‘I am Peter’: Explaining the Emergence of Gendered Hierarchies in Society

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Abstract: This thesis explores how gender norms influence hierarchy formation and achievable ranks by different social groups. Specifically focusing on why men predominantly occupy top positions despite efforts towards gender equality. Gender is viewed as a social construct, used as a symmetry breaker to facilitate coordination generating inequitable conventions. These conventions perpetuate gendered expectations, limiting access to certain functions and opportunities. This thesis uses simulations in Net Logo to run a novel model of hierarchy formation and highlights the role of power disparities and proportion on men and women on the emergence and perpetuation of inequitable conventions. We find that the effect of power disparities is stronger than the effect of differing proportions of men and women on reaching fairer outcomes. We also find that the effect of differing proportions can be offset by improving the power exerted by the minority.

Keywords: Gender, Hierarchy, Power, Simulations, Norms

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Declaration of Originality

This is to certify that to the best of my knowledge; the intellectual content of this thesis is the product of my own work. I confirm that I have clearly referenced, in both the text and the bibliography, all sources used in the thesis. No data or findings in the thesis have been falsified. No content of the thesis has been used previously for other courses.

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Sophia Schaaper

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Introduction

Gender inequalities and the associated distribution of power among different social groups continue to persist as pervasive issues in societies around the world. Despite significant efforts in the past century to promote gender equality, men, particularly white men, continue to predominantly occupy top hierarchical positions in various domains, including politics, business, and academia. As of 2020, women held less than a third of managerial positions worldwide (28.3%) (UN Women, 2022), and a mere 10.4% of fortune 500 CEOs are women, a quarter of which only started last year (Hinchliffe, 2023). Furthermore, in the Netherlands, the number of CEOs named Peter (6%) exceeds the number of women CEOs (4.8%). Despite decades of extensive work addressing biases and discrimination, the progress in promoting gender equality seems to have plateaued. This stagnation is evident, for instance, in the gender wage gap, which, although improved between 1982 and 2002, has seen minimal reduction in the last 2 decades (merely 2 percentile points). This indicates that gender inequality exists beyond personal biases, in fact there is much literature on the existence of inequitable gender norms reinforced and perpetuated by epistemic processes of learning. However, the role of these gender norms, or of social group membership broadly, in the access to powerful positions, to higher ranks in the labor market has yet to be uncovered and understood.

This thesis aims to shed light on the origins and perpetuation of inequitable conventions that arise within hierarchies, particularly in the context of gender. The term "gendered hierarchies" refers to hierarchical structures that systematically favor certain genders over others, resulting in, but also arising from, imbalanced power dynamics. Within such hierarchies, one's gender systematically restricts individuals' access to certain functions and opportunities. The emergence of gender roles as norms plays a crucial role in perpetuating these inequities. This stands in contrast to an economically efficient division of labor, where specialization occurs based on abilities and preferences, not based on arbitrary features. The systematic limitations imposed by gender norms hinder the realization of an equitable society with fair equality of opportunity. As advocated by scholars like Okin (1989) who argue for the abolition of gender on the grounds of justice, these scholars claim that this phenomenon is unfair by drawing on Rawls' principles of justice where equality of opportunity requires that social and economic inequalities are attached to offices and positions open to all.

We will first establish a framework for understanding the concept of gender in Section 1. This analysis on the origin and function of gender implies that gender is merely an arbitrary social construct that emerged, merely to facilitate coordination. Section 2 will delve into the features of hierarchical organizations and provide empirical evidence on the interplay of gender and power within these structures. We will then explore existing models on the effect of gender on resource division in Section 3. These models will be adapted to develop a new model of hierarchy formation with types, i.e., gender. By employing NetLogo, an agent-based modeling platform, this thesis will demonstrate how hierarchical structures perpetuate existing power dynamics in bargaining. The results of these agent-based simulations will be discussed in Section 5, shedding further light on the complex dynamics and variables involved in the persistence of gendered hierarchies.

I. Gender as an Arbitrary Social Construct

a. Gender as a Performance

For this analysis, I will adopt Butler's (1988) understanding of gender as a performative act. It is important to emphasize that gender is not a fixed nor innate essence, but rather a set of behaviors and actions that are performed within a social and cultural context. Gender is not prior to gendered acts or behavior; it is constituted by them. As Butler argues:

> "Gender is not something that one is. It is something one does. An act, a 'doing' rather than a 'being'" (Butler, 1993)

This perspective challenges the notion that gender is predetermined or biologically determined. Importantly, Butler highlights that the performative nature of gender is not an individual endeavor. It is instead a product of social and historical forces that influence and regulate the range of acceptable gendered behavior and gendered expectations. It is an 'act' as it implies playing a role, but also because it is not a one-time occurrence. It is constantly enacted and reproduced, allowing for gender norms to be reinforced and perpetuated. By understanding gender as a performative act defined by historical and cultural 'possibilities', or constraints, we can understand how it functions as a symmetry breaker in coordination problems.

b. Gender in Coordination

This view of gender as an arbitrary construct constituted by a set of behaviors raises questions about the origin and purpose of this category. O'Connor in her book, *The Origins of Unfairness* (2019) offers a game-theoretic explanation for the function of gender. Gender, as O'Connor argues, has historically served as a behavior-differentiating mechanism to divide labor within traditional societies. Empirical evidence showcases the cross-cultural variation in the assignment of gender roles. Murdock and Provost (1973) reviewed 185 traditional societies and found that, although some activities like hunting and mining were performed exclusively by men, and others like laundering or spinning mainly by women, a majority of activities, such as planting crops or house-building, were performed by one gender in some societies and the other in others. Costin (2001) researched the manufacturing of crafts and found significant division of labor by gender but much cross-cultural variation in who makes what. These findings reinforce Butler's notion of gender as a socially constructed and constantly enacted and perpetuated performance.

In coordination problems, effective communication and cooperation is crucial for achieving desirable outcomes. One way to facilitate coordination is through the use of arbitrary markers or ‘tags’ that allow agents to differentiate their behavior based on the type of agent they are interacting with. A very trivial example of this would be the dancing game, where two players are dancing the tango and they need to decide who steps back and forward first. A tag serves as a signal of commitment to one specific role, for example if one of the agents is a man, this signals that they will step forward first.

Axtell et al. (2000) were the first to model the effects of such an arbitrary ‘tag’ like gender. They show that these tags do not hold any economic or social significance but acquire it through path-dependency effects in the form of endogenously arising conventions.

c. Gender Norms

Conventions are behavioral regularities generating expectations (Lewis, 1969). Once widely accepted and stable, these conventions become social norms. Deviating from established norms leads to social sanctions and punishments (Wood & Eagly, 2012).

Tags, such as gender, facilitate efficient coordination by differentiating behavior based on one's own type and the type one is facing. This process, referred to as "type-conditioning" by O'Connor (2019), allows individuals to adapt their behavior accordingly. For example, historically, men have often stepped forward first, establishing a convention. Adhering to this convention eliminates coordination problems in the dancing game when a man is facing a woman.

Over time, repeated observations and adherence to tag-associated behaviors lead to the emergence of conventions and norms. Agents rely on these tags for coordination, forming expectations regarding the roles and behaviors associated with each tag. These expectations become deeply embedded in social interactions, shaping economic outcomes. Path dependency effects reinforce the significance of these tags, establishing a feedback loop where individuals conform to and perpetuate gendered behaviors. The link between tags and social-economic systems solidifies as conventions become widely accepted. Consequently, individuals who deviate from these gendered expectations may face social sanctions and punishments. In this way, gender norms have emerged endogenously through repeated interaction with different, observable, types, i.e., gender. Type-conditioning and the historical context contribute to the perpetuation of gendered behaviors and the reinforcement of inequitable gender norms within social and economic systems.

d. Power and Homophily

Understanding gender as an arbitrary category, a social construct, leading to the emergence of unfavorable gender norms, helps unravel the inherent connection between gender and power. This analysis will be based on the concept of power-by-association, a term coined by LaCroix and O'Connor (2021). They provide a compelling game-theoretic explanation of how membership to a social category with relatively more powerful members can confer advantages in bargaining irrespective of an individual's own power. This occurs when agents generalize their learning and condition their behavior over entire social groups.

By extending Miranda Fricker's (2007) conception of power, we can argue that even individuals with lower agential power, i.e., the power they possess as individuals over others, can benefit from the structural power associated with membership in a group dominated by more powerful individuals. In essence, structural power goes beyond the direct exercise of power by individuals and becomes embedded within social structures, norms, and institutions. As a result, it can shape and constrain behavior while limiting opportunities within the entire group. This concept of power-by-association implies that agential and structural power are interconnected, where agential power can give rise to purely structural power.

