Low Income Housing in the Context of Jay Forrester's Urban Dynamics: A Lesson in Framing

Abstract:

This paper is a challenge to Jay Forrester's Urban Dynamics model. The resulting alternative model is compared to Urban Dynamics by running tests of actual U.S. Housing policies.

Karen Jarzynka
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I. Introduction

Adequate, safe, sanitary and affordable housing for low and moderate income people has been in short supply in urban areas at least since the industrial revolution. The very real issue of poverty in the United States was brought to the attention of the whole world in the recent media cover of Hurricane Katrina. People living densely packed together with no means of transportation and no money to go spend a few nights in a hotel were left behind to fend for themselves as New Orleans was destroyed by the hurricane. In a speech in Katrina's aftermath, Bush said that funding for the housing of victims would come from the budgets of existing programs. Congress passed $3.5 billion in housing vouchers for the victims (Hulse 2005) but with the shortage of units that will accept such vouchers, people on waiting lists pay the price with increased waiting. In a Philadelphia example relocated hurricane victims were moved in to Section 8 housing ahead of all 47,000 local people on the waiting list (Moran 2005). Such policy places burden on low income persons who do not get their housing voucher because it was granted instead to a Katrina victim.

Jay Forrester's Urban Model (Forrester 1969), showed the dynamics of city in both its growth and decay phases. He used this backdrop to study a series of urban renewal policies. His results showed that building low income housing was detrimental to the city. This paper is a challenge to his model and is a subset of my Master's Essay of the same title.[1] A solid understanding of Forrester's model is assumed in this paper. Without it, the challenges make very little sense. Appendix A contains Forrester's model equations.

[1] A copy of my master's essay is included with the supporting documentation at the system dynamics society website along with the appendices. An overview of the Forrester model is described in section I of that paper.

Opponents of subsidized housing claim that the free market can provide enough low income housing, but it has failed to do so. Jay Forrester's Urban model illustrates this by showing crowding. In fact his Housing Density constants show low income housing density twice that of middle income housing density and four times that of upper income housing density. These same opponents concede that it takes two earners at minimum wage to afford housing in this country (Husock 2003). Obviously not all households have that luxury. I am an advocate of housing assistance to various groups: to low income seniors who want and are able to live on their own, to low income people with children to provide a stable environment and to encourage exodus from detrimental living conditions, to homeless people to get them out of shelters and to those whose mental or physical limitations make them unable to fully support themselves and their families. Despite, the U.S. Department of Housing and Urban Development's (HUD) apparent propensity toward scandal[2] (Husock, 2003), housing assistance for those in true need should not be eliminated.

In Jay Forrester's Urban Model, he proposed a series of housing policies and showed their implementation effects in his model. They all failed to improve the city and sometimes accelerated the deterioration of it. In section II of this paper I make a set of challenges to Forrester's model. I make and test changes to the model. In section III, I compare the 2 models in test runs of various housing programs that have been implemented in the United States. Forrester's model predictions match researched evaluations of some policies. In section IV, I discuss Forrester's framing of the question. His results state that no short term policy that positively affects the lowest economic end of the population is beneficial to the city. This result

[2] This is just one of many possible sources for the charge of corruption in HUD programs throughout the history of the agency, both at the local and federal levels.

must be contested. His model uses economic stagnation of the city as the measure of urban success, but that is not the only way to frame the question. Quality of life, minimum living standards and who gains and who is hurt in policies concerning urban renewal and slum demolition also could be used as measures of success. Literature on this topic discusses differing policy maker's criteria and the difficulties in measuring the importance of each policy maker's criteria (Andersen and Rohrbaugh 1992 and Gardiner and Ford 1980). Finally conclusions are stated in Section V.

II. Challenges to Urban Dynamics

There are various ways to challenge a model. One is to question the structure. Does the structure represent real life? Do the assumptions about the model's structure cause reliable dynamics? The first challenge of the placement of all low income housing into a single stock regardless of its livability is in this category. A second way to challenge the model is to question its parameters. Are the values realistic? Are the graphical variables reasonable shapes? Are there missing parameters? The second set of challenges fall into this category. The shape of one of the attractiveness factors for the underemployed is challenged, the attraction to the city due solely to the existence of subsidized housing. Next, the omission of racism as a parameter in the model is questioned. A third way to challenge the model is to find an exception case. Forrester's model is of a generic city. Modifying parameters should be able to show the deterioration of a real city. If a city can be identified and shown to not be replicable in the model, then something else is missing in the model. Detroit is used as the hypothesis city.

The reasoning behind each challenge is discussed. The model changes or variable changes are described. Results are shown graphically, each with a comparative run to make the changes more evident. Finally, the results and implications to the model are discussed.

A. Livability of Low Income Housing

Forrester states on page 8 (Forrester, 1969), in the stagnant city there is crowding and empty housing at the same time. The ratio of people to housing may be low, but for economic reasons, many of the dwellings are unoccupied. Scarce jobs and low income force people to share space and rental costs.

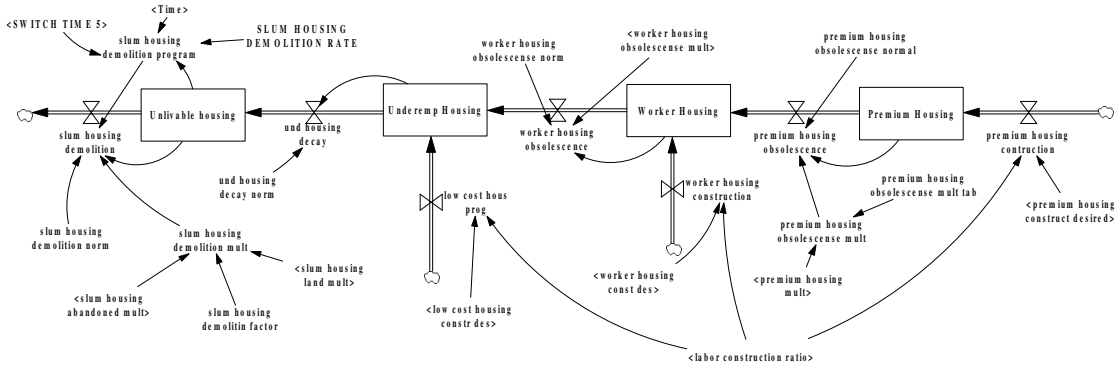
In Forrester's model the land used by housing is the sum of the three housing stocks. No where is there land being used up by unlivable or empty housing. This housing therefore, must be included in the low income housing stock. There are differing opinions on the number of vacancies in very low income units, but most agree that the vacancies often indicate inadequate living conditions. Many of the units have been condemned (Wright, et. al. 1998).

Two problems occur because of this structure. The first is that the actual availability of housing for the underemployed is inflated. As one of the attractors for the underemployed population, an inflated availability will draw them to the city quicker. Second, when Forrester applies his low income housing construction policy (or any of his policies for that matter), the ratio of low income households to housing units is below one. This implies that there is no low cost housing shortage. Adding additional housing, when there is no discernible housing shortage, does not make sense. The result, of course, is an increase in underemployed persons entering the city and because of the added attractiveness of these subsidized units as discussed above, not only do the underemployed arrive but they do so in large numbers.

To address these issues, the model is modified by adding an additional stock at the end of the housing chain to account for the "unlivable" housing. In so doing, the non- livable underemployed housing is removed from the livable underemployed housing stock. Variables concerning attractiveness use the crowding factors based only on the livable housing. Demolition

of housing is based on non-livable housing. The original normal deterioration rate is split between the two rates (und housing decay and slum housing demolition), such that the time for deterioration is unchanged from the original model. See the model structure in Figure 1 and the model run results in Figure 2. For equations changes, see Appendix B.2

