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The Gender Workforce Inequality

Büşra Kobya
Boğaziçi University

Elvan Durdu
Boğaziçi University

Table of Contents

ABSTRACT

Despite growing social awareness and advanced legislative frameworks, female participation in the global workforce remains disproportionately low. Traditional linear models often fail to capture the complex, persistent drivers of this gender gap, such as the double burden of unpaid labor and entrenched masculine organizational norms that prioritize constant availability. This study utilizes a system dynamics methodology to simulate the long-term macroeconomic trends of female workforce participation in the European context over 34 years (1990–2024). The conceptual model maps four reinforcing loops and one balancing loop to quantify the feedback between workloads, energy levels, productivity, and organizational culture. Three policy interventions were tested: government-supported childcare and paternal leave, top-down diversity initiatives, and a tiered financial incentive structure. The baseline model successfully replicates the historical inertia and slow growth of female labor participation. Findings indicate that childcare and paternal leave significantly improve workforce ratios and stabilize productivity by mitigating energy depletion. In contrast, top-down cultural initiatives and bias elimination efforts yielded only marginal demographic increases and failed to improve operational efficiency. Sensitivity analysis further reveals that financial incentives, such as wage bonuses, are insufficient when implemented without structural support. It is demonstrated that shifting organizational culture is a low-leverage point when applied in isolation. Sustainable gender equity requires structural, macro-level policies that actively alleviate the physical and mental constraints of the double burden. Systemic change is only achievable when financial support is reinforced by policies that foster an equitable distribution of domestic and childcare responsibilities.

Keywords: System Dynamics, Female Labor Force Participation, Gender Gap, Policy Simulation, Childcare Support, Sensitivity Analysis, European Labor Market, Workforce Inequality.

1. Introduction

While women represent half of the global working-age population, their participation in the labor market remains disproportionately low. According to International Labor Organization (ILO) data [1], women account for only 40% of total employment and approximately 35.4% of management roles worldwide. It is crucial to note that while the exact magnitude of these disparities varies significantly across different regions—for instance, the drastic differences in unpaid domestic working hours between developing nations and European countries—the underlying systemic drivers of this gender gap remain remarkably persistent on a global scale. Studies confirm that regardless of the specific geography, the same feedback mechanisms, such as the disproportionate burden of unpaid labor and embedded cultural norms, consistently drive this workforce imbalance.

The structural nature of gender inequality is evidenced by the staggering disparity in unpaid labor. According to the ILO (2024) [2] approximately 708 million women globally are outside the labor force due to unpaid care responsibilities, compared to only 40 million men. This 17-fold difference highlights that the double burden is not an anecdotal issue but a systemic barrier. Furthermore, the World Economic Forum (2024) reports that at the current rate of progress, it will take 134 years to close the global gender gap. This massive system inertia justifies our model's 34-year horizon and explains the stagnant behavior observed in the baseline simulation. Although this structural gender employment gap and the underlying 'double burden' are persistent phenomena observed globally across vastly different countries and cultures, this study specifically focuses on the European context. Europe presents a highly relevant macro-economic environment where, despite advanced legislative frameworks for gender equality, the 'glass ceiling' and workforce disparities remain deeply entrenched.

This disparity raises critical questions regarding the systemic barriers preventing women from entering, retaining, and advancing within the workforce. Addressing these obstacles is essential not only for gender equity but also for leveraging female talent to drive organizational performance. Unfortunately, women still experience unequal opportunity and treatment in the labor market despite social awareness. Gender imbalance in the workforce is a widespread problem which is encountered in many areas from the private sector to academia worldwide. Even though many organizations try to implement gender fair recruitment policies, the issue remains up to date. Globally, women encounter persistent structural barriers that limit their entry into the workforce and their subsequent advancement into leadership roles. When coupled with the disproportionate burden of unpaid labor—such as domestic responsibilities and childcare—these systemic imbalances manifest as a significant gender pay gap and an over-representation of women in low-positioned employment. The official statistical office of the European Union (Eurostat) reported that women earn 12% less per hour than men on average. In fact, the gender overall earnings gap arises as 36.7% based on the average hourly earnings gap, lower working hours of women due to the gender gap in domestic and childcare responsibilities, and the hiring rate. The gender employment gap is a critical economic problem at the macro level, costing €390 billion annually in the EU, which is 2.3% of the EU's GDP. Traditional approaches attempt to analyze this problem using stationary data, but overlook the cultural norms that influence workforce balance, organizational mechanisms, and the unpaid responsibilities of women. This study examines this problem as a complex dynamic problem that is composed of feedback mechanisms rather than being a static problem. Systems dynamics methodology is utilized to model interactions between recruitment and turnover processes, organizational culture, and worker efficiency. Then, this model is used to simulate different long-term policies and compare their outputs.

1.1. Problem Definition

The main problem of the study is to understand the dynamics of the change in the women's workforce. This is not only a social problem but also it is related to the efficient management and optimization of human capital. The underlying mechanisms that lead to a decrease in the number of women in the workforce despite organizational incentives are investigated. While many organizations have implemented targeted incentives to increase the hiring rate of women, these efforts are often neutralized by high female turnover rates. This leaky pipeline effect prevents the workforce from reaching its desired diversity targets. This is the result of the existence of low career visibility of women, which postpones the occurrence of an inclusive cultural atmosphere and decreases the effect of equality-based management commitment. A significant barrier to achieving this target is the prevalence of masculine cultural norms within the workplace. Research indicates that organizations are often dominated by traditional masculine values, such as control and competitiveness. In practice, these implicit norms translate into structural barriers, such as application profiles that emphasize competitive traits at the expense of social qualities, inherently imposing a male standard on candidates. Furthermore, these norms dictate that higher-level management positions implicitly require full-time, uninterrupted availability. When the "ideal worker" is defined by these masculine metrics that ignore outside responsibilities, it creates a systemic mismatch for women experiencing a double burden. Furthermore, in a male-dominated organizational structure, the advancement mechanisms are inherently susceptible to in-group bias, often referred to as homosocial reproduction. Because decision-making and managerial roles are predominantly occupied by men, candidates are implicitly evaluated against male-coded leadership metrics. Consequently, male employees are statistically more likely to be promoted, which continuously replenishes the male-dominated leadership pipeline and creates a structural 'glass ceiling.' This vicious cycle ensures that even if hiring rates become equitable, the existing masculine cultural norms remain deeply entrenched at the upper echelons, ultimately driving down female retention. Low retention levels not only decrease the number of working women but also lead to a critical decrease in the experience level of women, and accordingly, the number of women in the workforce generally stays below the target level. Another important factor is the double burden of women, which constitutes the domestic and childcare workload. These unpaid works are considered mostly the responsibilities of women due to common cultural norms. It is the most important determinant of the energy level and productivity of women. Although the inclusion of men in domestic responsibilities increases over time, work-life balance still causes conflicts for women compared to men. The roles that society imposes on women slow down the career progression of women and bring the gender pay gap to a critical level. It is aimed to analyze the system by considering different policies such as paternity leave, bias elimination efforts, and childcare service access, etc., and determine their effects on the solution of gender imbalance issues and evaluate in terms of bringing the system into a sustainable condition. The goal is to identify the leverage points required to transition the organization from a state of imbalance to a gender-equitable condition.

1.2. Research Objectives

The main aim of this project is to understand long-term dynamics of women representation in the workforce by analyzing the relationships between individual energy levels, domestic burdens and organizational culture. The model is focusing on the European context. While similar workforce gender gaps and leaky pipelines are prevalent globally, the European macro-economic level was selected due to the availability of highly standardized, cross-national data. It represents the aggregated dynamics of the female working-age population across European labor markets. While the internal feedback loops simulate corporate behaviors like mentorship or inclusivity, they represent the weighted average behavioral trends of the European corporate sector. The objective is to analyze how Europe-wide structural drivers, such as the 'double burden' and shared cultural norms, maintain the gender gap across European countries. First, it is desired to analyze the double burden effect by quantifying how the combination of job, domestic, and childcare workloads impacts the long-term energy sustainability of women. Second, it evaluates the productivity feedback loops by exploring how fluctuations in the energy level of women influence the overall hiring rate through the mediating effect of productivity and efficiency. Then, the cultural barriers to retention are identified, and it is examined how masculine cultural norms and gender pay inequality create loops that affect perceived retention and turnover. Finally, it is aimed to test policy interventions and simulate the impact of management commitment and childcare service access on stabilizing the current female in workforce ratio toward the target ratio. To achieve the objectives above, the study seeks to answer the following research questions:

1. How do shifting workloads (domestic vs. childcare vs. job) impact the energy level of women?
2. To what extent do masculine cultural norms delay the impact of management's effort to eliminate bias in the hiring process?
3. How does gender pay inequality influence the female turnover fraction, and what is the resulting drain on the women in the workforce?
4. Can increasing childcare service access significantly reduce the maternity leave duration, and does this lead to a more stable current female ratio in the workforce?

1.3. Literature Review

Classic statistical models frequently treat women in workforce problems as a straightforward, linear pipeline, incorrectly predicting that gender gaps will vanish naturally as more women join the workforce. In practice, however, higher numbers of women employment have failed to produce equal representation of women in the work life. System dynamics offers a more robust methodology by focusing on the feedback loops, systemic delays, and internal cultural forces that actively maintain these gender imbalances over time. Extensive research has been conducted into female labor force involvement and the long-standing gender disparities found within professional markets. Many researchers analyze the gender gap as a human capital supply chain issue, often relying on the Pipeline Delay Hypothesis. However, system dynamics research, such as Dudley's [3] ten-stock aging chain model, proves that these delays alone cannot explain the lack of women in various roles. Expanding on the critique of the pipeline hypothesis, Palmer [4] shifts the focus from educational supply to internal organizational dynamics. This is conceptualized as a push-pull mechanism where push dynamic is recruitment and pull dynamics is retention barriers. Recent studies have transitioned from purely quantitative pipeline models to those incorporating soft variables, such as shared perceptions and cultural norms, as the fundamental drivers of gender inequality. Bleijenbergh et al. [5] utilize system dynamics to illustrate how unofficial, man-made rules in professional environments, specifically the masculinity of norms, create systemic barriers. This research identifies a reinforcing loop where the ideal worker is defined by constant availability, a standard that creates a perceived mismatch for women, particularly those with maternal responsibilities. This perceived incongruity triggers lower promotion rates, decreased professional visibility, and restricted access to influential informal networks.

Beyond organizational culture, the literature highlights a critical psychological and physical constraint: the limited energy stock of individuals. For working mothers, the simultaneous management of job, childcare, and domestic workloads creates a double burden that leads to role strain. Building on Homer's [6] dynamic model, research shows that when excessive demands deplete physical and mental energy stocks faster than they can recover, individuals enter a burnout cycle. As energy declines, hourly efficiency and productivity drop. Working mothers often attempt to compensate by working harder. This cycle is not merely an individual struggle but a systemic failure arising from traditional gender roles and insufficient support systems. Without interventions like workplace flexibility or affordable childcare, the energy shortage makes sustainable labor force participation nearly impossible. As a solution strategy, the literature identifies paternity leave as a crucial mechanism for addressing gender inequality in domestic labor by shifting societal norms and ensuring a more equitable distribution of childcare responsibilities. According to Pizarro and Gartzia [7] , such policies facilitate a smoother transition for mothers returning to the workforce by significantly reducing their cumulative mental and physical workloads. Moreover, the primary catalyst for the challenges mothers face in the labor market is the lack of accessible, high-quality, and affordable childcare support systems. As Hoffman et al. [8] supposed, this creates a significant economic barrier where workforce participation becomes a calculated decision based on a wage threshold. To remain in the labor force, mothers must earn wages that are high enough to offset the substantial costs of daycare and professional childcare services. These dynamic highlights that labor force participation is not solely a matter of individual choice but is heavily dictated by the availability of affordable support infrastructures.

