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Unevenly Spatially Distributed Resources. Emergent Dynamics in an Agent-Based Approach.

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Contents

Introduction

Cities are complex systems: they are formed by many components, living or otherwise, interacting continuously among them. In most cases their shape is the result of centuries of this never-ending process, whose dynamics also determine how the system can react to external events (migration, economic crises, epidemics, famine, earthquakes, sieges...). Each of these forces and events leaves a mark on the urban fabric: buildings, streets, roads were built for a purpose, whether economic, military or social; and those same reasons may have led to the decline of other structures or areas. The economic logic that led to a factory being built in a certain place may have disappeared, or other areas, disused industrial sites may experience the construction of new houses as a result of migration and demographic increases. Or, conversely, certain parts of the city may have kept the same role over the centuries. In almost every city rise and decline and steady states can coexist.

The causes of all these urban transformations are usually many, and sometimes hard to fully understand, since they can be a mix (among others) of politics, demography, economics, sociology and chance. This work focuses on some of these phenomena, trying to suggest few (very theoretical) dynamics that can affect the way agents, in an artificial simulation, can locate in a space where resources are unevenly distributed. In particular, chapter 1 describes the first ideas that influenced the beginning of the thesis (some of them were then further explored, while others abandoned). The second chapter deals with the phenomenon of the spatial segregation which largely affects modern cities, both from a theoretical agent-based perspective and by reporting some empirical findings. Chapter 3 reviews part of the literature whose aim is to formulate and implement political tools in order to understand the urban reality and the directions in which new policies can be implemented. Chapter 4 examines the theoretical models proposed, the main ideas behind them, how their simulations were built and their outcomes. Finally, some conclusions will be suggested.

Chapter 1

Starting ideas

The initial aim of this work was (is) that of exploring residential dynamics in urban contexts, paying particular attention to the way how different income levels (or better a unequal wealth distribution) could plausibly affect the landscape of cities.

Many urban areas, and generally the biggest ones, tend to show patterns of spatial segregation, as widely stated in the literature. These phenomena are recognizable both in developed and developing countries. With respect to the latter, an important starting idea for this work can be considered the research made by Barros in [3], where the phenomenon of *peripherisation* is studied by mean of an agent based model. In her paper is presented the idea that, in Latin-American cities, some kind of consolidation process of peripheries must be at work, since peripheral rings around urban areas are enlarging despite population growing rates (commonly seen as the main causes of the birth of peripheries) have slowed down since the 1980's.

With respect to the western world instead, another interesting point for this thesis can be found in the work of Ross and colleagues [25], where the study of the increased residential segregation occurred in Canada during the 1990's (a period of economic stagnation) has led Ross *et al.* to suggest that income inequalities, though softened by tax and transfer system, can anyway be detected in spatial dynamics. This phenomenon may be linked to the empirical findings quoted in Aronson [1], showing that, once removed the causes of differences (real or pretended) among groups, still individuals tend to keep the perception of the diversity between them and the others.

These considerations may lead to the hypothesis that wealth inequalities can generate stable and "rigid" outcomes regarding spatial location of households, somehow alike to those characterising models of ethnic segregation (e.g. Schelling's model and its descendants), where communities tend to divide and to keep separated one from another. The simulation is intended to inspect such possibilities that, if proved, may lead to consider the chance that people tend to locate next to (or separated from) each other according to an idea of "proximity" of conditions shared with other individuals.

The ambition of the model is to create a self-organizing system, according to the view of the city presented by Portugali [22] showing how spatial segregation and peripherisation may emerge from endogenous dynamics concerning wealth distribution; and then to compare the results obtained with other models of "ethnic-based" segregation, as those presented by Portugali [22] and Hatna [16] In these latter the main localisation drive is considered the level of tolerance within different groups.

The model of the thesis has been preliminary and roughly conceived as follow: at the very beginning only a small group of individuals (at least composed by two members) is created in the primitive environment. Each one of them chooses a place, ideally a piece of land, from which she can extract an income that is different from one agent to another. Agents can reproduce and, at their death, can pass their wealth to their heirs, which hence add this stock of wealth to their current income. The process is then repeated several times for each agent. Inequalities in wealth distribution are created trough two main channels: individuals can be gifted with different working abilities, thus earning more or less income accordingly; and they may receive different inheritances, following their fathers' fortune. Spatially, all agents try to find a location next to their parents, possibly affecting the price of land. In case the same area is already occupied by an individual, the one wanting to locate there will succeed only if she is the richest.

This basic dynamic may be then further complicated considering other factors and frictions affecting the wealth distribution and other dynamics at work in a urban environment., e.g. phenomena of rise and fall along the social ladder or the role of social capital as expressed by Putnam [23] according to which the network of relationships produced by the interaction of individuals can have a "bonding" effect, caused by feelings of solidarity and reciprocity within a certain social group (mechanism arising also as opposition of the group against the rest of society), as a possible cause of consolidation of peripheral urban areas and of social stratification: who is already rich have more chances to become richer, whereas the poorer will more likely continue to occupy their position (which is not necessarily the case: minorities may put the community efforts in making some of its members arise to a better social condition). These mechanisms may plausibly intervene and be reinforced as the generations of agents proceed.

Chapter 2

Spatial segregation and integration

This chapter is dedicated to a review of the wide and continuously enlarging literature existing the field of spatial segregation, with a particular focus on divisions based upon ethnic and socio-economic factors. Since it would take too long to fully and properly examine all the academic production in this area, the following references have been chosen in the hope that they can be helpful in the comprehension of the logic, the dynamics and the relevance of this phenomenon as it has been studied, both under a theoretical agent-based perspective and in empirical studies and surveys.

2.1 Schelling model

Fundamental in the field of spatial segregation is usually considered the work of Schelling [26] which, from a pure theoretical perspective, and by mean of an individual grounded logic, showed how a rather low degree of preference towards people belonging to the same group (whether ethnic, religious, socio-economic *etc.*), by affecting the procedure of localization choice of agents, can result in a well-defined path of segregation, even if unwanted in advance. As Schelling [26] writes:

> This article is about the kinds of segregation -or separation or sorting- that can result from discriminatory individual behavior. By 'discriminatory' I mean reflecting an awareness, conscious or unconscious, of sex or age or religion or color or whatever the basis of segregation is, an awareness that influences decision on where to live whom to sit by, what occupation to join or to avoid, whom to play with or whom to talk to.[...] The only requirement of the analysis is that the distinction be twofold, exhaustive, and recognizable.

Individual motivations driving the locational choice of agents (represented in the model by stars and zeros) are quite straightforward in Schelling's main line of reasoning: people may just want to live among those belonging to their same group or to escape from the presence of others, according to the level of tolerance towards the other group; the different individuals will make their choice on whether to move or to stay considering if they are satisfied or not with their current position.

Schelling model is built under certain conditions:

- the population is completely divided between two groups (e.g. blacks and whites);
- each individual has a membership which cannot be changed;
- each individual is able to observe the colour of people occupying a certain portion of space;
- everyone is able to move if she is not content of the position occupied;
- each one has a specific location at any moment.

Schelling [26] first represents his model through a straight line on which stars and zeros are randomly distributed. Each one of these agents is assumed to care about the shape of her eight closest neighbours (four on each side) and, in particular, each one wants four out of these eight to be of her same group. If this ratio happens to be lower, the dissatisfied individual will move to the nearest place in which she feels comfortable. Individuals moves from left to right, one by one, and do not anticipate others' movements. Once all the dissatisfied ones have found the new position, a next analogous round is performed in order to accommodate those which have become discontent as they were previously left by similar but unhappy neighbours. The game is repeated according to the same scheme until everyone is satisfied and does not want to move from her place. The result of this game, as reported by Schelling, is that the population gets to be distributed in few homogeneous clusters of the same colour and that, globally, each individual resulted to have more than the 80% of their neighbours of the same colour. Including themselves in the whole neighbourhood, everybody lives in a cluster in which the ratio of like members is higher than five to one, against the five to four desired at the beginning of the game. On the whole, these results are independent from the initial distribution of stars and zeros: as Schelling reports, the features of the outcome (i.e. the formation of clusters characterised by high ratios of same group members) do not change.

Once found and highlighted this main pattern, the attention of Schelling [26] shifts to the manipulation of few variables, e.g. narrowing the area of what is considered the neighbourhood, fact producing no significantly different outcomes. Another manipulation performed concerns the reduction of the number of one of the two groups. The establishment of a minority and of a majority results in a greater segregation, which increases the greater is the gap between the two groups. As pointed out in the paper, this pattern comes out also due to the fact that, when the size of the minority group reduces, the possibilities of forming group lower as well, therefore minority members are likely to end up at last in the same cluster.

The third result reported concerns how a restriction imposed upon the freedom of movements affects the final figure. In details, the individuals have an allowed radius of travel within they can look for a suitable accommodation. If it is not the case (no such accommodation is found within the radius), agents are allowed to join the first place presenting a ratio of neighbours of three out of eight of her same colour. What happens is that everyone ends up in a satisfying location where half or more of the neighbours belongs to the same group. Clusters appear to be smaller and more frequent, furthermore they are formed trough a procedure that is assimilable to that resulting from planned (*concerted* in Schelling's own words) movements or *anticipatory* actions, since conscious agents may set up in an area knowing that their own presence increases the cluster, making it more attractive for newcomers: if I join a group of three people of my own group, I anticipate that my presence makes this small community reach the threshold of four, hence increasing the probability that others will join.

Schelling [26] continues his analysis implementing the model in two dimensions, which allows some different specifications. In particular, the dynamics of the model are now performed within a kind of squared lattice. The two groups have again the same size, but now approximatively one third of the squares in which the space is divided is left free, while previously the line was fully occupied by stars and zeros. The neighbourhood of each agent is defined as the eight squares surrounding her, and again discontent individuals move to the closest place satisfying their tastes, where at least one half of someone's neighbours must be of her same group.

Once again, the outcome of the game presents well defined patterns of segregation (even though a bit more hard to detect visually than in the straight-line case) where, on average, zeros and stars have more than the 80% of their neighbours belonging to their same group, a percentage far above the simple majority required to a neighbourhood to be satisfying.

As pointed out by Schelling [26], segregative phenomena evolve according to the rate of (in)tolerance among the population. In particular, it is noted that a demand for one-third of like neighbours generates a moderate segregative pattern, while when this is increased up to the 50% of similar individuals, the result becomes more striking, the causes of this phenomenon being the following.

- An increase in demand for similar neighbours increases, as well, the number of initially dissatisfied individuals.
- Such an increase makes grow the density of similar coloured agents, since the higher is this demand, the more similar neighbours the individual will get when moving; moreover she contributes to the growing density, since she is in turn a like neighbour of other agents.
- These higher requirements push more and more people to move towards original *nuclei* of satisfied individuals.

The outcome of this three effects is "...to make the resulting segregation a rapidly rising function of demands in the range from about 35% to 50%."(see [26]; for more considerations about non-linear patterns of self-organizing system, see Portugali *et al.* in [22]).

As done before in the straight-line case, some specifications are changed by Schelling. For instance, it is considered the case in which members of one group have a stronger demand towards like individuals, when compared to that of the other group. The result concerning segregation seems to be not impressive, since the difference in isolation between the two groups result to be slight, being separation a twofold relation: for one member joining a cluster, members of the other group become more isolated.

Another significant manipulation is to build the two groups so that they have the same rate of tolerance, but different sizes. What happens in this case, similarly again to the straight-line figure, is that the smaller the minority becomes, the less clusters there are in the final outcome. Moreover these clusters tend to become larger, thus making members of the majority (which can be a tolerant one) locally discontent with their location. An important corollary arising from this pattern is that, when in the space only one group is originally present and individuals of the other one arrive from outside the system, they will form a cluster around the first arrived, i.e. if in a world populated only by stars a single zero enters, all subsequent zeros arriving will locate next to the first forming a unique cluster, independently from the rate of tolerance shown by agents, as noted in [26].

All these previous results can also be inspected considering the density of clusters, since within them there can be found more or less empty spaces. With respect to the case in which one group is less tolerant, for example, even if the percentage of similar neighbours was not that different between the two groups, looking at the densities of clusters shows how the most demanding group ends up in a more dense region, leaving less blank spaces. The same dynamic is detected by Schelling [26] also in the case in which both are equally tolerant, but have different sizes (the minority in this case constitutes the more dense area). An even stronger result was obtained joining the two features, building a system where minority members have greater preferences towards their own group[1].

A further manipulation is to consider preferences for integration setting an upper bound to like neighbours desired, or a rank of preferred neighbourhood composition. Performing this exercise, Schelling points out three emerging dynamics that in purely segregative patterns were not detectable.