Multiple factors contribute to attributing higher power to men rather than women. Traditional and historical discriminatory gender roles have granted men greater decision-making authority, while women have been expected to conform to more submissive roles (Wood & Eagly, 2002). Furthermore, differences in historical economic opportunities based on gender have translated into biases. In fact, according to Chibber (2013), this is what allows hierarchically organized firms to reinforce and perpetuate societal power dynamics, confirming discriminatory conventions and biases. He argues that employers, or hiring authorities, who hold prejudices about what workers they perceive as adequate rarely have their biases challenged. Once workers who are already believed to be better or more efficient are hired, their successful job performance seemingly confirms the biased belief. However, these employers, due to their biases, tend to very rarely, or even never, hire individuals from different backgrounds to genuinely address these biases.

Furthermore, the concept of homophily in networks can illustrate the role of power-by-association in real-life settings. Homophily refers to the tendency for individuals to associate and form connections with individuals that share similar characteristics. Jackson (2010) argues that this phenomenon has significant implications for labor markets, as people often seek employment through their homophilous connections. Additionally, employers are more inclined to trust new employees who have been internally referred by their current employees.

This implies that individuals belonging to specific social categories and networks have preferential access to certain positions, thereby exerting higher power solely by virtue of their membership in those social categories.

Furthermore, Koski et al. (2015) conducted experiments aimed at understanding the relationship between perceivable cues and higher status. Among their findings, they discovered that masculine features were often associated with higher status. However, it is important to note that the causality of this association remains difficult to pinpoint. It is unclear whether the attribution of higher status to masculine features has contributed to men being more powerful, or if men being more powerful has led to the association of higher status with masculine features. The complex interplay between social perceptions, power dynamics, and gender norms makes it challenging to establish a clear cause-and-effect relationship in this context. Nevertheless, these findings shed light on the role of societal constructs in contributing to the perpetuation of power differentials based on gender.

Power differences between genders lead to diverging fallback positions, representing alternative options when preferred outcomes are unattainable. In societies with gender imbalances, men often have broader fallback positions due to societal norms and biases. This grants them more opportunities, flexibility, and autonomy. Conversely, women face limited fallback positions, constrained by traditional roles and barriers. These disparities perpetuate gender inequalities by reinforcing norms and impeding women's advancement. The limited options available to women curtail their ability to challenge and break free from oppressive norms, contributing to the persistence of unequal power dynamics.

II. Hierarchies

a. Properties

Hierarchies exhibit certain properties that contribute to their formation and functioning. One reason as to why hierarchies form is their ability to enhance group cohesion and productivity. These structures are prevalent across species and observed from early ages in humans, suggesting their natural and potentially necessary nature (Koski et al., 2015). These structures are argued to maximize efficiency by constraining the decision-making of subordinate groups, leading to more stable outcomes compared to alternative organizational structures (Demange, 2004). This efficiency-driven perspective helps explain why many institutions and sectors adopt hierarchical structures and underscores the importance of examining the fairness of the processes by which hierarchies are formed, as this has important implications on equity and fairness. Human hierarches are inherently not neutral nor merit-based systems, instead they are social structures allocating power, resources, and opportunities. If the formation of hierarchies is tainted by unfair practices, it can exacerbate existing inequalities. By scrutinizing the fairness of these processes, we can shed light on any systemic advantages and allow us to address barriers to equal opportunity.

Within established hierarchies, an individual's rank is influenced by various factors. Chase (1982) conducted experiments on chicken hierarchies and identified "aggressiveness" as a key individual characteristic that determines one's position within the hierarchy. However, it is crucial to note that these individual characteristics alone do not fully determine one's rank, Chase found a low coefficient of repeatability in his experiments, pointing to a significant role of observed dominance relations and existing hierarchy in determining one’s rank. Chase introduced the concepts of "Double Dominance" and "Double Subordinance," wherein winning or losing in previous interactions influences the behavior of newcomers. This highlights the multidimensional and self-reinforcing nature of human hierarchies, which are context-dependent and shaped by historical power dynamics (Koski et al., 2015). In this context, power dynamics are at play, as winning begets winning (Double Dominance) and losing begets losing (Double Subordinance). These dynamics highlight how power relations are embedded within hierarchical structures, perpetuating and reinforcing existing advantages or disadvantages. Understanding these dynamics is crucial for comprehending why so many hierarchies are gendered.

b. Empirical Evidence

This theoretical conception of gender as a socially constructed performance leading to inequitable conventions finds valuable empirical backing through a variety of studies. Research examining differences in bargaining behavior based on gender has shown that women are less likely to initiate negotiations, whether that be for wages or for positions. This means there is a gendered convention where women are less inclined to assert their interests and engage in negotiations (Erikson and Sandberg, 2012). Additionally, it seems that these conventions are self-reinforcing, leading to norms with social sanctions. Bowles, Babcock and Lai (2007) found that women who deviate from these norms by initiating negotiations were perceived as demanding, less likeable, and more difficult to work with. These perceptions are considerably more negative for women initiating negotiations than for men. These disincentives perpetuate gender disparities in bargaining behavior and power, and hence create barriers for women in resource allocation and access to higher hierarchical ranks.

Moreover, empirical evidence on homophily in networks, the tendency of individuals to associate with people that have similar characteristics (ethnicity, gender, interests, etc.), contributes to empirically explaining how these conventions are reinforced leading to unfavorable gender norms. Suurna and Leibbrandt (2021) found that the larger percentage of men with higher academic ranks and leadership positions in surgical faculties (in the US) played a significant role in impeding women's career advancements and contributing to their disadvantage. Along with findings from Zeltzer's (2017) and Kleinbaum et al. (2011) which reveal how homophilous networks hinder women's access to influential positions and limit their potential earnings in a formally structured hierarchical organization. These findings underscore the significance of examining the process of hierarchy formation and rank determination to uncover and address the specific barriers hindering women's progress and equality.

III. Gendered Hierarchies

Simulations, particularly those using agent-based modeling platforms, such as NetLogo, are a valuable tool to understand and illustrate dynamics of complex social systems, and can provide insights into the origins and perpetuations of inequitable conventions. In this section we delve into existing models of resource division highlighting the emergence of inequitable gendered conventions and we develop a new model to illustrate the role of these conventions in hierarchical structures.

a. Resource Division Models

There are several recent models that examine how conventions emerge from this 'type-conditioning', particularly in relation to the division of labor and resources. Axtell et al. (2000) followed by O'Connor (2019) have run agent-based models based on the Nash demand game. In this game, agents bargain to divide a specific resource, say 10 euros, by making demands of High (6 euros), Medium (5 euros), or Low (4 euros).

	Player 2			
Player 1		**High**	**Medium**	**Low**
	High	0, 0	0, 0	6, 4
	Medium	0, 0	5, 5	5, 4
	Low	4, 6	4, 5	4, 4

Table 1. Nash Demand Game, in Resource Division Models

If both agents request Low, they each get 4 euros, resulting in an inefficient outcome with leftover resources. Similarly, a Low-Medium leads to an inefficient outcome of 4 and 5 euros, respectively. The equilibria in this game, the Pareto optimal outcomes, occur in High-Low (and, inversely, Low-High) and Medium-Medium. Bargaining breaks down when the agents make incompatible demands, these are High-High, Medium-High, and High-Medium.

These models classify the population into two undefined but observable types, this means the only difference between agents is their membership to a binary and arbitrary category. Tools from evolutionary game theory are then employed to uncover the effect of this category. Agents engage in random and repeated interactions, updating their strategies after each interaction. These rules for updating strategies are called dynamics and play an essential epistemic role in understanding social dynamics. They shed light on agents' learning processes and decision-making mechanisms. Various dynamics, such as replicator dynamics, differential imitation of successful group members, bounded rationality, and best response dynamics, have been used in these models, yielding similar outcomes but differing in the speed of the emergence of this advantage.

As predicted in one of the original models by Young (1993), class inequities arise endogenously in a population with distinguishable types. These models, by not considering agents' preferences or abilities, emphasize the role of social interactions and conventions in shaping behavior, highlighting the arbitrary nature of gender roles and norms. The main finding is that when people are paired with others from their social group, they tend to make fair requests, 'Medium', the prominent outcome being Medium-Medium within groups. However, when they are paired with other groups the prominent outcome is High-Low. This points to the presence of outgroup discrimination, where individuals exhibit differential treatment or behavior towards members of other groups based on their group identity.