The reviewed literature suggests a fundamental shift in how gender inequality in the workforce is understood, moving from linear pipeline models to complex, feedback-driven systemic perspectives. A critical theme emerging from the research is the double burden, the systemic failure to account for the simultaneous demands of professional labor and disproportionate domestic responsibilities. Despite the insights of the studies from literature, a significant gap remains: few models explicitly quantify the dynamic feedback between domestic time constraints, energy depletion, and professional advancement. Moreover, there is a lack of longitudinal evaluations that systematically test policy interventions, such as paternity leave or childcare subsidies, within a quantified framework.

2. Model Conceptualization and Construction

Several assumptions and simplifications have been made in the model. The model's parameters are grounded in European socio-economic data. For instance, the workloads and participation tendencies are mostly derived from Eurostat (2024) reports, which provide a standardized baseline for the European workforce. This macro-level aggregation allows the model to capture systemic 'European-wide' delays and inertia, making the findings applicable to broader policy discussions within the European Union's gender equality framework. Since the dynamic model is constructed to examine the inequality of women in the workforce, it focuses on the various effects, causes, and cases that affect female labor participation. The men in the workforce are included in the model to calculate the current female ratio and are considered to have a constant inflow through the years based on the employment rate increase and population growth. However, a detailed structure is not constructed. Research showed that the average working hours of women are higher than those of men in total of paid and unpaid jobs. Therefore, the base working hour is set to the average working hour of men. In the real world, women on maternity leave are still officially counted as part of the workforce. However, because this simulation looks at a massive 34-year macro-trend, tracking short-term absences (like a 6-month or 1-year leave) would make the model unnecessarily complicated. For the purpose of tracking the effects of maternity leave, women in maternity leave are assumed to be leave from women in the workforce stock. The simulations are made over 34 years, and death is not considered in the equations for both the female and male populations.

A critical assumption is the conceptualization of the energy level of women. While variables such as *Women in Workforce* track macro-level population stocks, the *Energy Level* is modeled as an aggregate, normalized index (scaled from 0 to 1) that represents the average physical and psychological stamina of the entire female workforce. Although individual energy levels, support mechanisms, and stress tolerances vary significantly in reality, utilizing an average energy index is a deliberate methodological choice. It allows the model to capture the macro-level feedback between systemic overwork and collective productivity drops without unnecessarily complicating the model's resolution. The energy level is a measure proxy for effective work hours. It is assumed that a significant proportion of working-age women do not enter the labor market from the very beginning. Therefore, the *women looking for job fraction* operates within a structurally limited initial supply, meaning parity, 50-50 ratio, cannot be reached solely through organizational hiring efforts if societal participation remains unequal.

Stocks, flows, and converters that build the models are introduced in the following tables.

Stock Variables	Definition	Initial Values (EU-27 Based)	Flow Formulation
Unemployed Working Age Woman	The total number of women without a job in the working age	37400000,00	women growth rate - employment rate
Women in Workforce	The total number of employed women	75000000,00	employment rate + return from maternity leave - maternity leave - turnover rate
Women in Maternity Leave	The total number of female employees in maternitiy leave	15000000,00	maternity leave - return
Men in Workforce	The total number of employed men	103000000,00	men growth rate
Perceived Retention	The level of how females of working age view the employment	0,05	perception change rate
Energy Level of Women	The current state of energy level of female workers, both psychologically and physically	0,67	recovery rate - depletion rate

Table 1. Stocks with related information.

Flows	Definition	Flow Formulation
Women growth rate	The number of increase in unemployed working age women	turnover rate * fraction of re-employment rate + new female employment number
Men growth rate	The number of increase in working men	constant (150000)
Employment rate	The number of newly employed women	Unemployed Working Age Woman*hiring fraction*women looking for job fraction
Turnover rate	The number of women who quit the job	female turnover fraction*Women in Workforce
Return from maternity leave (Return)	The number of women who return to work from maternity leave	Women in Maternity Leave / MAX (maternity leave duration/52, 1)
Maternity leave	The number of women who leave their job for maternity leave	female fertility * Women in Workforce
Perception change rate	The rate of change in retention of unemployed women	(retention-Perceived Retention)/perception delay
Recovery rate	The recovery rate of energy level of women	(target energy-Energy Level of Women) * recovery fraction
Depletion rate	The depletion rate of energy level of women	Min(Energy Level of Women/TIME STEP,depletion fraction*relative work load)

Table 2. Flows with related information.

Converter set - 1	Formulation	Value	Unit
Target energy	Constant	1	unitless
Depletion fraction	Constant	0,25	unitless
Relative workload	working hours of women / base working hour		unitless
Base working hour	Constant	3733,6	hours/year
Working hour of women	childcare workload of women + domestic workload of women + job workload of women		hours/year
Job workload of women	Constant	1960,4	hours/year
Domestic workload of women	Constant	837,2	hours/year
Childcare workload of women	Constant	1820	hours/year

Table 3. Converter set-1 with related information.

Converter set - 2	Formulation	Value	Unit
Gender pay gap	1 - ((effofProductivity*effofFemaleRatio)^(0.5))		
Maternity leave duration	WithLookup(Childcare service access)		week
Retention	max retention fraction*(effofPayGap*effofMentorship)/0.56		
Max retention fraction	Constant	0,1	
Base turnover fraction	Constant	0,063	
Female turnover fraction	Min(1 , (0.05* base turnover fraction/retention))		
Perception delay	Constant	5	year

Table 4. Converter set-2 with related information.

Converter set - 3	Formulation	Value	Unit
Women looking for job fraction	0.1 * EXP (Perceived Retention)		per year
Current female ratio	Women in Workforce/ (Women in Workforce + Men in Workforce)		
Effort to elimimate bias	management commitment*(1-masculine cultural norms)		
Management Commitment	commitment sensitivity*pressure for diversity		
Commitment Sensitivty	Constant	0,7	
Target female ratio	Constant	0,5	
Pressure for diversity	MAX(0,(target female ratio-current female ratio)/target female ratio)		
Hiring fraction	base hiring fraction*(1+effort to eliminate bias/9)		per year
Base hiring fraction	0.37 * effectofProductivityonHiringrate		per year
New female employment	Constant	2300000	person

Table 5. Converter set-3 with related information.

Related lookup functions of converter sets are shown in A.1.

2.1. Causal Loop Diagram

The holistic causal loop diagram of the model is shown in Figure 1.

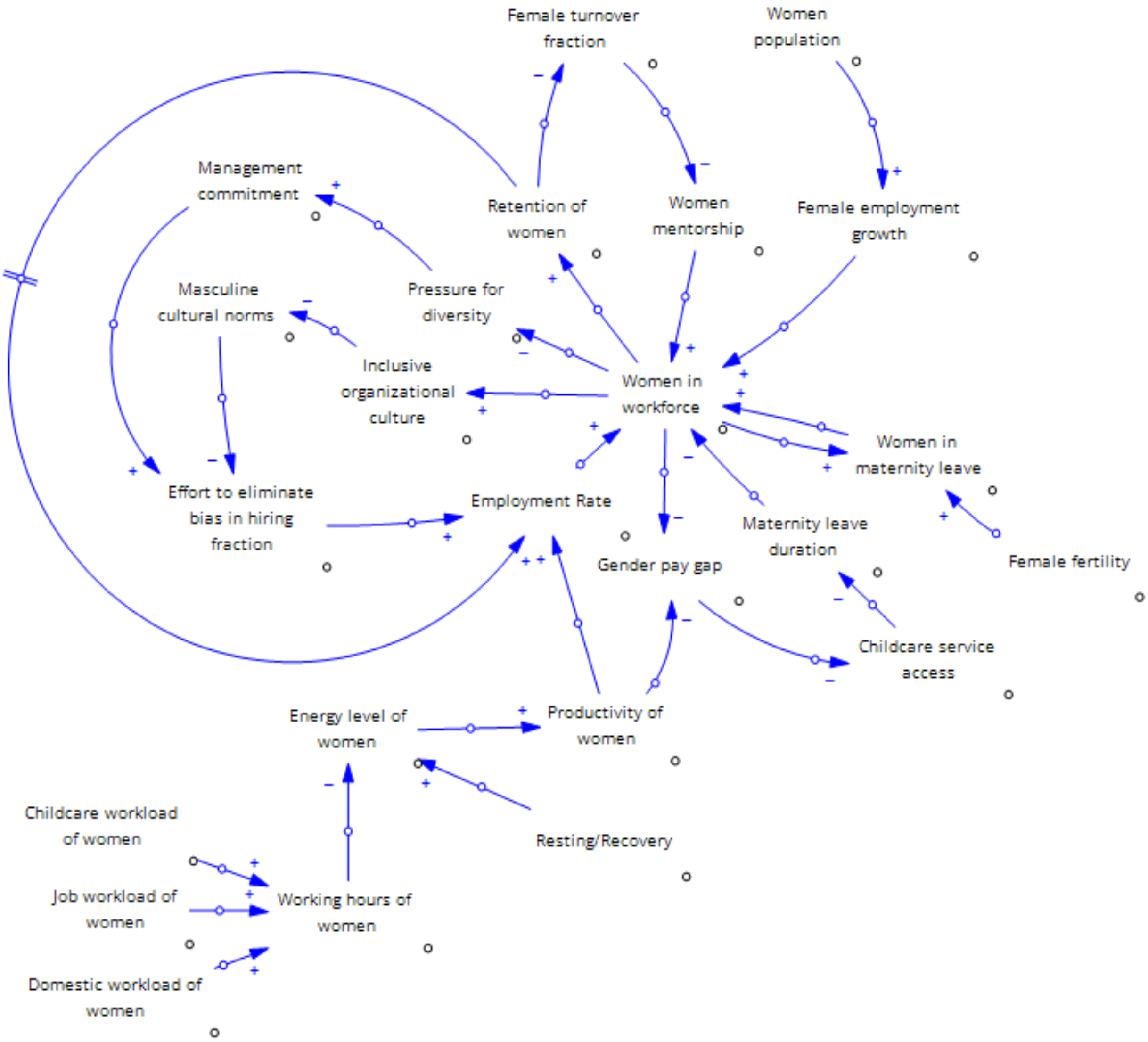

Figure 1. Holistic simplified causal-loop diagram.

Four reinforcing loops and one balancing loop constitute the main dynamics of our conceptual model. Their effects are shown in more detail below.

