A Model to Assist Leaders Increase Diversity in their Organizations

Abstract

In this paper, we discuss how an exploratory System Dynamics model that was developed in an earlier study [will be cited after review] was validated, calibrated, and applied to a real organization. The leaders of the organization could see where they were in terms of diversity, how it got there, and if nothing changes where it is heading in the future. The model provided useful insights about what might need to change to reach a specific diversity goal in a specific amount of time. We tried to demonstrate how this might work by conducting some scenario analyses. In our case study, we showed that diversity was fairly high in the organization and had been increasing in the past. However, based on projections into the future, it appeared the diversity growth may be expected to slow. We showed simply removing bias in hiring and promoting may not provide the desired level of diversity in a reasonable amount of time and that more affirmative action may need to be taken to reach a stretch goal. This model has the limitation that policies were assumed to take effect immediately. This approach will be changed in future work to see how policy implementation time might delay desired results. Several feedback loops could be added to the model in future work. This model could be expanded and potentially applied to a large organization. It could also be converted to an Agent-Based Simulation to be better applied to very small organizations.

1. Introduction

In July 2020, the System Dynamics Society established a Special Interest Group on Structural Racism [1]. As of November 2020, the Special Interest Group was still developing a set of objectives and goals. One of the objectives of the authors of this paper is to demonstrate the value of quantitative System Dynamics models in developing strategies to overcome Structural Racism which was suggested in a seminal paper [2]. One of the first quantitative models developed was an exploratory model of bias in hiring and promoting Black, Indigenous, and People of Color (BIPOC) individuals in organizations. This model was based on one developed to determine policies to avoid bias and increase the diversity of women in the Science, Technology, Engineering, and Mathematics (STEM) fields in higher education [3, 4, 5, 6].

According to the 2016 Census visible minorities made up 21.3% of the working population of Canada and indigenous people made up another 4% [7]. There are many ways in which racism shows up in the Canadian workplace [8, 9, 10, 11]. However, in this study, we will focus on the ability of organizations to increase diversity.

We built a System Dynamics model of a stylized organization that includes many of the elements of bias in hiring and promoting BIPOC and shows its impact on its diversity over time. Our model contains more than 20 parameters that can be manipulated to affect the diversity of the organization.

In Section 2, we provide the Stock and Flow diagrams for its various sectors and the formula used to estimate the probability of hiring a minority applicant or promoting a minority worker. In Section 3, we show how this model was applied to a real organization and how the model was validated, calibrated, and used to make projections

into the future. We examine some scenarios to show how the model might provide insights into how a diversity goal can be achieved in a reasonable amount of time. In Section 4, we provide conclusions and possible directions for future research.

2. The Stock and Flow Diagrams[1]

The goal of this model is to determine how policies might be implemented to improve diversity levels. We will look at an organization where the initial values are set in 2013. So the values between 2013 and 2020 are considered the historical patterns of behavior. We implemented a switch in the model in 2020 that can be used to introduce policies that affect future patterns of behavior. Our model considers a highly stylized organization consisting of only two types of employees (workers and managers) from two simple populations (the majority and the minority).

We will begin our examination of the model by looking at how the number of worker positions is determined[2] (see Figure 1). We begin with an initial number of workers in the organization[3] and assume that the initial number of worker positions is equal to this value. Therefore, we assume that when we start the simulation all the worker positions are filled. We have several worker positions[4] added per year, the actual number of worker positions will seek to reach this value. Over time the actual number of positions may be higher or lower than the number of worker positions filled which is the

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[1] In this study, we found the advice of Sterman [12] and Richmond [13] useful in formulating the model. We used the special purpose package called Vensim [14] to formulate and describe the model. However, we converted this model to Microsoft Excel [15] and used the Solver to calibrate the model and look at some policies that could be applied under various scenarios.

[2] The worker positions is a stock and we use capital first letters as a naming convention to distinguish them from external parameters and endogenous variables.

[3] This value could be considered as an exogenous variable and therefore shown in all capitals. However, for simplicity, we calculate this value based on other exogenous variables. So, we have labeled it with all small letters to show it is calculated inside the model and therefore endogenous.

[4] This is an external parameter that takes on a constant value. External parameters influence all of the calculations in the model and are shown in all capitals. Their values will be considered as input to the model and their influence on the diversity of the organization will be examined in the next section using a design of experiments approach.

sum of the majority workers and minority workers. We subtract the worker positions filled from the current worker positions to obtain the open worker positions[5]. If there are more employees than positions, we set the open positions to zero[6]. There is a parallel system for the management positions as shown in Figure 2.

Figure 1. Establishing worker positions
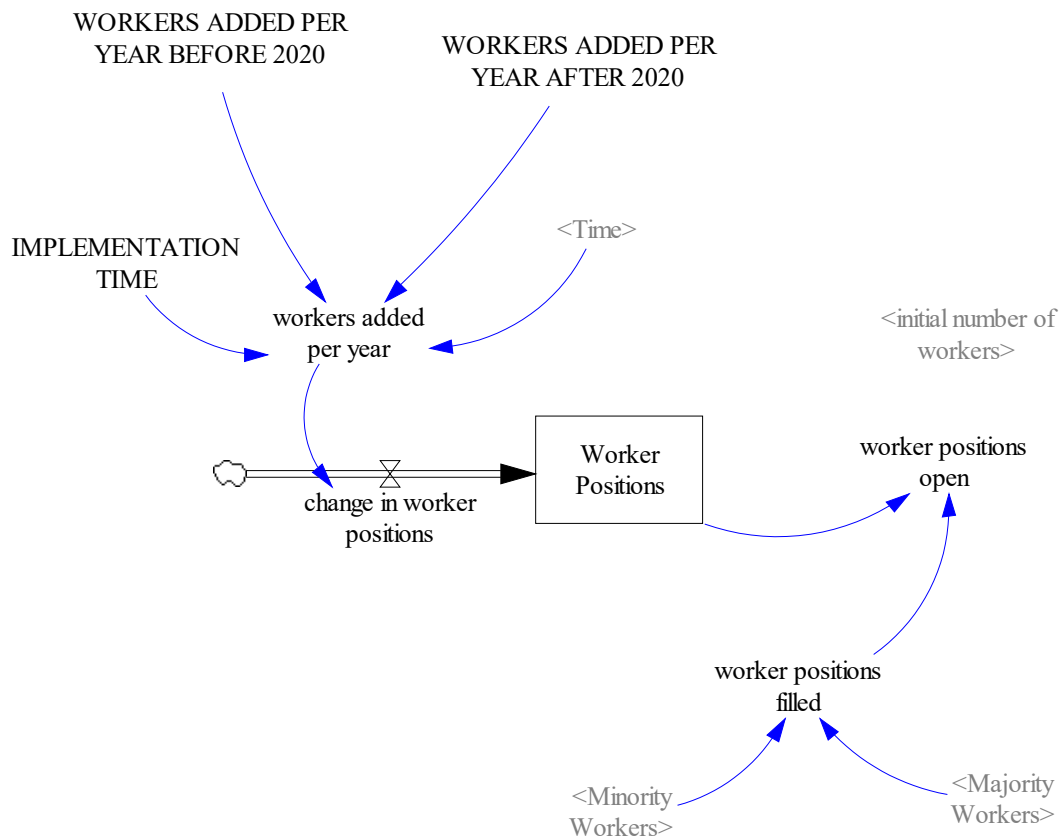
**Figure 2. Establishing management positions**