- Integration is a more complex phenomenon than segregation, since more movements are required to a larger number of individuals in order to achieve an equilibrium. Moreover there might be subjects which cannot find a satisfying position.

- If one of the two group is a minority, then to achieve the integration desired, minority members have to be "shared" among the majority, leading to a figure where minority may distribute herself somehow differently from the segregative case (e.g. not in clusters, but rather on lines).

- The movements can lead to the formation of "dead spaces", using Schelling's words, i.e. homogeneous areas which are stably left blank because of the new structure of preferences, which makes people move away from "single-coloured" areas.

[1] Another consideration made by Schelling is about what he calls "congregationist preferences", when individuals simply desire to have three out of eight similar members and are neutral to the presence of other group's agents. Consistently with previous findings, the outcome of this experiment is similar to the case in which the agents want to be the majority in the neighbourhood.

2.2 Schelling's consistency

Together with this theoretical conceptualization, many empirical researches regarding segregation phenomena can be found in the academic literature. For instance, Clark [6] shows empirically (by mean of telephonic interviews) how the tolerance thresholds supposed by Schelling are consistent with real urban localisation of black and white households. Furthermore, he provides evidences of the fact that, at least for what concerns the first group, the actual rate of (in)tolerance declared by the sample of the survey reaches a point well beyond that threshold found by Schelling, above which can be detected the emergence of segregated patterns. Clark [6] also suggests that the segregation processes are likely to be reinforced by considering that people tend to socialize with neighbours showing similar social conditions and interests. In fact, Clark remarks that integration is harder when black households wanting to move to a "white" neighbourhood are of a lower social status. It must be added, anyway, that the opposition tends to be stronger when the number of newcomers of the different group is large, even if they have a similar socio-economic level, while in case of small groups, old residents are usually more tolerant. Clark reports in [6] also cases in which researchers have found full segregation, due only to the different income level of the two ethnic groups, whereas *per se* none of the households seems to show any strong prejudice. Anyway, again Clark observes, the existence of stable integrated equilibria is quite unlikely.

2.3 Practical cases

The following section will report some findings of practical researches in the field of ethnic segregation. The first subsection will deal with the review made by Charles, in [5], of surveys conducted in the U.S. at the end of the last century. The second will report some findings of the research made by Hatna and Benenson [16] regarding the cities of Yafo and Ramlah, in Israel.

2.3.1 The U.S.: a review

Charles [5] produced a review regarding the main sociological theories and findings in the fields of racial segregation of the last decades of the twentieth century. In that period the overwhelming failure of the antidiscrimination policies and acts implemented by the U.S. government, showed that segregation was not a mere problem of legislation and get scholars to question about the true social dynamics behind this phenomenon. Moreover, since the 1970s, the ethnic American landscape has become more diverse and complicated, due to the arrival of new groups of immigrants, such as Hispanics and Asians. The trend during the last two decades of the century shows that phenomena of residential segregation have affected, in 1990, a number of metropolitan areas (almost thirty) which has doubled since ten years before.

Within this pattern, blacks seem to experience the strongest segregation, when compared to that suffered by Asians and Hispanics, although these last groups seem to become more and more isolated as their communities become larger. Consequently, it has been observed that *chain migration patterns*, through the enlargement of ethnic communities, cause the concentration of large groups into limited urban areas, hence increasing the isolation; while, consistently with Clark [6], it has been noted that small groups are less likely hit by spatial segregation. Concerning in particular the blacks and whites dynamics, data presented by Charles show that the areas experiencing the biggest decline in segregation in the 1980-2000 period are the most multiethnic, i.e. those having at least another nonwhite group, and/or those ones in which the black community is smaller (no more than the 10 % of the population). Furthermore, this decrease in blacks isolation seems to be mainly due only to the increasing presence of Hispanics, to which the exposure of Afro-American communities has grown. In order to find an explanation to the persistence of residential segregation phenomena, despite the antidiscrimination norms implemented across the last decades, several theoretical explanations have been proposed, grouped by Charles [5] in to the following two main currents.

Spatial Assimilation The first approach aims to explain the segregation patterns, highlighting the socio-economic differences shown by different ethnic groups.

In general, nonwhite people tend to have a lower education and low level jobs, therefore earning less. Consequently, residential patterns reflect the average status of the group. A higher level of wealth would allow them to move from poorer to richer neighbourhoods, where white people are more likely to live, hence resolving, or at least weakening, the segregation problem. A proof to this statement can be found considering social dynamics of Hispanic and Asian groups: researches quoted by Charles show that, as their social status improves and new generations of native born start to appear, segregation phenomena decline. This approach, anyway, fails to explain the whole pattern, in fact studies distinguishing among different subgroups of Hispanics, found that black and mixed-race (being white Hispanics the third subgroup considered) experience segregation patterns close to those lived by Afro-Americans, therefore suffering discriminations not imputable to socio-economic status differences. Another criticism is that aggregate-level analyses do not inspect the characteristics of urban areas in which segregation takes place: they can be rather relevant, if one considers that blacks living in the suburbs tend to settle in older and poorer neighbourhoods, experiencing higher criminality rate and social disorganisation (see Charles in [5]).

To address these issues, individual-level analyses were run: among their findings, it has been detected that black households present lower rate of return on education and lower income when compared to other groups, and that they suffer from a negative residential outcome effect due to houseownership, i.e. blacks owning their home tend to live in more segregated and less rich neighbourhoods compared with black people renting their residence. This effect is not present in any other ethnic group and gains even more meaning considering that, within the black community, the association between socio-economic status and residential outcome is positive. All these phenomena contribute to the formation and the preservation of the social gap existing between blacks and whites. Additionally, middle class African-Americans are generally less segregated, but they use to reside next to less affluent whites. The areas in which they live are then less rich than those in which their white socio-economic counterparts stay. Consistent with the aggregate-level surveys, is the evidence that black Hispanics tend to live in neighbourhoods similar to those of African-Americans, despite the general condition of Hispanics is more affluent.

Individual level researches, according to Charles [5], are a powerful tool also for what concerns national-origin differences, which can be a relevant feature in order to check the consistency of the spatial assimilation hypothesis. For instance, when the analysis is brought to this level, it appears that recent white immigrants, such as Irish, Italians and Polish, are likely to settle in poorer areas when compared to older white communities like British, French and German. Similarly, for black communities, Afro-Caribbeans experience better outcomes than African-Americans. For Asians and Hispanics this dynamic is even more striking: Indians, Vietnamese and Filipinos are found in worse neighbourhoods if compared to other Asian national groups like Korean, Chinese and Japanese, a result reflecting the poverty or the wealth of their original countries accordingly: this finding is not attributable evidently to linguistic issues, since English is broadly used both in India and in the Philippines. Among Hispanics, the nation of origin seems to penalize Cubans and Puerto Ricans (other individual characteristics being equal), and it has to be added the already mentioned difficulties hitting black Hispanics. These three last subgroups tend to reside in poorer and lower status neighbourhoods, when compared to other Hispanic households.

Summarizing, according to Charles [5], aggregate-level researches' conclusions are on the whole confirmed, and their findings are generally consistent with the Spatial Assimilation hypothesis, with the exclusion of the patterns of segregation affecting blacks, both American and Hispanics: as mentioned before, black suffer from negative effect generated by the ownership of their home[2]. Another point of weakness in this approach is that white non-Hispancs tend to reside in better and richer urban areas, irrespective of their socio-economic status. These last remarks, Charles states, are signals of persistent phenomena of racial stratification, contrary to the Spatial Assimilation theoretical framework.

Place Stratification The second group of theoretical explanations takes the label of Place Stratification and tries to address the emergence of racial dynamics.

The starting point of this field has been the consideration that, even if the Fair Housing Act of the 1968 should had put an end to the dualism of the housing market, racial segregation persisted and still persists. The hypothesis to be explored is hence that of localisation schemes affecting ethnic groups according to "their group's relative standing in society" (Alba and Logan quoted by Charles [5]), a phenomenon preventing individuals of certain minorities to live next to whites of a similar socio-economic status. In the opinion of the supporters of this thesis, actions implemented by white communities in order to preserve social gap through the use of spatial segregation can be better detected under the light of discrimination and racial prejudice.

Charles reviews, in [5], the alternative explanations that go under the broader idea of Place Stratification. The first considered (labelled by Charles as *Neighbourhood Racial Composition Preferences*), is related to the conception of dis-

[2]Scholars quoted by Charles argued that this oddity could be explained considering the existence of a dual housing market, pushing them to live in black neighbourhoods; mixed effects with respect to Hispanics and Asians should be the proof of a weaker dual market also for these minorities. But this dualism does not seem to hit renters

crimination phenomena as arising from individual preferences, in location, towards members of their own ethnic group, i.e. segregation arises as a direct consequence of a rather natural ethnocentrism. To test this tendency, scholars cited by Charles run different experiments and surveys. In the Detroit area, black and white participants to a survey conducted at the end of the 1970s were asked to rank, according to their preferences, four different neighbourhood (composed by fifteen houses) settings having different levels of racial integration. As result, it appeared that the 25% of whites was uncomfortable to accept even one single black neighbour in the fourteen houses surrounding them, the 40% if one third of the area was occupied by blacks, and the 80% if the blacks were the majority. On the contrary, black people seemed more favourable to racial mixing, since the largely most preferred setting (i.e. ranked as first or second choice by the 85% percent of the participants) was that in which the two communities were equally represented. Moreover, the 38% of blacks would have been satisfied in a neighbourhood populated only by whites (see [5] for more details).

This experiment was replicated in the early 1990s in other Northern-American metropolitan areas (Atlanta, Boston, Los Angeles and again Detroit) adopting the same methodology, but including in the potential neighbourhood settings also Asian and Hispanic minorities. With respect to the previous survey, whites seem to be more comfortable with integrated spaces (the majority of them would be fine in a neighbourhood of which one-third is occupied by another group), although the ethnic origin of their neighbours is not irrelevant: whites prefer Asians to Hispanics and Hispanics to blacks. Significantly, nearly one half of white households would not like to move to a district populated by one third of blacks. Yet, similarly to the 1970s, blacks, as well as the other non-white groups, show a stronger preference for integration, remaining the two most preferred settings the most integrated ones. There are anyway some differences among groups. For instance, blacks do not seem to mind about the ethnic origin of their neighbours, while both Asians and Hispanics have preferences towards white neighbours, and, at the same time, the majority of these two communities prefers segregation if the possible neighbours are black. Somehow coherently, the percentage of Hispanics and Asians willing to reside in a completely-white district is twice that of African-Americans (10% and 5% respectively). Shared, instead, by all the three minorities is the discomfort towards a mixed situation in which all the groups are present. Other experiments in the same field, conducted using a different approach, have led pretty much to the same conclusions, i.e.:

- all groups show preferences for neighbours of their same ethnic origin;
- these preferences varies according to the group considered, whites having the strongest and blacks the lowest;
- integrated quarters are perceived as more or less comfortable according to the other group populating them, being white the most favourite neighbours and blacks the least;
- as the number of ethnic groups residing in the neighbourhoods increases, the preference towards integration decreases.

Again, see Charles [5] for further details regarding all the mentioned surveys.

The second contribute to the Place Stratification comes from the issue of how does "race" matter, and the role of racial prejudice. Charles, in [5], named these contributes as *Prejudice Versus the Alternatives.* Scholars in this field have found that there is a strong association between negative stereotypes about blacks and the white resistance against living next to them, as well as their propensity to stay, or to move to, integrated areas. More generally, it has been found that negative stereotypes against ethnic groups are influencing preferences regarding other and same-race groups, and stereotypes are good predictors of preferences. On the contrary, effects of the perception of other groups social status and measures of ethnocentrism (i.e. preferences towards the same group) do not seem to have a particular relevance. Negative stereotypes affect the preference for integration, regardless of the composition of the out-group (i.e. it does not matter whether they are blacks, Hispanics etc.) and get preference for the same group to increase. These last considerations are found particularly true for white people, whereas findings within blacks are the weakest among the groups considered. Preference of blacks towards integration is then found to be driven by the desire of improve ethnic relations and the belief in the value of integration. Instead, preferences towards the own groups, again among blacks, seem to be tied to the worry about discrimination coming from white people. As reported by Charles, this phenomenon does not provide validation to the ethnocentrism and racial hypothesis, since only few blacks seem to show these behaviours.

For what concerns whites attitude towards other groups (the research quoted by Charles in [5] is referred to the area of Los Angeles), it has been developed an analysis distinguishing between "racial" and "race-associated" motivations. When asked to explain the reason of their break out from certain urban districts, whites tend to use the second kind of reasons, meaning that they are likely to refer to concerns tied to stereotypes, like the fear of an increase in the criminality rate or the lowering of the price of houses; these findings are again consistent with the racial and ethnocentric hypothesis, since the distinction between open racial (racist) and "race-associated" motivation is purely semantic[3]. Interestingly, education seems to matter in the kind of explanation given by the surveyed: it appears that better educated whites are more reluctant to link the reason of their escape from an integrated neighbourhood to negative stereotypes. They are more likely to give racial associated motivations instead, since they may be more sensitive to social desirability and are more used to express their racial preferences in more sophisticated manners.