Figure 1. Unlivable Housing Model Changes



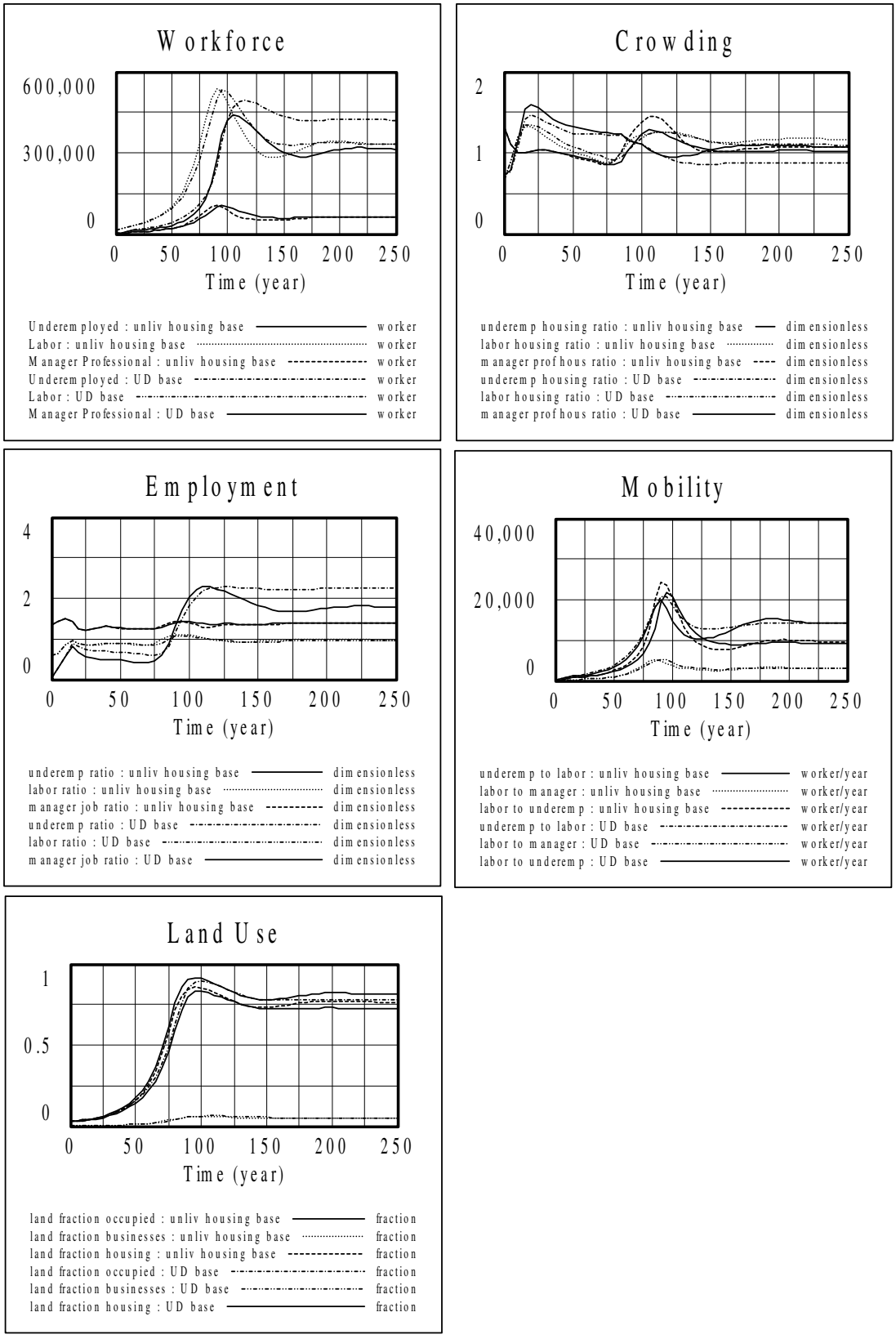
The run from this challenge shows some interesting results. The biggest difference to notice is that underemployed crowding is now reflected. The attractiveness of the city is decreased with the housing shortage and this is reflected in the decrease in the underemployed population. With fewer people, the unemployment decreases for the group. Nothing else changes in the model. However, since mobility is in absolute numbers, the underemployed to labor is a higher percentage of the population since the total population for the group is lower.

Forrester's model cannot be rejected by these results, but the change seems to more closely match reality in terms of the underemployed housing shortage that is seen in cities across the country.

B. Attractiveness of Low Income Housing Programs

In Forester's examination of the impact of programs that include building low income housing in the urban model, he adds a multiplier to the underemployed attractiveness variable. It

Figure 2. Output From Livable Housing Changes



varies from a value of one to a value of three based on the amount of housing built. This means at the high end of this scale, underemployed people are three times as likely to be drawn to the city solely due to the presence of subsidized housing. For many reasons this number seems to be too high.

First, there is already an attractiveness multiplier for the availability of housing of the same class. Second, attractiveness is relative to other options (other urban areas). If funding exists at the Federal level as Forrester assumes for these programs, all or most cities would get money for low income housing. In fact all cities have housing authorities that administer these funds. Our city, therefore, compared to others would not appear more attractive, based only on the presence of the program. Third, all over America, housing authorities, currently and historically, have long waiting lists to get into subsidized housing. Many cities have closed waiting lists due to excessive demand (Wright, et. al. 1998). Just because it is built, does not mean that people moving to the area will get housing. Of course the program is need based, so some number of incoming folks may qualify even with a very long waiting list. Fourth, in the housing turnover literature (vacancy chains) the data suggests that housing at the tail end of the vacancy chains (the lowest income level) are more likely to go to people already residing in the city, not new comers in to the city (Sands and Bower 1976). These people would come from less adequate housing or from an overcrowding situation or from people moving into housing for the first time such as young people moving out of parental housing, newly weds, etc. Fifth, migration literature suggests that decisions on moving to a city are based on opportunity, means and information that is often imperfect—1) if underemployed housing is built the opportunity(if it truly exists) may not be known to people in other locations, 2) even if the people know about opportunity, they may not have the means to move. Again from the vacancy chain literature,

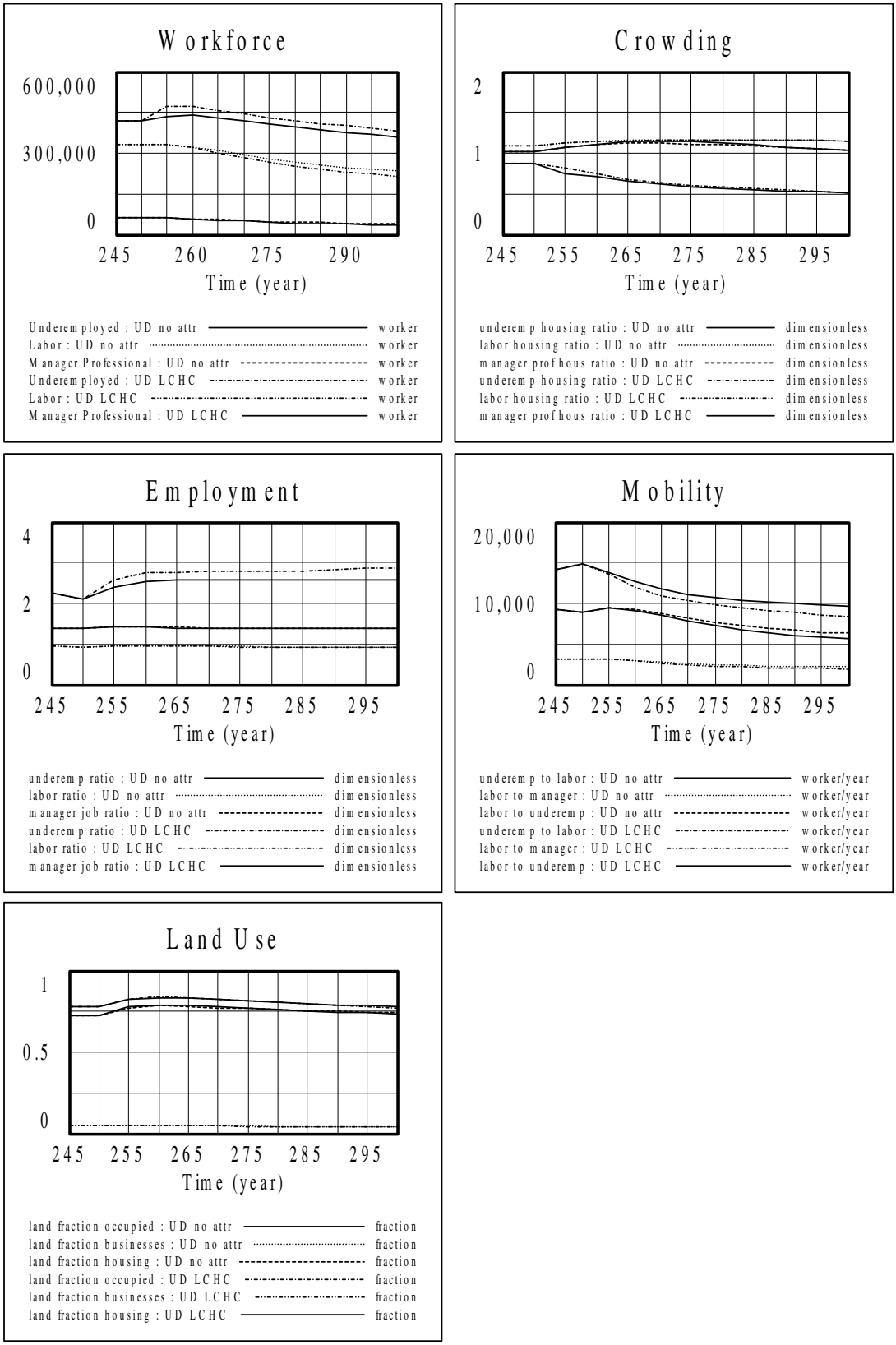
when the vacancy chains were ended due to in-migration to the city, the household was more likely to be of higher income (Sands and Bower 1976). These five reasons indicate that the multiplier is either too high or too steep. The increase in in-migration when new housing is built can as easily be explained by the increased availability of housing rather than by the fact that it is subsidized.

Forrester did not do sensitivity testing on this variable (any way none that is documented in his book). Limited sensitivity testing is performed here to determine whether the value of this variable significantly affects the model. This graphical variable is used as a multiplier. To make the variable have no effect on the model it can be set to the value of one, i.e. no effect. That is no additional effect to attractiveness occurs due solely to the construction of low income housing.

The results are shown below in Figure 3. Note that the comparative run in this test is not the base run for the original model. In the base model no underemployed housing is built so the multiplier is never activated. The comparative run for this test is Forrester's Low Cost Housing Construction policy run as described in the Chapter titled "Failures in Urban Programs." The policy is to build housing for 5% of the underemployed each year. The policy goes into effect at year 250 and runs until the end of the simulation, year 300. The graphs cover only the time period of the policy.