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[5] The idea of open positions was also an important contribution of the work of Rúa Gómez and Arias-Gaviria [3, 4]. They focused on tenured STEM positions in academia. Again, we saw no reason to restrict this idea to academia and we are simply applying the idea to a generic organization.
[6] Notice that the worker positions are a related but different concept from the workers in those positions.
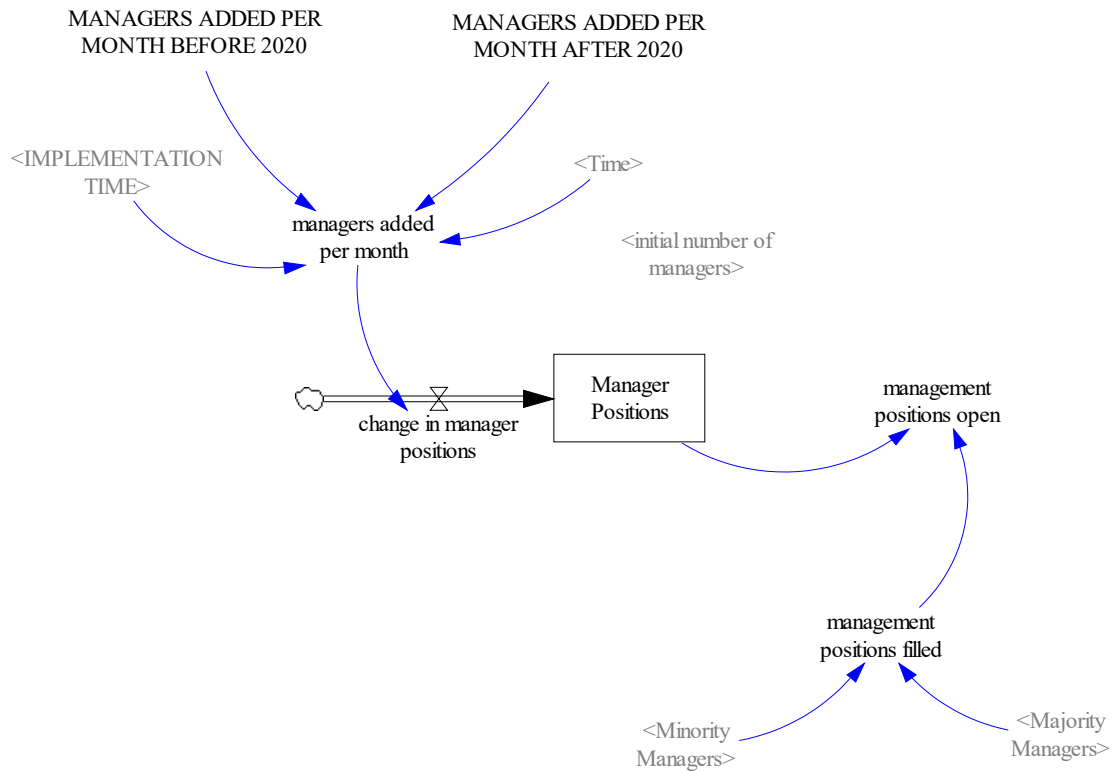
The next sector of the model that we will look at is the hiring and promotion of people from the majority population. The people in the organization from the majority population are shown as moving from left to right in Figure 3. There are initial values for the number of applicants, workers, and managers from the majority population. When a worker position comes open, which was calculated in Figure 1, there is a certain probability the position will be filled by an applicant from the majority population. We will see how this probability is calculated in a subsequent sub-model. It will take some time to conduct the recruitment process of application evaluation and interviews and this is shown as the time to hire a worker.