These models serve as simplified representations of the actual state of the world. Subsequent models introduced additional variables, such as population size and metrics for agents' power. In the following section I will detail how I adapt these existing models to represent hierarchy formation and discuss the findings of my simulations. Additionally, I will delve into the utilization and justification of power and population size as additional variables and examine how the outcomes differ when they are incorporated.

These existing models explain how the construction of gender has given rise to gender norms which are reinforced and perpetuated. More specifically, they highlight how these conventions lead to inequitable divisions of resources. However, simulations showing how the existence of such an arbitrary category as gender leads to inequitable access to powerful hierarchical positions seem to be missing. In the next section I will setup a new model to represent this.

b. Hierarchy Formation Model

In this part, a novel model that explores the formation of hierarchies will be introduced. Here, agents, referred to as 'candidates', compete for positions in a hierarchically structured organization. For instance, who gets first co-author on a paper, who takes the lead on a team project, or who gets a highly ranked position in a firm. However, this is a simplified process of how ranks may be determined in such a hierarchical structure as there is often a third party involved in determining ranks. We instead assume that candidates are equal in their preferences and abilities, meaning that the outcome depends solely on the candidates' strategies which is contingent on their beliefs of their opponent's strategy. In this model the 'opponent' will be referred to as 'partner'. In this way, this model can be understood as a bargaining process occurring between the two candidates alone.

All 'candidates' start at the bottom rank, denoted as rank 0. The number of candidates interacting is denoted by a variable 'n' which ranges from 0 to 512. The candidates are split into a binary category, men and women, denoted by blue and red respectively in the agent-based modeling platform NetLogo. The proportion of men is a variable 'p' varying between 0 to 1. In the first round, candidates pair up randomly with any other candidate, in subsequent rounds candidates can only partner with others on the same rank as them. It is important to note that the binary category of gender has been chosen here, but these results could potentially be interpreted in the context of other socially distinguishing categories, such as skin color, immigrant status, and other relevant differentiators. These categories may offer alternative lenses for understanding the dynamics of power, discrimination, and inequality in society. By considering these additional categories, we can explore how different social dimensions contribute to the emergence of hierarchies and the distribution of resources and opportunities. However, the assumptions used here are meant to represent current gender differences and different assumptions would need to be justified for other differentiators.

Candidates engage in a 'lead-follow game', a version of the hawk-dove game, as illustrated by the matrix below. Here L ('lead') suggests aggressively bargaining for a leading position, while F ('follow') implies somewhat conceding. This game has two Nash equilibria, {lead, follow} and {follow, lead}. When these outcomes are reached, the candidates playing L receive a payoff of 2 and move up a rank, while those who played F stay at their current rank. There is one inefficient outcome, {follow, follow}, when this is played neither candidate moves up a rank. Bargaining breaks down, or fails, when {lead, lead} is played. Here, the candidates receive what is called their BATNA, best alternative to a negotiated agreement, or disagreement point (d). Effectively, this is their fallback position, what they have already achieved or their potential achievements. This is variable d which varies between 0 and 1 and is different for men and for women (d_m and d_f, respectively). These disagreement points can be interpreted as a proxy for the respective groups' power, as discussed in Section I, part d, power-by-association explains why these can be generalized over the entire group.

	Player 2		
		Lead	**Follow**
Player 1	**Lead**	d_1, d_2	2, 1
	Follow	1, 2	1, 1

Table 2. Lead-Follow Game, in Hierarchy Formation Model

Each candidate possesses a memory which gets updated after each round, after each pairing. This memory consists of four variables: the number of men encountered who played L, the number of them who played F, the number of women who played L, and the number who played F. Based on this memory agents develop beliefs about what their new partner will play, given their type (their gender). They then choose a bargaining strategy, either L or F, given their beliefs. These beliefs come about from calculating their expected payoffs. The expected payoff of playing F is always one. If the expected payoff of playing L is greater than one, they choose L, if it is less than one, they play F, and when it is equal, they randomize, as they all do in the first round. The expected payoff of playing L is calculated by weighing their believed likelihood that their partner plays F multiplied by its associated payoff (2) and adding that to the likelihood that their partner plays L multiplied by their disagreement point, from now on referred to as 'd'. This likelihood is calculated from their memory, where the proportion of one type playing either strategy is divided by the total number of candidates encountered of this type. They are then assigned a payoff according to their strategy and given their partner's strategy. Only when this payoff is two are they able to move up one rank, only if they played lead when their partner played follow[1].

In the next section the results of running this model in the agent-based modeling platform NetLogo will be discussed, along with the effect of changing the variables p and d, to more accurately represent the current state of affairs.

IV. Discussion

Simulations allow researchers to create virtual environments and populations to mimic real-world scenarios. This means they eliminate the need for large sample sizes and avoid the

[1] See Appendix for the NetLogo code where tis calculation effectively take place.

logistical challenges of data collection, allowing for more flexibility and efficiency in exploring hypotheses in various malleable experimental conditions. Moreover, they allow to analyze the effect of specific variables while 'controlling' for other factors, such as individual preferences, abilities, and environmental conditions, that may confound real-world observations. All parameters can be manipulated to efficiently isolate and observe the effect of certain variables of interest, for instance gender, in a variety of different contexts. This facilitates the identification of underlying causal dependencies and sheds light on the mechanisms driving the observed outcomes.

a. Results

We run this simulation 200 times with a variety of different settings (for d_m, d_f, and p) to analyze the results, and interpret them to understand different scenarios of hierarchy formation.

The simulation runs until at least one of the percentages of candidates of one type, partnered with someone of the other type, playing either strategy (L or F) reaches 0 or 100. So, if 100% of men are playing L the simulation stops, similarly if 0% are playing L the simulation stops. It is important to note that these percentages are calculated by dividing the number of men playing a specific strategy when partnered with a woman by the total amount of men who partnered with women in that round.

This means that the simulation stopping could imply that either type has gained an advantage as they systematically play either strategy when faced with the other type. However, this could also merely be coincidental. We use the amount of rounds that the candidates play before the simulation stops and the average ranks of each type as metrics to compare the different settings and the extent to which one type may be advantaged, we also plot some the percentage of men and women playing L when partnered with the other type. It is important to note that the average ranks at the end of the simulation are not the average achievable ranks of a certain social group, or type. If the simulation didn't stop, those who have been playing L with 100% probability could keep climbing ranks in the hierarchy, inversely the other could most likely not keep climbing.

We start with some default settings, where the proportion of men (p) is constant at 0.5, so that we have the same amount of male and female candidates. We also maintain the disagreement points for men and women at the same level. We run two different scenarios, one where the disagreement points are both at 0 and one when they are both 1. It is important to note that when the disagreement point is 1, playing L becomes a weakly dominant strategy, meaning it is more rational to play than F, for both types.

When both d's are 1, the average ranks for men and women are 2.70 for both. We have plotted the percentage of men and women playing L when partnered with the other type.

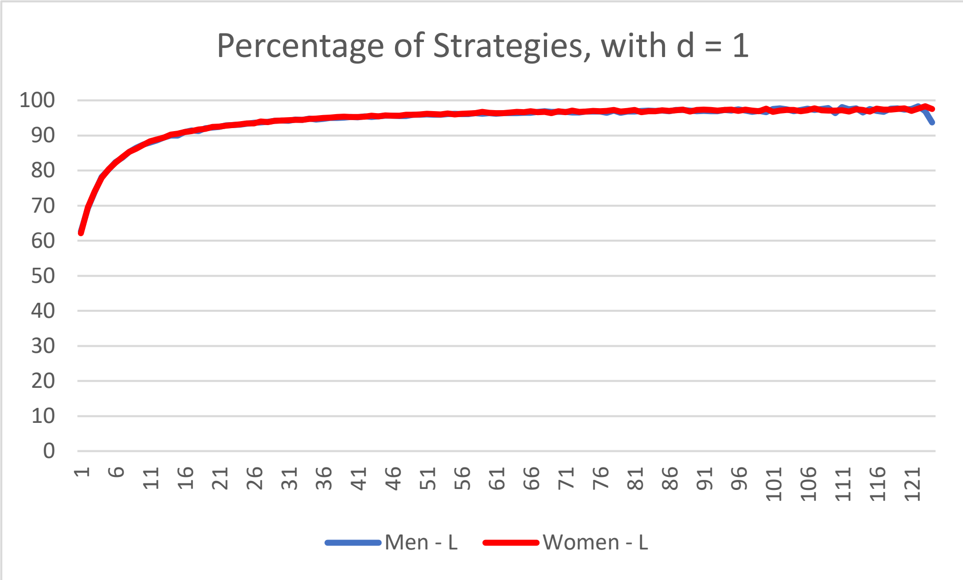

Figure 1. Percentages with $d_m = d_f = 1$

On average, over the 200 runs of the simulation, for one of these strategies to reach 100% it takes 68.95 rounds.