The results show no change in the shape of any of the displayed graphs. Since the attractiveness for the programs were not multiplied in, the underemployed population decreased. The employment ratio improved slightly and crowding was unaffected. Remember that this run is off the original model so the underemployed population is not experiencing a housing shortage. To make quite sure that removal is acceptable, additional tests were run on the modified model with different levels of underemployed housing construction. Values equal to half and twice the

Figure 3. No Extra Attraction for Low Cost Housing Program (0.05)



percentage of underemployed housing construction funded by the program, 2.5% and 10% of the underemployed population each year were chosen. Comparative runs with matching policies were run on the original model. The results for these runs are not shown. Both were as expected, with no real difference from the original model comparative runs. Since the changes are so negligible, it can be concluded that removing or nullifying this attractiveness multiplier has minimal impact on the system.

C. Racism, Classism and the Story of Detroit

These sections are merged together for reasons that will become apparent. Detroit's empty land, "if there is space they will build theory", is the primary reason it is the challenge city. Forrester's model has business construction based primarily on land availability.

His model is at equilibrium (though he adds a caveat that the equilibrium is minus the random influence due to technological advances, economic cycles and world events) after 250 years. However in the Detroit scenario, the equilibrium is not based on the unavailability of the land as suggested in the model. In Detroit there is space; 60,000 lots empty (Vergara 1995). If Forrester's model cannot achieve this scenario, then something else is missing from his model. Detroit is in a severe state of urban decay. There is excess housing, abandoned housing and abandoned business structures. Detroit has an interesting history in respect to Forrester's model. The city historically built very little public housing, far less than most other cities. There were political reasons for this but also economic. The construction companies could build private housing at a greater profit and the demand for private housing was high as opposed to cities like New York. Detroit also, as time went on, used slum clearance and zoning to make large land tracts available to businesses (Sugrue 1996). Land that was close to transportation infrastructure, but the businesses did not come. This was after the boom of the car industry and the World War

II defense manufacturing boom. In the 1950s and 1960s when other cities saw large increases in jobs and prosperity, Detroit and other "rust belt" cities saw huge declines. The automotive companies moved to locations with cheaper labor and the supporting contract companies followed. The result was that the city had plenty of empty land for business, zoning that made the land usable by businesses, minimal subsidized housing programs and a highly skilled workforce (Sugrue 1996). In deed Detroit was Forrester's ideal city, but the businesses did not come.

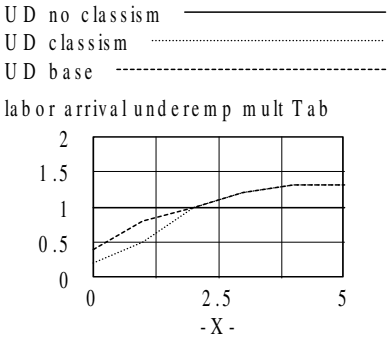
Urban Dynamics contains no demographic information on its population except income in the form of what could be called "class"; manager/professional class, worker class and underemployed class. Forrester allows for the movement between these classes but he includes no information on age, race, gender, education attainment or any other characteristic.

In the history of the U.S. it is difficult to disregard the effects of prejudice based on race, national origin, etc. Adding demographics to the model when none exist is outside the scope of this project. Instead, racism is addressed loosely in terms of classism. "Classism" is defined as prejudice based on economic well being. Racism is only partially to blame for the economic stratification in Detroit. But, racism plays into political and economic issues. Even President George W. Bush in a speech in the aftermath of hurricane Katrina said, "poverty has roots in a history of racial discrimination, which cut off generations from the opportunity of America." (Bumiller, et. al. 2005) Among the Detroit examples of this were that FHA loans were denied to blacks, making home ownership more difficult and more expensive, African Americans were excluded from trade guilds and apprenticeships and segregated schools for this population had lower expectations, smaller budgets and fewer qualified teachers. Structural prejudice is what allowed blacks for example to only fill low end jobs that had minimal upward mobility and were

the most likely to be replaced with technological advancements(Sugrue 1996). In Detroit, as well as in other places, this structural prejudice limited the African American population as a whole to fewer opportunities to move between classes (Sugrue 1996). For these reasons, racism is replaced with classism for the purpose of this analysis.

In Forester's model, there is one variable that can loosely be considered to be a measure of classism. This variable is the ratio of the working class to the underemployed class. It is a graphical multiplier that affects the city's attractiveness to the worker class. As the population of the underemployed increases in relation to the worker class, the worker class is less attracted to the city. Likewise, the worker class will be more likely to leave as this ratio decreases. Forrester has his "no effect" value at two, meaning that if there are twice as many working class people as underemployed people then there is no effect of the underemployed population on the worker class. If there are more than twice as many workers as underemployed, the worker class will be more attracted to city based on this fact alone. If there are fewer than twice as many worker to underemployed people, then the worker population will leave the city at a quicker rate as well as be less attracted to it. The graphical function is shown in Figure 4.[3]

Figure 4. Classism Graphical Function

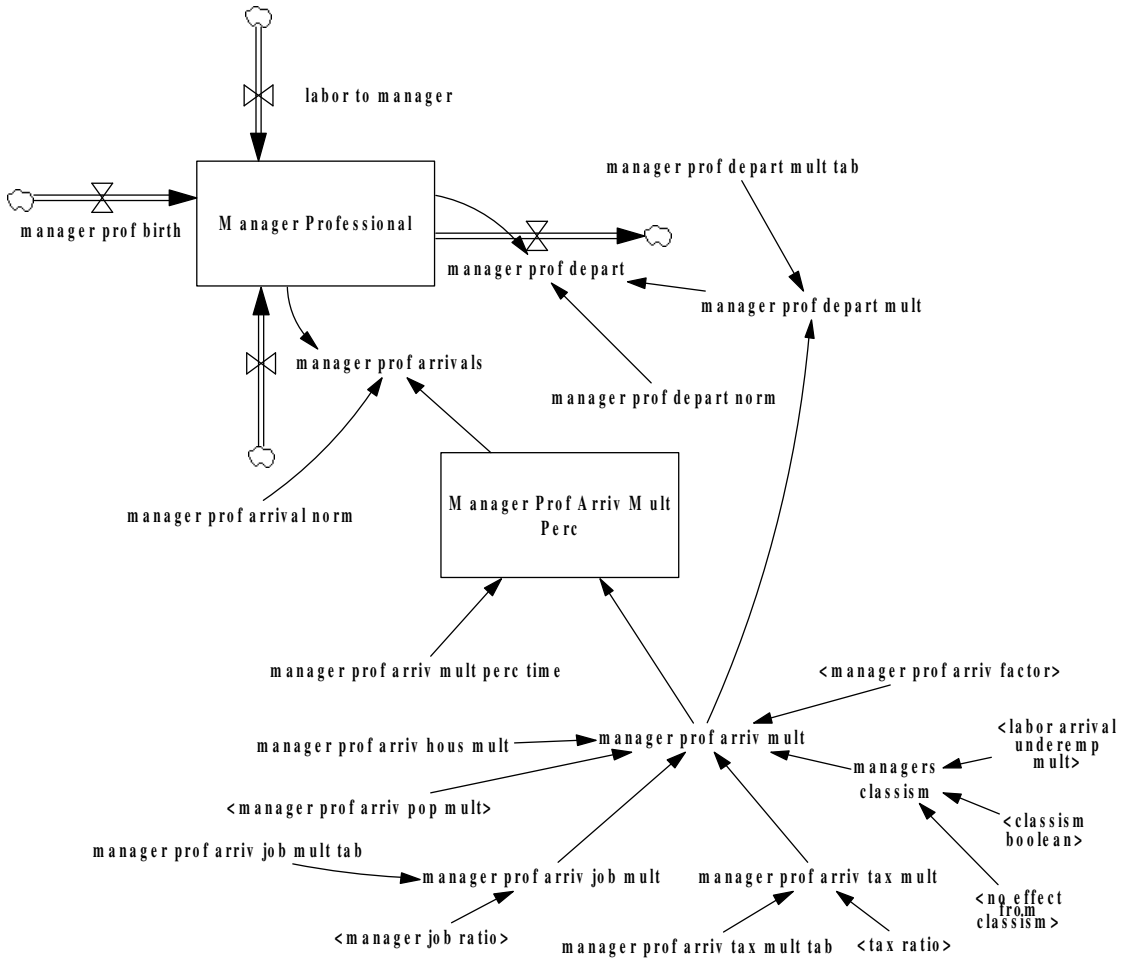


[3] "UD base" is the original shape of the variable in Forrester's model. The other lines are the values used for the two test runs in this challenge.

The premise of this challenge is that classism has a bigger effect on the city than is assumed by this multiplier. To simulate an increased effect from classism, two changes were made to the model. First a classism multiplier was applied to the attractiveness formulation for the managerial population. See model graph in Figure 5 and Appendix B.3. for equations.

Since the original model does not include this multiplier, a switch to activate the effect is added. When the switch is turned on (set to one) the multiplier that is used for worker class' attractiveness is also applied to the managerial class. Modifying the worker class graphical variable for classism is the other piece of the modification. The "UD classism" run increases the

Figure 5. Manager Classism Model Changes



effect of classism and the "UD no classism" removes even the original effect from the model by setting the multiplier to always be one. Again, a multiplier of one results in no change to the attractiveness. To increase the effect of the multiplier, attractiveness needs to be decreased. In the original model for example, when the worker population equals the underemployed population, the attractiveness of the city is 80% of what it was when there were two times as many workers to underemployed persons. In the challenge run that number is decreased to 50%.