Figure 3. Hiring and promoting from the majority population
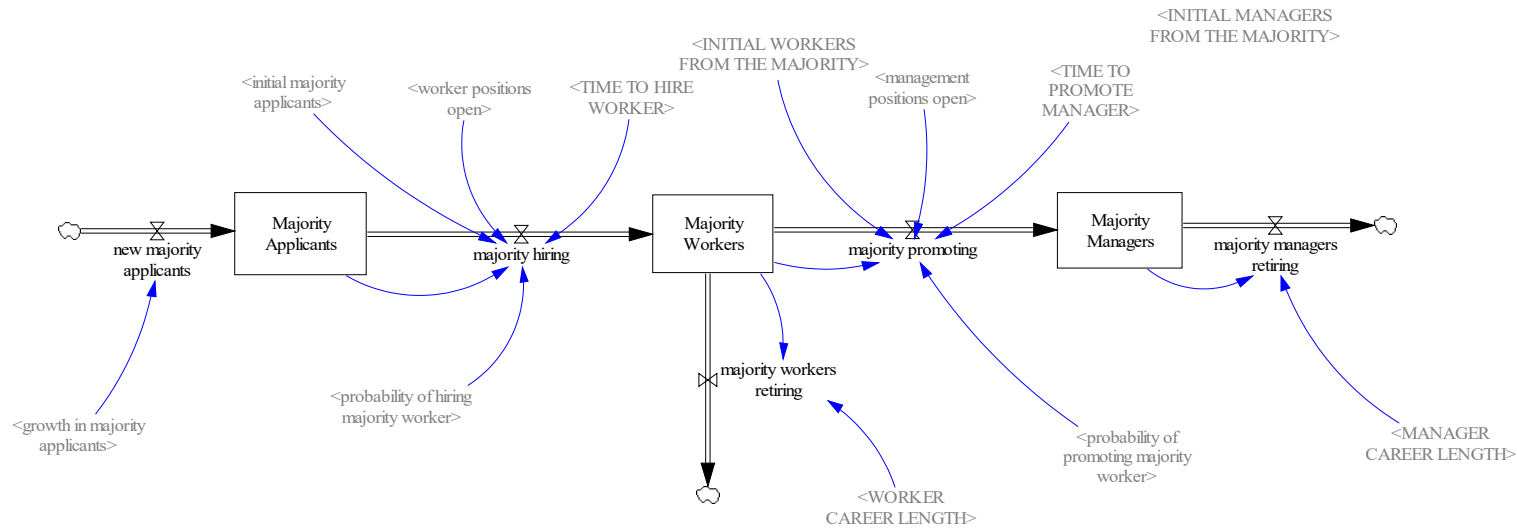
# Figure 4. Hiring and promoting from the minority population
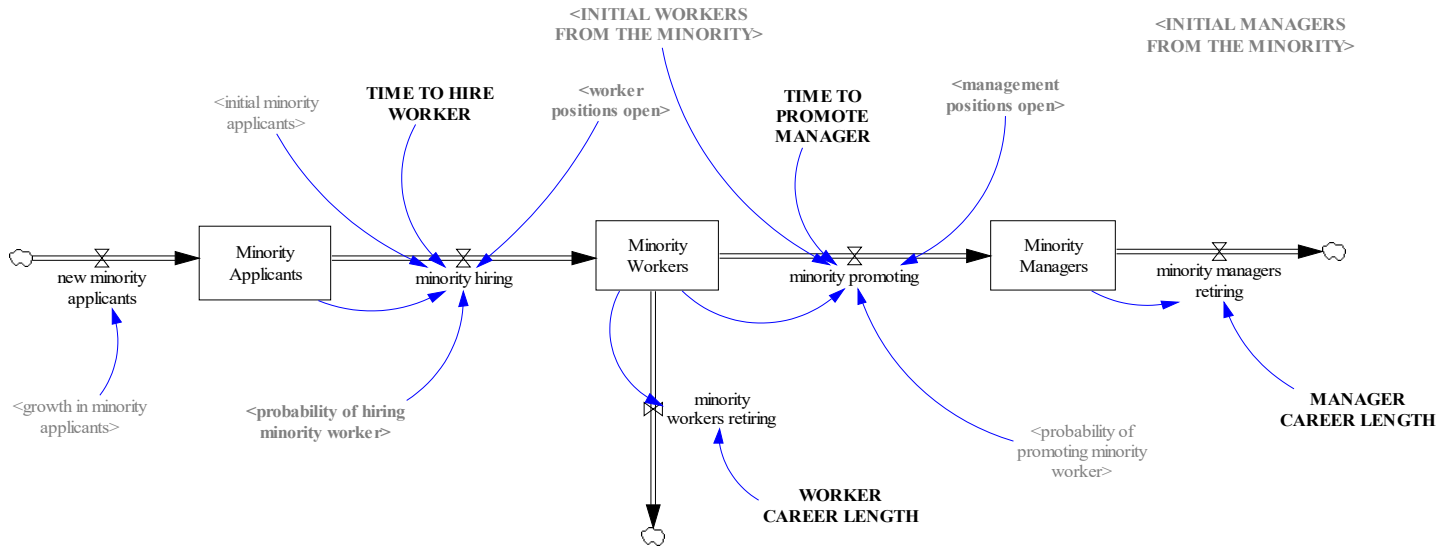
Some workers will retire or leave the organization after a relatively long career while others may leave the stock of workers by being promoted to management. When a management position comes open, there is a certain probability of promoting a worker from the majority population to that management position. The process of opening the management position was shown in Figure 2. The probability of promoting a worker from the majority population is calculated in a subsequent sub-model. It takes some time to obtain candidates for promotion and conduct the competition process before the management position will be filled. Then, it is assumed that the managers from the majority population will retire or leave the organization after a reasonable number of years. There are exactly parallel processes for hiring and promoting people from the minority population as shown in Figure 4.

Before we move on to the biases in the hiring and promoting processes, we will take some time to consider the population outside the organization. There is a population from the minority and the majority, which are stocks, that change based on their net growth rates (see Figures 5 and 6). It should be noted that the population growth rates for the minority and majority populations may be different.

In Figure 5, we calculate the growth in the number of minority applicants which is a flow into the Minority Applicants stock in Figure 4 by multiplying the net growth in the minority population by the proportion of the minority population with the necessary qualifications and the proportion of the qualified minority population who are interested in the organization. We also calculate the initial value for the minority applicants by subtracting the number of workers and managers from the minority population already in

the organization. In Figure 6, we see the same structure to obtain the majority applicants'
growth rate.