When both d's are set to 0, it instead takes 1939.58 rounds on average for one of the strategies to reach 100%. It takes almost 30 rounds more in this case because candidates always start by randomizing their strategies but when d is 1 they quickly start playing L more often because it is rational. This is because the expected payoff of L is always greater than 1, while the expected payoff of F is always 1 and hence automatically less than that of playing L. The average ranks when d is 0 are 155.22 and 116.94. Figure 2 illustrates the resulting hierarchy, with women and men represented in red and blue respectively. We have also plotted the percentage of men and women playing L at each round in Figure 3.

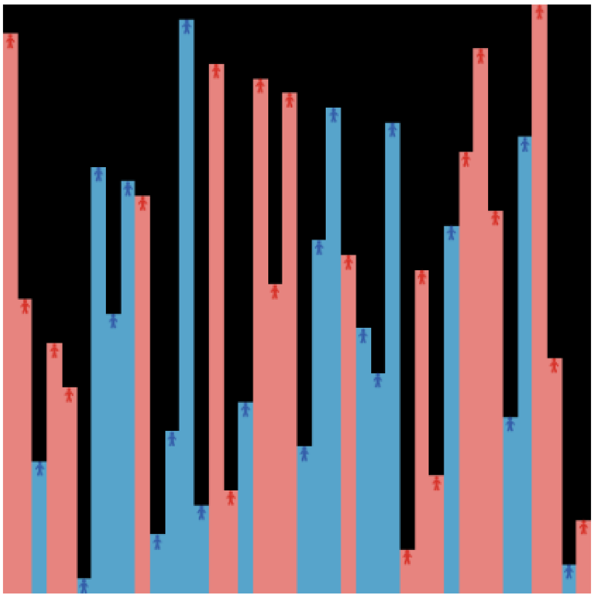

Figure 2. Hierarchy whend $d_m = d_f = 0$

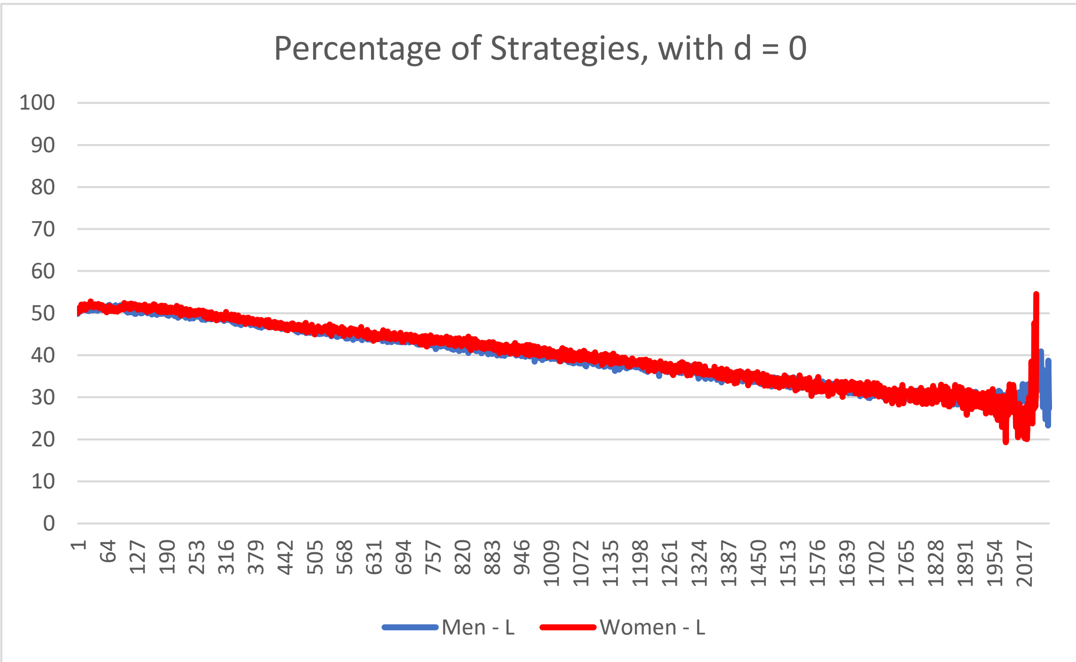

Figure 3. Percentages with $d_m = d_f = 0$

We find a larger difference in ranks in this case most likely because of the increased length of each run allowing for more randomness and variation. While when d is 1, candidates tend to stick to playing L regardless of their beliefs on what their partner may play. This means that when d is 1, it happens very quickly that candidates of one type play L with 100% probability when partnered with the other type.

It seems that there is no significant difference between the percentage of men and women playing L in both these cases, as the lines on both graphs almost entirely overlap. Hence, when both groups are equally as powerful, no group manifests any advantage over the other. This shows that promoting equal representation, through quotas for instance, and ensuring equality in terms of disagreement points or power, through empowerment policies, would allow the role of social group membership in the determination of one's hierarchical rank to be minimal if not irrelevant.

b. Role of Power

Instead of assuming that candidates are in an equal position when bargaining breaks down or fails, when the lead-lead outcome is reached, a more accurate representation of reality is to look at background conditions, what are the potential, or actual, alternative opportunities, what is the status quo, outside of this specific bargaining interaction per group.

The higher the disagreement point, or the more secure a candidate's fallback position is, the stronger their bargaining power. This is because the more favorable their fallback position is, or status quo, the more they can afford to be demanding, the higher their standards are. They reject proposals that fall below their disagreement point and find lower outcomes less beneficial. This means they are more likely to achieve outcomes closer to their preferred position, while a candidate with a lower disagreement point is more likely to accept lower, less favorable, offers. When a candidate has a higher disagreement point than their interaction partner, the bargaining outcome will tend to favor this more powerful player. Moreover, given the discussion on power in Section 1.4, it seems justifiable to roughly generalize a disagreement point over an entire social group, even when some agents within the group may be more powerful than others.

To examine this effect in hierarchy formation and the impact it has on the achievable ranks of each group, scenarios with different levels of disparity were introduced. In cases of strong power imbalances, where $d_m = 1$ and women's $d_f = 0$, playing lead became a weakly dominant strategy for men but not for women as the expected payoff of playing 'L' would always be greater than 1 (the expected payoff of playing 'F'). Notably, with 50 agents, it took an average of 5.47 rounds for an advantage to manifest for men (reaching 100% of men playing

L). With 512 agents, it took longer, averaging 12.59 rounds, indicating that the advantage took more time to materialize as the number of participants increased, despite the proportion of men remaining at 0.5. Moreover, as can be seen in Figure 5 where the percentage of the strategies employed by each type is tracked for each time period, it becomes apparent that the strategies employed by men evolve faster. This means that men will exert their influence and dominance, effectively forcing women to conform and adapt to follow suit due to the disproportionate power dynamics at play.