These surveys, Charles claims in [5], are anyway not free from methodological limitations. In fact, as noted above, when asked about their preferences, people may be influenced by the social (un)desirabilty of their answers in the field of racial preferences. Furthermore, continues Charles, it is hard to distinguish between what is the direct effect of the ethnic composition of a district, and what is indirectly caused by the characteristics of the area that participants to the survey assume to be due to its ethnic composition. In order to control for potential biases generated by other variables affecting the localisation decisions, such as criminality, school quality, houses price *etc.* in the early 2000s was run an experiment in which whites were asked to imagine to have two children and

[3] "[I]n the end, each of the reasons is an articulation of a racial stereotype", Krysan, cited in [5].

to have to look for a new house. They were told to suppose, in addition, to have already found the ideal house (close to work and financially affordable). Then, before buying, they were provided with certain random neighbourhood characteristics regarding e.g. the housing market, public school quality, criminality and racial composition. Findings show that white households do not seem to matter about the presence of Hispanic or Asian ethnic groups, while concerning blacks, it was find a significant aversion: after having controlled for the other variables, whites are unlikely to settle in a district with more than the 15% of black residents. In particular, this feature seems to be stronger among families with children. These last results, along with the previous, lead Charles to conclude that racial prejudice is rather determinant in shaping patterns of integration and segregation and their persistence. Specifically, prejudices coming from the white community have a double reinforcing effect, since from one side, they shape their preferences towards segregation, from the other, they affect also the localisation dynamics of other group, as response to their hostility. Charles [5] reports, in fact, that blacks worry about the negative attitude shown by whites, and this is the main factor making them wishing for presences of neighbours of their same community.

In any case, Hispanics, African Americans and Asians show a propensity for integration greater than that of whites and, Charles notes, ethnocentrism seems to have a little part in the segregation phenomena. A more significant role is played by racial prejudices, that affect preferences of households directed to another group (e.g. causing its avoidance) and towards the desirability of coethnic presence in their own neighbourhood.

The third and last contribute to the Place Stratification, according to Charles, goes under the name of *housing market discrimination*. Even if legal and formal barriers have been abolished several years ago, empirical evidences show that this kind of discrimination is persisting, mainly thanks to whites discomfort about integrated areas. In fact, it appears that white household are generally willing to pay more in order to live in white neighbourhoods. In order to detect this less visible form of discrimination, different kinds of surveys have been performed. The first considered is an audit study, in which prepared auditors were asked to report their experience in the housing market. Of the two testers, one belonged to the Hispanic or the black minority, whereas the other was white. Houses on which they have to inquire were randomly chosen on newspapers advertisements. On the whole, there have been reported examples of discrimination, considered as the orderliness in treating worse the nonwhite auditors, going from the will to address them into segregated districts, to the availability of agents to show them more or less accommodations, to the readiness shown in answering to phone calls[4]. The results of 50 of these researches, run in the 1980s, have led to the conclusions that discrimination continues to affect the real estate market, that minorities (blacks and Hispanics) experience some form of discrimination in around the 50% of their interaction with landlords and agents, that the discrimination in this field is usually hard to detect and that the frequency of these phenomena has not changed.

[4]Many doubts have been raised about this kind of empirical investigation, such as the way through which houses announcements were drawn from major newspaper, the possible distortion of judgement in which testers may incur and how do they should be trained, the importance of their accent and of their figures and so on. Anyway, tells Charles, audit studies get to be refined and are accepted and regarded in the social science community.

Surveys made few years later, based on the Housing Discrimination Study, report how discrimination affects the different steps in which the search for an accommodation can be divided. In particular:

- In first place, people generally ask to agent about an advertised property and about similar units. Researches show that, on average, African Americans and Hispanics received informations about 25% less units than their white counterparts. In the 5-10% of times, informations were not given to black and Hispanic applicants.

- Secondly, real estate agents can take actions in order to make easier the conclusions of the bargaining. This may includes supporting instruments, such as follow-up phone calls or financial facilities. It came out that minorities were less likely to receive such considerations.

- The final aspect considered consists in the location of different accommodations offered to the potential clients. In particular, they may be pushed by agents to consider more an area than another. The 40% of times, black homeseekers were constrained in their choice in this way (this percentage goes to the 28% for Hispanics), while white applicants were likely to receive negative advises and comments about integrated neighbourhoods. These kinds of behaviours cause practically phenomena of racial steering, which are formally forbidden, but that are eventually legal, as they arise from simple marketing practices.

Other scholars focused their attention to the concession of mortgages to minorities. After having controlled for variables such as individual characteristics, the default risk, lending costs and so on, it was found that minorities (Hispanics and African Americans) have a rate of loan denial of 56% higher than whites. It was also found, in another study, that credit rating given to minorities was systematically lower than that attributed to white applicants: the perception of the reliability of a client seems to be dependent from her ethnic look. In 2000 data have been recollected, minorities seemed to show a significant improvement regarding the likelihood of receiving a worse treatment compared to whites. Nevertheless, other sources of discrimination persisted or worsened. For instance, the practice of steering black applicants away from white districts have increased through the decade; moreover Hispanics renters seemed to suffer an increase in discrimination (see Charles in [5]).

Finally, even if less studied, there exist successful cases of *stable* integration, despite the end of subsection 2.2. In fact, in 1990, ten millions of American citizens lived in stably integrated areas. At that time, it was found that in almost the 20% of American neighbourhoods[5] were located and integrated different ethnic groups, where the 15% were whites and one third were blacks. Ten years later, the 75% of those communities were still existing.

Interestingly, integrated quarters present an heterogeneity of both ethnic groups and socio-economic classes, residing there well educated and well paid middle-class households, as well as people not that affluent having low level jobs; in these areas the housing market is coherently diversified, with one quarter of the units belonging to the rental sector. These neighbourhoods show also desirable characteristics in terms of safety, architecture and location, and have places

[5] Ellen in Charles [5].

where the interracial contact is daily feasible (e.g. parks, stores, schools *etc.*), Furthermore, there is a strong presence of institutions and organizations rooted in the community that are, directly or not, maintaining diversities, taking care of issues affecting the whole community (e.g. safety and schools), or promoting the cross-ethnic dialogue[6]. Residents of such neighbourhoods tend to value the diversity of their districts and are generally more tolerant, working to preserve this diversity.

Anyway stable integrated equilibria, notes Charles in [5], are more often arising in situations in which the black minority is relatively small and in areas distant from the main minority groups. As Charles writes in her conclusions:

> Recent efforts to understand the causes of persisting residential segregation highlight the complexity of our emerging multiethnic world at the same time that they remind us, matter-of-factly, that race still matters. As the dominant group, whites have the luxury of living in relatively affluent, safe neighborhoods, with high-quality schools and services, even when their own financial resources are limited. Although recent immigrants may be initially disadvantaged by low socio-economic status and limited English proficiency, they can be assured of gradually making their way into neighborhoods comparable to those of whites. As has been the case for much of our history, however, groups racially defined as black continue to face profound barriers to their quest for the American dream.

(See Charles in [5].)

2.3.2 Outside the U.S.: the Israeli case

Hatna and Benenson [16] have instead recently applied the theoretical framework proposed by Schelling to inspect segregation / integration phenomena in the Israeli urban areas of Yafo and Ramlah, situated respectively in the municipality of Tel Aviv and some 20 Km South-east from the capital. These two cities present a fractionated ethnic context composed by a majority of Jews and a consistent minority of Arabs (both Muslims and Christians).

What Hatna and colleague note in the Yafo and Ramlah panorama is that, with respect to the traditional segregation / integration dichotomy detected in the classic Schelling model, households localisation is more variegated: integrated patches may be found next to the segregated ones or, instead, they can be separated by non-populated zones. The quest for an explanation to this phenomenon has led Hatna and Benenson [16] to focus on the emergency of patterns generated by different thresholds of tolerance within two different ethnic groups, perhaps also of different size[7]. The main findings of this work are that, in case of only one perfectly tolerant group, there exist mixed situations between the fully integrated and the fully segregated pattern, while, as in the classical Schelling model, whenever the two groups have the same tolerance threshold the passage from integration to segregation is abrupt and sudden with the decrease of the tolerance rate. Thus, the mentioned paper suggests that, considering the existing segregation patterns in the two Israeli cities, the model they propose

[6] The importance of associative attitudes is deeply studied by Putnam in [23].
[7] The rate of tolerance stays, however, equal for members belonging to the same group.

can be, at least up to a certain degree, related to the reality: empirically, Arab minorities are rather tolerant, in the sense that they do not seem to mind to much to the presence of Jewish people in their neighbourhood, hence generating kinds of mixed patterns close to those obtained by the model.

Anyway, as Hatna and Benenson remark in [16] in their conclusive discussion, the real figure is much more confused and harder to understand, mainly considering that, in the households' localisation choice, many other factors are likely at work and the tolerance level varies through members of the same community.

2.4 Social relevance of ethnic segregation

Spatial segregation patterns are, as one may well expect, of a certain relevance within the social texture. As Charles [5] states, districts where poverty is concentrated present high level of long-term unemployment, lower average salaries earned, high rates of school retirements, of criminality and of social disorders; in addition the poorer the district is, the worse are public services (schools above all). Moreover the role that spatial segregation plays in these patterns seems to be rather important since, according to Cutler and Glaeser quoted by Charles in [5]:

> [A] one-standard-deviation reduction in segregation (13 percent) would eliminate one third of white-black differences in rates of high-school completion, single parenthood, and employment as well as earnings.

Discrimination phenomena as those referred in 2.3.1, are likely to get minorities to live in poorer and depreciated neighbourhoods, even if the households considered may not be experiencing extreme poverty, since (as again reported in Charles [5]) middle-class blacks too are unable to avoid high criminality areas. In practice, spatial segregation negatively affects upwards social mobility of minorities, and this can happen either because of direct discrimination,e.g. Charles reports that employers are able to use space as a discrimination tool against job seekers of a certain community, or through other channels, like the already mentioned low level of education on average. Significantly, it has been found that people moved to mainly white neighbourhood have improved their educational attainments as well as their employment outcome. Those who have experienced this kind of "good" mobility are inclined to give great importance to improved safety, as contributing significantly to their achievements.

Empirical findings seem to agree with this suggested cause. The disadvantage experienced by people residing in segregated areas, continues Charles in [5], is likely to come from the high rates of violence affecting segregated neighbourhoods, since people coming from these kind of situations tend to show lower academic attainments regardless of their socio-economic condition, of schools quality and of their psychological and intellectual preparation. Furthermore, in addition to the higher exposure to violence, these individuals are more likely to be hit by stressful life experiences, fact leading to a higher family stress, worse health conditions and a major involvement in their family events. Things, these, that represent a disadvantage in the academic life and a significant obstacle to the fully attainment of people's potential (again, see Charles [5]).

2.5 The city as a self-organising space

Approaching to the chapter in which the models are going to be reported and described, it could be a good idea to see how hypothetical urban spaces have been simulated and treated in the work of more quoted scholars.

In particular, the work of Portugali, Benenson and Omer (in [22],already mentioned in chapter 1), is built upon "an approach that perceives the city and the various processes of sociospatial residential segregation in it as a system in self-organization". With this aim, Portugali *et al.* propose a Cellar Automata (CA) simulation where the future state of the different cells is determined as a function of their current state, the configuration of the neighbouring cells, the set of the possible states it can assume and of the transformation rule determining its configuration[8]. The mechanism of the whole model built by Portugali and colleagues [22] basically involves two groups of individuals (actually invisible, since a CA simulation model is just composed by a lattice of cells), the blue and the green ones, competing for a place where to settle. Green individuals, preferring green neighbours, are more likely to settle in a cell as long as the surrounding cells are green as well. This probability, for this kind of "household", is negatively proportional to the number of neighbouring blues; blue individuals behave in the same way with inverted colours. Free spaces are then subjected to the competition between inner "citizens", dissatisfied with their old position and searching for a new one, and immigrants coming from outside the system. The processes above described is divided in three ordered steps.

1. The probability of abandoning a certain place is computed according to the individual's and her neighbours' characteristics. Cells stay occupied or are left empty accordingly, creating inner "migration" phenomena.

2. In the second phase, it is computed the probability that each empty place is occupied by "place-hunters"(following the terminology of the paper). These lasts find their new location following these probability.

3. The second step is then repeated for immigrants arriving from outside the system.

These probabilities were computed through Monte Carlo simulations[9].