Reinforcing Loop 1 represents a man-dominated culture concept where the environment becomes self-sustaining through promotion dynamics. In heavily male-dominated structures, decision-makers exhibit an implicit in-group bias, making it structurally more likely for men to be promoted over women. This homosocial reproduction reinforces masculine cultural norms and suppresses organizational inclusivity. Conversely, introducing a higher representation of women disrupts this bias, improves organizational inclusivity, and reduces masculine norms. Reduced norms increase the effort to eliminate bias in both hiring and promotions, which boosts the employment rate. This is a virtuous cycle that, with more women in the workforce make it easier to hire even more women.

Balancing Loop 1 represents the push dynamic, the active efforts by management to reach gender parity. When the number of women in the workforce is low, it creates a gap relative to the target female ratio, leading to higher pressure for diversity. This pressure drives management commitment and the subsequent effort to eliminate bias. This increases hiring until the workforce reaches a level that satisfies the diversity target, at which point the pressure and the extra hiring effort decrease.

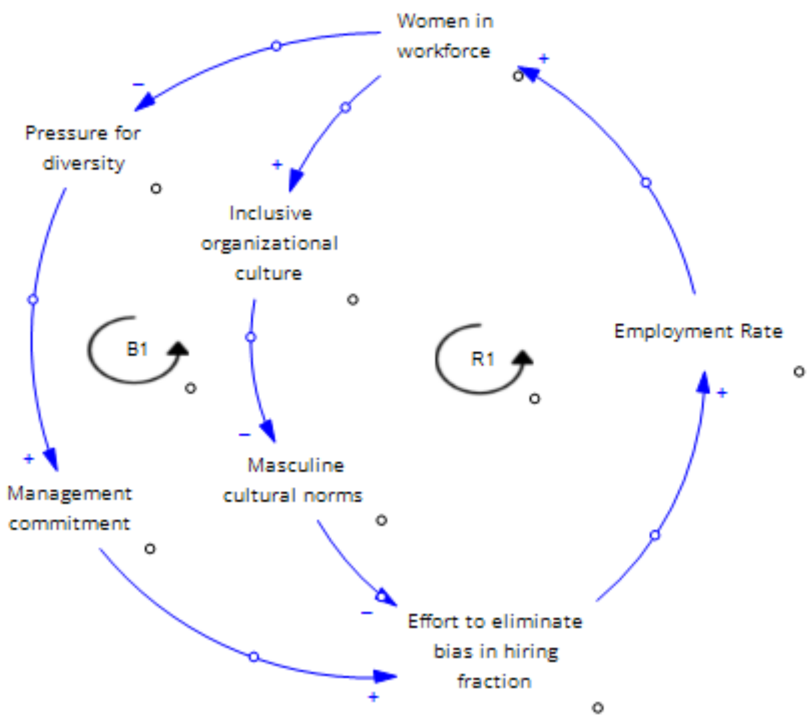

Figure 2. Reinforcing Loop 1 and Balancing Loop 1.

Reinforcing Loop 2 shows how institutional support helps retain women, addressing the pull dynamic where toxic or unsupportive environments lead women to quit. As the number of women in the workforce grows, the availability of women's mentorship increases. Better mentorship improves the retention of women, which directly maintains the women in the workforce stock by reducing the female turnover fraction.

Reinforcing Loop 3 shows how an increase in retention of women increases the employment rate by positively affecting the rate of women who are looking for a job in the long run. Hence, with the increase in women in the workforce, women's mentorship also increases, that support retention of women.

Reinforcing Loop 4 shows the effects of physical and mental limits of working women, often referred to in literature as the double burden. The women in the workforce not only face job-related workload but also maintain significantly higher hours of unpaid workload, such as domestic and childcare workload, compared to men in the workforce worldwide. This high workload depletes the energy level of women, which lowers productivity. It has several significant consequences. First, lower productivity causes a lower hiring rate among the women who are looking for a job. It causes a decrease in the employment rate which lowers the number of women in the workforce. Unless women's participation in the workforce increases, the gender pay gap cannot be closed. On the other hand, higher productivity helps close the gender pay gap. Better relative pay improves childcare service access by making it more affordable. Better access to childcare reduces the maternity leave duration, allowing women to return to the workforce sooner. This reinforces the number of active women in the workforce.

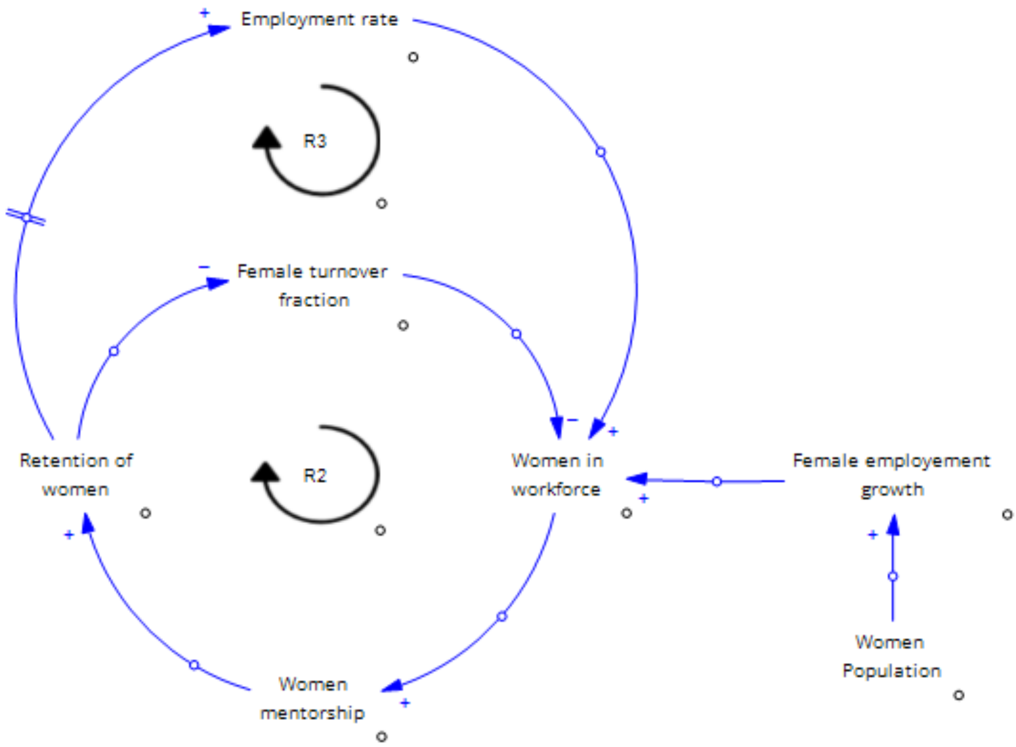

Figure 3. Reinforcing loop 2 and reinforcing loop 3.

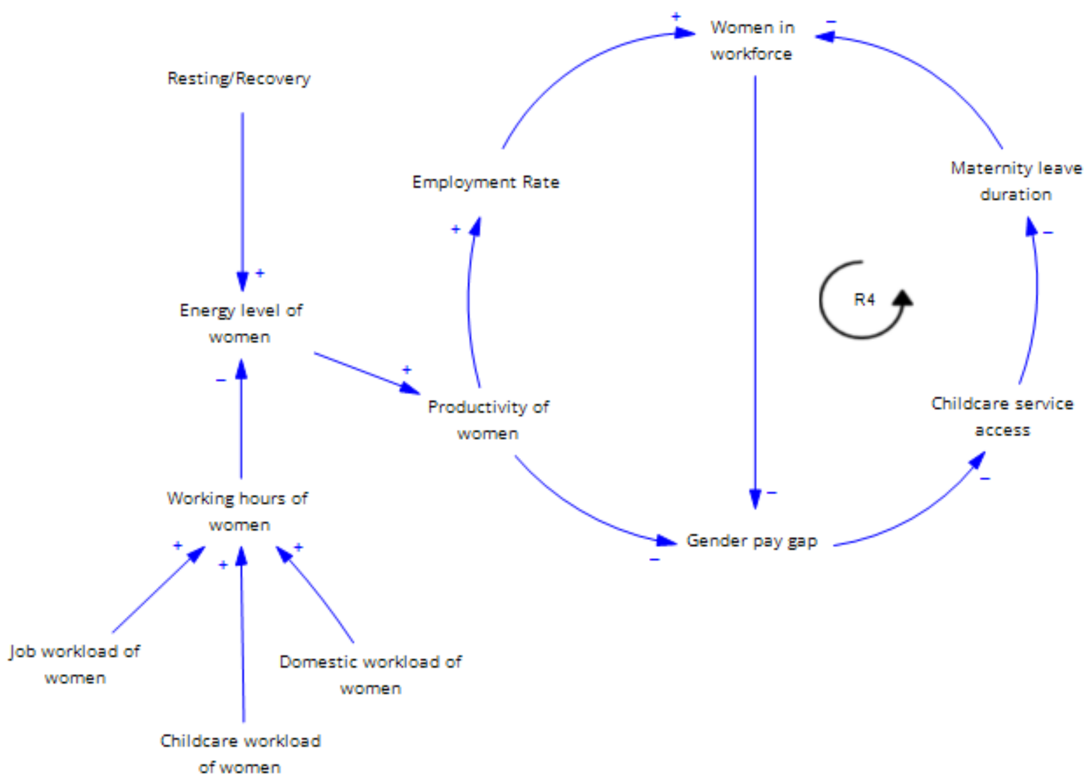

Figure 4. Reinforcing Loop 4.

2.2. Stock-Flow Diagram

The stock-flow diagram of the model is shown in Figure 5.