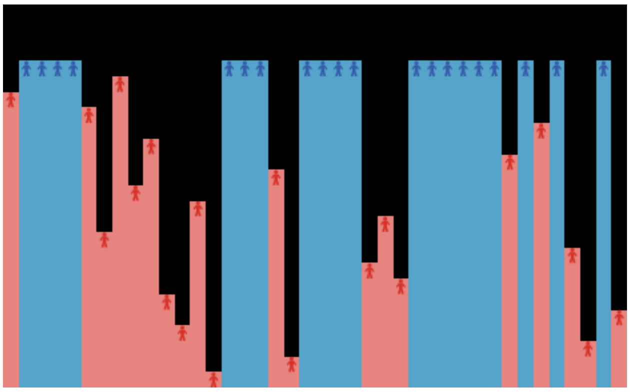

Figure 4. Hierarchy when $d_m = 1$ and $d_f = 0$

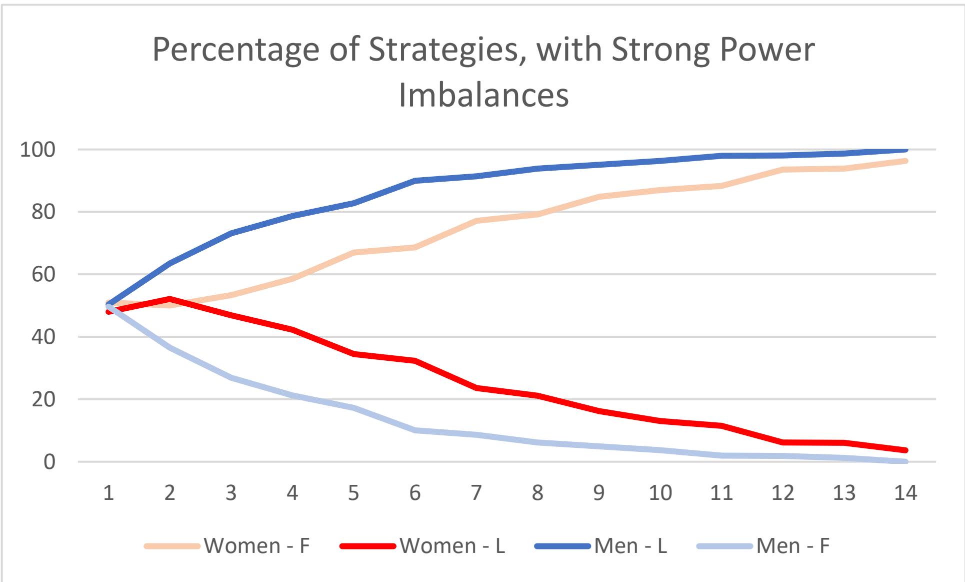

Figure 5. Percentages with $d_m = 1$ and $d_f = 0$

In scenarios with moderate power imbalances, varying d_m between 0.5 and 0.9, but maintaining d_f at 0. We observe that the enactment of men's advantage required more rounds as the power imbalance decreased. Below a table summarizing the findings so far with the average ranks, and the difference in percentage between them, when relevant, and the average rounds it took for one of the strategies to reach 100%.

Variables								
	d_m=d_f=0	**d_m=d_f=1**	**d_m=1**	**d_m= 0.9**	**d_m=0.8**	**d_m=0.7**	**d_m=0.6**	**d_m=0.5**
Men – Ranks	115.22	2.70	1.94	2.25	2.79	3.72	5.41	8.22
Women – Ranks	116.94	2.70	1.37	1.68	2.03	2.70	4.01	6.27
Difference	/	/	41.61%	33.92%	37.44%	37.78%	34.91%	31.1%
Rounds	1939.58	68.95	12.59	15.39	19.17	25.97	39.24	62.35

Table 3. Overview Resulting Metrics when Varying d_m, and d_f = 0

For d_m = 0.5, the average rounds were 62.35. As d_m increased to 0.9, the average rounds decreased to 15.39 progressively. These results suggest that as the power imbalance strengthened, the advantage was enacted sooner. This is very important as it shows that the more we aim to close these power differentials the longer it takes for men to dominate, reducing the effect of the Double Dominance and Double Subordinance phenomena postulated by Chase (1982). This means policies, whose effects take time to materialize, are more impactful, and successful, as the power disparities reduce. Here we have plotted the strategies when d is 0.5.

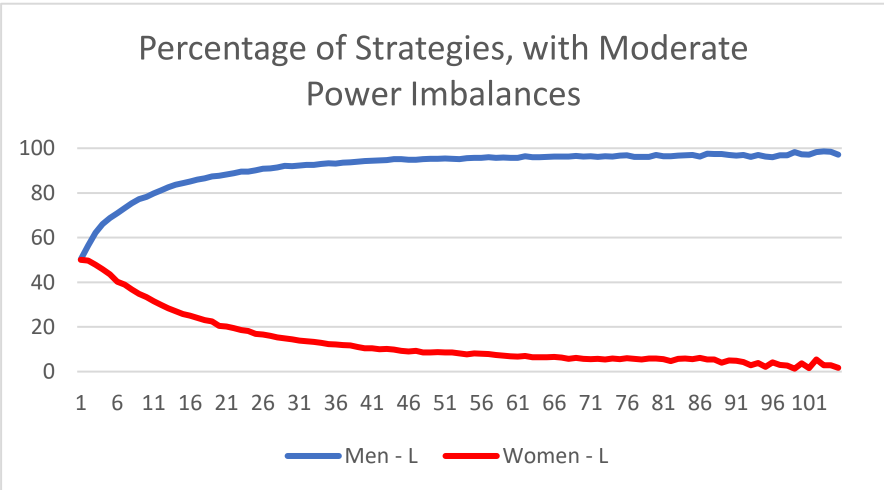

Figure 6. Percentages with d_m = 0.5 and d_f = 0

Here we can see that it takes the same number of rounds, when d is 0.5, for the percentage of men playing L to reach 80% as it does to reach 100% when d is 1. It takes almost 10 times the number of rounds for the advantage to be fully manifested and the percentage of strategies to reach 100.

Interestingly, the difference in the average ranks is not a stable increasing trend as d_m is increased from 0.5 to 0.9. Instead, it seems to plateau at $d_m = 0.7$, this could mean that at such a power disparity between the two groups any additional increase does not matter as the advantage is already enacted and prominent. However, the average ranks do not mean highest achievable ranks, as those who played L can still keep climbing. In this case men's ranks can still improve on average but women's cannot. Therefore, these percentage, of how much higher men's ranks are compared to women's, are not necessarily representative of the difference in achievable ranks between the two.

Furthermore, if instead of maintaining the disagreement point for women at 0, we up it to 0.5, we find that the average rounds when men's d = 0.9 were 19.98, with average ranks of 2.43 for men and 2.07 for women. For men's d = 1, the average rounds decreased to 15.56, with average ranks of 2 for men and 1.6 for women. These findings indicate that increasing d_f resulted in shorter average rounds and higher ranks for women. Figure 7 with the strategies when d_m is 0.9, and Table 4 comparing both scenarios to some previous ones.

Variables						
	d_m=d_f=0	**d_m=d_f=1**	**d_m=1**	**d_m= 0.9**	**d_m=1 d_f=0.5**	**d_m=0.9 d_f=0.5**
Men – Ranks	115.22	2.70	1.94	2.25	2.00	2.43
Women – Ranks	116.94	2.70	1.37	1.68	1.60	2.07
Difference	/	/	41.61 %	33.92%	25%	17.39%
Rounds	1939.58	68.95	12.59	15.39	15.56	19.98

Table 4. Overview Resulting Metrics with Various Power Disparities

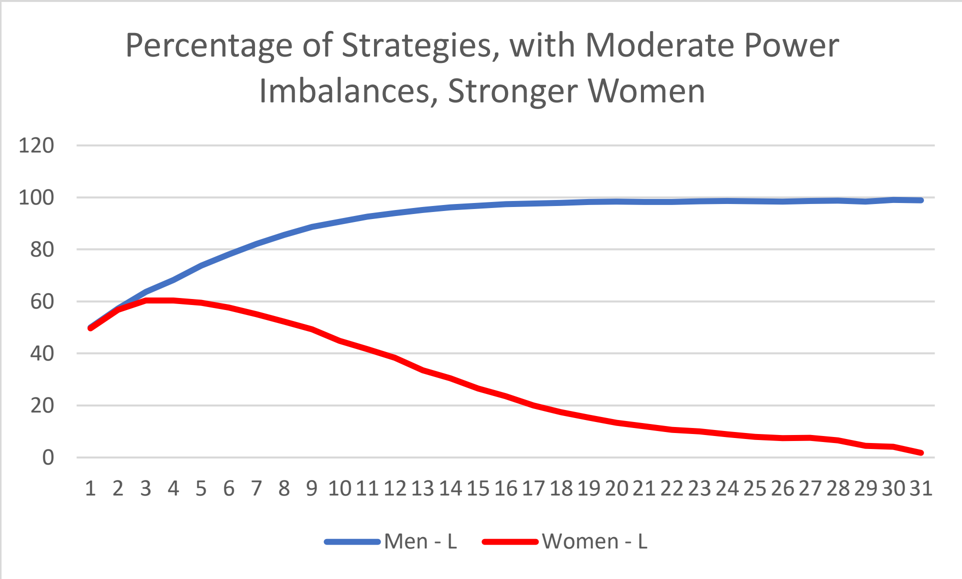

Figure 7. Percentages, with d_m = 0.9 and d_f = 0.5

We find that increasing d_f, regardless of d_m decreases the difference in average ranks between the two, making women better off, even if d_m is 1. This shows that some affirmative action policies or providing benefits to women applying for leadership positions increases their chances. We also observe in the graph with the strategies that women start off by increasingly playing L but eventually 'back down'. This gives some room for certain policies to come in effect.