The results in figure 6 below are astonishing. The population falls 10% or more in all categories, with huge drops among the underemployed and labor populations. Land use plummets. Underemployed to labor mobility drops and labor to underemployed mobility rises. Unemployment and crowding have small changes in comparison to the dramatic changes in the other indicators.

Increasing classism has dramatic effects on the model; depopulation, high unemployment and plenty of empty land. The model has indeed produced Detroit. The changes to the model needed to produce this result are very minor and would more likely support the model rather than disprove it. Determining a "real life" function for classism is definitely out of the scope of this project, but migration information that contained income level may be a starting point.

For completeness, a run with no classism is performed. Remember that this variable is in the model already. The challenge just increased its effect and applied it to the manager class as well as the labor class. For this run the same multiplier is set to always equal one, no effect. The results for the no classism run are shown below in Figure 7.

In the no classism run, the only difference is an increase in the labor population and the crowding increase that accompanies a population increase. It is interesting that removing the

Figure 6. Classism Output

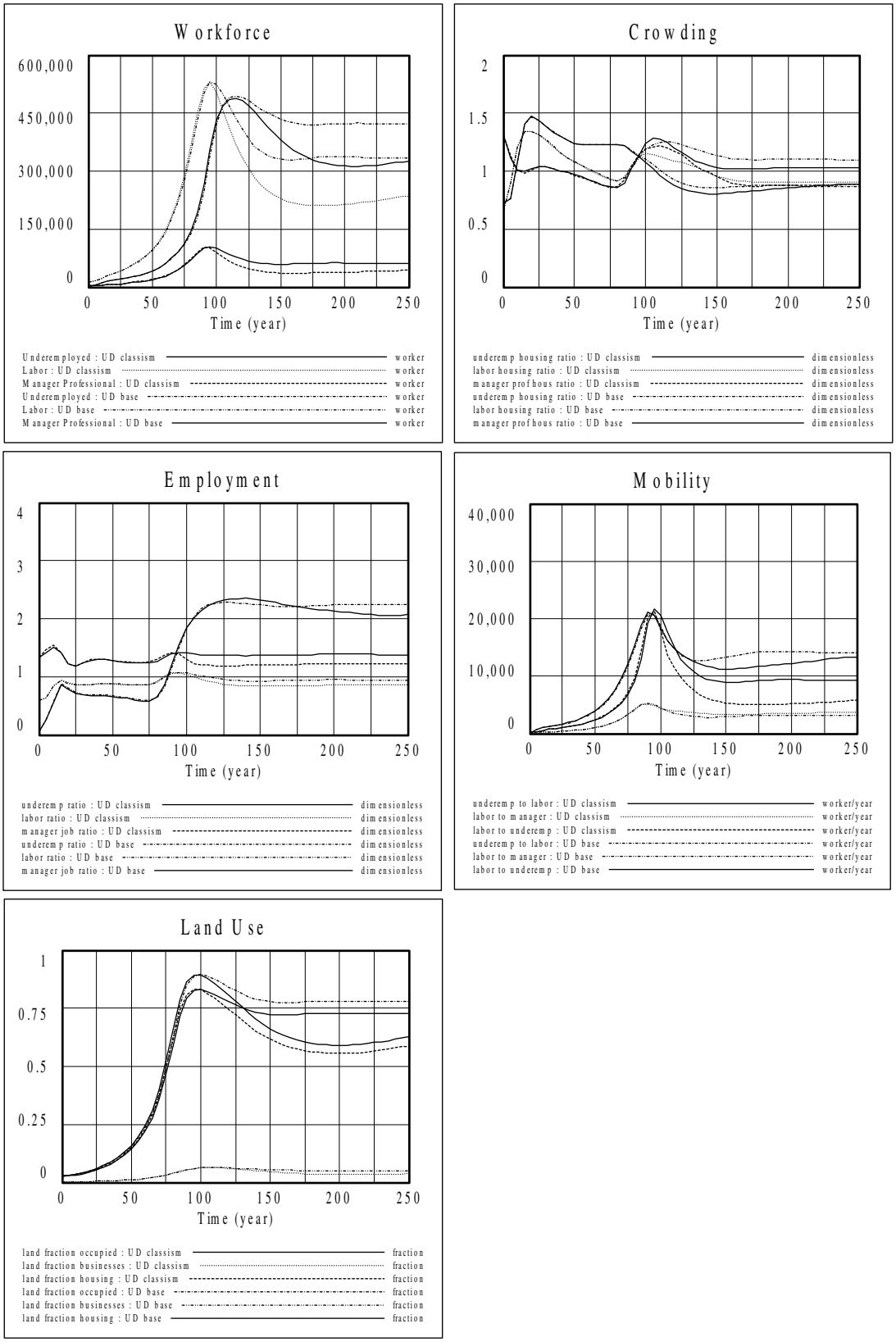
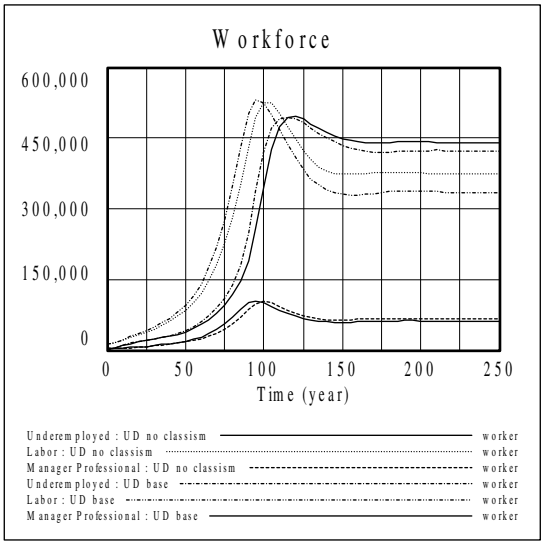
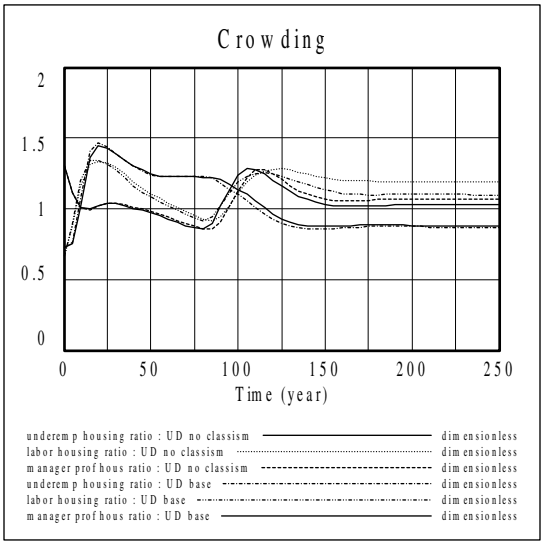
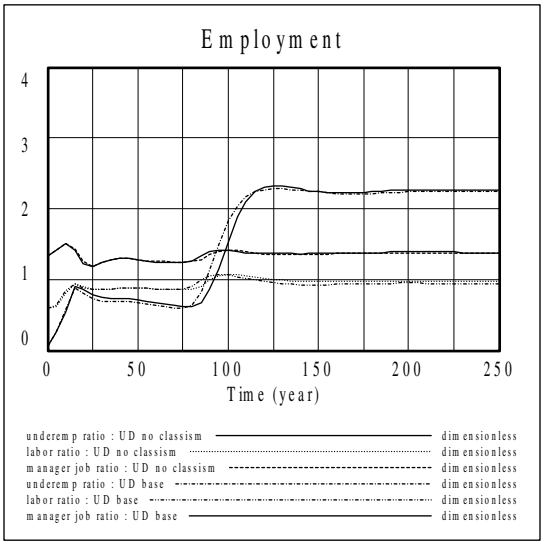
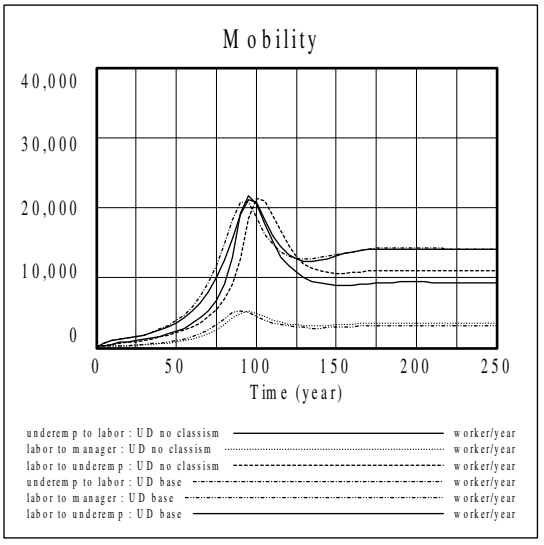


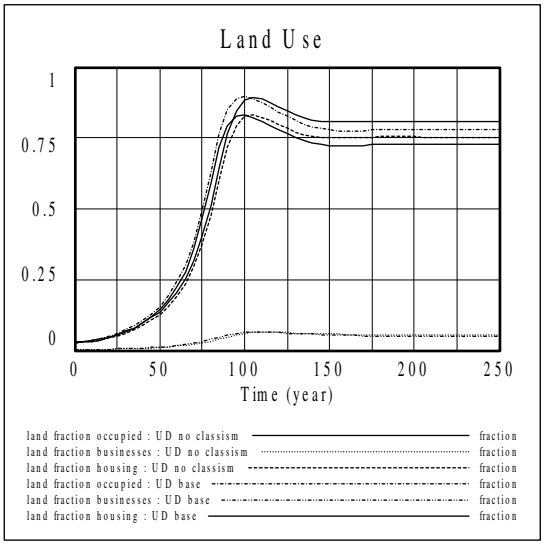
Figure 7. Classism Removed Output











base model effect of classism altogether has such a small effect on the model. It seems that the original setting is too close to "no effect" and that increasing it may be in order for a "true" effect.