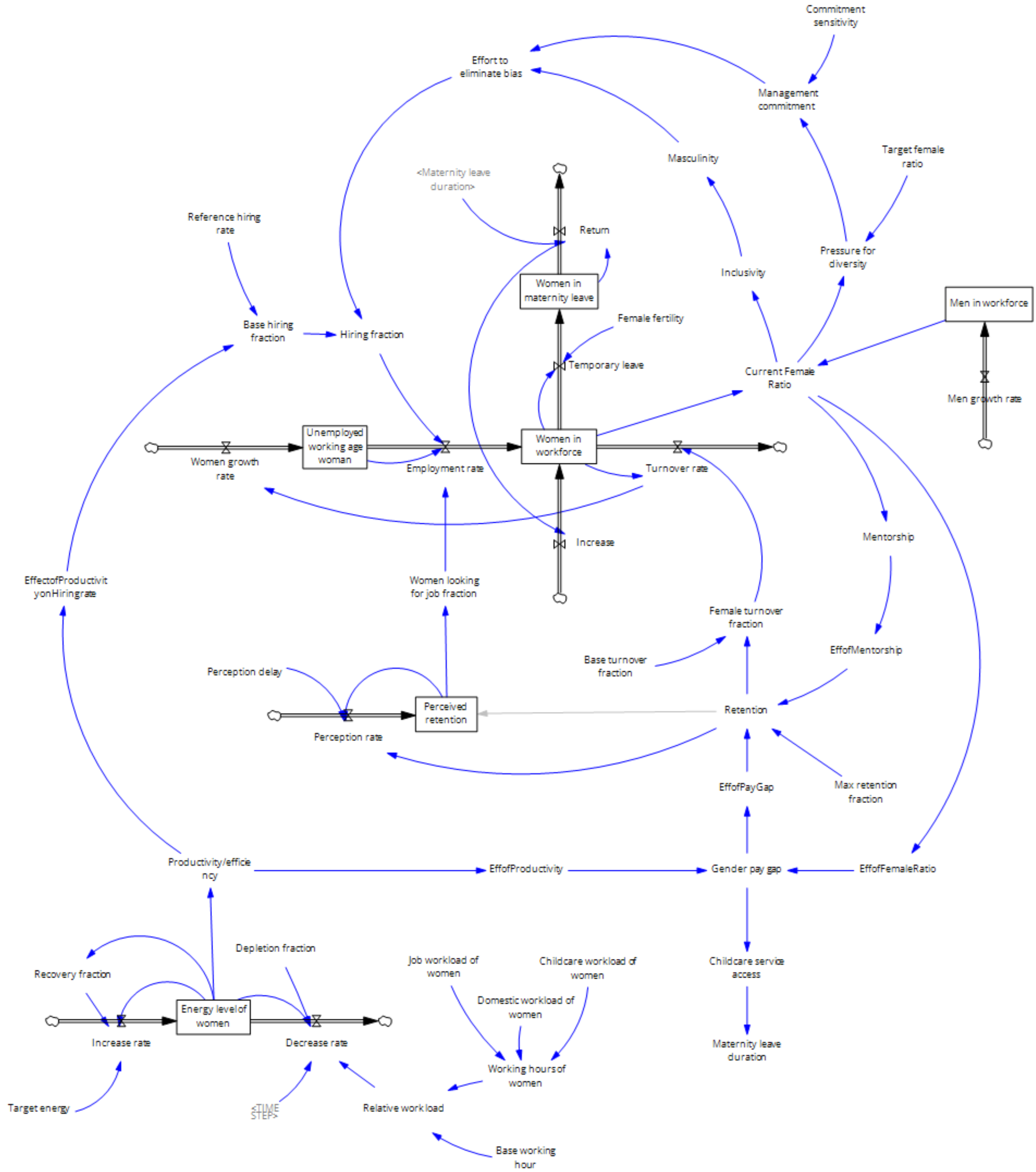

Figure 5. Stock-Flow Diagram

3. Testing

3.1. Verification

Verification focuses on the technical accuracy of the simulation model. The simulation model captures all the intended equations and variables that are defined in the conceptual model. Thus, it can be concluded that verification is provided for our model.

3.2. Validation

3.2.1. Structural Validation

3.2.1.1. Extreme Condition Test

Extreme condition test is a fundamental component of the system dynamics model validation process. These tests aim to show structural robustness and behavioral consistency of the model under extreme parameter values. In this study, three different scenarios are utilized to verify the model's integrity.

The first test examines a zero-hiring condition. It is assumed that hiring is suspended due to extreme internal or external factors. For this purpose, the base hiring fraction is set to zero. As expected, the employment rate immediately drops to zero because it is a multiplicative function of the hiring fraction. Over time, women in workforce stock depletes toward zero because of continuous outflows from turnover rate and temporary leave. Consequently, the stock of unemployed working age women increases linearly. This is because the inflow, growth rate, continues to increase while employment is blocked. The outputs provided below confirm this behavior.

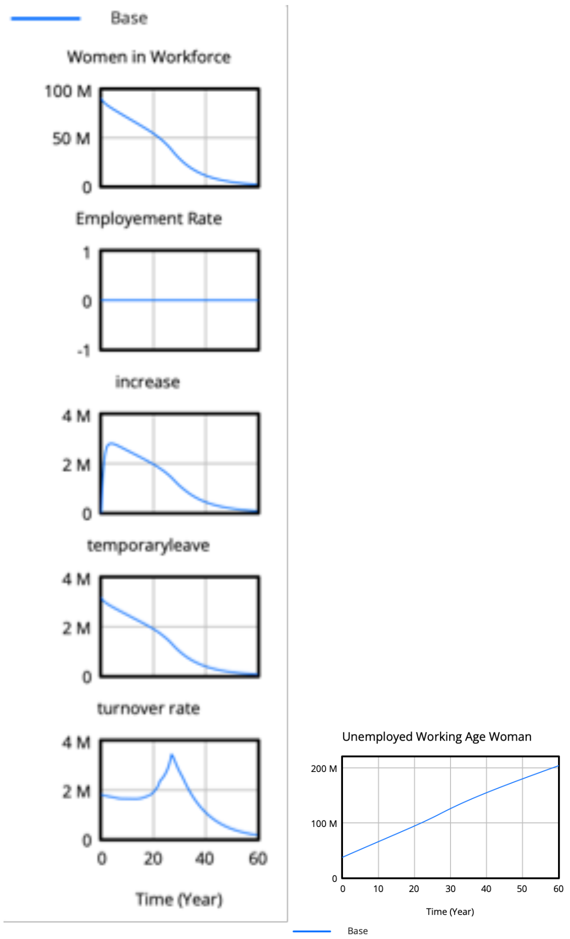

Figure 6.: Outputs of Extreme Condition Test 1

The second test simulates an infinite workload for women to evaluate the system's response to unsustainable workload levels. In this scenario, the job workload of women has increased tenfold. As the relative workload reaches extreme levels, the decrease rate of energy accelerates. In the baseline model, the energy level of women falls into negative values, forcing productivity to zero. This result confirms that without internal coping mechanisms, extreme workload leads to a total collapse of labor participation and hiring.

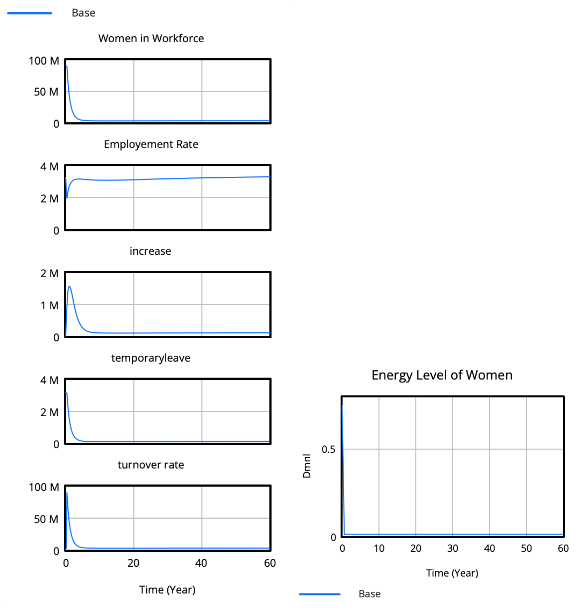

Figure 7. Outputs of Extreme Condition Test 2

The third test examines a zero-retention scenario, simulating an organizational culture where female employees do not wish to remain in their positions. The max retention fraction is set to a near-zero value, 0.00001, to avoid numerical errors. Consequently, the female turnover rate reaches its maximum limit of 1, meaning every woman leaves the job within the same year they are hired. As a result, the number of women in workforce stock rapidly declines to zero.

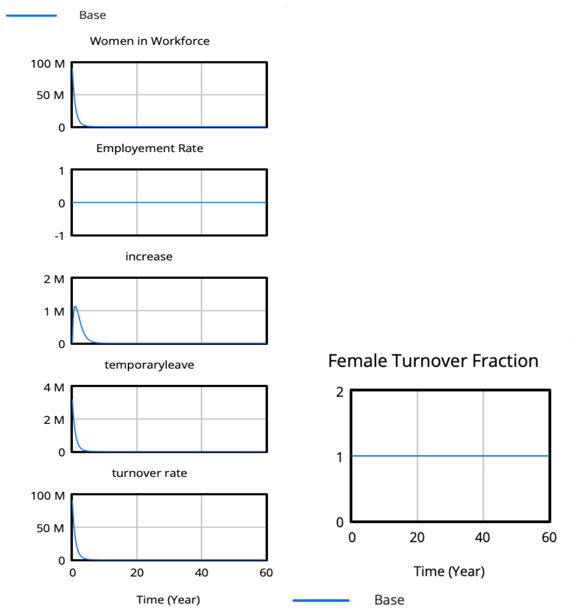

Figure 8. Outputs of Extreme Condition Test 3

3.2.1.2. Dimensional Consistency Test

Dimensional consistency test is another step of structural validation. The equations in the model are dimensionally consistent. It is also verified in Vensim by using the unit checking feature and the model passed with no dimensional errors.

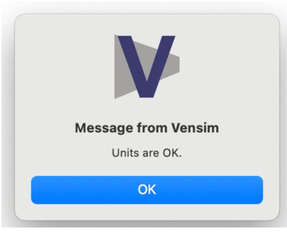

Figure 9. Vensim Screenshot for Unit-Checking Procedure

3.2.2. Behavioral Validation

Behavioral validation ensures that the model can reproduce the qualitative and quantitative patterns observed in the real-world system. This involves comparing the simulation outputs with the expected reference mode of workplace gender dynamics. The primary reference mode for this study is the persistent gender gap in workforces.

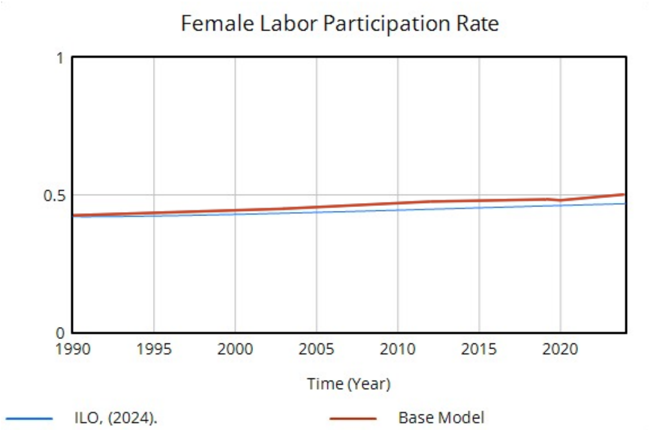

Figure 10. Female labor force participation rate, 1990 to 2024 (ILO, 2024).

When the model outputs are compared with real-world data, it is observed that our model successfully captures the slow upward trend in the women's workforce participation rate observed between 1990 and 2024.

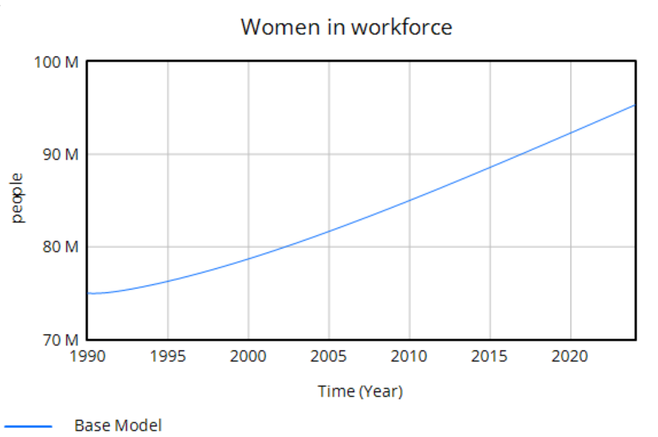

Figure 11. Women in the workforce.

Furthermore, the model is consistent with real-world data regarding the number of women in the workforce between 1990 and 2024. The number of women in the workforce was approximately 75 million around 1990 and increased slowly to 95 million around 2024, as in the real world [16, 17].