Figure 5. The growth in potential minority applicants
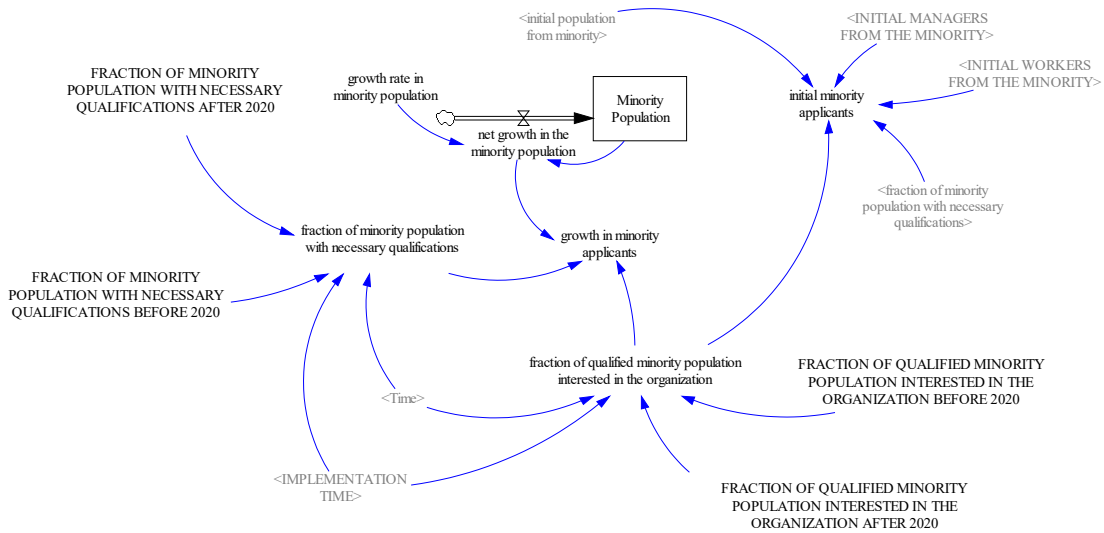
Figure 6. The growth in potential majority applicants
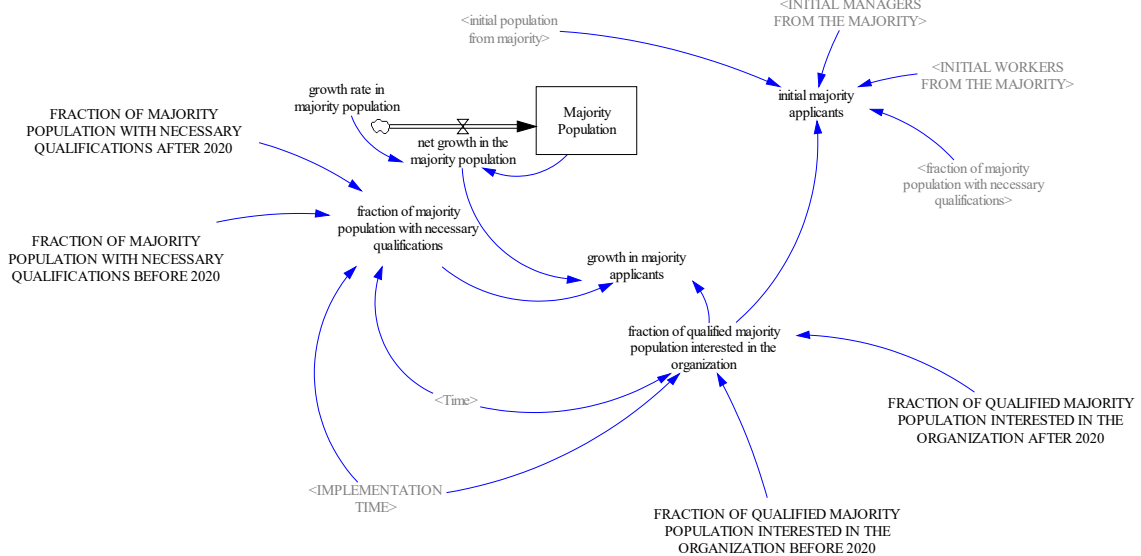
Now that we have covered the preliminaries, we will look at the modeling of bias in the hiring and promoting processes[7]. We will begin with the simplest part of the hiring bias sub-model which is systemic bias. We assume that managers in the organization form a hiring board and they may have a bias towards or against hiring a worker from the majority. The bias towards hiring a person from the majority is a simple proportion representing the proportion of majority applicants who will be hired when there is a choice between two applicants, one from the majority and one from the minority. If this value is 0.5, there will be no bias. If this value is greater than 0.5, there will be a preference to hire the majority applicant. If this value is less than 0.5, there will be a preference to hire the minority applicant.

Now we will examine the effect of self-bias in the minority and the majority population on the number of people who will apply for a position in the organization. Self-bias might be based on the potential applicant's perception of the chance of getting the job if they apply or possibly the perception about the inclusiveness of the organization if they are hired. We will begin with the self-bias of a qualified and interested majority person. We have already seen how the number of majority applicants is calculated in Figures 4 and 6. All of these people may apply for the job. By multiplying one minus the self-bias and the applicants from the majority, we obtain the actual number of applicants from the majority population.

Now we will look at the minority applicant's self-bias. That is, how much the potential minority applicant can see themselves working in the organization. By

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[7] These models of bias in the hiring and promoting processes were inspired by the work of Rúa Gómez and Arias-Gaviria [3, 4].

multiplying one minus this self-bias and the potential number of applicants from the minority, we get the actual number of applicants from the minority population.

So, now that we have the actual number of applicants from the majority and the actual number of applicants from the minority, we calculate the proportion of the applicants who are from the minority population. Since by assumption all of these people are qualified for the job, we can calculate the probability of hiring a person from the minority by applying the following formula:[8]

*probability of hiring minority worker = (1 - bias towards hiring majority worker) * the proportion of applicants that are from minority / ((1 - bias towards hiring majority worker) * the proportion of applicants that are from minority + bias towards hiring majority worker * (1 - the proportion of applicants that are from minority))*

There is a parallel model of the systemic and self-bias in the promotion process. In this case, the applicants are replaced with workers inside the organization who compete for an open management position. The systemic bias towards promoting a worker from the majority population is based on the promotion board's impression of how well a majority worker would fit into the management team compared to a minority worker. The proportion of majority and minority workers competing for a management position is based on the maximum number of workers who are interested in a management position and a self-bias effect. The maximum number of workers interested in a management position is based on an external parameter representing the proportion

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[8] See [3 and 4} for a full description of the formula.

of the workers in each group interested in a management position times the total number of workers in each group. One minus the self-bias for each group multiplied by the maximum number of workers interested in a management position from each group gives us the actual number of workers from each population who will compete for an open management position. From these values, we can obtain the proportion of workers from the minority who compete. Then combining the systemic bias and the proportion of workers from the minority competing, we can obtain the probability of promoting a minority worker to an open management position. The formula is similar to the one for hiring.