The last scenario examined when varying power differentials is one with considerably weaker power imbalances, where d_m = 0.8 and d_f = 0.6, we find that it takes on average 44.13 for a group to manifest an advantage. Average ranks were 4.81 and 4.16 for men and women respectively. This is, relatively, a less significant disparity in ranks than any other power imbalance scenario. This implies that the closer we aim to bring both types' disagreement points the more we close the gap in access to leadership opportunities for women.

Variables							
	$d_m=d_f=0$	$d_m=d_f=1$	$d_m=1$	$d_m=0.5$	$d_m=1$ $d_f=0.5$	$d_m=0.9$ $d_f=0.5$	$d_m=0.8$ $d_f=0.6$
Men – Ranks	115.22	2.70	1.94	8.22	2.00	2.43	4.81
Women – Ranks	116.94	2.70	1.37	6.27	1.60	2.07	4.16
Difference	/	/	41.61%	31.1%	25%	17.39%	15.62%
Rounds	1939.58	68.95	12.59	62.35	15.56	19.98	44.13

Table 5. Overview Resulting Metrics with Various Power Disparities, Updated

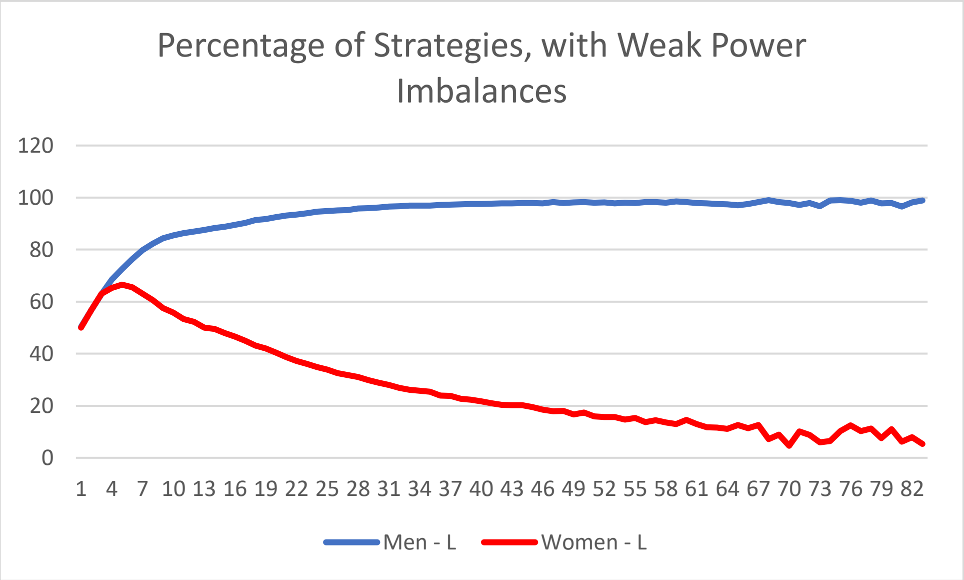

Figure 8. Percentages with d_m = 0.8 and d_f = 0.6

From these findings it seems that reducing power disparities could delay the emergence of hierarchical advantages. Policies promoting equal decision-making power, such as affirmative action policies or policies that would provide preferential treatment to underrepresented groups could help achieving a more equitable distribution of ranks.

c. Cultural Red King Effect

The Cultural Red King Effect is related to the impact that majority group interacting with a minority group has on the state of norm evolution. This term comes from the field of biology where two species co-evolve but the majority evolves faster. In a cultural context, we can see two groups co-evolving. However, if one is more prevalent, the minority meets agents from this group more commonly than the other way. This implies that the demands of the majority have a significant reactionary effect on the minority group who quickly need to learn how to interact in order to not 'go extinct'. In this way, the minority is more likely to end up at a disadvantage as they learn to accommodate the majority's needs.

Whether it is justifiable to assign different population sizes to men versus women is worth considering for this variable. In fact, nowadays it seems safe to assume that men and women are, on average, equally competing for the same positions, especially at lower levels of hierarchy. However, there are still some important sectors that are male dominated, such as finance, IT, engineering (Work-Chron, 2020). Moreover, the higher up ranks we go in most sectors the more male dominated they are, notably academia (European Commission, 2021). The subject of this thesis is to analyze why one gender is prevalent at the top of the hierarchy, it makes sense to acknowledge the current demographic already existing there.

We start by resetting the disagreement points to 0. We then test when the proportion of men is 0.7 and 0.9. In the table below, we see that as p increases so does the difference in average rank between the two types. Intuitively, if the types are of the same power, the distribution of ranks should not differ, yet the average is considerably lower for the minority group, here women. The amount of rounds it takes for the advantage to settle in decreases as p increases, implying that women 'go extinct' faster the bigger the proportion of men.

Variables		
	p = 0.7	**p = 0.9**
Men - Ranks	97.66	52.54
Women - Ranks	71.56	36.73
Difference	36.47%	43.04%
Rounds	1167.90	542.74

Table 6. Overview Resulting Metrics with Varying Proportions

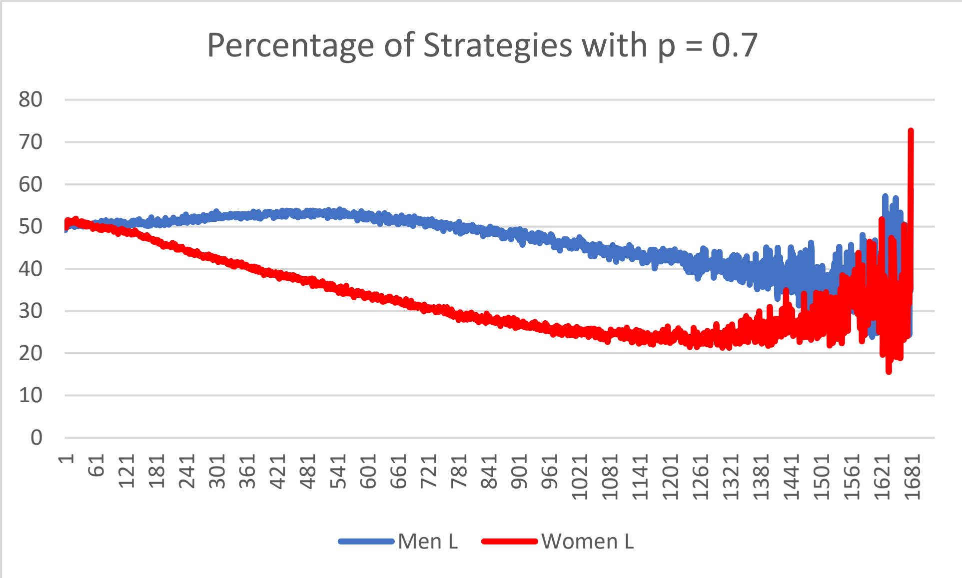

Figure 9. Percentages when p = 0.7

The influence of gender composition on the distribution of ranks in hierarchy formation is highlighted by these findings. It seems therefore that aiming to increase the representation of women, through quotas or more inclusive recruitment practices would lead to a potentially fairer outcome.

Instead of maintaining both d's at the same level, we then test if these population size disparities between men and women could be offset by increasing the minority's, women's, disagreement point.

Variables				
	p = 0.7	**p = 0.9**	**p = 0.8 d_f = 0.1**	**p = 0.8 d_f = 0.2**
Men - Ranks	97.66	52.54	99.89	52.25
Women - Ranks	71.56	36.73	88.39	58.79
Difference	36.47%	43.04%	13.01%	-11.12%
Rounds	1167.90	542.74	1277.68	573.14

Table 7. Overview Resulting Metrics, Offsetting Proportion Disparities

It seems that as we increase the disagreement point, even minimally, the disparity is already considerably reduced. To the extent that once this d reaches 0.2 women already gain some advantage over men, see Figure 11. This shows us that the effect of a power disparity is considerably stronger than that of size disparities. However, it also shows that policies empowering and encouraging women in fields dominated by men would allow them to achieve considerably more.