From a theoretical point of view, Portugali and colleagues emphasise the role of a city as a "typical system in self-organization", using their own words in [22]. More precisely, they consider it as an *open* and *complex* system, since:

- it presents both inwards and outwards flows of migration, a fact that can keep the system away from an equilibrium state;

- there is a large number of individuals, each of them showing her own features, interacting with the others and changing their properties accordingly.

[8] A classical example, proposed in the list of readings suggested by Axelrod and Tesfatsion in [2], of a CA is the so-called "Game of Life", created by John Conway. Uri Wilensky inserted a version of it in the library of NetLogo.

[9] In order to do the computation, it has to be considered also the number of outer immigrants arriving, of which kind they are, and the probability according to which place-hunters finding no new location leave the system.

Moreover, the system enjoys the property of being self-organizing, since no rule shaping the aggregate and global patterns was previously established. On the contrary, these figures emerge from the composition of single individual interactions, noting that:

> ...City's global properties are not the sum of its parts and it exhibits phenomena of nonlinearity.

(See Portugali *et al.* in [22].)

The model has other rather relevant features, according to its creators. First it is probabilistic, as the behaviour of its single parts is not deterministic, as described above. Second, it is a spatial model, since, belonging to the CA class of models, aggregate figures are the result of spatial interactions among cells: the properties enjoyed by a single place, and therefore the probabilities according to which it will change or not its state, are function of those owned by the neighbouring cells. Third, it is a heuristic model, in the sense that no aprioristic assumption was formulated about migration decision and the determination of the cells state: it is learnt by simulating the model which starting condition lead to different scenarios. As final property, Portugali and colleagues examine in [22] the relationship between local interactions and global properties, highlighting the fact that, as also previously stated, the system is not causally determined, but it shapes itself reacting to both internal and external influences.

Passing to the description of the model, Portugali and colleagues propose three different experiments, each one designed from a different starting point. In general, there are two groups of individuals, the green and the blue ones, which are composed by segregative and neutral members. The first kind like to live next to members of their own group. The probability that they will occupy a place are monotonically increasing with the number of similar neighbours, as well as the probability of leaving monotonically increases with the number of "diverse" individuals. Conversely, neutral placehunters are not driven, in their locational choice, by the attractiveness exercised by similar individuals, nor by the repulsion against the other group[10].

First experiment: segregative groups. In the first experiment set by Portugali *et al.*, both groups are composed by segregative placehunters; immigrants coming from outside are of the same sort. After the first time steps, the pattern becomes rapidly clear: the space appears as fully segregated, divided between homogeneous blue and green areas. No significant change intervenes as new individuals arrive in the system and the state reached is stable.

Second experiment: one segregative group vs a less segregative one. In this second experiment, the blue group is again composed only by segregative members, while the green one experiences the presence of tolerant members. The behaviour of greens is then tested with increasing proportions of neutral individuals arriving from outside. The outcome of the game is that, regardless of the number of tolerant greens, one single fully intolerant group is sufficient to have again a segregative pattern at global level. Interestingly, as noted by Portugali and colleagues, it is the more neutral green region to be the most segregated one. In fact, the blue area is more mixed, presenting in its interior

[10] See [22] for more details.

also tolerant greens. Anyway, the preservation of a pattern of segregation is visible by noting that an increase in the proportion of tolerant green cells is not accompanied by an increase in the number of greens situated among the blue area.

Third experiment: both neutral and segregative individuals within the two groups. As last instance, it is set up a game in which tolerant newcomers belong to both groups. The global patterns is again tested by stepwise increasing the proportion of neutral individuals. The most interesting result of this experiment is that different outcomes appear to be nonlinear. In fact, a proportion of one third of neutrals in both groups generates again patterns segregation, while a proportion twice as bigger results in a global integrative dynamic. This implies the existence of a threshold between the two patterns (as also suggested by [26], previously quoted in 2.1), that Portugali and colleagues find as lying between the 50% and the 60% of tolerant members in both groups. Another important feature (present also in the precedent experiment) according to Portugali and colleagues in [22], is the localisation, in segregated patterns, of neutral individual next to the boundaries dividing the two main areas. For what concerns the stability and the instability of the system, as remarked in [22], it has to be considered that self-organization is a feature of open and complex systems which are far from equilibrium or, differently formulated, that are always in motion. Therefore stability and instability are characteristics of the movements of this system which lead also to a certain notions of predictability. As stated again in [22]:

> ..a system in self-organization is, in principle, unpredictable; [...] one can discuss predictability and unpredictability only with reference to the past. For example, it can be said that [...] "judging from the past, it is probable that the system will behave in a certain way".

As pointed out by Portugali and colleagues, a phenomenon typically affecting cities is that they follow globally stable dynamics, while, locally, there may exist areas of unstable behaviour. For example, the outcome of the first experiment is a world shared between two homogeneous areas defined by boundaries dividing them. Local instability is found only next to these borders, while the global figure is completely stable and changes happen only in a very slow manner. Regarding the second game, it is interesting to highlight that the most segregated area is the less intolerant. In fact the experiment two was designed (as told above) including some tolerant green cell. The outcome is that green individuals can be found in the blue area, while no blues are settled in the green one. The reason, as explained by Portugali *et al.* in [22] is that greens do not mind about living in a blue neighbourhood, while for intolerant blues this is clearly not happening. This observation may lead to a better understanding of urban patterns such as those of subsection 2.3.2, in which the spatial panorama is shaped by the different degrees of tolerance between groups. Moreover, Hatna and Benenson in [16] give as possible explanation to what occurs in Ramlah and Yafo, the fact the these areas may be still in transition, which is what Portugali and colleagues find as the real-world counterpart of those area of local instability detected in the first experiment. As other instances of tolerant households residing in intolerant neighbourhood, again Portugali *et al.*[22] cite also the cases of blacks living in white districts (as also reported by Charles in [5]), or lower-middle-class members in working-class areas. All these patterns contribute to the idea, furthermore, that a feature of a certain area may depend more on people residing in other district than on local households' characteristics (the structure of the green zone is a consequence of the behaviour of the blues, not of the greens). With respect to the third exercise, the most relevant result is the evidence of nonlinear patterns shaping the system, since there is a threshold, as previously noted, between the 50% and the 60% of neutral individuals among the two groups. The consistence of the statement that "City's global properties are not the sum of its parts " is easily shown by noting that, when both group have the 33% of tolerant members, instability is greater than the case in which only one group have the 67% of neutral individuals.

Chapter 3

On the concept of space

The concept of space, and its role in the attainment of social justice, has been widely debated in the past forty years. The present chapter is aimed to report how it has been treated by some scholars, and to discuss the idea of "spatial justice" that arose in recent years.

3.1 The space and its social role

The history of space in the western thought dates back long ago. According to Lefebvre [19], it began to acquire an autonomous value with Descartes and his conception of *res extensa*, which marks a turning point from the Aristotelian idea of space as a simple category. Since then, the debate has continued, emancipating progressively the space from its mathematical and geometrical origins and ended up affecting also other disciplines. This section is focused on the role it played in political philosophy and, consequently, in geography: a role that has arisen from the social and political debate of the 1970s and has developed ever since.

3.1.1 The social space and its dynamic

Space, in its social component, can be seen as a product of human forces, as well as the outcome of intellectual efforts (as in Lefebvre [19]), which are frequently, if not always, in contrast with each other, particularly in urban context (see Harvey [15]). The dynamic of these contrast has been long analysed following the schemes of analysis and the theoretical categories of class struggles already built by Marxian scholars. The first debates on this subject among such scholars revolved around the question on whether the social space was simply a mere expression and reflection of the social structure (which is, in this view, based upon the social relations of production), or if it deserved to be considered an autonomous structure, with its inner dialectic dynamic and transformation processes. Commenting upon this academic dispute, Edward Soja (in [27]) suggests, instead, that relations of production have always the double feature of being social *and* spatial. These two components are then homologous, in the sense that they both arise from the mode of production, and are moreover interconnected in their specific dialectic dynamics. For instance: class structure from the social side, and organized space (centre and periphery) from the spatial one. The first affects the second and is in turn affected by it, with no specific priority.

To begin with his reasoning, Soja [27] makes a first distinction between "contextual" space and "created" space[1]. The former is the one conceived by the materialist vision, according to which the matter exists in time and space, and therefore these three concepts are intrinsically connected: time and space give to the matter its objective form. From this ("physicalist" in Soja's words) point of view, space represents the container of the existence and of human life. This approach, anyway, seems to be a rather weak basis from a social vantage point. Indeed, in Soja's vision (again in [27]), space can be also organized, used and transformed by human action: it can be seen as a social product just as other social construction. The "created" space, or "second nature" using a Lefebvre's expression (reported by Soja in [27]) is thus that space arising from the human labour and from the objectification of the social structure, or, more precisely, a structure made by the society. As Lefbreve, quoted in Soja [27], writes:

> Space is not a scientific object removed from ideology and politics; it has always been political and strategic. [...] Space has been shaped and molded from historical and natural elements, but this has been a political process.

Soja [27], once recognized that the space is organized, or produced, by social forces, argues that the focus of the analysis shall be shifted to the relationship between space (in this latter sense) and others socially produced structures. It appears then that social and spatial relations are :

> ...dialectically inter-reactive, interdependent; that social relations of production are both space-forming and space contingent (insofar as we maintain a view of organized space as socially constructed).

(See [27])

In order to demonstrate these relationships, Soja passes to analyse the role covered by the city through the different evolutionary stages of the capitalist society. Urban space have deeply evolved through the centuries since the first industrial revolution, following, according to Marxian arguments, the modifications occurred in the productive structure. Soja [27] posits that the city's function has passed from being simply a centre of production and accumulation, that accompanied the urban development under the competitive capitalism of the XIX century, to cover the function of being a place "charged" of the control of the capitalism reproduction trough "labour power, exchange and control "(*ibidem*) in the monopoly capitalism. As a consequence, more attention was paid to urban planning, housing, public facilities, workplaces *etc.* i.e. to all those issues relevant for the social organization of space. This resilience[2] of the city can explain, according to the Marxian vision of Lefebvre (in Soja [27]) why

[1] Significantly, Lefebvre [19] begins his paper with a review of the different notions of space given in the history of philosophy.

[2] This term "resilience" has been recently used as an analytic tool for the ability of complex systems to respond, and to cope with, internal and external forces and changes (see Graeme S. Cumming in [7]). Although Lefebvre and Soja wrote the cited papers decades earlier, still the idea can be evoking.

capitalism has so long survived. It was able to transform itself and to weaken what are, in the Marxian vision, its internal contradictions: capitalism was able to resist thanks to the occupation and production of space (Soja [27]), keeping separated even from an epistemological perspective the different notions of space (Lefebvre [19]). More precisely, Soja reports the position of Lefebvre according to which social space (mainly the urbanized one) has been the place in which the productive structure is reproduced, along with its relations of dominance and subordination. The urban space as been progressively occupied by advanced capitalism, fragmented and organized into cores and peripheries and consequently centrally controlled through the invasive state action, while formerly the continuation of the social order was left mainly to market forces (Soja in [27]).

In this process, and in the new "monopoly" capitalism, a growing importance has been taken by the financial sector, thanks also to the increasing real-estate speculations (Harvey in Soja [27]) which have become a main source of surplus, overtaking the role that industry covered in the previous stage of capitalistic economies. Real estate sector has also had its part in shaping social space, being deeply involved in the organization of urban area for collective consumption and in the increasingly leading role played by the state. In the Marxian view, as the decades passed by, the financial development has become essential to expansion and the survival of the capitalist system, first by providing the means necessary to find new markets and new resources (e.g. the imperialist age), and then by helping it to reproduce its production mode in times of crisis. Those particular years, like the 1970s, saw the birth of both the monopoly capitalism and the big financial centres, as well as the impoverishment of the low working class, with all the spatial consequences that these phenomena brought (see Soja [27] and Soja, Morales and Wolff in [29]). In particular:

> During the early phases of stagnation in the 1970s, financial barriers had a major effect; they were largely responsible for the transformation of metropolitan cores, through urban renewal and reduced low income housing supplies, into spectacular new centers for finance capital institutions. But deepening economic crisis shifted the burden back to the reduction of real wages, thereby establishing the need [for the working class] for a two-front struggle over consumption and production relations.

(Soja [27])

Along with these cyclical crises, the Marxian analysis posits also that another necessary outcome of capitalism is the uneven development of different areas. Regarding this point, Soja in [27] adds that the capitalist mode of production purposely acts in order to create and maintain development unbalances. These disequilibria are not only specifically geographic (at any level: urban, local, regional, global etc.), but they can also refer to certain sector or industry, since growth of productivity of a certain area, whether economic or spatial, can be accompanied by the stagnation, or the underdevelopment, of another[3]. But Soja

[3] According to the Marxian school,indeed, the underdevelopment of a certain area is a structural by-product of the development of other regions or sectors. In the monopoly capitalism, following the same vision, the survival of the production system is tied to the achievement of "super" profits that can only be obtained through the exploitation of poorer or underdeveloped areas.