Recent statistics reveal the fact that the share of the women workforce among all employees does not increase as expected in the long-term despite higher involvement of women both in education and career. As expected, women in the workforce stock in our model do not respond rapidly to policy changes. This indicates high system inertia and confirms that long-term commitment is required to see substantial shifts in gender balance. The alignment between the expected reference modes and simulation outputs validates that the model captures the structural delays and feedback loops inherent in the workplace gender gap. Thus, it can be concluded that the behavior of our model is valid.

4. Simulation Experiments

4.1. Base Model

The simulation is executed 34 years between 1990 and 2024 with the Euler method using a dt value of 0.0625. The energy level persists at a particular threshold unless women's high relative workload and constant working hours are improved. Consequently, they cannot operate at their maximum efficiency, which leads to a lower hiring fraction. These behaviors are illustrated in Figures 12, 13 and 14.

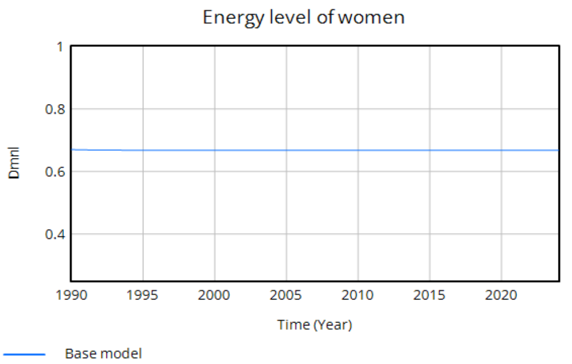

Figure 12. Energy level of women in the base run.

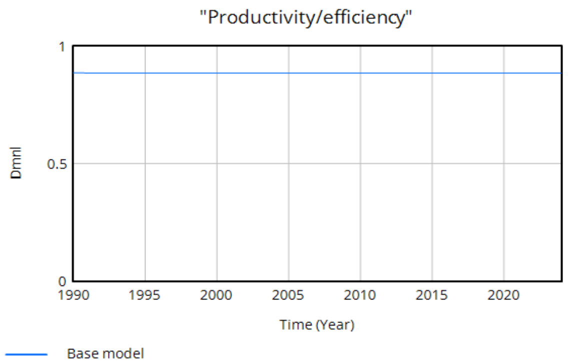

Figure 13. The productivity of women in the base run.

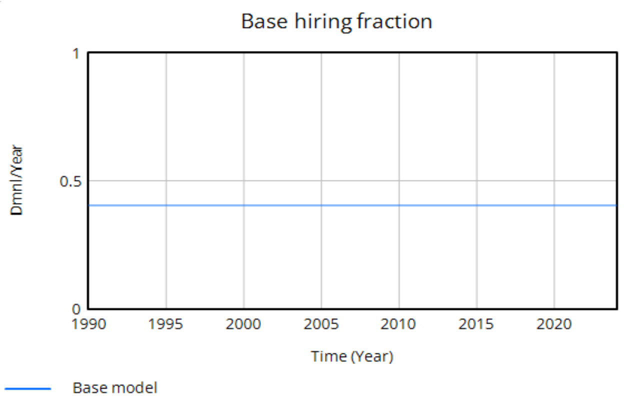

Figure 14. Base hiring fraction of women in the base run.

In these base conditions, the number of women in the workforce gradually increases based on the employment rate flow from 75 million to 96 million which is shown in Figure 15. It is proper to say that the current female ratio, which can be seen in Figure 16, starts around 42% and slowly increases to 46% in 34 years.

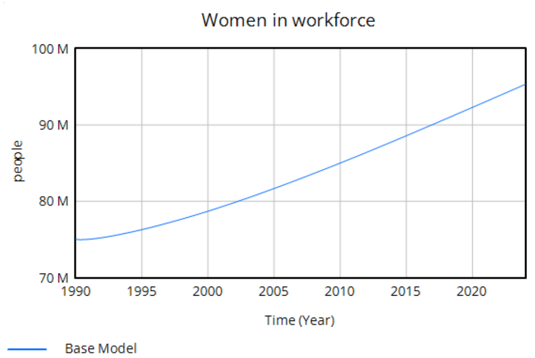

Figure 15. Women in the workforce in the base run

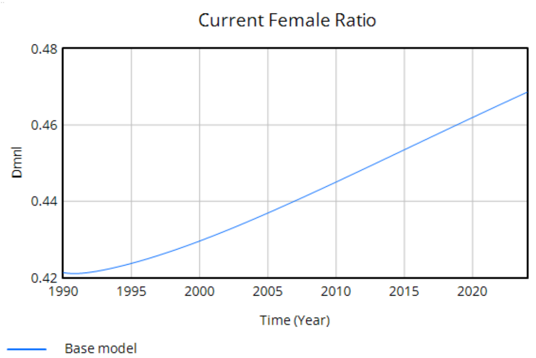

Figure 16. Current female ratio in the base run.

The greater the participation of women in the workforce, the higher their retention becomes due to the enhanced mentorship opportunities and collective support systems among women in the workforce. It is followed by a decrease in the female turnover fraction and an increase in the perceived retention. The outputs are shown in Figures 17, 18 and 19.

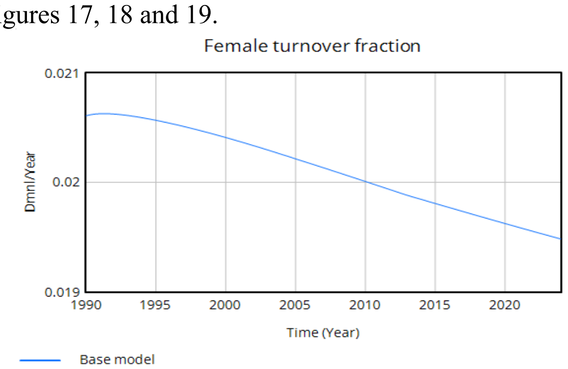

Figure 17. Female turnover fraction in the base run.

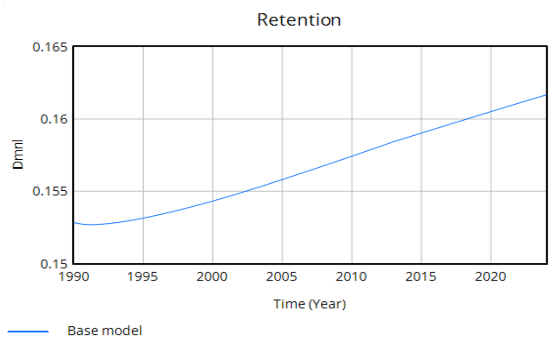

Figure 18. Retention in the base run.

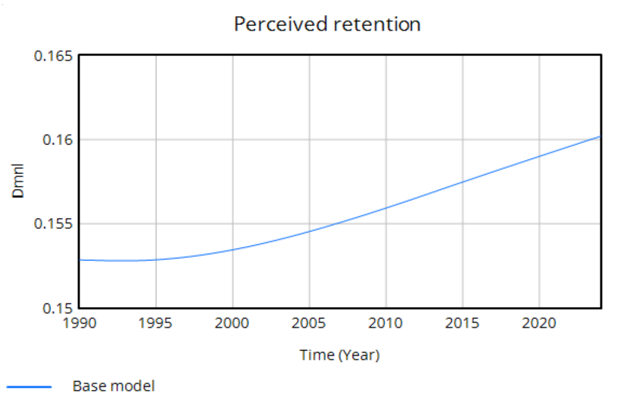

Figure 19. Perceived retention in the base run.

An increase in perceived retention also increases the women looking for a job fraction at the beginning. Thus, a reinforcing cycle that increases the current female ratio arises. The increase in the current female ratio decreases the gender pay gap, which is followed by an increase in childcare access, and therefore decrease in maternity leave duration. The decrease in maternity leave duration makes the return to work from maternity leave faster. Figures 20, 21 and 22 show corresponding results.

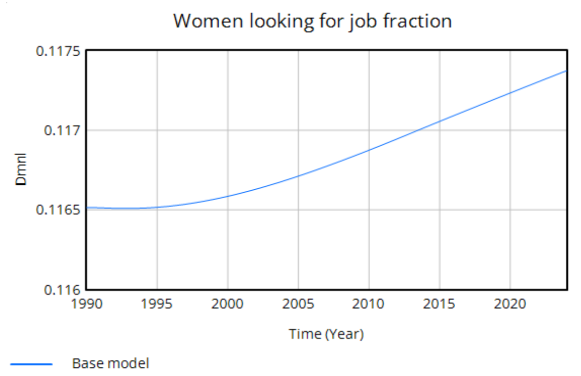

Figure 20. Women looking for job fraction in the base run.

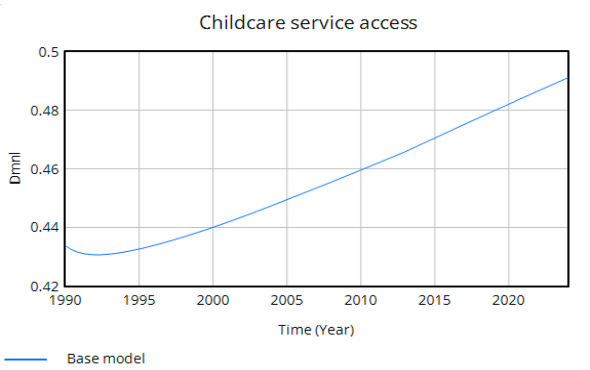

Figure 21. Childcare service access in the base run.

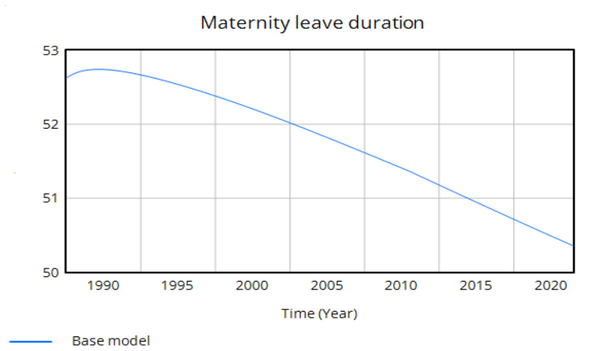

Figure 22. Maternity leave duration in the base run.

4.2. Policy Analysis

4.2.1. Policy 1: Government Support of Childcare Access & Paternity Leave

Government-based policies would be significantly effective in both social and economic aspects. An increase in childcare access is possible through financial support to families for balancing the cost burden of childcare institutions, and investment for developing more credible childcare facilities. This policy can prevent women from being forced to leave working female workforce stock. Also, legal regulations to introduce and increase paternity leave can effectively reduce gender inequality in responsibility and unpaid working hours.

Firstly, the paternity leave variable is introduced into the model, which reduces both the duration of maternity leave and the total working hours of women. This led to a faster return for women in maternity leave, and an increase in productivity of women via an increase in their energy level. Also, government childcare support is introduced, which increases access to childcare. Therefore, maternity leave duration is again decreasing, and the productivity of women is protected by preventing the experience interruption. Figure 23 shows the related part of the updates stock flow diagram.