> *probability of promoting minority worker = (1 - bias towards promoting majority workers to managers) * the proportion of minority workers competing for management position / ((1 - bias towards promoting majority workers to managers) * the proportion of minority workers competing for management position + bias towards promoting majority workers to managers * (1 - the proportion of minority workers competing for a management position))*

This is a complete description of the System Dynamics model of a stylized organization. The Vensim and Excel versions of this model are available through this website[9]. We will now use this model along with reasonable estimates for the external parameters to examine the change in the diversity of the stylized organization over time. Then we will conduct a few simple scenario analyses to find policies and strategies to

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[9] Link will be added after review.

change the model parameters in ways that might improve the diversity of this stylized organization.

3. Scenario Analysis

3.1 The baseline case
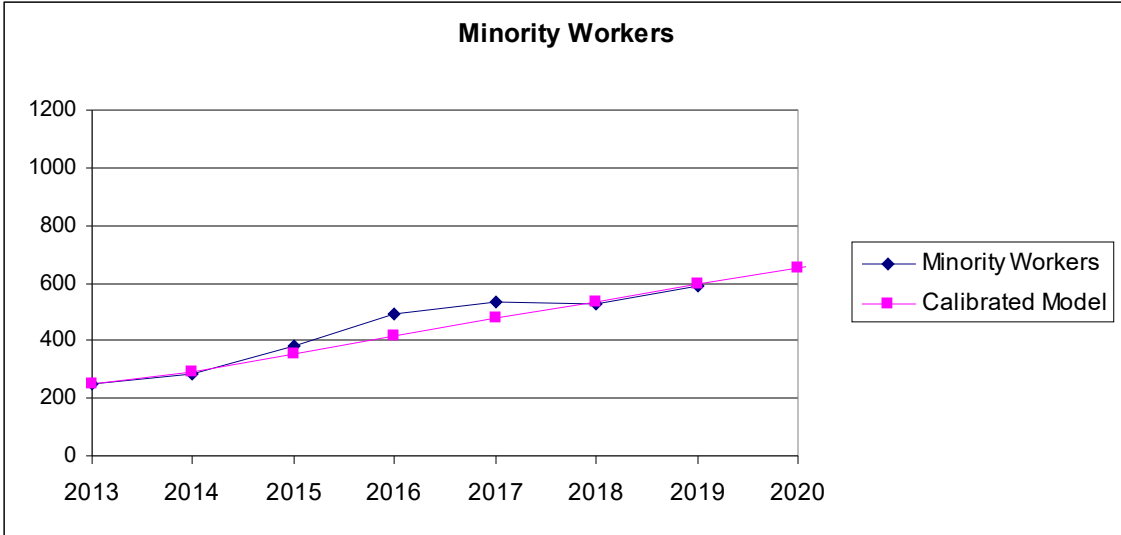
The model was calibrated using time-series data from the organization. We can see in Figures 7 through 10 that the model was able to replicate past behavior in the system.
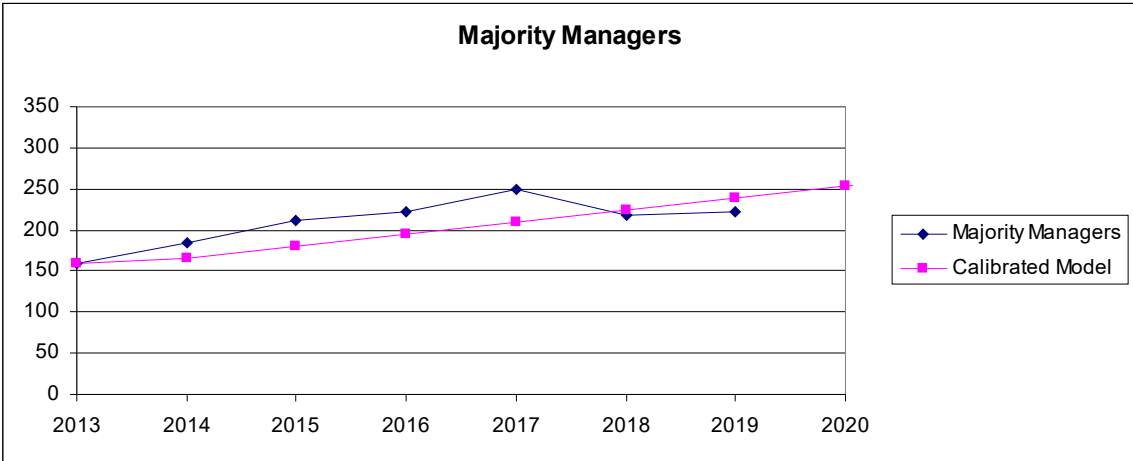
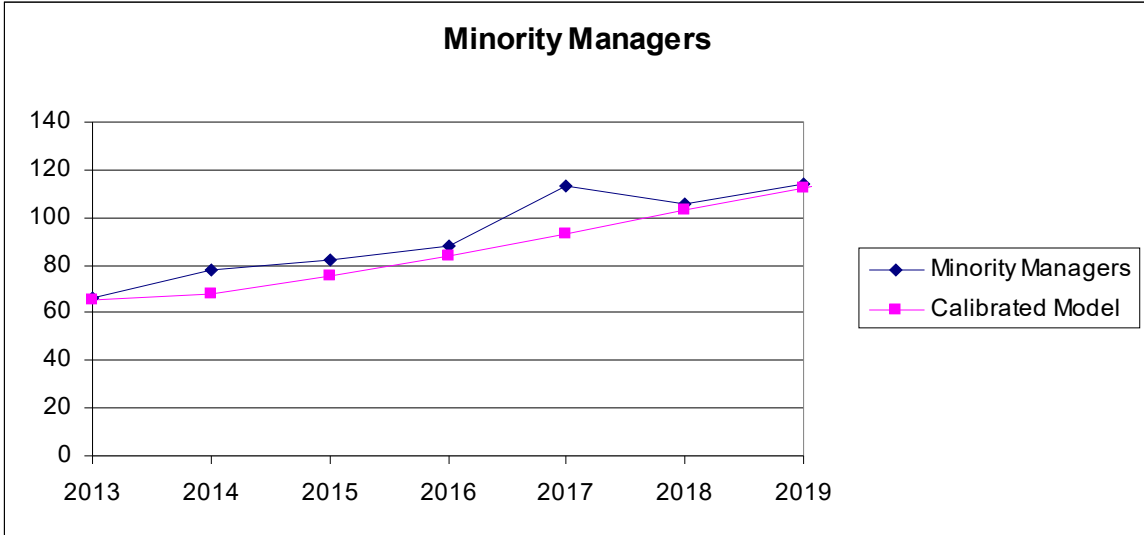**Figure 7. Model calibration for majority workers**
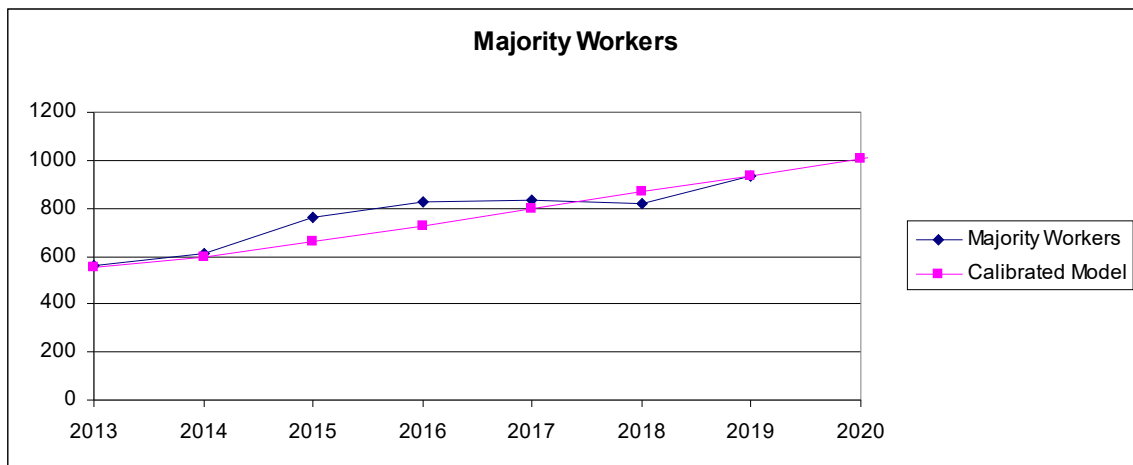
Figure 8. Model calibration for minority workers