[27] argues also that, anyway, the expansion of capitalist mode of production leads also to an increasing tendency towards an homogenization and equalization of regional differences. What arises from these two opposed movements (the birth and the preservation of economic unbalances and flattening of areas at different development stages) is a dialectical tension which in turn affects the evolution of the capitalistic system.

At the urban scale, a practical instance of the contemporary presence of underdeveloped areas and industries can be seen in the core-periphery relationship. Soja [27] supports this idea suggesting a dialectical link between affluent and dominant centres, which are also the axes of capital accumulation, and the subordinated and dependent peripheries. This dynamic connection can be seen as a spatial implementation of the productive relations between dominant and productive classes[4] : both these structures, social and spatial, are formed by the struggles made in order to control the means of production. These patterns are then replicated and reflected to other geographical scales at both horizontal-spatial and vertical-social level. Again Soja remarks that these two analytical areas are connected in the following sense:

> ...the vertical and the horizontal expressions of the relations of production under capitalism (i.e. relations of class) are, at the same time, homologous, in the sense of originating in the same set of generative structures (e.g. the relation between labor and capital); and dialectically linked, in that each shapes and is simultaneously shaped by the other in a complex interrelationship which may vary in different social formations and at differently historical conjunctures. There is no permanent and rigid dominance of one over the other in all concrete historical and geographical circumstances.

(See again Soja in [27]).

3.1.2 The practice: the case of Los Angeles

Once examined the theoretical framework so far built, it can be now interesting to see how these analytical tools have been applied by Soja and colleagues. More specifically, Soja, Morales and Wollf (in [29]) have focus their attention to the restructuring process of society in the age of economic stagnation of the 1970s. The aim of their work is to inspect the determinants of the urban restructuring that took place in western countries in general, and in Los Angeles' areas in particular, during the first decades after World War II.

A history of economic cycle and urban restructuring. Los Angeles, as the authors note, has experienced since the 1960s a strong growth for what concerns the number of inhabitants and of employment in non-agricultural industries. These positive trends continued also during the crisis of the 1970s. This expansion was accompanied by an increased centralization of financial centres, industrial activities, of corporate wealth and by a boom in offices building.Also in these decades, an intensive process of urban restructuring took place. Coherently with the previous paper (Soja [27]), Soja and colleagues [29] argue that

[4] Soja uses the expressions of “horizontal” and ”vertical“ structures to identify spatial and social structures respectively.

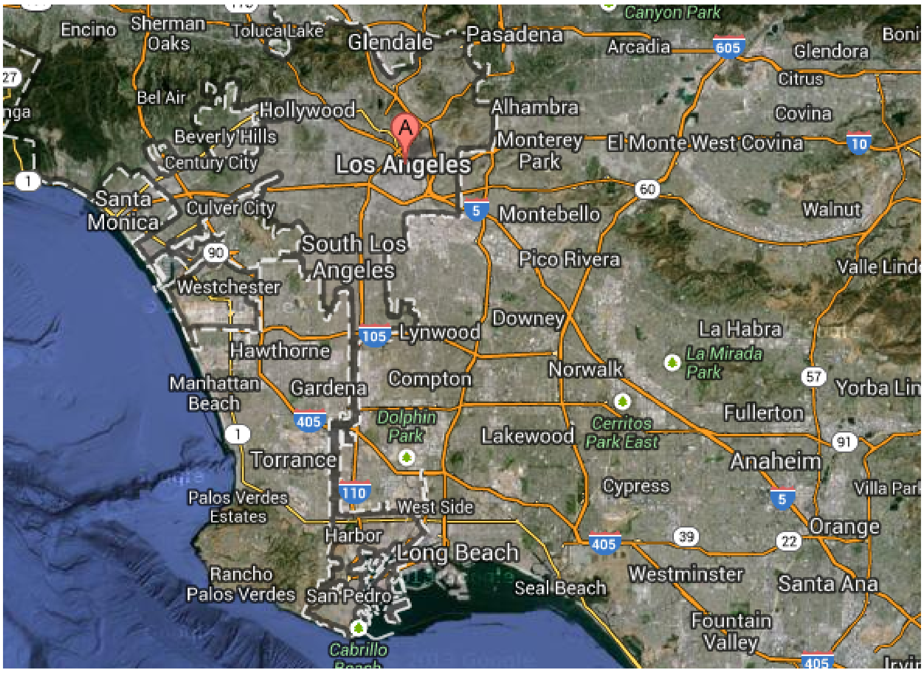

Figure 3.1: The urban area of Los Angeles (source: Google Maps).

the contemporary intense process of urban restructuring that followed these dynamics affected the composition of the labour force, as well as the distribution of workers in the different sectors and the organization of the labour processes. Together with these locational aspects, the area experienced a substantial economic growth at the aggregate level and a wealth concentration, while, at the same time, a large number of workers was fired, several factories shut down and poverty phenomena (like an increase of the homeless number and of unemployed) re-emerged; in addition also racial segregation grew. All these consideration make Soja, Morales and Wolff suggest that Los Angels experienced a mixture of positive and negative trends within the same period (Soja *et al.*[29]).

All these phenomena, occurred also in other historical periods, can be traced back to the periodical crises experienced by the capitalist system. In Soja and co-authors' opinion [29] these economic depressions were determined by over-accumulation, i.e. over-production periods, that, in certain cases, happened to be enough heavy to affect sectors and regions different from those in which the crisis began. Such ages were then characterized by decreasing incomes, growing unemployment rate, an excess of industrial capacity, a decline in corporate profits and stagnant productivity. These periods, lead then to the necessity of reshaping social and spatial productive relations, in order to gain again profitability and to reorganize production processes. These kinds of processes had a deep impact on the urban landscape as the authors report:

> Each phase of urban restructuring was part of a wider process of change, readjustment, and social struggle within capitalist and social relations.

> What can be called the *Monopoly Capitalist City* was early consolidated after the global depression of the 1890s, shaped by the qualitatively different form of capitalism that led the early twentieth century economic boom. Greater corporate centralization, an increased segmentation of the labor force into monopoly and competitive sectors, and the separation of management and production functions had widespread effects on the urban division of labor.

(See Soja *et al.* [29], italics in the original paper.)

The evolution of this kind of urban configuration was also determined by the increasing tertiarisation of the city centres: a large number of corporate headquarters, public and financial offices, together with all the connected services, started to find their location in the urban cores. At the same time, following the late nineteenth century crisis, many industrial activities "migrated" to outer city areas and to satellite cities, in order to escape from the increasing working class militancy (Soja *et al.*).

All such movements were accompanied by the rise of suburban residential areas (mainly occupied by upper-middle class representatives like mangers and professionals) and by an increase in geographical administrative fragmentation (e.g.the tendency to the annexation of the neighbouring municipalities was replaced by that of incorporating them). Theses different dynamics contributed in general to the change in the spatial division of labour (see Soja *et al.*).

The next round of great urban reorganization took place during the Great Depression of the 1930s. In Soja and colleagues' opinion, this new phase deepened all the previous tendencies, with the great novelty that now another important player entered in the game, i.e. the state. In fact in those years Keynesian new policies were implemented in order to propel aggregate demand and control monetary and fiscal policies. The government intervened in the economic life through massive investments and social welfare programmes creating the base for the future post-war development and growth (Soja *et al.* [29]) this new path undertaken by the economy went again together with socio-spatial modifications. As the authors report:

> In the *State-Managed Capitalist Metropolis*, a much larger scale suburbanization took place, now with substantial state support, to include sizeable portions of the working class, blue as well as white collars. Expanding metropolization, an even greater fragmentation of political jurisdictions, and accelerated decentralization (not only of industrial plants but also of corporate headquarters, retail, and other services) led to a selective abandonment of the now relatively smaller central cities. The established urban cores were left with a residual mix of competitive sector firms, older industries, some luxury shops and hotels, key agencies of the state and financial capital, remaining corporate headquarters and a bloated irregular marginal economy comprised of minorities and the poorest segment of the metropolitan population...

(In Soja *et al.* [29], italics by the authors)

This mode of production and this kind of urban restructuring came eventually to an end during the 1970s, preceded by the political turmoil of the 1960s [5]

[5] Soja *et al.* [29] report with respect to this point also the demonstrations that took place

which weakened the ideological trust given to the state. Furthermore the Keynesian policies had become more and more expensive and increasingly hard to maintain, and the recession of the next decade obliged the productive system, included the state, to confront with economic decrease, growing public deficits, large numbers of failures and general discontent. What Soja and colleagues expect by the time they write (1983), is another round of deep economic and urban restructuring (See [29]).

A new organisation of capital. Approaching then closer to the 1980s, the authors report that this process of reorganization began already a the end of the 1960s with its own features. With respect to the economic restructuring, they write:

> ...another round of of increasing centralization and concentration of capital has been taking place since the late 1960s, creating a more pronounced oligopolistic structure of world capitalistic production. Expanding beyond earlier forms of centralization [...] huge corporate conglomerates have been organized combining industrial and financial capital and operating in many different sectors and at many different locations. The intensification linked with the extensification brought about the increasing internationalization of industrial and financial capital [...] has led to the formation and vigorous expansion of transnational corporations able to explore and exploit global commodity, financial, consumer, and labor markets to a degree never before achieved. Increasingly mobile and "footloose" from localized territorial constraints (including direct state control), these giant firms operating collectively as *global capital* have markedly expanded their role in the current period of economic and political restructuring.

(See Soja *et al.* in [29])

This loss of local constraints and the increased importance of transnational capitals, together with technological improvements in communication and transportation, led to an increasing internationalization of the labour division. In those years many Third World countries experienced economic "booms" thanks to the outsourcing of industrial activities in the search of bigger profits, the achievement of those was facilitated by cheap labour supply and favourable (from a managerial perspective) governmental environments (Soja *et al.* [29])

The effect of the outsourcing process complementary contributed to the partial and selective deindustrialization of the leading economies, starting what Soja and colleagues [29] call the "peripheralization"of the centre, meaning the attempt to recreate, in countries of older development, those conditions that facilitated the industrialization and the economic growth in the emerging countries. This led also to the dismissal, at least partially, of most of the traditional industrial productions, such as automobile, civilian aircraft, housing construction and all the related industries (steel, glass, construction material industry etc.).

in Los Angeles during those years.

Labour reorganisation. This economic and capital reorganization proceeded together with the restructuring of labour, made in order to overcome obstacles to the implementation of new profitable activity (from the adoption of new processes to the weakening of workers protection). As a result, the authors report the following:

> One effect of labor restructuring in the United States has been a reversal of the post-war rise in working class living standards, especially among the most organized and formerly secure segments of the workforce. This dramatic shift began in the late 1960s with the reduction of real wages and salaries through taxation and rising inflation and has been reinforced under conditions of deepening recession in many different ways: recent union "givebacks" and acceptance of poorer working conditions; the deterioration of public service system under increasing fiscal pressures on the local and national state; the virtual elimination in many areas of available and affordable private working class housing (and the virtual disappearance of large-scale public housing construction); expanding unemployment and workers layoffs accompanied by sectoral shifts into lower paying service employment; the increased use of "illegal workers" and other laborers (immigrants, women) who work for lower wages under poor working conditions; intensified mechanization of production in many sectors, effectively the economic power of skilled labor (unusually also the most organized); and the mounting of anti-union offensives...

(See Soja*et al.* [29])

These steps marked the entering of the economy in the so-called Post-Fordist age (or "Neo-Fordism" using Soja and co-authors terminology in [29]), ending the period in which the dominant production and labour technique was the Taylorist one, which determined, among the rest, also the separation between the intellectual and the manual work and the atomisation of the productive process, decomposed into the repetition, for each worker, of small and quick tasks. Consequences of this mode of production were a consistent increase in productivity and the possibility of a strict control over the labourers work. Under such circumstances, in the post-war years, was also achieved a break in the conflict between corporations and the workforce [6] (Soja *et al.* [29]) .

Since the end of the 1960s, anyway, many signal witnessed the crisis of the Fordist began to show (according to Soja and his collaborators [29]):

- the skill content of the work reduced continuously, as well as the control of the work process practised by workers because of the growing employment of electronic information system and computer programming;
- the progressive decomposition of those production functions, once carried out in the same place, into different locations sometime in different countries;
- the increased breakout of tasks under the production control and management;

[6] The terms of the deal, according to Soja *et al.* [29], were that improved salaries and working conditions were exchanged with a tighter corporate control over the production process

- a growing capital mobility in order to obtain higher rate of profit and more control of the labour force.