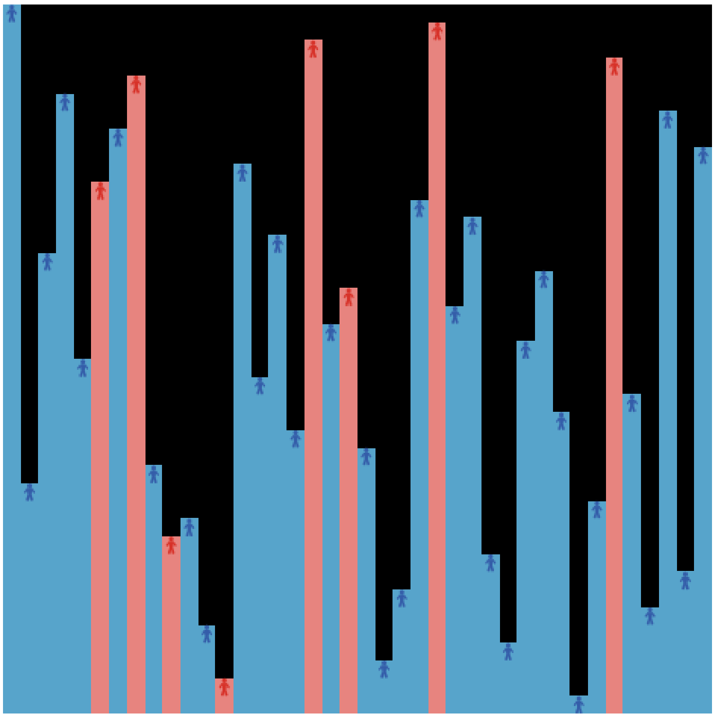

Figure 10. Hierarchy when p = 0.8 and d_f = 0.2

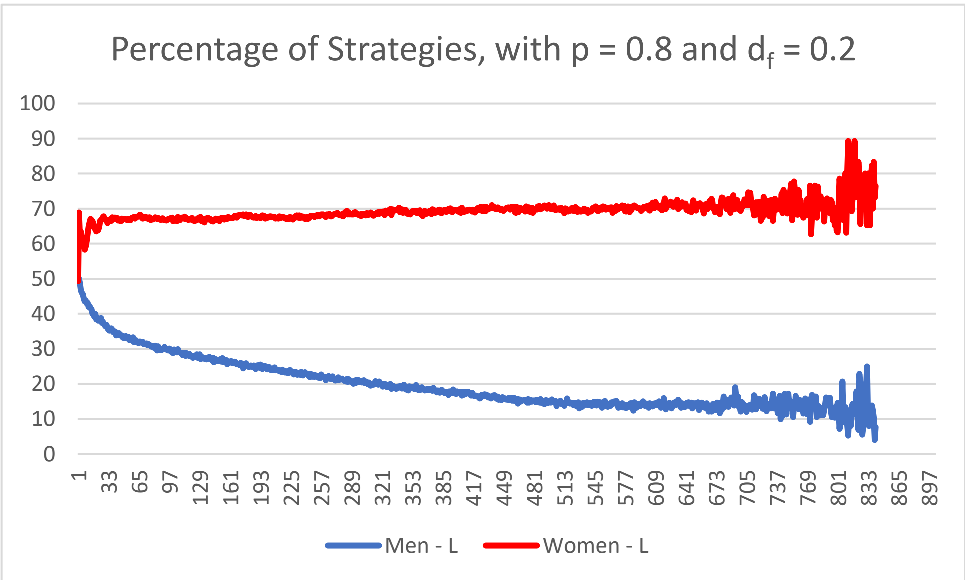

Figure 11. Percentages when Proportion Disparities are Offset

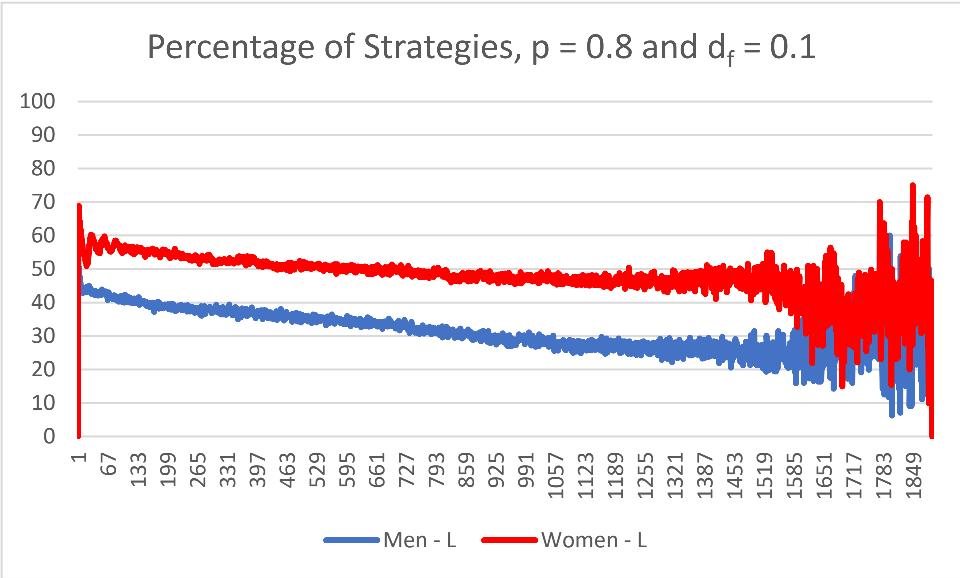

Figure 12. Percentages when Proportion Disparities are Offset

d. Limitations

Despite the valuable insights that simulations can provide, it is important to acknowledge their limitations. Simulations are theoretical representations of complex social dynamics. They rely on many assumptions and simplify an intricate web of interdependencies, meaning that certain factors which could influence real-world outcomes may be neglected. They, therefore, require substantial empirical backing to justify their outcomes. Without such empirical support, the findings can be said to be speculative and lack credibility. It is crucial to complement these outcomes with empirical data in order to establish the reliability and validity of the model, especially when generalizing parameters and initial conditions. The sensitivity of the model to variations in parameters and initial conditions is crucial to assess the robustness and applicability of the results.

Another limitation lies in the assumptions and parameters used in simulations. These assumptions and parameters are often generalized over a group, overlooking the nuances of power dynamics that exist within that group. Everyone within a system has specific characteristics and differences which play a significant role in shaping outcomes. Simulations, by necessity, rely on simplified representations of agents, assuming homogeneity in decision-making processes. However decision-making processes are not binary, individuals consider a range of options and negotiate through various strategies that can greatly impact the dynamics being studied.

Simulations often do not account for external influences such as policies or interventions that can significantly impact social dynamics. These external factors can shape outcomes in real-world scenarios, and their absence in simulations limits the comprehensiveness of the analysis.

In summary, simulations are very powerful tools to investigate complex phenomena, such as causal dependencies in social systems, and to provide a platform for hypothesis testing. However, it is important to back up the assumptions and outcomes with empirical data to ensure the reliability of these hypotheses.

Conclusion

In conclusion, this thesis aims to highlight how gender norms affect the formation of hierarchies and the associated achievable ranks per gender. Despite efforts to promote gender equality, we aim to understand why men still predominantly hold top hierarchical positions overall.

By taking gender to be a performative act, giving rise to this concept as an arbitrary and coincidental category, we can understand how inequitable gendered conventions arise and are perpetuated in society. This concept of gendered conventions and norms is explored, highlighting how tags, such as gender, facilitate coordination but also reinforce gendered expectations, restricting access to certain functions and opportunities. This is accompanied by empirical evidence illustrating how homophily and power disparities affect the positions of individuals in hierarchies.

We then adapt existing models of resource division per gender to a model for hierarchy formation when the population is separated into two types, a binary gender category, although the findings can be extrapolated to other potential binary categories. Finally, we run 200 simulations for each variety of settings to find what the average ranks are for each type and how many rounds it takes for an advantage to be attained by either type.

We investigate the role of power and proportion of each type on the extent of this achieved advantage. We find that the bigger the power disparities, the bigger the difference in ranks between the types and the quicker the advantage manifests itself. We also find that differences in proportion between men and women can be offset by increasing the minority's power. These findings highlight the unfairness of power disparities arising from arbitrary categories, such as gender, and the significance of the impact they have on available opportunities.

This provides insights for understanding the effects of certain policies targeting gender inequalities in hierarchically structured organizations. It seems that addressing power disparities and promoting equal representation can lead to more equitable outcomes.

However, it is crucial to acknowledge the limitations of simulations have as a methodology in representing simplified versions of complex social dynamics. Therefore, these findings should be interpreted with caution and considered alongside real-world observations and empirical evidence. Since this is a novel model, it seems crucial to conduct further research to understand real-world complexities and ensure the assumptions behind the parameters are justifiable.