III. Housing Policy in Urban Dynamics

To determine if housing policies really lead to the downfall of the city, comparative policy runs are performed between Forrester's model and the modified model generated from the previous section. The final modified model includes only the unlivable housing change and the flattened attractiveness factor for subsidized housing. Classism is not included since a better guess at reality values is unattainable.

Four policies are examined; slum clearance, filtering, HOPE VI and Section 8. Most of these are simulated by parameter changes to the base model and indeed were run under different names in Forrester's book. Similar to the last section rational is followed by implementation, results and analysis.

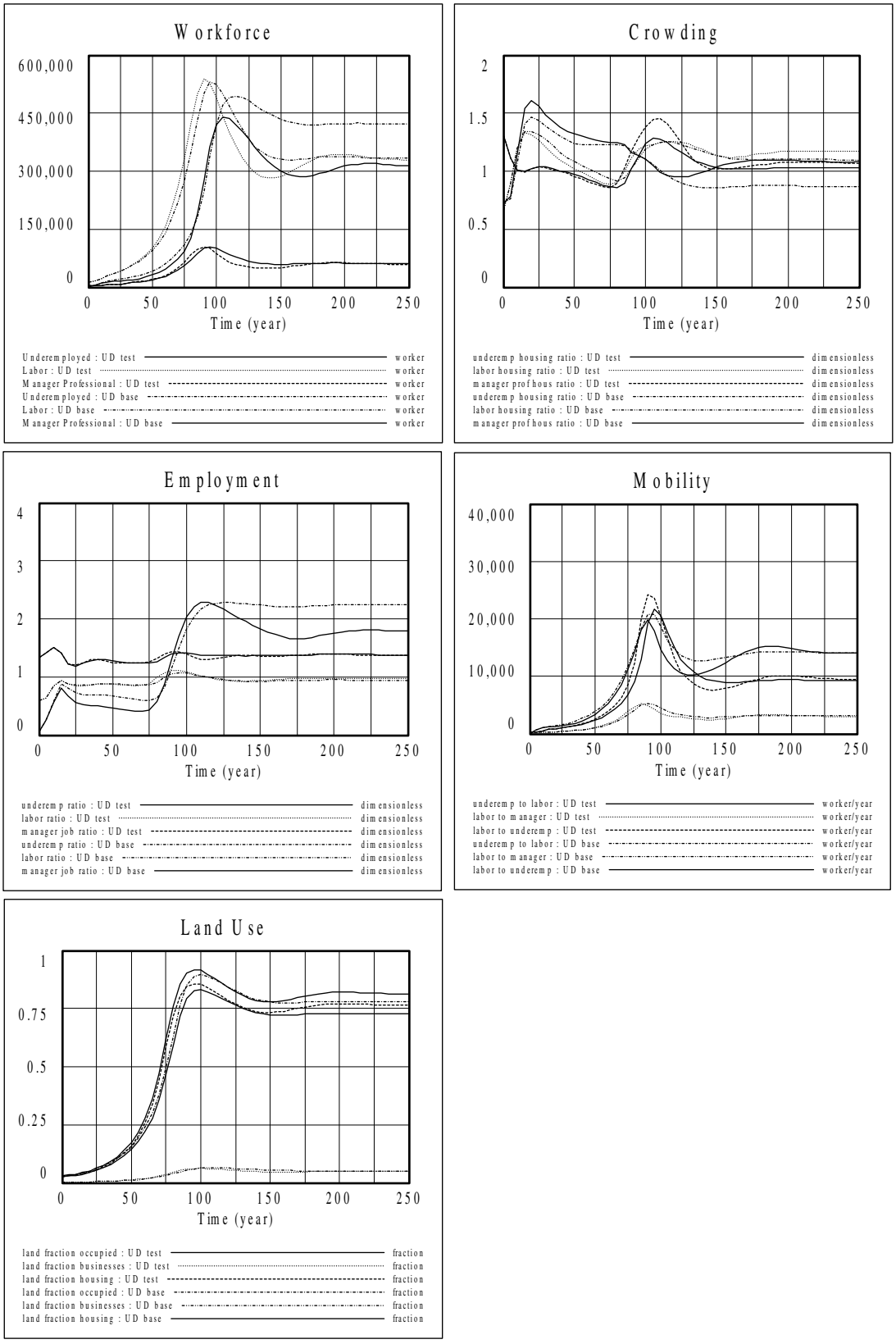
The output on the following page shows the base run comparison between Forrester's model and the modified model. All subsequent runs are policy runs. The policy start times are the year 250. The end time for each is at year 300. Graphical output is only shown for the policy run time frame.

A. Slum Clearance

As already known, we run out of land in this model. Too much land is being used for housing. Forrester's model and many American cities performed slum clearance to free land for other uses.

There is no spatial detail in this model. Slum clearance is done only on unlivable housing in the modified model. This kind of slum clearance politically would be much more palatable

Figure 8. Policy Baseline Output



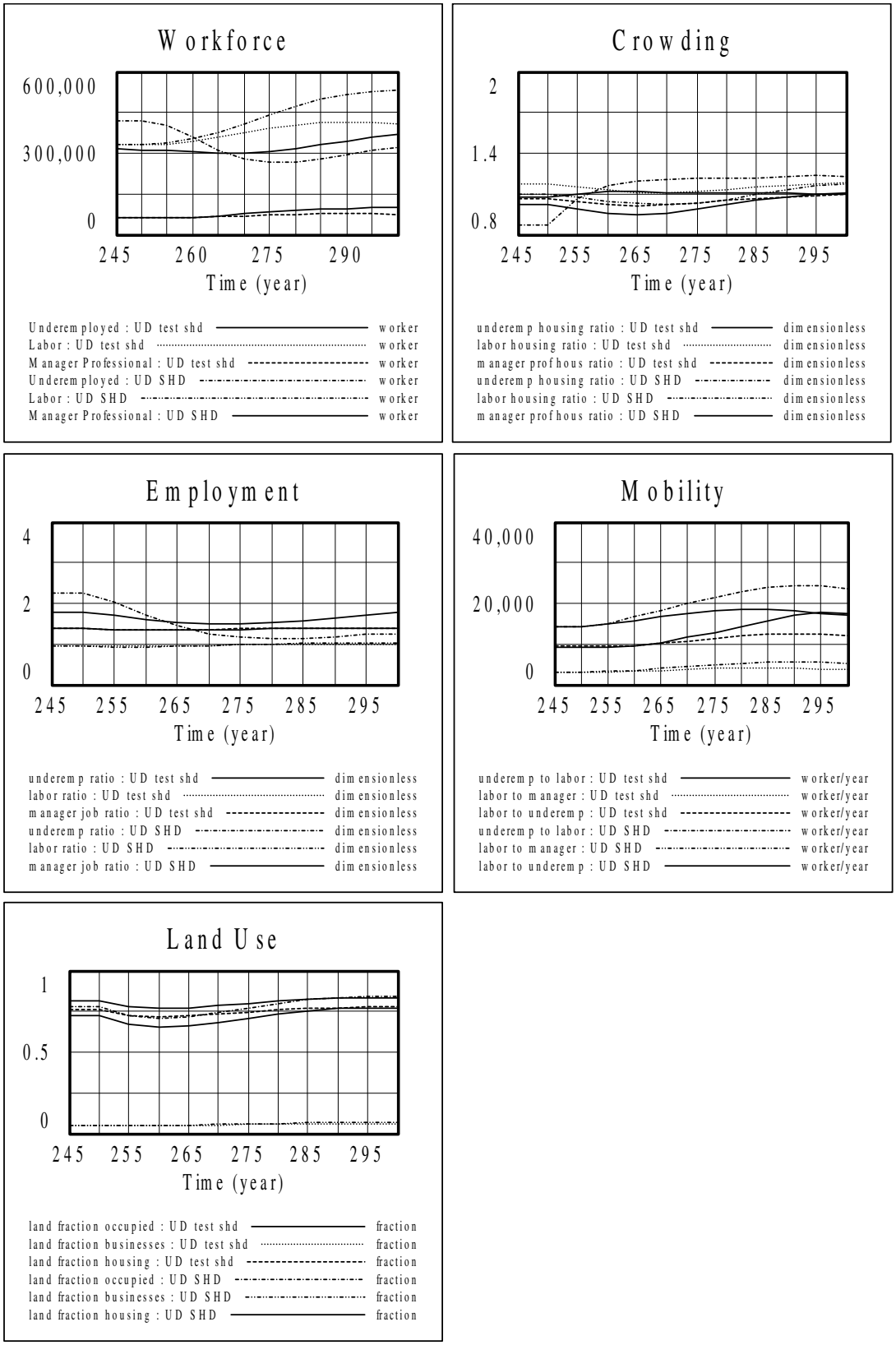
than that from the original model which demolished regardless of occupancy. Historically, these clearance projects were spatial. A section of slum that was cleared contained dilapidated houses, inhabited housing, dilapidated office space and occupied office space. This kind of clearance produced a large section of land that could be regenerated into something else. In Albany, NY for example, slum clearance was used to make room for the Empire State Plaza. The modified model's version of slum clearance does not tend to attract rebuilders because the land is in neighborhoods where both housing and business investment opportunities are limited. The mass clearance removed both the buildings and neighborhoods.