Figure 9. Model calibration for majority managers

Figure 10. Model calibration for minority managers

Minority Managers

Tables 1 and 2 show the model parameters obtained from the calibration that were used to establish the baseline results for the scenario analysis. It was possible to estimate these values for the organization using a time-series on the number of employees from the majority and the minority in the organization over the period 2013 to 2019 assuming there was no bias in the hiring or promoting processes. We assumed the population that we were drawing employees from consists of 19,500,000 people of which 25% are from the minority. However, only a very small number of these people have the necessary qualifications to apply for an entry-level job (0.82% of the majority and 0.13% of the minority). This was compensated somewhat by the interest of the minority in the organization compared to the majority (20% for the minority and 1.7% from the majority). However, it was estimated that the majority employees were slightly more interested in promotion compared to minority employees (55% to 47%).

Table 1. Baseline parameters based on majority and minority populations

Parameter Name	Majority	Minority

Net Population Growth Rate	0.015	0.015
The Proportion of Total Population	75%	25%
Initial Number of Workers	550	250
Initial Number of Managers	160	65
The Proportion with Necessary Qualifications	0.82%	0.13%
The Proportion of Qualified Population Interested in the Organization	1.7%	20%
The Proportion of the Workers Interested in a Management Position	55%	47%
Self-Bias Effect on Applicants and Workers	0.5	0.5

Table 2. Baseline parameter settings based on the organization's workers and managers

Parameter Name	Workers	Managers
Initial Number of Positions	800 people	225 people
Positions Added Per Year	135 people/year	25 people/year
Time to Change Positions	2 months	4 months
Career Length	30 years	15 years
Time to Hire or Promote	3 months	6 months

In 2013, 31% of the workers were from the minority and 29% of the managers were from the minority population. We can see in Figure 11 that if there is no bias in the hiring and promoting processes, the proportion of the workers grows steadily as does the proportion of the managers from the minority. We can see if nothing changes the organization might expect to obtain nearly 40% of its workforce from the minority by 2025.

Figure 11. Behavior over time of the proportion of workers and managers in the organization from the minority

Diversity Levels

Proportion of Minority Workers : Baseline
Proportion of Minority Managers : Baseline

3.2 Scenario analysis

Now we will examine a stretch goal to reach 50% diversity by 2025. First, we will examine the situation where there is no bias in the hiring or promoting process and the only thing changing is the interest of the minority in joining the organization or seeking promotion if they are working in the organization. We will assume all other things are equal. Even when we increased the interest levels to 100% for both minority applicants and minority workers, we can not reach the diversity goal of 50% (see Figures 12 and 13). There is a modest improvement in the diversity level of the worker population and there is a more substantial improvement in the diversity of the management team.

Next, we will consider the possibility of adding affirmative action as an additional strategy to achieve the diversity goal of 50%. In this case, if we increase the interest level

of the qualified minority in the organization from 20% to 80% and increase the interest in management among minority workers from 47% to 67% then by applying an affirmative action strategy which would favor minority applicants 92% of the time and favor minority workers 70% of the time, we could achieve the 50% diversity goals by 2025 as shown in Figures 14 and 15. Thus, we can see that achieving this stretch goal would be very difficult even under the best possible conditions.

4. Conclusions and Future Work

We have seen how a quantitative System Dynamics model of hiring and promoting employees can be realistically applied to look at increasing the diversity in an organization. We can see the nature of systemic and self-bias and can thus make some interesting observations on their impact. In particular, we found that simply getting rid of systemic bias and self-bias will not result necessarily in the organizational leaders reaching their diversity goals in a reasonable amount of time. This type of model could provide insight into the types of policies or combinations of policies that could be developed to reduce the time necessary for the organization to reach an ideal level of diversity.