These four points resulted, then,in an increase of the geographical dispersion of the labour force and decentralised production, which led to a growing number of plants closures and relocations. Consequently, and significantly, the year 1980 saw the first overtake of the population growth in small towns and non-metropolitan areas against the bigger cities. The outcomes at the aggregate level of this economic and labour restructuring process, then, has been a more flexible capital, able to find cheaper labour supply, to reorganize the labour discipline in order to achieve a better position on the business cycle and to move to more profitable sectors and geographical areas (again in [29]).

Urban changes. The two previous paragraphs illustrated the new path undertaken by the economy since the end of the 1960s. At this point, Soja and colleagues pass to examine how these modifications in the economy structure affected, and were affected and enhanced by, urban restructuring and transformations. About this, the authors point out the main tendencies observed:

> The increasing centralization and concentration of capital, most typically in the form of large conglomerates combining diversified industrial production, finance, real estate, information processing and other service activities.
>
> A more pronounced internationalization and global involvement of production and finance capital, sustained by new arrangements for credit and liquidity and by heightened capital mobility[...]
>
> A growing loss of local control and regional increasing footloose capital, combined with increasing expenditure of public funds to attract or maintain capital investments (resulting in intensified territorial competition among government units).
>
> An accelerating rationalization of manufacturing sectors, especially those which led the post-war boom (automobiles, steel, construction, civilian aircraft, consumer durables), expressed in a varying mix of deindustrialization and plant closures, the introduction of new labor-saving technology, increased internationalization, and more direct forms of labor discipline (e.g. deunionization, labor give-backs).
>
> A selective reindustrialization based primarily on high-technology and less-unionized sectors which are best able to compete within an international market or achieve some protection against international competition through the national and local state.
>
> Rapid growth in those employment sectors (including old as well as new industries; office, retail and business services; banking and international finance and trade) which can most easily avail themselves of cheap, weakly organized, manipulating labor pools, especially immigrants and women.
>
> An overall decrease in the relative proportion of manufacturing employment (led by older heavy industries) accompanied by an even more rapid increase in tertiary employment, contributing to significantly reduced (if not negative) rates of growth in wage levels and

> real income for workers and in statistical indices of productivity in the national economy.
>
> Deeper segmentation of the labor market, marked by a more pronounced polarization of occupations between high pay/high skill and low pay/low skill workers and reflected in a greater segmentation/segregation of residential space based on occupation, race, ethnicity, immigrant status, income and other employment related variables.
>
> Major locational shifts of industry and employment concentration associated with the decline of older established manufacturing areas and the accelerated growth of new centers of industrial production [...]
>
> Increasing fiscal crisis associated with reductions in certain social services, pressures to abandon the welfare functions of public planning and to weaken public employee unions, and more generally to transform the role of the state established during the post-war boom.

(See Soja *et al.* in [29])

Soja and colleagues remark, anyway, that these processes may have not taken place in every urban area, and that the reorganization led also to, sometime tough, social struggle, therefore the previous was not the only possible outcome. Moreover local characteristics are different among geographical area, hence the restructuring process could take other forms. What stated before are anyway the main tendencies, though not always evident, of the new production mode and social arrangement arising since the end of the 1960s (Soja *et al.* [29]).

The urban area of Los Angeles Given all the above mentioned social, economic, historical and political analysis, it can be worth to inspect the specific case of the city of Los Angeles and its neighbouring counties.

Historically, this region never gained a relevant role up to the last decades of the nineteenth century, when Los Angeles rapidly expanded both in economic and demography terms, acquiring all those features typical of what Soja *et al.* [29] call the Monopoly Capitalist city. Main financial and commercial activities, as well as public offices, were concentrated in the city centre and many surrounding municipalities were absorbed during the decade 1910-1920. Despite these phenomena, however, Los Angeles area presented already at that time patterns of decentralization [7], since the increase of population was higher in the suburban areas of the county rather than in the city's core. In the first half of the twentieth century, the industrial activities regarded mainly the aircraft industry, petroleum refining and cars assembly factories (which attracted also all the related activities). At the same time, together with the big corporations, a large set of small firms were also run (e.g. movie-making, food industries etc.) (see Soja and colleagues [29]). The Great Depression had here a softer negative effect, also because these was a place of strong immigration during the 1930s recession [8], fact that contributed to the accumulation of workforce in the area

[7] The metropolitan area of Los Angeles is formed by many autonomous municipalities and counties, like Santa Monica or Orange County.

[8] John Steinbeck wrote about those years "The Western States are nervous under the beginning change. [...] A half-million people moving over the country; a million more restive, ready to move; ten million more feeling the first nervousness."in [30]

(in Soja, Morales, Wolff [29]).

That contemporary presence of workers availability and of strategic industries allowed Los Angeles metropolitan region to attract the military industry during World War II and the Korean War total employment grew by more than 400,000 workers (almost 100,000 in the aircraft sector only), while the resident population doubled in the decades from 1940 to 1960 (Soja *et al.*, [29]). The area, as the authors suggest, became an axis of development of state-managed capitalism of the Fordist era, where the economic expansion was directly linked with public defence expenditure and the government was deeply involved in mortgage assistance and housing programs. The economic expansion and the population growth resulted in the birth of vast and low-density residential settlements, which have been mixed by a large number of roads and motorways. On the whole, the metropolitan area presented a great suburban growth along with the presence of highly segregated areas of poor Black and White workers (*ibidem*).

After the growth, arose since the New Deal, that system of production came to a crisis at the end of the 1960s, as already told: production and employment began to decrease in most of the industrial sector. Meanwhile, the tertiary (mainly services, wholesale and retail trade) started to acquire the new importance in the Los Angeles area. The increased level of unemployment and the growing difficulties resulted also in a rise of public expenditure and welfare payments (which soon led to years of austerity policies during the 1970s). The authors report then that, after the global recession of the 1973-1975 years, the city was able to recover only after a spatial and social renewal and reorganization (Soja *et al.* [29]).

Analysing more in details the situation, it comes out that, though what stated above is in general true for all the U.S. economy, other trends are more specific for the Los Angeles region. A first consideration can be made by noticing how the recession affected in different ways neighbouring areas: while in the Los Angeles county during the period 1960-1979 the employment in manufacturing sharply declined, it kept on growing in the Orange county, and the same observation may apply to other sectors (e.g. construction) (*ibid.*).

Another phenomenon that Soja an colleagues notice, is what they call the "composite character" of the regional reorganization: the city has passed from the typical production mode of the Fordist system, based upon heavy industry, large plants and highly unionised workers, to that of Post-Fordism age, in which the economy relies on high technology industries and on services. Services and manufacturing activities employed now much less (or not at all) unionised workers, that belong to the most fragile and weak social groups, like immigrants and women. Together with such phenomena, Los Angeles became also a global financial centre and one of the main location for financial and insurance firms and for transnational corporations headquarters (again in Soja, Morales and Wolff [29]).

From a geographical perspective, this new productive system is largely decentralized and localized in outer areas (e.g. the Orange county or the area surrounding the Los Angeles International Airport). As the authors report:

> Rather than being satellites of heavy industry and blue collar workers or suburbanized office and retail nodes, these new outer cities are large conglomerations of technologically advanced industry and ser-

> vices, huge new shopping and leisure-oriented complexes, and high-income and expensively-housed technicians, managers, and professionals, sprawling science-based New Town ...

(See Soja *et al. in* [29]).

A consequence of this decentralised new round of the economy, the authors argue, was a certain polarization in the productive organization: on the one hand the growing technologically intensive sector required high-skilled and capital-intensive operations performed by highly qualified workers (e.g. engineers) . On the other, the progressive decline of "traditional" and Fordist sectors left space and workforce for labour-intensive processes with almost no skill requirements, which were (and are) executed by low-skill workers, typically non-unionised and supplying their labour in exchange of poor salaries (*ibid.*). To spatial decentralisation corresponded the fragmentation of the workforce and of production processes.

The progressive abandonment of those industrial activities that led the economic development up to the 1960s, caused also the local deterioration of some areas. In particular, many people employed in the traditional sectors were fired, as well as many plants were closed, and geographically this process affected those places in which workers and plants were located (i.e. Los Angeles downtown, San Pedro and Long Beach ports, and San Bernardino county). Those were also the residential areas of the most unionised workers and relatively well paid blue-collars (Soja and colleagues [29]) This contemporary presence of developing and declining sectors and geographical areas is seen by the authors as linked and interconnected. The latter, identified as a reorganization and selective deindustrialization process, causing large unemployment and urban decay, created the basis for the new expansion of services and high technology productions, together with polarized and fractioned workforce, accompanied by a consistent reduction of the role played by the public sector (Soja and colleagues in [29]).

A significant part in the reorganization process was taken also by the large number of immigrants that arrived (many of them officially unregistered) in the Los Angeles area that ended up altering the demographic composition of the place: the sum of Blacks, Hispanics and Asians gave the 55% of the Los Angeles county population at the beginning of the 1980s, while they were less than the 15% thirty years before. This fact provided the area of a consistent presences of cheap, non-unionised labour supply and a workforce with little contractual strength, from which also many small firms took advantage. From a social and spatial perspective, moreover, these trends went together with the expansion of ghettos and racially segregated areas, since those minorities tend to reside mainly in specific areas like East Los Angeles or the San Fernando valley (*ibid.*).

Another distinctive feature of the new economic phase, was also the sharp rise of the financial sector, as already mentioned. This trend made Los Angeles the principal financial centre of the U.S. western coast, and in this development, a great role was also played by international capitals (e.g. British and Japanese banks). Accompanying the expansion of the sector was the sharp increase in office building, as Soja and colleagues write:

> The low density sprawl of the Los Angeles region and the unusually low level of development of the downtown area resulted in many prime locations being undervalued when compared to the office markets of other major world cities. This latent potential for expansion,

> however, has only recently begun to be fully realized, primarily in conjunction with a major influx of foreign capital, the expansion of military and defense based industries, and the availability of cheap labor to service high-rise office buildings and related food provision and hotel activities, all important features of the contemporary restructuring process.

(See Soja *et al.* in [29])

Significantly, the areas mainly affected by this great office building rise, are among those leading the reorganization and the economic growth, like the Los Angeles International Airport area and the Orange County.

3.2 Spatial Justice: concepts and debate

The previous section helped, that is the hope, to provide a practical example of socio-spatial analysis. From a theoretical perspective, political geographers developed the concept of "Spatial Justice" in order to understand, and eventually overcome, the dynamics creating social inequalities and their effect on urban, or broader, spaces. Thus the topic is deeply related to politics and civil rights. As Harvey writes in [15]:

> All ideals about rights hide suppositions about social processes. Conversely, social processes incorporate certain conceptions of rights. To challenge those rights is to challenge the social process and vice versa.

And P. Marcuse [20] states:

> No one who is interested in justice wants to sustain things as they are.

What follows is a brief and incomplete review of some of the ideas formulated around this theme.

3.2.1 The space as form or as process

One of the questions that have been recently arisen among some scholars, deals about the role played by space in shaping society along with its inequalities. Iveson [18] together with Fincher [13] report the two different approaches built by Soja and P.Marcuse, both starting from the idea presented by Lefebvre of the "right to the city" (see Iveson [18]).

A passage of Soja's exposition in [28] reports (italics added):

> A new emphasis on specifically urban spatial causality has emerged to explore the generative effects of urban agglomerations not just on everyday behavior but on such processes as technological innovation, artistic creativity, economic development, social change as well as environmental degradation, social polarization, widening income gaps, international politics, and, more specifically, the production of *justice and injustice*.

Concerning this spatial causality, there are three points on which Soja pays particular attention:

1. Beings are at the same time spatial and temporal, as well as social,
2. the space is socially produced (as in Lefebvre [19]),
3. the space is not only shaped by the social action, but it contributes to shape the society (as previously in [27]).

Putting together concepts that were already present in Soja's previously cited papers, he highlights the fact that spatial justice is not an alternative concept of justice, in contrast with other formulations (e.g. economic or social), but it rather conveys the idea that justice has always a spatial dimension too, as well as that the geographical space presents always some kind of justice and injustice manifestations embedded in itself (Soja in [28]).

The authors argues that spatial justice is at the same time an outcome and a process. As an example of the first feature, one can think about the locational discrimination, in which a particular population is advantaged because of its spatial collocation. This phenomenon highly contributes to the creation of spatial injustice and its cause can be traced back, e.g., to class, gender and race differences and prevarication (Soja [28]).