The goal of slum clearance in both the real world and the model is to revitalize the city. The models show an increase in businesses and jobs once land was again available. However, this policy is a political nightmare. The old buildings are often part of the character of a city. Neighborhood demolition often required eminent domain to acquire the land. Just because a place is run down does not mean that the people who live there want to leave. Forrester does not discuss the social costs of his proposed solutions (Jaeckel 1972).

In this policy run, 5% of underemployed or unlivable housing is removed per year of the program. The results are shown in Figure 9. Note that in reading these results, the change in the indicator for the run should be compared to change in the indicator for the base run, i.e. how did the same policy affect the equilibrium level in each case.

The results are much more favorable in Forrester's model than in the modified model. He sees a drop in the underemployed population and a rise in the labor population. Unemployment drops for the underemployed and the underemployed to labor mobility factor is up. The cost of this is the increase in crowding among the underemployed, but in this model there was a housing

Figure 9. Slum Clearance Results



surplus for this class so the cost is fairly low. The other cost is that the labor to underemployed mobility factor increases, downward mobility.

The modified model by contrast shows minimal effects due to the policy. The labor and underemployed populations both increase by smaller amounts and that is about the only change. Land use in either run is not affected in the long term.

This run illustrates the relevance of the starting point at policy implementation time. Slum clearance is a political hot potato and in the modified model does nothing to improve the city. While in Forrester's model the benefits probably outweigh the political costs.

B. Filtering

Filtering is the theory that by providing benefits for economically higher persons, the benefits will filter down to people lower on the economic ladder. The vacancy chain model is the filtering model for housing. The vacancy chain theory is that new housing is added to market at whatever level, premium, worker, or low income, government sponsored or private market generated. When a household moves into the new housing unit, the vacated housing unit becomes available. When a household moves into the vacated unit, they in turn leave a vacated unit that becomes an opportunity available for another family and so on. This string of vacancies is referred to as a vacancy chain. The research on these chains shows some interesting but no surprising characteristics. The housing quality decreases down the chain as well as the affluence of the new household.

The chain can end in a couple of different ways. First, the chain can end by in migration, i.e. someone moves into the area from outside the city. The link is not followed since the unit of measure is generally at the city level. Second, the housing left behind may not be available. It may be uninhabitable. It may be non-existent, when a homeless household moves into housing,

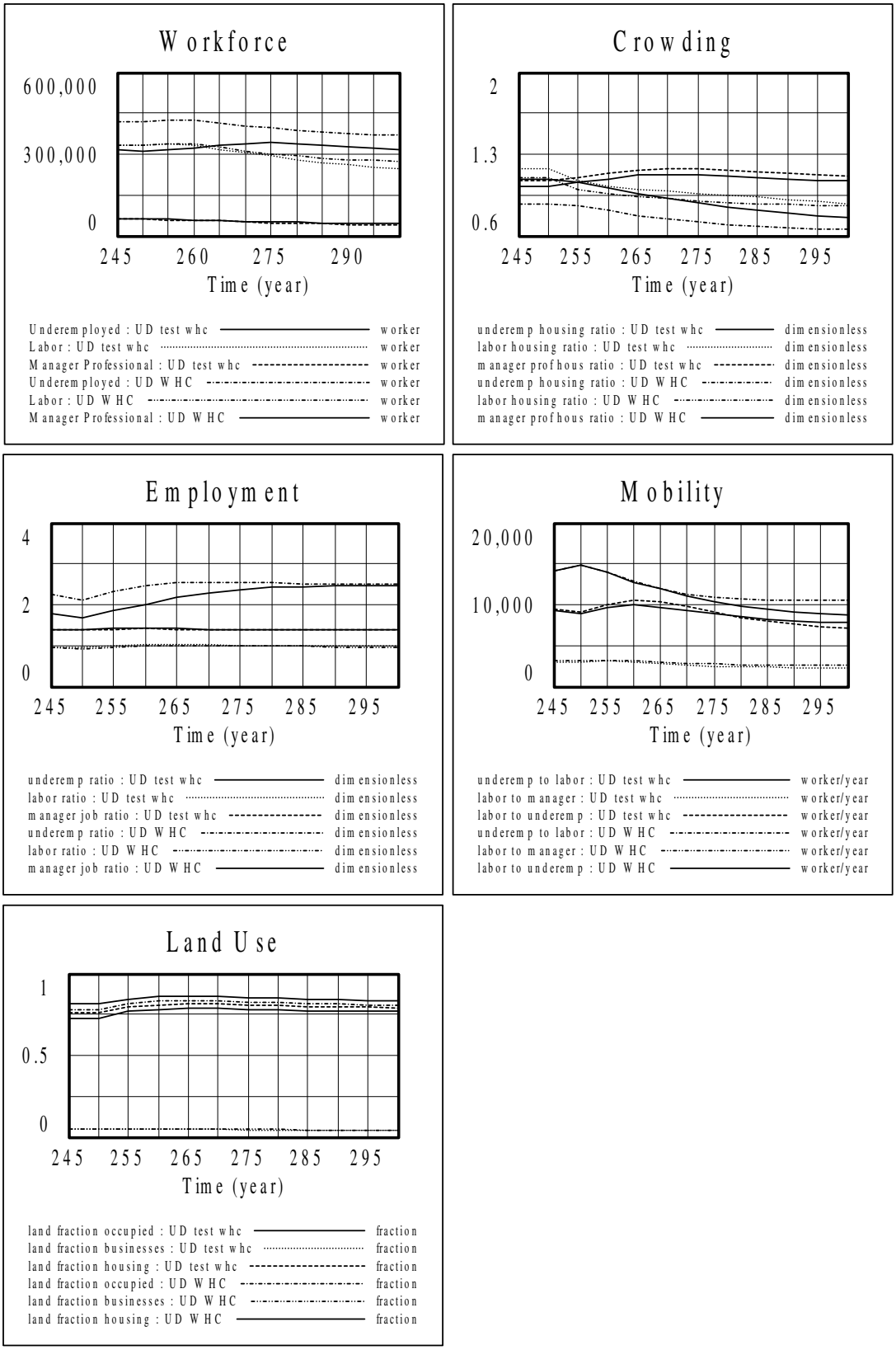
for example. It may still be use, i.e. when the new house is purchased as a second home or when half of a divorcing couple moves out, or when children move out of their parents' house, or when doubled up families can finally afford to get their own place or when owners simply want out of the rental business. How ever it happens, the chain ends when no vacancy remains for new inhabitants.

The data gathered from actual vacancy chain studies match the work that Forrester presents in his chapter on urban renewal, albeit with a different spin on the results. The vacancy chains followed in Sands and Bower had average chain lengths just over two.[4] What this means is that by the new construction of a unit three households improved their housing situation. In Forrester's model, he proposed an urban renewal program that increased middle income (worker class) housing. The results matched closely to Sands and Bower observations. Even though worker housing was increased by 2% in Forrester's model the net increase in worker housing was less. As Forrester explains, when more worker housing is available and there are not enough workers to occupy it, the housing "deteriorates" into low income housing. In the vacancy chain literature, the same phenomenon is described as low income people improving their housing situation by the availability of higher quality housing at lower rates.

Forrester runs both the 2% worker housing construction program as well as a premium housing program that provides housing for 5% of the manager/professional population per year. Both of these are expected to show the filtering phenomenon. Results are shown in figure 10 for the worker housing program, the results are not shown for the premium housing program.

[4] Higher value units for the original "link" does not always equate to longer chains. In-migration stops the chain and these were generally higher income people moving into higher income homes.

Figure 10. Worker Housing Construction Comparison



The modified model's results match Forrester's and the vacancy chain literature. In the worker housing run, crowding is decreased for both the labor and underemployed populations. The interesting thing though is the employment ratio. Unemployment increases and upward mobility decreases similar to the low cost housing construction program. Population decreases slightly and land use is only slightly affected.

The quality of housing may have improved for the people participating in the vacancy chains but the employment consequences are very difficult to ignore.