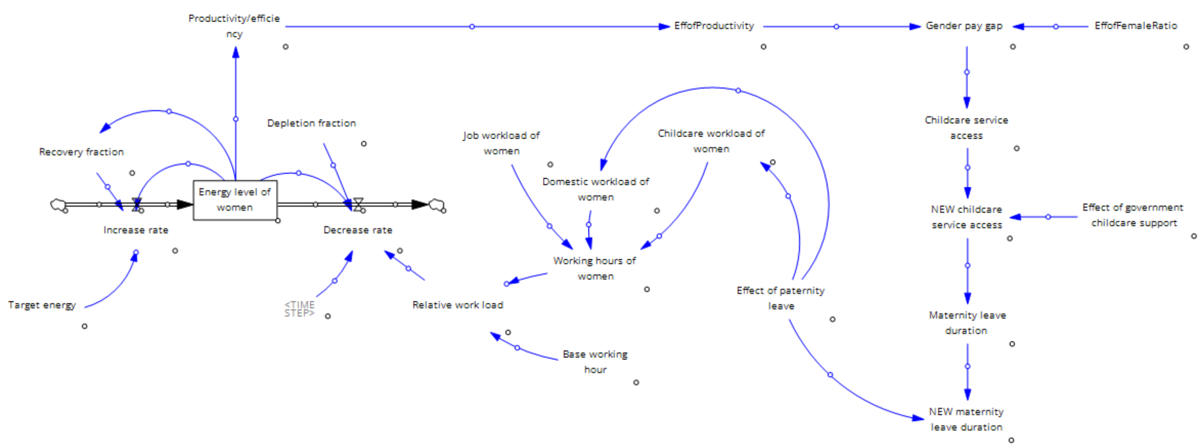

Figure 23. Updated part of the stock flow diagram.

Updated formulations are shown below.

- NEW childcare service access = childcare service access*effect of government childcare support
- NEW maternity leave duration = maternity leave duration/effect of paternity leave
- domestic workload of women = 837 * effect of paternity leave
- childcare workload of women = 1820 * effect of paternity leave
- effect of government childcare support = 1.4
- effect of paternity leave = 0.55

The outputs of the policy in Figures 24, 25 and 26 showed that the number of women in the workforce, the current female ratio, and the productivity of women have increased.

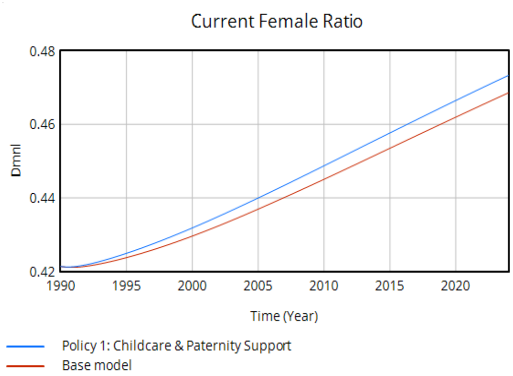

Figure 24. Current female ratio in policy 1.

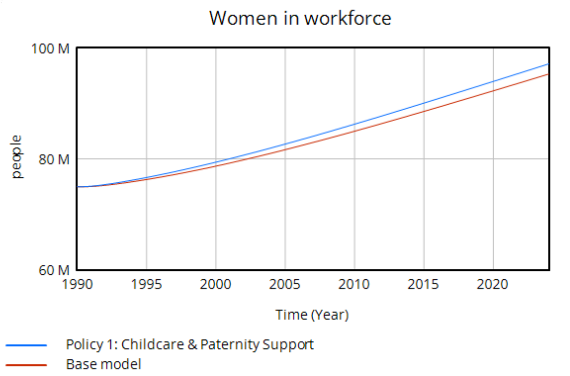

Figure 25. Women in the workforce in policy 1.

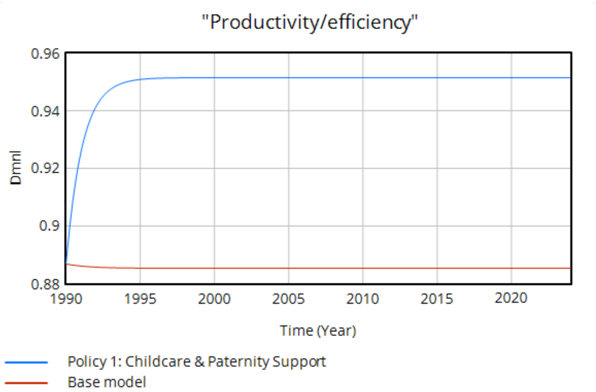

Figure 26. Productivity/efficiency in policy 1.

With Policy 1, women's participation and welfare improved as expected. A key element is that this policy will not only benefit women but also provide a significant economic contribution to the state through the efficient utilization of the potential workforce.

4.2.2. Policy 2: New Culture Adaptation

In the base model, the organization is reactive which means masculine norms only decrease if the number of women increases. It naturally leads to a more inclusive working environment over time. In Policy 2, an active exogenous intervention is introduced to simulate a deliberate cultural shift within the organization. To evaluate this scenario accurately, it is essential to decouple the real-world strategic actions from their mathematical representation in the model. In practice, this policy represents a radical, top-down implementation of Diversity, Equity, and Inclusion (DEI) initiatives. This includes redefining 'ideal worker' metrics by actively penalizing the glorification of overwork (e.g., staying late at the office) and implementing strict structural flexibility, such as core-hours policies or hybrid work models, to realistically accommodate the 'double burden', restructuring promotion criteria to equally reward collaborative skills alongside competitive traits, and deploying mandatory bias-elimination training. This includes implementing 'blind' resume screening and mandatory, scenario-based bias-elimination training for all hiring managers. In the simulation, these real-world actions are quantified by introducing a *Culture Transformation* variable. Then, it shows an 80% reduction in the negative impact of masculine norms. It is also assumed that management is willing to comply with this policy. Thus, management commitment is changed to 0.9 instead of 0.7. It shows a sharp decrease and stabilizes at 20 %. This can be to adapt an active diversity and inclusion training in the organization at the employee level. High commitment sensitivity shows strong leadership response to equity gaps. The stock flow diagram is updated as follows.

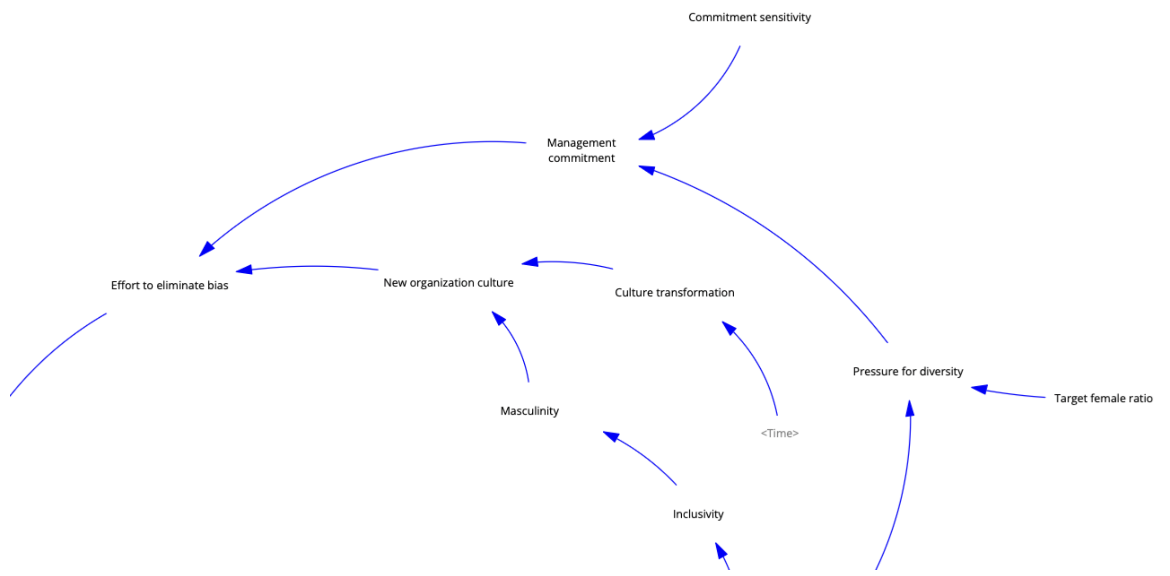

Figure 27. Updated part of the stock flow diagram for policy 2

Updated formulations are shown below:

- Effort to Eliminate Bias = Management Commitment*(1-New Organization Culture)
- New Organization Culture = Culture Transformation*masculinity
- Culture Transformation = f(Time)

Figures 28, 29 and 39 shows the outputs by comparing the Policy 2 and the Base case. There is a slight increase in the current female ratio and women in the workforce. The productivity/efficiency graph shows that despite the changes in the workforce composition, the productivity results for Policy 2 and Base are perfectly overlapping. The system stabilizes after year 10-15 but the leverage of Policy 2 is too low to make a large shift in equilibrium.

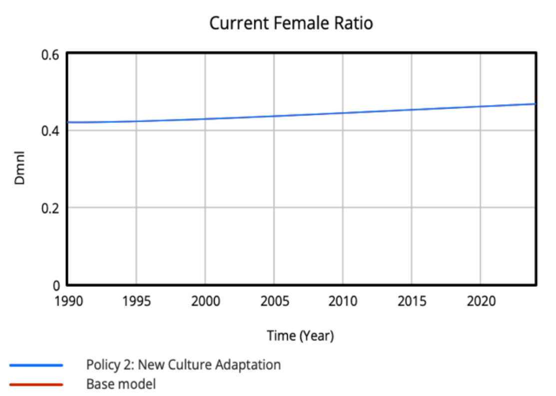

Figure 28. Current female ratio in policy 2.

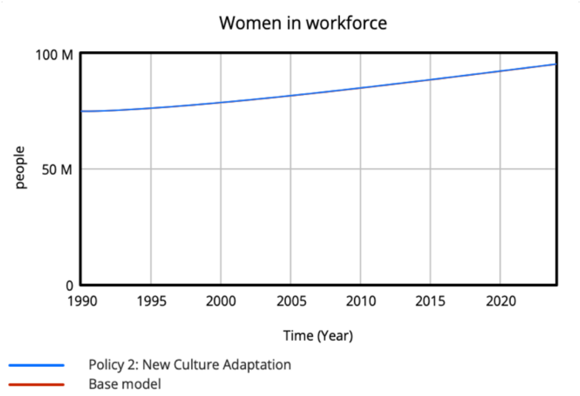

Figure 29. Women in the workforce in policy 2.

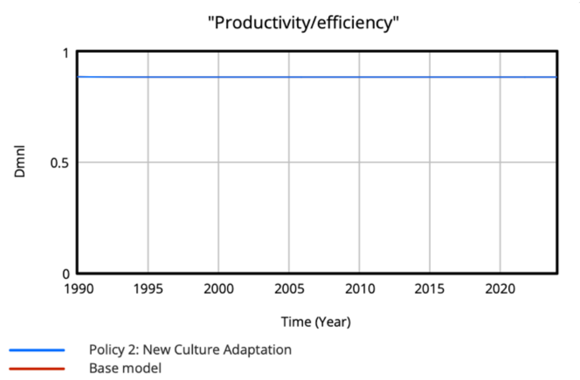

Figure 30. Productivity/efficiency in policy 2.