Figure 12. Improvement in diversity after 2020 when 100% of the qualified minority applicants are interested in applying for an entry-level job in the organization

Proportion of Minority Workers
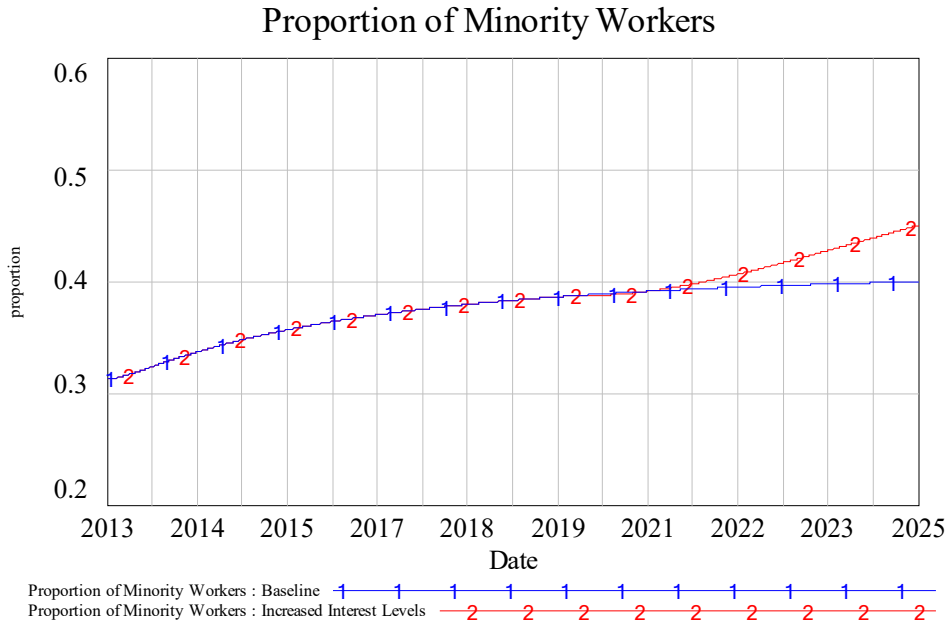
Figure 13. Improvement in the diversity of the management team after 2020 when 100% of the minority workers are interested in applying for a management position

Proportion of Minority Managers
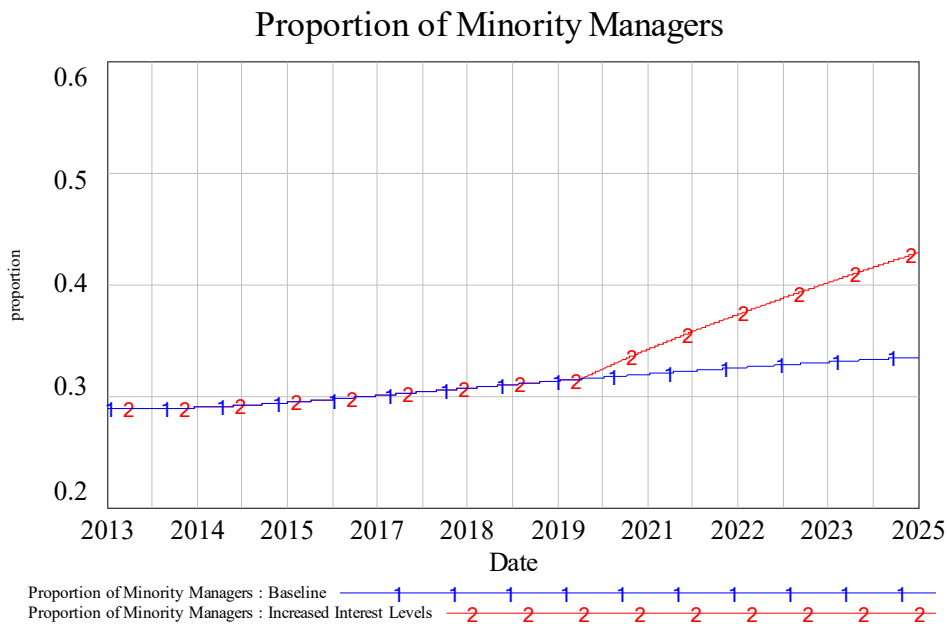
Figure 14. Improvement in diversity among the workers with changes to the interest levels and affirmative action

Proportion of Minority Workers
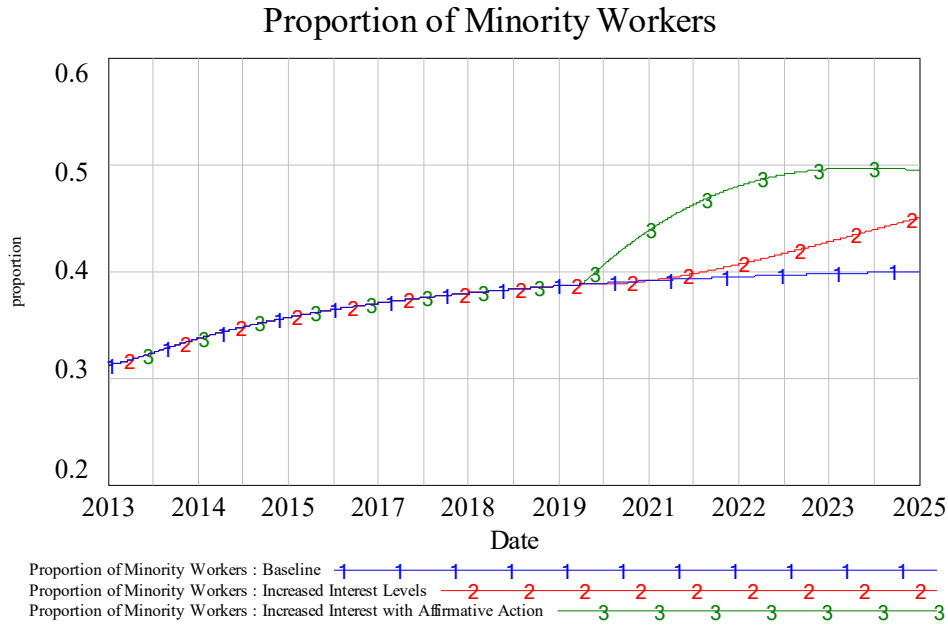
Figure 15. Improvement in the diversity of the management time with changes in the interest level and affirmative action