C. HOPE VI

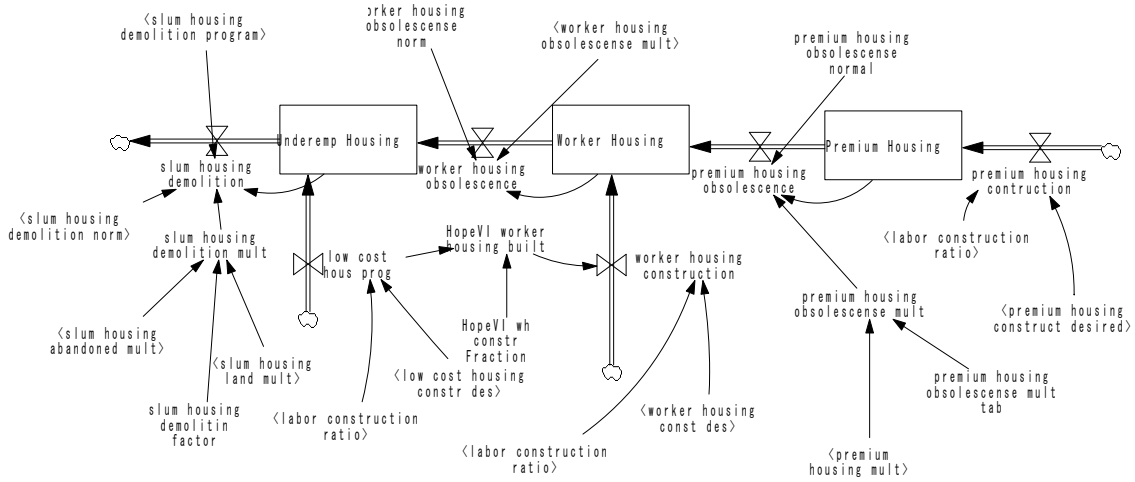
HOPE VI is a program developed as a result of recommendations by the National Commission on Severely Distressed Public Housing, which was charged with proposing a National Action Plan to eradicate severely distressed public housing. Under this program, distressed housing projects are demolished and replaced with mixed income housing, lessening concentrations of poverty by placing public housing in non-poverty neighborhoods and promoting mixed-income communities.[5] As of June 30, 2003, 76,393 housing units had been demolished or were slated for demolition and 44,871 units had been built or renovated as replacement (GAO 2003).

HOPE VI is simulated in this model by using a combination of Forrester's slum clearance policy and low cost housing construction policy. Additionally, a percentage of the rebuilt housing is slated for the middle income (worker) population. A number of units is calculated and added to the worker housing construction flow. The model modification is shown below. Equation changes are in Appendix B.4. Matching modifications are made to the modified model.

[5] US department of Housing and Urban Development, 2005, http://www.hud.gov/offices/pih/programs/ph/hope6/about/

Comparative runs are shown in Figure 12. The policy uses a 5% rate for slum clearance, 3% rate for the low cost housing construction piece and worker housing units are built at a rate of 25% of the number of low cost housing units built.

Figure 11. HOPE VI Model Changes



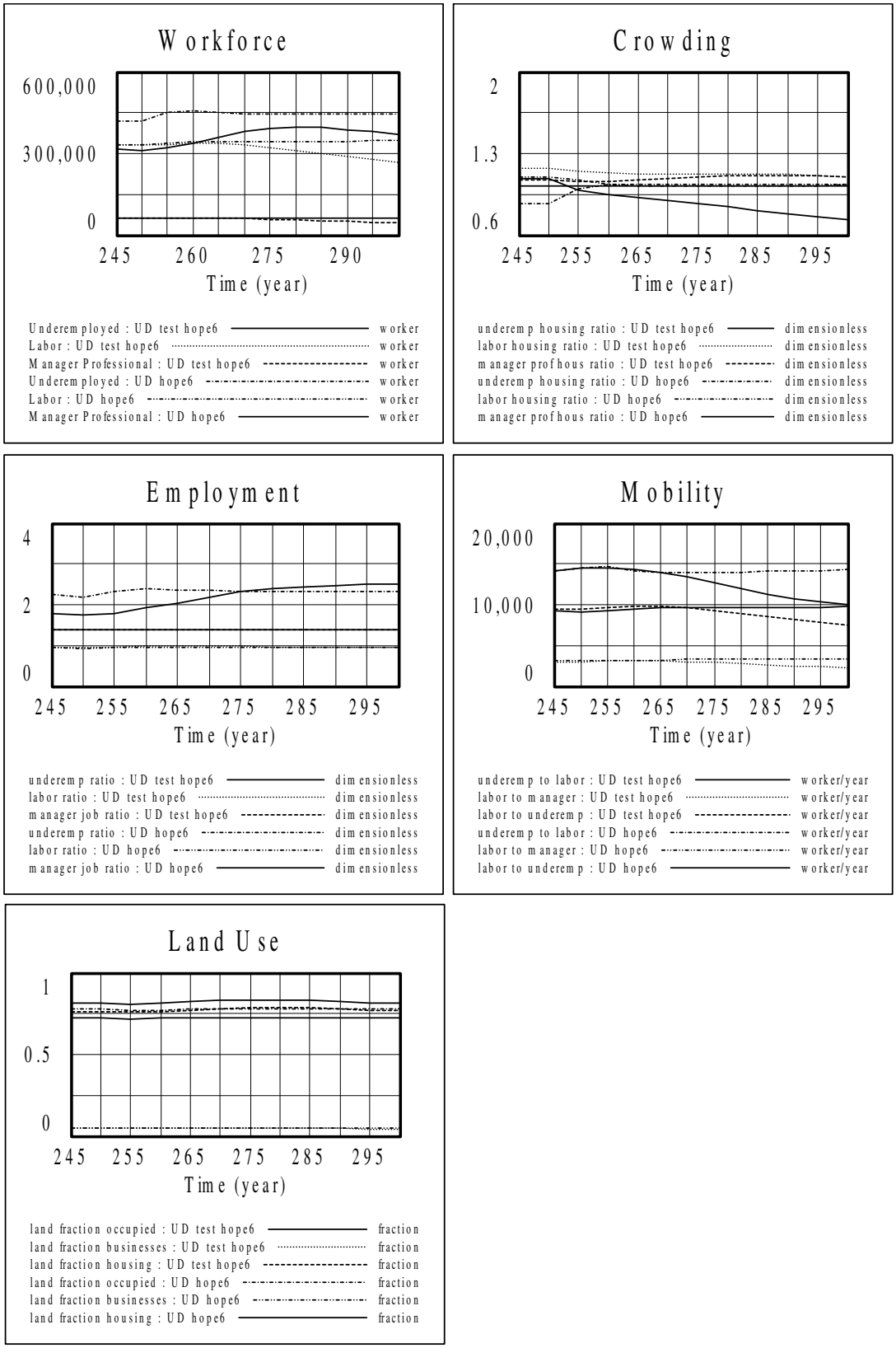
The results are similar to the low cost housing construction policy for the modified model. Too much housing is built for the system to absorb and the adverse unemployment effects occur. For Forrester's model, it almost looks like no program got run. Almost everything is flat except a slight increase in the underemployed population.

HOPE VI at the levels specified does not have a large negative affect on Forrester's city. It does not make an improvement either based on the criteria of evaluation. It seems this and other programs could be implemented if information was predictable about how much housing a city could absorb. As seen in the modified model run, too much housing is a very bad thing.

D. Section 8 Housing Vouchers

Section 8 is a program to increase affordable housing choices for very low-income families. Families with a tenant-based voucher choose and lease safe, decent, and affordable privately-owned rental housing. Very low-income families (i.e. families with incomes below

Figure 12. HOPE VI Comparison



50% of area median income) and a few specific categories of families with incomes up to 80% of the area median income are eligible for the program. Within limits, the Public Housing Authority pays the owner the difference between 30 percent of adjusted family income and the gross rent for the unit. The family may choose a unit with a higher rent than the payment standard and pay the owner the difference.[6]

One goal of section 8 housing is to disperse the lower income population throughout the city to avoid pockets of deep poverty. As discussed earlier in this paper, there is a severe shortage both of vouchers and places that will accept vouchers.

Section 8 is implemented in the model by adding two new stocks to contain worker quality housing and underemployed quality housing that is being used for Section 8 voucher holders. Landlords are more willing to rent to underemployed renters when the vacancy rate is higher.[7] Similarly, landlords want out of Section 8 rental agreements if the vacancy rate is low. A low vacancy rate assumes that housing is in higher demand and therefore can command higher rents for the same units. The worker housing used for Section 8 deteriorates into underemployed quality housing with time. Once this occurs, opting out is presumed less favorable since subsidized rents from Section 8 should be higher than what could be obtained from market based underemployed renters.

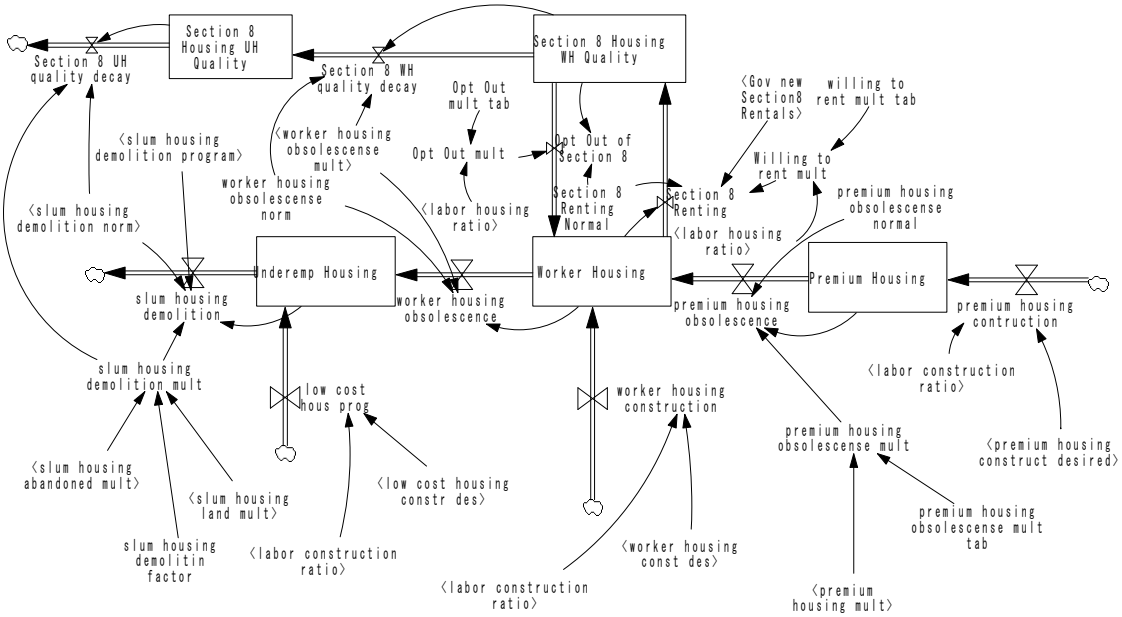
Section 8 housing stocks are added in all the summary variables to be used for tax assessment, calculations of land usage, etc. A policy switch is added to the models, "Gov new section 8 rentals". Like the other policy switches in the model, it uses time to enable the policy

[6] US department of Housing and Urban Development, 2005, http://www.hud.gov/offices/pih/programs/hcv/tenant.cfm
[7] The labor housing ratio is used as an indicator of vacancy.

and a value to determine the scope of that policy. In this case the value is the fraction of the underemployed population that will be provided new Section 8 housing vouchers per year.