Also the political and administrative organization of space can be considered a strong source of spatial injustice, for example trough the creation of manipulable electoral districts, the uneven appointment of urban investments, or the making of core-periphery structures (ranging from the local scale to the global one). Even the everyday life, according to Soja, gives its contribution to the rise of spatial injustice, as he writes in [28]:

> The normal workings of an urban system, the everyday activities of urban functioning, is a primary source of inequality and injustice in that the accumulation of locational decisions in a capitalist economy tend to lead to the redistribution of real income in favor of the rich over the poor[9].

From his side, Marcuse [21] pays attention to the spatial effects created by the even distribution of wealth and power at the social level, rather than on a supposed socio-spatial dialectic (as explained also by Iveson [18]). He thus reports and asks:

> ...I argue that distributive justice is a necessary but not sufficient aspect of a normative pitch in planning, which is badly needed. But, while necessary and needing buttressing, it fails to address the causes of injustice, which are structural and lie in the role of power. The Just City sees justice as a distributional issue, and aims at some form of equality. But a good city should not be simply a city with distributional equity, but one that supports the full development of each individual and of all individuals, a classic formulation.

(See Marcuse in [21])

With respect to the effect that space can have on social issues, the author asks in [21]:

[9]an example of the pro-rich distribution can be the reorganization of public transportation in order to serve affluent urban areas, as reported by Soja in [28].

> ...what is the relation of space to justice, and are there goals of planning policies that are not spatial?

His (Marcuse in [21]) argumentation relies on five propositions which are:

1. there exists two main forms of spatial injustice;
2. social injustice causes spatial injustice;
3. anyway, social injustice has always spatial effects, therefore it cannot be tackled without addressing these spatial outcomes;
4. the solutions to spatial injustice are not sufficient to fully address the issue, since it is a consequence of broader social injustice;
5. social, political and economic conditions affect the role of spatial injustice relative to social injustice.

With respect to the first proposition, Marcuse [21] posits that the first form of spatial injustice is the forced and involuntary confinement of certain parts of the population in limited areas, i.e. segregation or ghettoization[10].

The second form, instead, is the uneven geographical distribution of resources, including the limited access to jobs, wealth, political power, income etc. not justified on need or rational bases [21]. The second argument reflects the idea of the author that spacial injustice phenomena arise from broader causes, i.e. from social injustices. Therefore the spatiality cannon be isolated from its historical, social, economic and political environment (Marcuse [21]).

Thus the third, as a consequence of the previous, posits that purely spatial solutions to address injustice are not sufficient, since they are not suitable to attack and weaken the other forms of injustice (*ibid.*).

The fourth, however, recognizes that spatial remedies are necessary to resolve spatial injustice. They are not sufficient, but they must be kept into account, as spatial injustices can be a great contribution to social injustice (*ibid.*).

To explain the fifth, finally, Marcuse [21] reports the practical case of the district of Harlem in New York City. Harlem is a highly segregated area, in which the vast majority of the residents belongs to the African-American community. Though the segregation can be partially considered as voluntary (e.g. due to pride in African-American culture and history), the districts' population is highly discriminated because of historical and social issues. The injustices that resulted have taken then a spatial connotation, in the form of poor and segregated ghettos (as Harlem). To resolve this unbalances, attention has to be paid to spatial remedies, since resources are spatially allocated (school, public health, childcare etc.), but without forgetting that these are insufficient to resolve the problem: an example can be that of the gentrification, that makes an area more affluent, but ends up forcing poor households to move to another part of the city. The problem is not solved, it simply changed its geographical position. As Marcuse writes:

[10]Here Marcuse makes a distinction between ghettos and enclaves, the second arising by voluntary segregation and the will of people, e.g. of the same ethnic or religious origin, to live next to each other. Researches on the tendency of foreigners to live next to families coming from the same country has been for instance run by Tatjana Ibraimovic in [17], dealing with the case of the Swiss city of Lugano.

> Change is constant, and neither spatial nor social justice can be intelligently addressed without attention focused on the historical political, economic and social causes of all forms of injustice.

To end this subsection, it can be worth to report what Iveson [18] argues about the different points taken by Soja and Marcuse. The second, states Iveson, though concerned with the spatial consequences of social injustice, and believing that they are rather important, thinks that space is an outcome of social processes. Therefore purely addressing spatial issues will be not enough to attack the whole problem. The first, instead, seems to believe that space is itself a generative a process, and that every remedy will hence have its spatiality and its spatial effects (in [18]).

3.2.2 Other approaches to spatial justice

Other scholars have arrived to other (though not necessarily incompatible) ideas on how socio-spatial issues should be addressed. They trace back their ideas on the theory of justice elaborated trough the years by John Rawls, based upon the mutual recognition among equals, and the reciprocal understanding of each others rights (e.g. see Rawls in [24], bearing in mind that he published many further works). As Freeman writes in [14] (self-translation from the Italian):

> Discussions on distributional justice have often a limited focus on the distribution of income and wealth - on the question on whether it should be egalitarian or it should be taken into account the effort, the contribution, the need, the utility *etc.* Rawls transforms this limited way of understanding the distributional justice in a complex inquiry that regards the organization of the relations of production among democratic citizens, and hence the property and the control that they have on productive resources, and the distribution not only of income and of wealth, but also of powers and responsibilities in the economic field.

From a spatial and political perspective, the mentioned inquiry takes the form for Bret [4] of finding a way to conciliate two different tendencies of the contemporary global society, i.e. the tendency towards globalization, and that pushing towards the affirmation and the defence of local cultures and values. Thus the need is to find such universal values that prevent what can result in a progressive affirmation of particularism and, eventually, relativism. What Bret fears is that the reactions against the increasing globalization, i.e. "westernization" according to the author, which are anyway justified up to a certain point, could result in a progressive prevarication of cultural shaped and particular social values over the personal rights of the individuals. In a fragmented ethic context it is hard to find a principle on which justice can be founded (see [4]).

In this inquiry, argues Bret, a help can come from Rawls' theory, which he summarizes as follows:

> What founds the universality of Rawls' principles is the "veil of ignorance" between the subject and the real world, in such a way that an "original position" is gained from which to rationally state fair rules for "social partners", that is, rules that will ensure "the appropriate

> distribution of the benefits and burdens of social cooperation". For Rawls, the best division of material and immaterial goods is the one that serves the best the most disadvantaged social partners (maximises the share of those who have the minimum: principle of the *maxmin*) He does not posit that egalitarianism (the equality of all in all aspects of social life) would be the most efficient way to attain that objective. However, he gives priority to the principle of equality of the principle of the *maxmin*, in terms of people intrinsic value and rights. Rawls's system therefore articulates and establishes a hierarchy the principle of equality and the principle of difference.

(See Bret in [4], italics in the original article)

So far everything is very theoretical. What Bret argues is that Rawlsian ideas can be used as analytical tool to better understand and judge concrete cases. In his opinion, the principle of justice may help in measuring the world according to the rational (being the Rawlsian theory a product of rationality, leading to a rational social arrangement) content the inspected practice presents. The objective is to measure the gap between real-world situations and the idea of justice as fairness (Bret [4]).

The understanding of this gap shall then leads to practical since, as the author remarks, the Rawlsian principle of justice is not linked to any specific social or cultural situation. Its abstract nature makes it applicable to all real-world cases. In addition, it can favours a better comprehension, and therefore a better organisation, of the dualism between universalism and diversity, disciplining them under universal and rational principles. In Bret's words:

> Reality as transformed in direction of universal values tends towards *justice as fairness* along an asymptotic curve: Rawls's theory may be considered an utopia, but a positive utopia, which shows a path to improvement for world organization, without providing ready-made solutions, and which calls for public debate. Establishing a dialogue between civilizations is probably the most plausible method, because principles of justice take multiple forms in different cultural contexts, and because considering social partners as rational beings implies they are able to find a consensus by a convergence between initial positions.
>
> In other words, understanding the world and transforming it are two sides of the same coin in Rawls' philosophy. He distinguishes the *good* and the *right* by defining *good* as what a rational being can hope for and *right* as what is in conformity with principles of justice enounciated through a rational procedure. It is therefore logical to consider the *right* as *good* since the *right* gives a satisfaction which is a *good*. The priority of the right over the good [...] means both are related, through the happiness a rational being derives from acting in conformity with reason.

(Bret in [4], italics by the author)

Bret then argues that geographical studies can gain from Rawls' theories, since geography deals with spatial differentiations and planning in order to transform the space to make it compatible with social objectives. The idea of justice as fairness does not rule out all inequalities, but only those which can be considered, according to the same principle, as unjust. For instance, from a social and economic perspective, different spaces present different degrees of development (as in the core-periphery model) which can be in certain cases justifiable by the fact that this diversity may result in a dynamic process of development, benefiting the least affluent people in compliance with the maxmin principle. Rawls' principle helps thus in distinguishing between these situations and those in which the spatial socio-economic diversity is simply translated in an unjustifiable exploitation and deprivation of means and resources (Bret [4]).

Bret recognizes that these statements are rather simplistic, but since reality is complex, sometimes it can be worth to have clear objective and analytic tools in order to enhance actions undertaken to correct unjust situations. It is precisely the complexity of reality that makes Rawls' criteria suitable to lead the political and geographical analysis, according to Bret:

> Justice can only be understood in all its dimensions, the historic dimension as well as the social dimension and spatial dimension.[...] Produced by a reason deliberately abstract from reality, *justice as fairness* encounters people, their histories, their territories and proves to be the theory which can account for the world, and because it is rational, can also transform it.

(See [4], italics by the author)

The practical objective in order to attain the just city, applying Rawlsian principles, is seen by Fainstein [12] as the improvement of participative and democratic deliberation in urban planning. Her argumentations start from the recognition of the bias present in contemporary societies, favourable to already affluent social classes. One contribution to this problem, she argues, can come from the enhancement of deliberative forms of democracy, which are able to really function only if it is achieved a mutual respect and recognition of the parties involved in the decisional procedure; otherwise even redistributive policies will not truly help in the attainment of a just society, since economic inequality has demonstrated to be able to persists and reproduce itself (Fainstein [12]).

Fainstein argues that the role of the planner should be that of acting as a mediator among different claims, and searching a consensus to her action by listening, mainly, to subordinated social groups opinion. What can go wrong, if this principle is applied, is that sometimes people decisions may lack of an appropriate time horizon, preferring short-time results and considerations, or their action can be selfish and disadvantageous for minority groups (Fainstein reports the so called "NIMBY" effect as an example of egotistic and narrow minded behaviour). Thus the problem becomes that of the participation and a truly inclusion in the deliberative process, in which all those involved are able to redefine their interests and claims, affected by the interventions of other points of view. As expressed by the author.

> For both theories of deliberative democracy and social justice, scale presents an important problem. In terms of democratic participation, any deliberation that excludes people who will be affected by a decision is not fair. [...] In summary, both the communicative and just city models run counter to the unequal distribution of resources within modern, capitalist economies and are hence utopian.

> Both represent attempts to reframe discussion about spatial planning so that poorly represented groups, especially low-income minorities, will benefit more from the uses to which land and the built environment are put. The dilemmas posed by issues of scale confront the two of them. It is maintained here that the just city model subsumes the communicative approach in that it is concerned with both processes and just outcomes but it also recognizes the potential for contradiction between participation and just outcomes. Although the attainment of social justice must take the both into account, it is my contention that just outcomes should trump communicative communicative norms when the two conflict.

(Fainstein, *ibid.*)

In Fainstein's opinion, the fact that the just society imagined by Rawls results in a system in which individuals enjoy equal opportunities, and therefore a legal and political environment that prevents the creation of excessively large concentrations of wealth and property, means that the aim of public policies and planning, within the urban context, should be that of lessening disadvantages and inequalities in the benefits distribution, equalizing the share of primary goods (not only wealth, but also self-respect) for each member of the society (Fainstein [12]).

The attainment of these goals, anyway, is not easy to perform. As the author explains, many of the distinctive features characterizing the just city are often in contrast among them. For instance equality and diversity are hard to conjugate, since redistribution may weaken the claims for recognition made by specific social groups an vice versa. Or the tensions existing between the fair representation and the participation of heterogeneous characteristic and claims, against the ability of a political system to take and implement decisions (which can also go towards the realization of a more just city). And even within the context of single issues many contrasting elements can be found, e.g. : how to, and in which measure, allocate resources according to the different needs of people, therefore denying the equality of treatment among members of the same society; or again how far should go the recognition of others' community and individuals diversity, if they are intolerant or have authoritarian tendencies[11] (Fainstein [12]).

