Cybernetics Society*, *34*(4), 1774–1785.

Kerr, S. (1975). On the Folly of Rewarding A, While Hoping for B. *Academy of Management Journal, 18*(4), 769-783.

Andries, K., Cools, M., & Van Uytbergen, S. (2017). To Shift or Not To Shift? Intertemporal Income Shifting as a Response to the Risk Capital Allowance Introduction in Belgium. *The European Accounting Review, 26*(3), 531-559.

Baccelli, & Mongin, P. (2016). Choice-based cardinal utility: a tribute to Patrick Suppes. The Journal of Economic Methodology, 23(3), 268–288.

Evans, D., Boggero, I., & Segerstrom, S. (2016). The Nature of Self-Regulatory Fatigue and “Ego Depletion”. *Personality and Social Psychology Review, 20*(4), 291-310.

Evans, & Phillips, K. L. (2016). Advantages of an Ellipse when Modeling Leisure Utility. *Computational Economics*, *51*(3), 513–533.

Applebaum, S.H. Bregman, M. Moroz, P. (1998). Fear as a strategy: effects and impact within the organization. Journal of European Industrial Training 22/3. 113–127.

Vecchio, R. P., & Appelbaum, S. H. (1995). *Managing organizational behaviour: A Canadian perspective*. Toronto: Dryden.

Egozcue, M., García, L., Wong, W., & Zitikis, R. (2011). Do investors like to diversify? A study of Markowitz preferences. *European Journal of Operational Research, 215*(1), 188-193.

Cottrell, N., Wack, D., Sekerak, G., & Rittle, R. (1968). Social Facilitation of dominant responses by the Presence of an Audience and the mere Presence of others. *Journal of Personality and Social Psychology, 9*(3), 245-250.

Henchy, T., & Glass, D. (1968). Evaluation apprehension and the social facilitation of dominant and subordinate responses. *Journal of Personality and Social Psychology, 10*(4), 446-454.

Wang, S., & Noe, R. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review, 20*(2), 115-131.

Zhou, X., Zhai, H., Delidabieke, B., Zeng, H., Cui, Y., & Cao, X. (2019). Exposure to ideas, evaluation apprehension, and incubation intervals in collaborative idea generation. *Frontiers in Psychology, 10*(JULY), 1459.

Reitzig, M., & Maciejovsky, B. (2015). Corporate hierarchy and vertical information flow inside the firm-a behavioral view. *Strategic Management Journal, 36*(13), 1979-1999.

Laffont, J. & Martimort, D. (2009). *The Theory of Incentives: The Principal-Agent Model*. Princeton: Princeton University Press.

Jensen, M., & Meckling, W. (2009). Theory of the firm: Managerial behavior, agency costs, and ownership structure. In *The Economic Nature of the Firm* (pp. 283-303). Cambridge University Press.

Fischer, Möller, K., & Schultze, W. (2015). Controlling : Grundlagen, Instrumente und Entwicklungsperspektiven (2., überarbeitete Auflage.). Schäffer-Poeschl Verlag.

Mintzberg, H. (1979). The Structuring of Organizations. Prentice Hall, Englewood Cliffs, NJ

Gordon. Loeb. Tseng. (2006). Capital budgeting and informational impediments: A management accounting perspective in Bhimani, Alnoor, & Bhimani. Contemporary Issues in Management Accounting (OUP Catalogue). Oxford: Oxford University Press.

Levinthal. (1997). Adaptation on Rugged Landscapes. Management Science, 43(7), 934–950.

Hrebiniak, Lawrence G. and Joyce, William F. (2002). Organizational Search: Analysis of the Factors Affecting Search in Complex Organizations. Available at SSRN: https://ssrn.com/abstract=314099

Laursen, K. (2012). Keep searching and you'll find: what do we know about variety creation through firms' search activities for innovation?, *Industrial and Corporate Change*, Volume 21, Issue 5, October 2012, Pages 1181–1220.

Katila, R., & Ahuja, G. (2002). Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction. *The Academy of Management Journal*, *45*(6), 1183–1194.

March, J.G. (1991). Exploration and Exploitation in Organizational Learning. Organization Science, 2, 71-87.

Linsker, R. (1988). Self-organization in a perceptual network.
Computer, 21(3):105–117.

Van Hulse, J.D., Khoshgoftaar, T.M. & Huang, H. (2007). The pairwise attribute noise detection algorithm. *Knowl Inf Syst* 11, 171–190.

Satopää, Salikhov, M., Tetlock, P. E., & Mellers, B. (2022). Decomposing the effects of crowd-wisdom aggregators: The bias–information–noise (BIN) model. *International Journal of Forecasting*.

Abstract

The goal of this work was to investigate the effects of disutilities and psychological aversions on organizational search such as their treatments among different structural configurations. For this purpose, the effectiveness of organizational search among different archetypes was condensed to its most fundamental factors with the help of the NK-model and Rivkin & Siggelkow's organizational archetypes (Siggelkow, N. Rivkin, J.W. 2005). Organizational search-processes are deconstructed into common principles to better isolate their fundamental differences. Without information asymmetry or impediments to goal-congruent search among agents and the central, the search performance of an organizational configuration can be determined by the search scope, search depth and processing power in the decision-making phase. From this basis, it became clear that decisions based on binary preference-information in adhocratic structural configurations are superior to central control at reducing biases caused by subjective utilitarian interests. Situational psychological impediments like evaluation apprehension that cause no ex-post disutilities can be fully overcome by a well-informed central. Finally, an alternative decentralized coordination mechanism is discussed, that cancels subjective biases more effectively through a pair-wise attribute noise detection algorithm (PANDA) for small groups or through a crowd-wisdom aggregator for larger groups.

Abstract

Ziel dieser Arbeit ist die Untersuchung der Effekte von subjektiven Suchkosten und Aversionen auf organisationale Suchprozesse, sowie deren Behandlung in unterschiedlichen strukturellen Konfigurationen. Zu diesem Zweck wurde die Effektivität organisationaler Suchprozesse bei unterschiedlichen Archetypen mithilfe des NK-Modells und Rivkin & Siggelkow's organisationalen Archetypen (Siggelkow, N. Rivkin, J.W. 2005) auf ihre fundamentalen Fakturen kondensiert. Organisationale Suchprozesse wurden in gemeinsame Prinzipien dekonstruiert, um ihre fundamentalen Unterschiede besser zu isolieren. Ohne Informationsasymmetrie oder Beeinträchtigungen zielkongruenter Suche zwischen Agenten und der Zentrale kann die Suchperformance einer organisationalen Konfiguration aus dem Suchumfang, der Suchtiefe und der Verarbeitungsleistung in der Entscheidungsphase bestimmt werden. Darauf basierend wurde festgestellt, dass Entscheidungen auf Basis binärer Präferenzinformationen in adhokratischen strukturellen Konfigurationen bei der Reduktion der Effekte subjektiver Suchkosten zentraler Kontrolle überlegen sind. Situationale psychologische Beeinträchtigungen wie Bewertungsangst, welche keine ex-post Kosten verursachen, können vollständig von einer gut informierten Zentrale überwunden werden.

Abschließend wird ein alternativer dezentraler Koordinationsmechanismus diskutiert, welcher subjektive Biases durch Pair-Wise Attribute Noise Detection Algorithmen (PANDA) für kleine Gruppen, oder Crowd-Wisdom Aggregatoren für größere Gruppen auflöst.