In Forrester's model the Section 8 housing of Underemployed housing quality deteriorates through slum housing demolition. In the modified model it deteriorates into the unlivable housing stock. The changes to Forrester's model are shown below. The changes to the modified model are not displayed but equations for both are in Appendix B.5.[8]

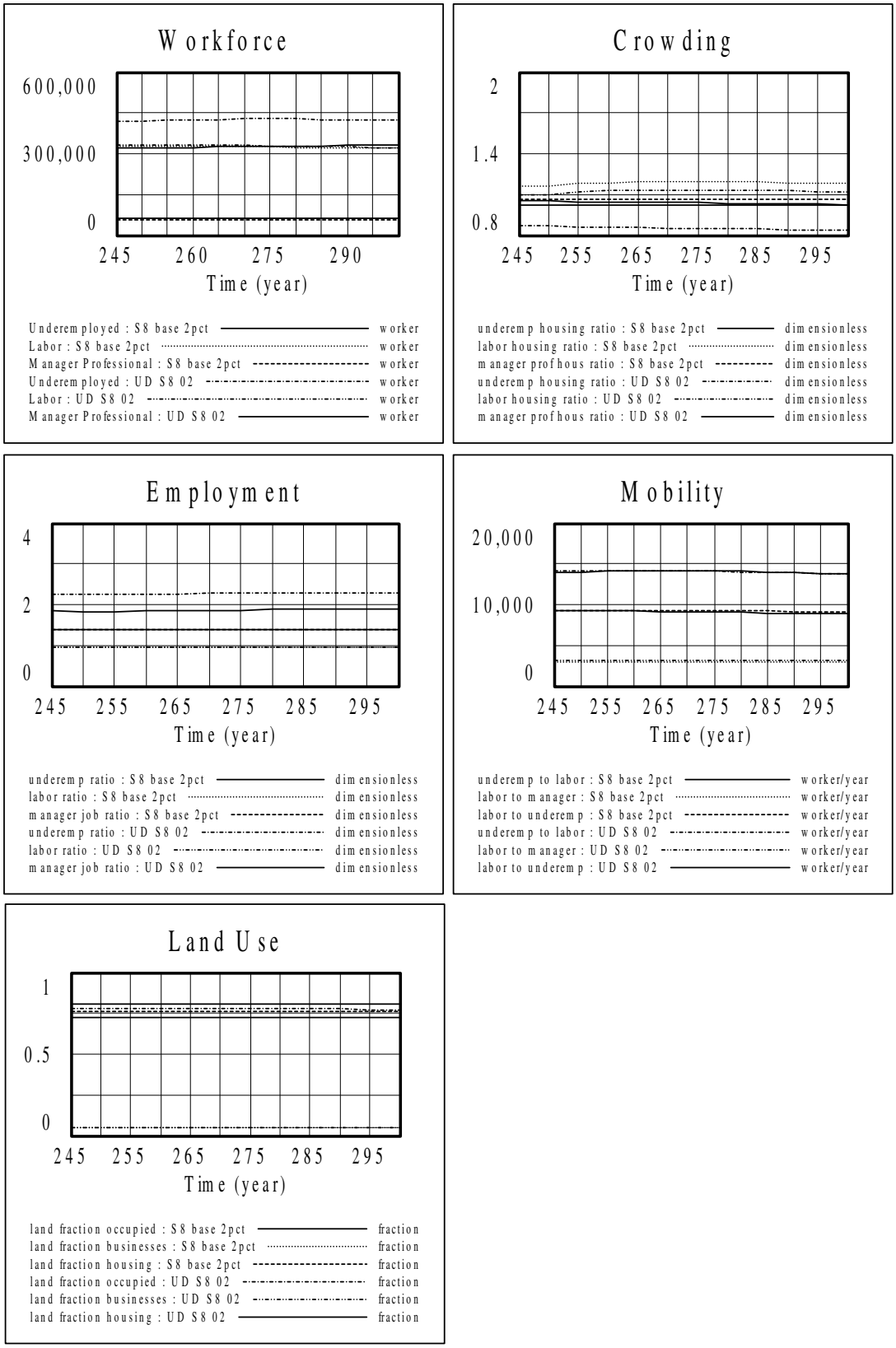
Figure 13. Section 8 Model Changes



The test runs use a rate of 2% of the underemployed population to receive new Section 8 vouchers each year. The results displayed in figure 14 show nearly no effect on the system with the implementation of this policy. One reason is that relatively few worker housing units are being used by voucher holders since the total number of worker housing units is so large. When larger percentages of the underemployed population are issued vouchers (these results are not

[8] Building Section 8 housing was once part of the program but it was discontinued in the early 1990s. This model does not attempt to implement that piece of Section 8 but it could reasonably be simulated with the inclusion of the worker housing construction program.

Figure 14. Section 8 Comparison



shown) the crowding for the labor population creeps up. However, a ridiculously large percentage must be used before the effects are even really noticeable.

Forrester's model does not show a housing shortage so using non-underemployed housing can be beneficial since the higher the vacancy rate, the quicker it deteriorates and is demolished. In the modified model there is a housing shortage and for the first time alleviating the problem does not come at the cost of adverse employment effects. Using the evaluation criteria that have been used throughout this analysis, Section 8 is an acceptable policy for improving the housing quality of the underemployed.

IV. Framing the Issue and Interpreting Results

Framing an issue means determining what is important to that issue. It is a lens with which to look at a problem. Every dynamic system modeler frames the problem when she selects which stocks, flows and parameters to include in the model and which to omit.

Forrester chose the frame of the initial problem of the city as stagnation at a low economic level. His primary criteria were land use and population composition. He determined that too much land was being consumed by housing and too little land was used for businesses. Also, he determined that the ratio of underemployed population to labor was too high. Other choices might have been unemployment, segregation or overcrowding. Defining the frame scopes the relevance, the analysis, the conclusions and the recommendations (Jaeckel 1972).

In addition to defining the criteria with which to look at the problem, a modeler also defines the time frame to be considered. Short term and long term fixes have different political and social costs (Arvech and Levine 1971). Forrester's analysis was heavily biased toward the long run health of the city. Not all individuals agree with his preferred time frame (Andersen and Rohrbaugh 1992). Nor would they all agree with his criteria.

Forrester's model is extremely comprehensive. It allows the kind of analysis that is performed in this paper as well as those used in the hundreds of critiques of his model. In several places in his book, Forrester invites the reader to perform their own analysis, to change parameters, to add new pieces. He encourages customizing the model for a specific use. He therefore encourages the use of other frames. The work by Gardiner and Ford and Andersen and Rohrbaugh among others is done in attempts to find consensus among frames. By using decision making techniques on top of models, they attempt to analytically determine policy decisions.

Forrester's results are indeed a function of his frame, but no person comes to any project without a frame. My frame is shorter term. I prefer to first cause no harm to the city as well as to improve the living conditions for the underemployed population. The graphical outputs and my analysis reflect my frame just as Dr. Forrester's reflected his.

V. Conclusions.

The results from the challenges made to Forrester's model do not disprove it. They in fact mostly reinforce it. That Detroit was recreatable by making only minor changes to the model shows robustness. Even the unlivable housing changes used in the final modified model did very little to influence the outcome of housing policies with the exception of slum clearance and HOPE VI.

Forrester's conclusion that housing is the problem is difficult to dispute. Every program that built housing for any income level resulted in adverse employment effects especially for the underemployed population. The lack of demographics, especially age and workforce participation make it difficult to determine if underemployed, non-working individuals, retired or disabled for example, are also adversely affected. About a third of public housing is for senior citizens who are unable to improve their status by getting a better job.

The Section 8 results are promising in that the negative employment consequences do not coexist with improving the housing for the underemployed. The focus of this paper is on housing, but an analysis of what else is happening in the model when the Section 8 program is implemented may be useful.

Considering different frames for an issue is a good thing. As a society we need people looking out for the whole city in the long term. We also need people looking out for the population in need right now. Often common ground can be found through consensus building where both groups can be satisfied. Housing programs that do not make the city worse, but help to improve the housing of those in need, is a possible example. With the homeless population in this country numbering between a quarter of a million and three million[9] persons (Yeich 1994) it is difficult to imagine that housing is not at least part of the solution to the still present urban crisis. In the end, it comes down to what as a society we see as problematic and what we are willing to do to fix it.

[9] Depending on who is counting and how the counting is done.

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