The simulation of Policy 2 demonstrates that while targeted interventions can successfully alter the demographic makeup of the organization by removing hiring biases, these changes do not inherently lead to gains in operational efficiency. Because this policy does not alter the fundamental domestic and childcare workloads, the 'double burden' driving Reinforcing Loop 4, the newly hired women still experience the same rapid energy depletion as in the base run. It can be concluded that only organization culture policies are low-leverage points when applied in isolation. Changing the culture is necessary but insufficient for improving system performance. Without accompanying structural changes to protect the female energy stock, the system's efficiency remains constrained by burnout rather than its human composition.

4.2.3. Policy Stress Test: Sensitivity Analysis of Fertility Targets

The number of children per capita, particularly in Western countries, tends to decrease. The total fertility rate stood at 1.34 per woman in the EU in 2024 [18]. It remains well below the replacement threshold of 2.1. This deficit suggests a long-term population decrease as the replacement rate is not being met. In addition to its social impacts, the economic dimensions of this situation pose a significant risk, such as a shrinking labor force. As a result, it is observed that governments are implementing policies to encourage an increase in the number of children. This policy aims to increase fertility rates by providing financial incentives to mothers as a wage bonus, increasing access to childcare services, and enhancing income tax deductions. A key point is that these supports will increase proportionally with the number of children women have. However, it also considers that each additional child increases the burden of childcare and domestic work for women, which decreases their energy level.

To evaluate the resilience of the proposed policy framework, a policy stress test was conducted. This test examines the system's behavior under three escalating fertility growth targets: 5%, 10%, and 15%. The objective is to determine whether the compensatory mechanisms—wage bonuses, tax deductions, and childcare access—are sufficient to increase women's participation in the workforce despite the intensified home-life pressures.

Firstly, the domestic and childcare workload of women are updated to make them depend on the fertility rate, which increases the depletion of energy level of women and decreases their productivity/efficiency as the number of children per woman increases. Then, the effect of the childcare support system is added, which decreases maternity leave duration. The decrease in maternity leave makes women return to work faster. Also, the effects of wage bonuses to women are added to represent financial support, which makes the gender pay gap lower. Therefore, retention is positively affected which decreases female turnover fraction and increases women looking for job fraction. Since these incentives mitigate negative perceptions regarding the sustainability of women in the workforce, it is assumed that the base hiring fraction is positively impacted. Related part of the stock flow diagram is shown in Figure 31.

Updated formulations are shown below.

- Base female fertility = 0.035
- Domestic workload of women = 837 * (((Female fertility / Base female fertility) - 1)/2)+1
- Childcare workload of women = 1820 * (((Female fertility / Base female fertility) - 1)/2)+1
- Childcare service access = WithLookup (Gender pay gap / (EffofChildcareSupport*2)) where EffofChildcareSupport = Female fertility / Base female fertility
- Gender pay gap = (1 - ((EffofProductivity*EffofFemaleRatio)^(0.5))) / (EffofWageBonus*2) where EffofWageBonus = Female fertility / Base female fertility

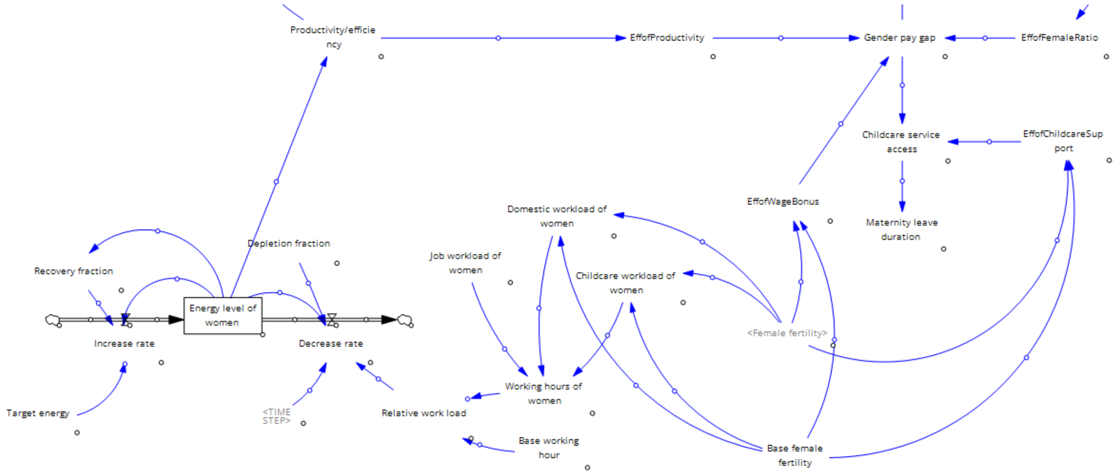

Figure 31. Updated part of the stock flow diagram for policy stress test.

Figure 32 shows that while retention initially improves at higher fertility rates due to the incentives, this growth soon exhibits diminishing returns. The retention rate begins to trend downward following the initial peak. Once the fertility rate exceeds an approximately 55% increase, retention falls even below the levels observed in the base model. The outputs in Figure 33 indicate that as the fertility rate increases, the energy level of women undergoes a significant decline. The same consequences exist in women in the workforce in Figure 34, and the current female ratio values in Figure 35. It is shown that the resulting decline in productivity and the inevitable progression toward burnout because of increased fertility cannot be resolved only by financial incentives.

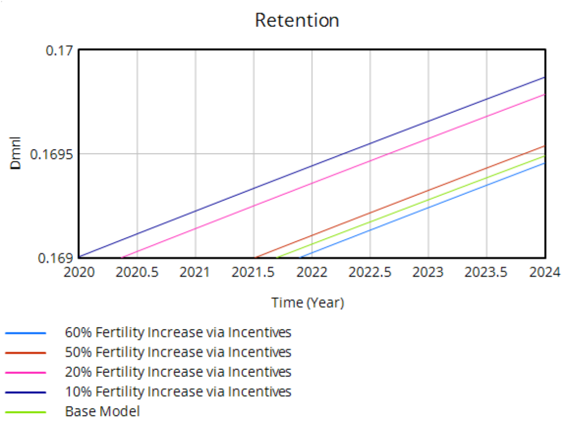

Figure 32. Retention in the workforce in the policy stress test.

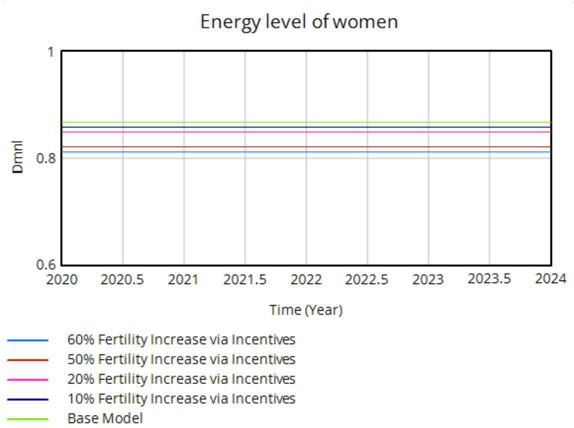

Figure 33. Energy level in the workforce in the policy stress test.

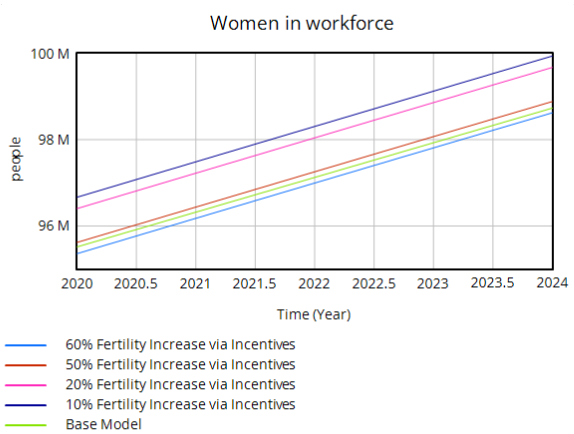

Figure 34. Women in workforce in the policy stress test.

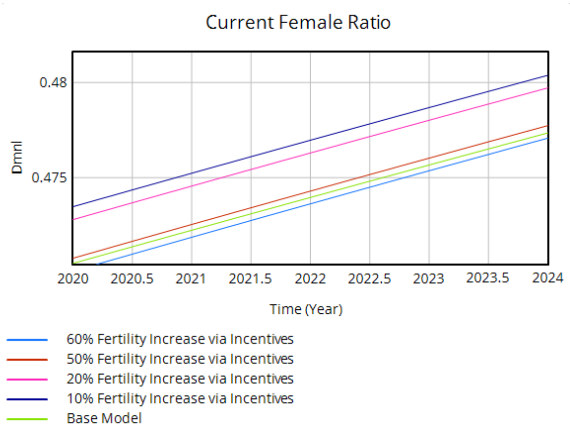

Figure 35. Current female ratio in the policy stress test.

5. Discussion and Conclusions

Women hold many different roles simultaneously, which is caused by the unequal participation of domestic and childcare workload between genders. They face significantly higher workloads compared to men in almost all countries in the world. Also, masculine cultural norms create inequality in recruitment and hassle in the workplace for women. The insufficient rates of women's participation and sustainability in the workforce raise critical dynamic problems in both social and economic aspects.

In this study, a model is built to investigate the dynamics of the gender gap in workforce participation. After the validation and verification processes, it is concluded that the model is robust and adequate for conducting research. Base run simulation is made over 34 years, which is followed by policy analysis.

Policies have been created with the aim of improving female working conditions and decreasing the gender gap in employment rates. In the first policy, governmental regulations are considered. Effects of paternity leave and childcare access are analyzed. It is seen that the female ratio in the workforce can be increased, and the work-life balance of women can be improved. In the second policy, a deliberate cultural shift is implemented in the organization structure and the effect of this intervention is analyzed. It is observed that the number of women in the workforce slightly increases but the efficiency of women is not influenced by this structural change. Failure of second policy to impact productivity is one of the critical findings and it shows that organization level attempts are not sufficient for improving the system outcomes by themselves. Finally, in the policy stress test, collaborative financial incentives that aim to increase the fertility rate is evaluated. Different fertility rates are examined to analyze if the incentives are sufficient to sustainability of higher fertility rates. It is seen that even though financial benefits increase retention and decreases gender gap, they cannot prevent women’s energy level and productivity decrease. In addition to financial support, regulating social roles and balancing the domestic and childcare workload burden between men and women are critical for a sustainable solution.

While the current model provides significant insights into the dynamics in the workforce, it also highlights areas where further structural complexity is required to capture the full socio-economic picture of gender inequality. For instance, the model can be elaborated to show the economic aspect of changing dynamics in women's workforce participation. Since the gender gap in the workforce has significant negative effects on the economy of nations, it would be beneficial to investigate both micro-level and macro-level economic effects by adding related dynamics, variables, and stock to the model. For future research, an aging chain for female workers can be introduced to the model to track long-term retention. Besides gender imbalance in the workforce, the model can be elaborated by also analyzing the problem of the low number of women in leadership positions.

6. Acknowledgement

We extend our heartfelt thanks to Assoc. Prof. Gönenç Yücel for his expert guidance, encouragement, and valuable insights provided throughout this research project.