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Appendix

NetLogo Code:

```
globals [
  percentage-male-l
  percentage-male-f
  percentage-female-l
  percentage-female-f
  percentage-male-l-list
  percentage-male-f-list
  percentage-female-l-list
  percentage-female-f-list
  male-rank-list
  female-rank-list
  stop-simulation
  male-rank-mean
  female-rank-mean
]

turtles-own [
    rank
    partner
    m
    num-male-l
    num-male-f
    num-female-f
    num-female-l
    num-male
    num-female
    strategy ; either l or f
    payoff
    epl-male
    epf-male
    epl-female
    epf-female
    rank-history
]




;; SET UP
to setup
  clear-all
  setup-patches
  setup-turtles
  setup-history
  update-patch-color
  setup-lists
  set stop-simulation false
  reset-ticks
end

to setup-patches
  resize-world 0 (n - 1) 0 (n - 1)
end
```

```
to setup-turtles
  ask patches with [pycor = 0] [
    sprout 1 ]
  ask turtles [
    set color white
    set shape "person"
    set partner nobody
  ]
  ask n-of (p * n) turtles [ set color blue set size 1 ]
  ask turtles with [color = white] [ set color red set size 1 ]
  ask turtles [ set rank pycor ] ; and plot this somehow
end

to setup-history
  ask turtles [
  set m ["num-male-l" "num-male-f" "num-female-l" "num-female-f"] ; creates
variable as a list
  set num-male-l 0
  set num-male-f 0
  set num-female-l 0
  set num-female-f 0
  set num-male (num-male-l + num-male-f)
  set num-female (num-female-l + num-female-f)
  ]
end

to setup-lists
  set percentage-male-l-list []
  set percentage-male-f-list []
  set percentage-female-l-list []
  set percentage-female-f-list []
  set male-rank-list []
  set female-rank-list []
end




;; INTERACTIONS
to go
  partner-up
  expected-payoffs
  choose-strategy
  update-memory
  payoffs
  move-up
  update-patch-color
  update-rank
  strat-counter
  update-percentage-lists
  update-rank-lists
  check-stop-condition
  tick
end

;re-initiate

to partner-up
  ask turtles [ set partner nobody ]
  ask turtles [
    let potential-partners turtles with [ pycor = [pycor] of myself and
```

```
partner = nobody ]
    if any? potential-partners [
      set partner one-of potential-partners
    ]
  ]

end

to update-memory; what their partner does gets recorded in their memory in
order to update their expected belief in the next round
  ask turtles [
   if partner != nobody [
    if [color] of partner = blue [
      ifelse [strategy] of partner = "l"
        [ set num-male-l (num-male-l + 1) ]
        [ set num-male-f (num-male-f + 1) ]]
    if [color] of partner = red [
      ifelse [strategy] of partner = "l"
        [ set num-female-l (num-female-l + 1) ]
        [ set num-female-f (num-female-f + 1) ]]]]

  ask turtles [
    set num-male (num-male-l + num-male-f)
    set num-female (num-female-l + num-female-f)
  ]
end

to expected-payoffs
  ask turtles with [color = blue]
    [
      ifelse num-male != 0 [
        set epl-male (((num-male-l * d-m) + (num-male-f * 2)) / num-male)
        set epf-male ((num-male-l + num-male-f) / num-male)
    ]
    [ set epl-male 0 ]
      ifelse num-female != 0 [
        set epl-female (((num-female-l * d-m) + (num-female-f * 2)) / num-
female)
        set epf-female ((num-female-l + num-female-f) / num-female)
    ]
    [set epl-female 0]
  ]

  ask turtles with [color = red]
  [ifelse num-male != 0 [
      set epl-male (((num-male-l * d-f) + (num-male-f * 2)) / num-male)
      set epf-male 1
    ]
    [ set epl-male 0]
    ifelse num-female != 0 [
      set epl-female (((num-female-l * d-f) + (num-female-f * 2)) / num-
female)
      set epf-female 1
    ]
    [set epl-female 0]]
end

to choose-strategy; they choose a strategy given their beliefs of what
their partner will play (given the expected payoff function)
  ask turtles [
    if partner != nobody [
```

```
      if [color] of partner = blue [
        if (epl-male < epf-male) [ set strategy "f" ]
        if (epl-male > epf-male) [ set strategy "l" ]
        if (epl-male = epf-male) [ set strategy one-of ["l" "f"] ]
      ]

      if [color] of partner = red [
        if (epl-female < epf-female) [ set strategy "f" ]
        if (epl-female > epf-female) [ set strategy "l" ]
        if (epl-female = epf-female) [ set strategy one-of ["l" "f"] ]
      ]
    ]]
end


to payoffs; given what they and their partner play, they are assigned a
payoff
  ask turtles [ set payoff 0 ]
  ask turtles with [color = blue] [
    if strategy = "l" [
      ifelse [strategy] of partner = "l"
      [ set payoff  d-m ]
      [ set payoff 2 ]
    ]
    if strategy = "f"
      [ set payoff 1 ]
  ]
  ask turtles with [color = red][
  if strategy = "l" [
      ifelse [strategy] of partner = "l"
      [ set payoff  d-f ]
      [ set payoff 2 ]
    ]
    if strategy = "f"
      [ set payoff 1 ]
  ]
end

to move-up;
    ask turtles [
    if payoff = 2 [
    setxy pxcor (pycor + 1)
  ]
 ]

end

to update-patch-color
  ask turtles with [ color = red ] [
    set pcolor 17
  ]
  ask turtles with [ color = blue ] [
    set pcolor 96
  ]

end

to update-rank
  ask turtles [set rank pycor]
end
```

```
to plot-male-ranks
  plotxy ticks mean [rank] of turtles with [color = blue]
end
to plot-female-ranks
  plotxy ticks mean [rank] of turtles with [color = red]
end

;; TO PLOT
to strat-counter
  let males-partnered-with-females turtles with [color = blue and partner
!= nobody and [color] of partner = red]
  let females-partnered-with-males turtles with [color = red and partner !=
nobody and [color] of partner = blue]

  let total-male count males-partnered-with-females
  let total-female count females-partnered-with-males

  let total-male-l count males-partnered-with-females with [strategy = "l"
]
  let total-male-f count males-partnered-with-females with [strategy = "f"
]
  let total-female-l count females-partnered-with-males with [strategy =
"l" ]
  let total-female-f count females-partnered-with-males with [strategy =
"f" ]

    ifelse total-male > 0 [
    set percentage-male-l ((total-male-l / total-male) * 100)
  set percentage-male-f ((total-male-f / total-male) * 100)
  ]  [
    set percentage-male-l 0
    set percentage-male-f 0
  ]

  ifelse total-female > 0 [
    set percentage-female-l ((total-female-l / total-female) * 100)
  set percentage-female-f ((total-female-f / total-female) * 100)
  ]  [
    set percentage-female-l 0
    set percentage-female-f 0
  ]
end

to plot-male-l
  plotxy ticks percentage-male-l
end

to plot-male-f
  plotxy ticks percentage-male-f
end

to plot-female-l
  plotxy ticks percentage-female-l
end

to plot-female-f
  plotxy ticks percentage-female-f
end

;percentages
to update-percentage-lists
```

```
  set percentage-male-l-list lput percentage-male-l percentage-male-l-list
  set percentage-male-f-list lput percentage-male-f percentage-male-f-list
  set percentage-female-l-list lput percentage-female-l percentage-female-
l-list
  set percentage-female-f-list lput percentage-female-f percentage-female-
f-list
end

to report-percentages
 print (word "Percentage Male L: " (sentence percentage-male-l-list))
 print (word "Percentage Male F: " (sentence percentage-male-f-list))
 print (word "Percentage Female L: " (sentence percentage-female-l-list))
 print (word "Percentage Female F: " (sentence percentage-female-f-list))
end

;ranks
to update-rank-lists
  set male-rank-list lput mean [rank] of turtles with [color = blue] male-
rank-list
  set female-rank-list lput mean [rank] of turtles with [color = red]
female-rank-list
end

to report-ranks
  set male-rank-mean mean male-rank-list
  set female-rank-mean mean female-rank-list

  print (word "Male Rank Statistics: Mean - " male-rank-mean)
  print (word "Female Rank Statistics: Mean - " female-rank-mean)
end

to check-stop-condition
  if (percentage-male-l = 0 or percentage-male-l = 100 or
      percentage-male-f = 0 or percentage-male-f = 100 or
      percentage-female-l = 0 or percentage-female-l = 100 or
      percentage-female-f = 0 or percentage-female-f = 100) [
    set stop-simulation true
  ]
   ifelse (stop-simulation = true) [
  report-percentages
  report-ranks
  print ticks
  stop]
  []
end

;example experiment
to tick-check
  Repeat 200 [
        Setup
        While [stop-simulation = false]
[go]
    Print ticks]
end
```