Proportion of Minority Managers
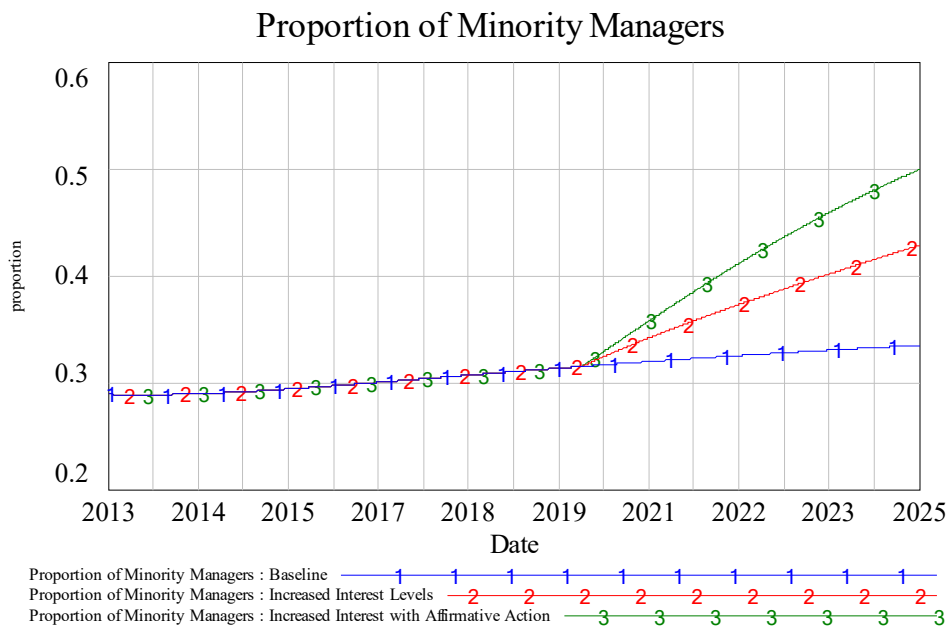
For example, changes in the qualifications necessary to apply for an open worker position, and changes in the interest in the organization, and interest in a management position in the organization can significantly improve diversity over time. Although not shown in this paper, we found that expansion or contraction of the organization will not increase or decrease the diversity by a great degree. This was a surprising result because it was felt that opening up positions to hire into should help the diversity level. However, it was found that this would only be the case if it was combined with pro-active policies regarding qualifications, interest, and affirmative action.

This model examines the diversity of the management team somewhat independently of the diversity of the worker population in the organization. The nature of the model, with only internal promotions to management, means that the change in diversity will be even slower in the management team. However, similar factors that were found to be useful in improving the diversity of the worker population could be applied to the management team.

In our case study, we found that the minority was at a significant disadvantage in terms of the percent of the population with the necessary qualifications to apply for an entry-level job. We examined historical data and found that the organization had achieved a considerable amount of diversity in the past and the diversity level had been growing over time. We hypothesized that if there was no bias in the hiring and promoting processes, this might be explained by the fact that the minority individuals may be more interested in working in the organization than the typical individual from the majority.

When we calibrated the model and used it to project into the future, it was felt that the organization had a good chance of reaching a 40% diversity level by 2025. However,

we found that although there had been a large increase in the diversity levels in the past, those rates of increase would not likely be seen in the future. So when we looked at a stretch goal of reaching 50% diversity by 2025, we found that it would not be possible by increasing the interest levels by themselves. An affirmative action program would be required to favor members of the minority in the hiring and promoting process

One limitation of the current model is that when policies are implemented it is assumed they have an immediate effect, that is, there is no time lag to implement the policies and start seeing results. It is quite possible to model the gradual increase and decrease in the parameters over time after a policy is implemented or rescinded. It would also be useful to model policies that change the parameters dynamically so that the policies adapt to the changing levels of diversity in the organization with some parameters increased or decreased to obtain more rapid growth in diversity but then moving to the no-bias parameter settings as the ideal level of diversity is reached.

Furthermore, it would be interesting to examine other changes in parameter levels over time. For example, population growth rates are not constant but will be affected by many different social and political factors, such as changes in birth rates, life expectancies, and immigration levels. Similarly, qualification levels are not static but instead change over time based on changes in the education system.

Several other feedback loops should be considered in future work. In particular, the impact of inclusiveness, or the lack of it, should have an impact on the average career length. It could be imagined that self-bias might not just relate to the choice to applying for a job or a promotion but might also relate to continuing the individual's career in the organization. Also, morale could be modeled explicitly and this might lead to positive or

negative word-of-mouth influences on the interest in the organization as a good one to work in or one where there is a good chance of upward mobility.

We can envision the expansion of this model to include more sub-organizations and more levels of management so that it could be applied to a more complex organization. We have demonstrated that historical data on the past patterns of diversity along with other information can be used to estimate the parameters of the model. With these parameter values to initialize the model, we can determine where the organization is currently in terms of diversity, how it got there, and where it might be heading in the future if nothing changes. Then the nature and effectiveness of the potential policies could be examined by the organization's leaders to determine if a better state of diversity could be reached in a reasonable amount of time. This would include the recognition that some past policies had detrimental effects and these need to be corrected.

The use of System Dynamics with its highly aggregated populations and its continuous flow of people throughout the organization might not be as applicable to small organizations, large organizations with many sub-organizations, or if many different minority groups were evaluated for their diversity. This limitation can be corrected in future work as we develop an Agent-Based Model of hiring and promoting in an organization that models employees as individuals, with statistically distributed characteristics. There would appear to be no limitations to translating the System Dynamics model into an Agent-Based Model. However, the analysis of the results would require a large number of replications and careful statistical analysis to remove the noise in the results created by using a random number generator with the probabilities of

different outcomes at each stage of the model. Thus, it is likely that considerable computing power would be required.

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