7. References

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ec.europa.eu/eurostat/statistics-explained/index.php?title=Fertility_statistics

A. Appendix

A.1. Look-up Functions

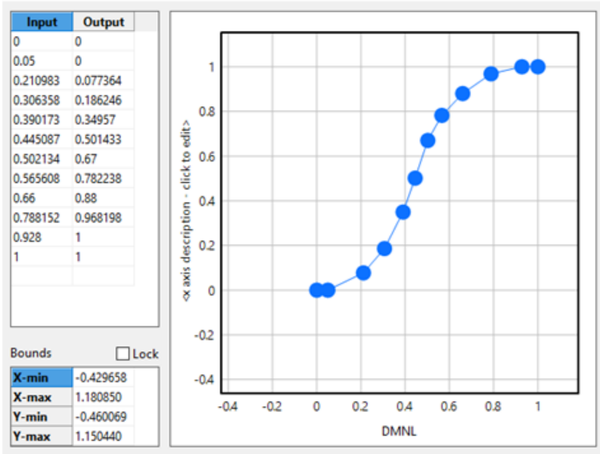
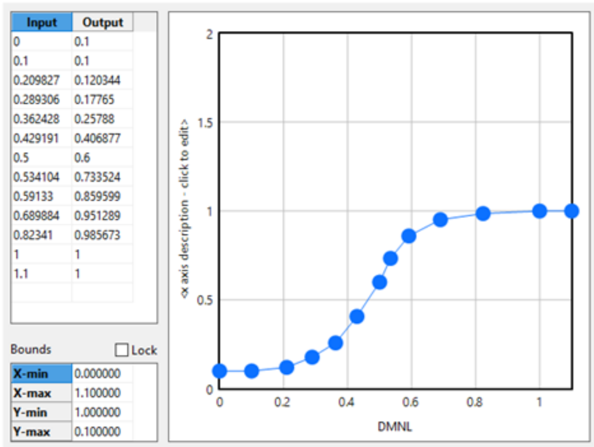
Converter set - 1	Formulation	Lookup Function Graph
Productivity/Efficiency	WithLookup (Enery Level of Women)	
Recovery fraction	WithLookup (Enery Level of Women)	

Table A1. Converter set-1 with related lookup functions.

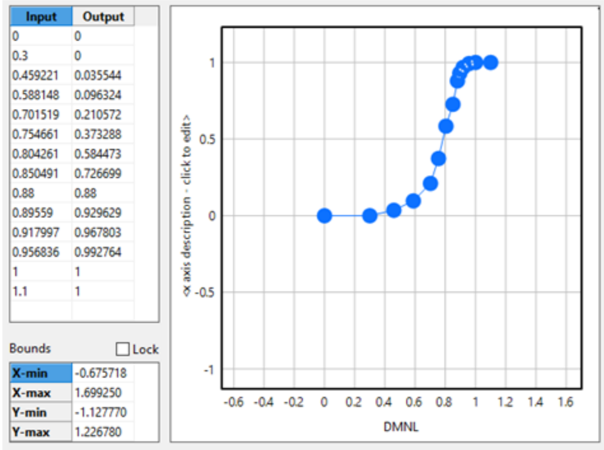
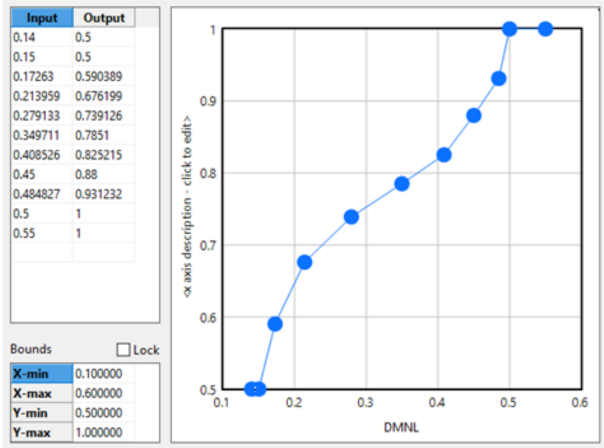
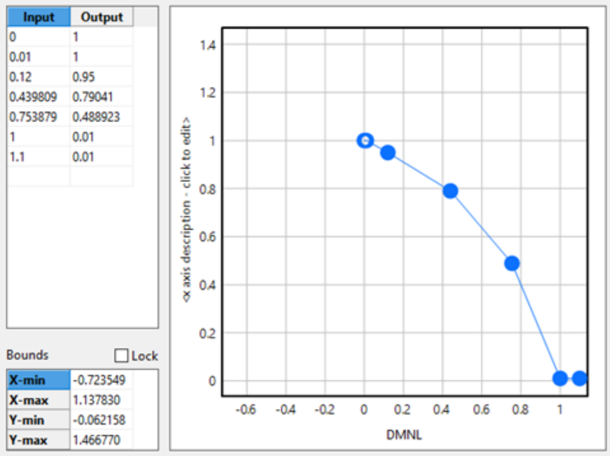
Converter set - 2	Formulation	Lookup Function
EffofProductivy	WithLookup(productivity/efficiency)	
EffofFemaleRatio	WithLookup(current female ratio)	
EffofPayGap	WithLookup(gender pay gap)	

Table A2. Converter set-2 with related lookup functions.

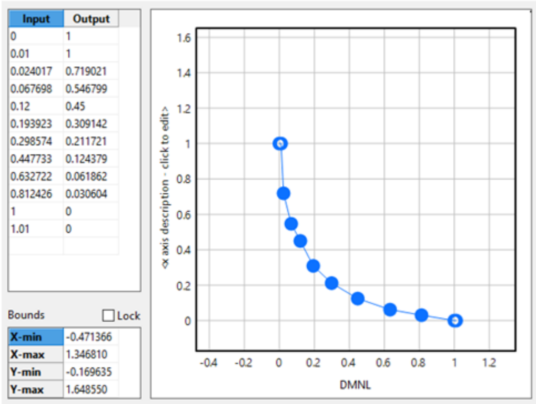
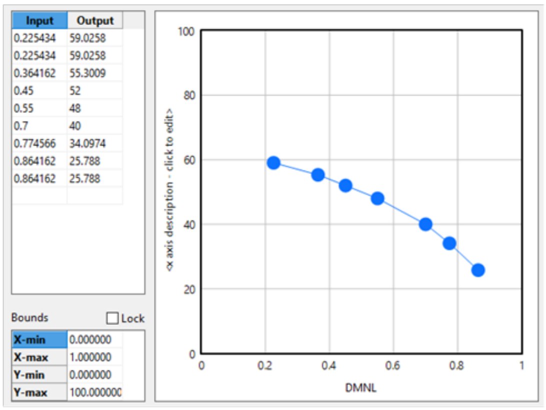
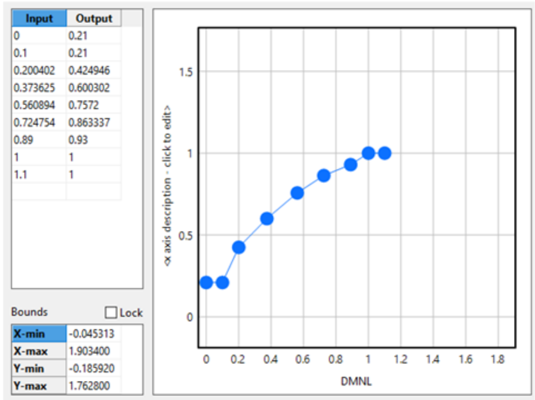
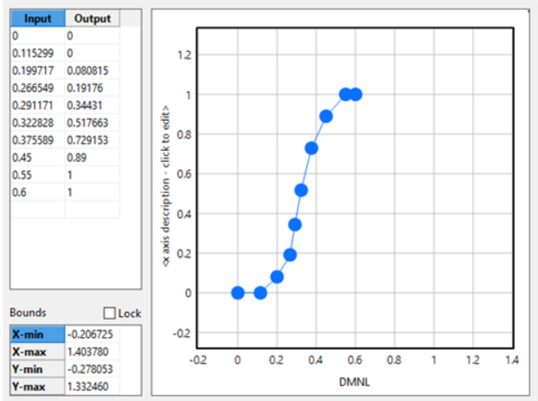
Converter set - 2	Formulation	Lookup Function
Childcare service access	WithLookup(gender pay gap)	
Maternity leave duration	WithLookup(Childcare service access)	
EffofMentorship	WithLookup(mentorship)	
Mentorship	WithLookup(current female ratio)	

Table A2. Converter set-2 with related lookup functions (Continue).

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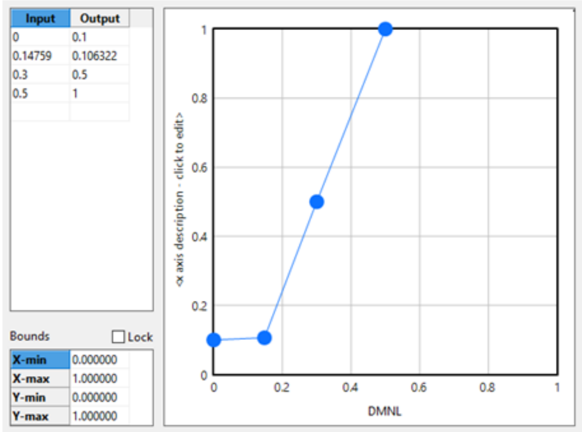
<tr><th>Converter set - 3</th><th>Formulation</th><th>Lookup function</th></tr>
<tr><td>Inclusivity</td><td>WithLookup(current female ratio)</td><td>
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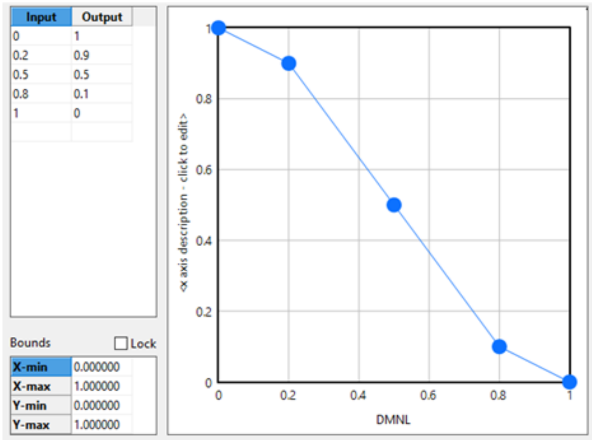
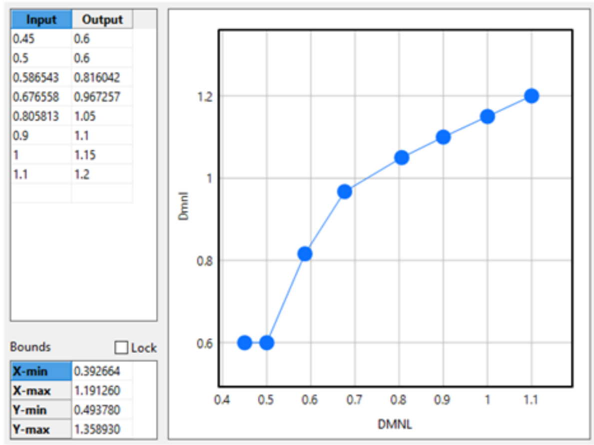
<tr><td>Masculinity</td><td>WithLookup(inclusive organizational culture)</td><td>
</td></tr>
<tr><td>EffofProductivityonHiringRate</td><td>WithLookup(productivity/efficiency)</td><td>
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Table A3. Converter set-3 with related lookup functions.