Fainstein, finally, proposes three practical examples of urban restructuring, evaluated trough the three criteria of equality, diversity and participation. The first case is the one of New York City, where in the last years has been launched a program of urban renewal in order to improve the situation in five of the city's districts. With respect to the criterion of equality, the author highlights how, despite the creation of more affordable houses and flats, as well as new parks, the main plans will consist in expensive projects (utilizing public money and tax forgiveness) that are going to radically change the nature of the areas, like the construction of two baseball stadiums or the creation of a shopping mall in the place of a multi-ethnic wholesale market. Furthermore the focus of the project is simply on land use, since no connection with education or job training has been added. From a participation perspective, the communities involved by the

[11] A common example can be that of providing public houses to gipsy communities, living in miserable camps in the periphery of many cities without any health service, instead than giving priority to those enrolled since years in public lists for the attribution of a flat.

transformation have played only a little part: discussion groups were organized, but only regarding marginal issues, the agency charged of the development of the plan had not the duty to listen to the opinions expressed by the communities. The only criterion, according to Fainstein, in which the project did more, was that of the diversity, since to prevent excessive gentrification rent regulation and public housing policies have been maintained (Fainstein [12]).

The second case is that of London, when a program named London Plan took place in 2004. The principal goal of the program was to provide an accommodation for the future population growth, but public issues like education, health, public facilities have been considered as an integral part of the projected urban development. Judging from the point of view of equality, as reported by Fainstein, the picture is better than that of New York, since the British Government, after the "Tatcherian" age, have been more concerned towards the accessibility of new houses (all new development plan with more than 15 housing units, has to provide the affordability of the 50% of them). This stronger commitment on accessibility should have also positive effects on the diversity of the urban panorama, since part of the new houses, reports Fainstein, are likely to be occupied by immigrants and low income families, avoiding the high level of segregation achieved by New York. However this plan is probably not enough to have an effect on already existing affluent area, mainly occupied by the upper class. From the point of the participation in the deliberative process, the author tells that the Mayor's plan states the formation of partnerships among private business, local authorities and organization of citizens. Even though most of the project relies on private capital (therefore giving in practice to private constructors the leading role in the transformation process), British private investors are influenced by the fact that they must submit shared project in order to have them approved (Fainstein [12])

Third and last case analysed by the author is that of Amsterdam. In the Dutch city a great attention has been paid in the urban development process since the end of World War II. In particular from 1945 to 1985, the 90% of all new houses was dedicated to social rent housing, fact that led the city to present a an environment in which both diversity and equality were granted. With respect to the participation in urban renewal process (Fainstein quotes the case of the social housing complex of Bijlmermeer), moreover, the government showed a great commitment towards multiculturalism and community participation,even if some of the projected changes resulted in an increased gentrification. In the Nederlands, argues Fainstein, the issue regards the future, seen the rise of conservative political parties and of anti-immigration sentiment (*ibid.*).

Chapter 4

The Models

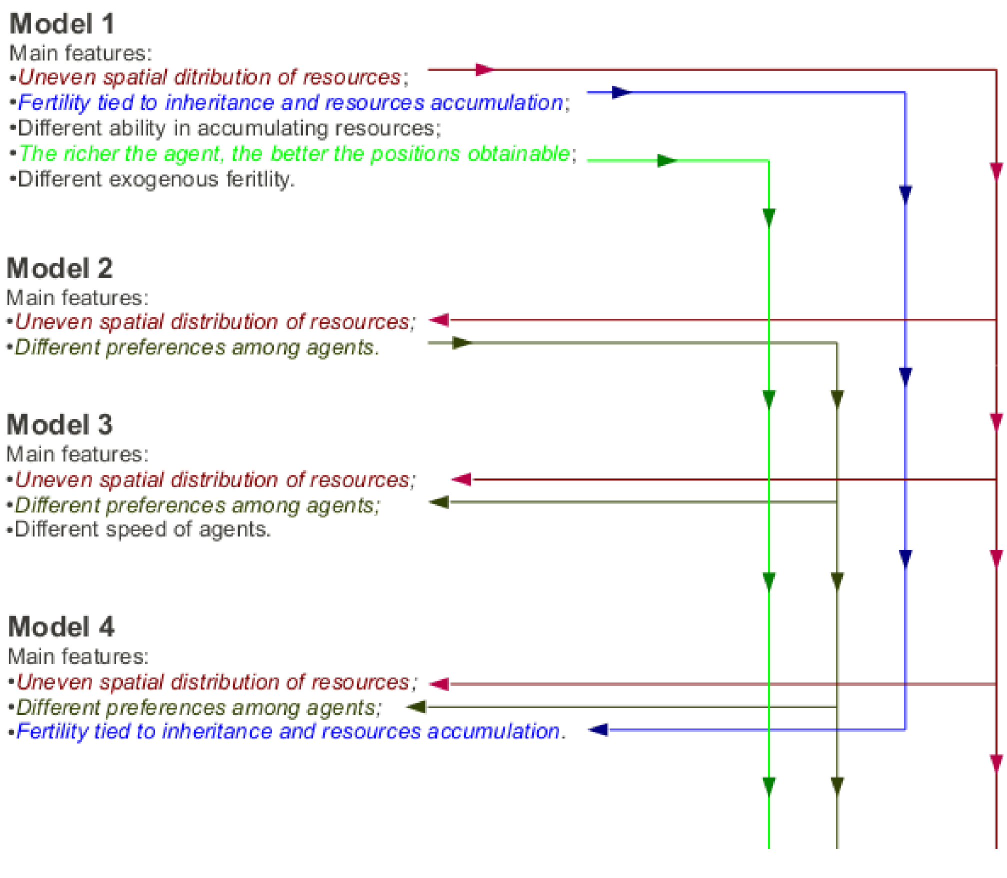

Figure 4.1: Models Map (first part).

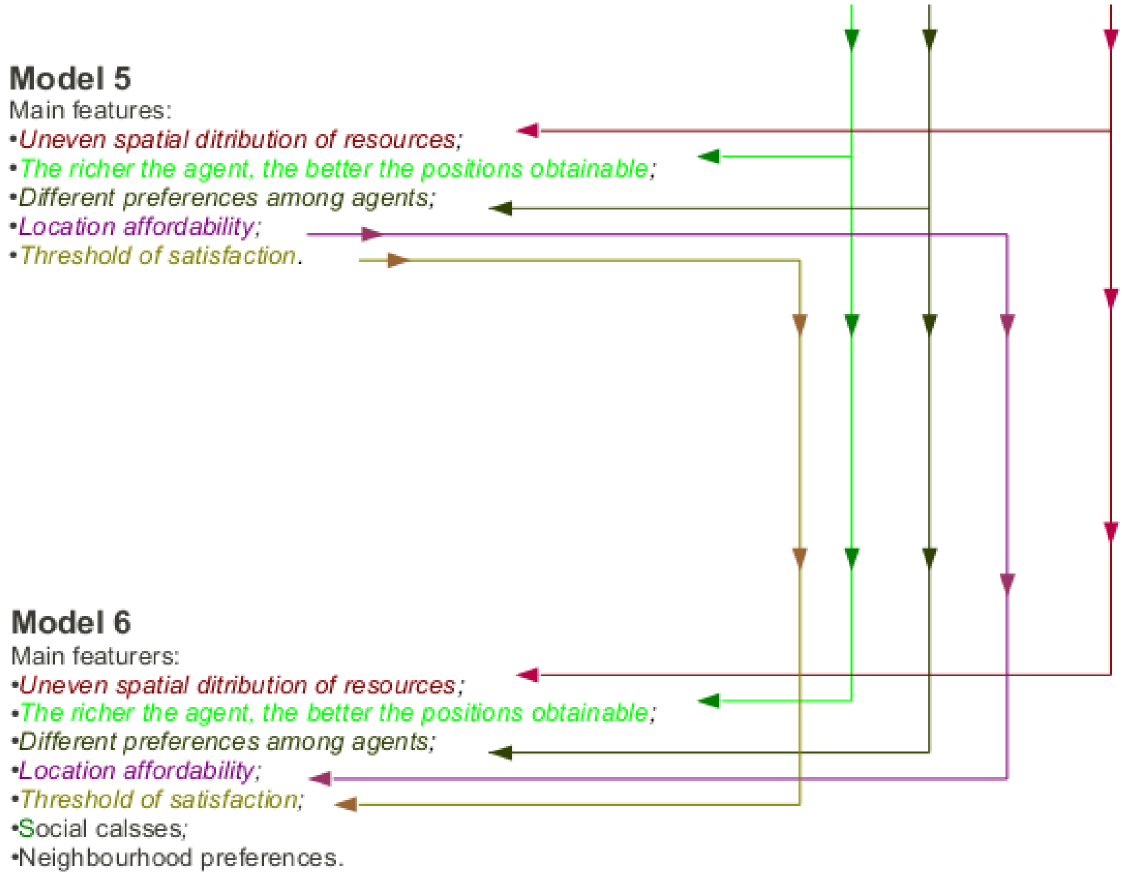

Figure 4.2: Models Map (second part).

The aim of this chapter is to describe the models built along the development of this thesis. The technique used is that of the Agent Based Modelling, which allows to build and simulate *bottom-up* models, where a set of more or less stylized agents (e.g. the turtles of NetLogo) interact with an environment and among themselves. Following the conceptualization made by Epstein and Axtell in [10], a model such constructed is composed[1] by:

1. *agents*, i.e. the model's "people" (according to the definition given in [10]), which may have different internal states, some of them fixed and some others that can change according to the interaction with the environment or with other agents, and that obey to certain behavioural rules;

2. an *environment*, which is the medium upon which the agents move and act, and with which they can interact;

3. *rules* according to which the agents and the environment behave. In particular, these rules can create interactions among different agents, among different element of the environment (e.g. different cells or patches, as in the following models), or finally between agents and the environment.

This list of constitutive features well describes how the models to be soon presented work (e.g agents pick-up resources from the environment and search for certain kinds of neighbours, the state of a patch is determined by its neighbouring cells etc.)

Each of the models herein represents a further development of the previous one, as well as each model gave new ideas and suggestions (arose also from the literature read) worth to be inspected and analysed in subsequent simulations.

4.1 Model 1

The first model built is very simple and rather deterministic. Here the world is split in two parts and the patches of each are endowed with a certain amount of product exogenously given. Red patches carry exactly one half of the product provided to the green ones, thus the system is divided into a rich and a poor area. Two turtles are then generated and placed one per each. Those turtles own an income which is given by the patches' product, i.e. if one turtle finds a place on a patch whose product is 5, the turtle will immediately gain 5 units of income at each time step. Once a turtle reaches a threshold of 10 units of income, she reproduces giving birth to a new turtle (only one turtle per each patch is allowed)[2]. From here on can begin the action of the observer.

There are on the interface five different switches: the " no-inheriting" switch, which allows the daughter turtle to inherit 10 units of income from her mother; the "win-patch" switch, which works by allowing the richer turtles to displace the poorer ones, in case they arrive on a patch next to an already occupied spot; the "random-ability" switch, that multiplies the income earned through patches by a random decimal factor included between 0 and 1; the switch labelled "poor-higher-fertility", which makes poorer turtles reproduce more frequently than

[1] Actually, Epstein and Axtell refer to artificial societies, which anyway arise from agent-based models.

[2] This spatial disparity of resources is aimed to, naively, build a link with the debate over the spatial justice, as in Soja [28] and as reviewed in Fincher and Iveson [13]

their richer counterparts according to a given birth-rate, provided that the 10 income units threshold is met. Finally the last switch is named "kill-turtle": switched on it makes work a mortality rate, equal for both the rich and the poor group, that is chosen by the observer through the slider underneath.

Now we shall pass to the explanation of the programming code commenting upon some significant pieces of it.

Code explanation. The first four lines of code reported in figure 4.3 assign to the existing turtles (only two at the very beginning of the simulation) default features, some of which are going to be manipulated later on. In particular, these lines create a world divided between the left red half, where patches carry 5 units of product, and the right green ("lime" in the code) half, which carries twice the product, i.e. 10 units. The two original turtles are then created with no unit of the variable "income" and a value of the variable "ability" equal to 1.

```
ask patches
 [ifelse pxcor < 0 [set pcolor red set product 5] [set pcolor lime set product 10]]
   ask turtles [set income 0
 set ability 1]
```

Figure 4.3: Default features

```
to go
  ask turtles [move-to patch-here
    set income income + (product * ability)]
   set n-of-turtles count turtles if n-of-turtles > 2000
    [stop]
```

Figure 4.4: Income dynamics

The short lines in figure 4.4 are reported in order show how turtles accumulate streams of income: they simply add to their current income the product they extract from patches in the next time step, multiplied by the variable ability described above. The first line just makes the turtles locate in the centre of each patch, while the last line asks the turtles to stop executing instruction once their number is equal or above 2000.

```
to reproducing
   ifelse poor-higher-fertility [ ask turtles [ifelse color = blue
    [if income >= 10 and
      random 100 < 50
      [ hatch 1 [
           if no-inheriting [set income 0]
       ifelse random-ability
      [set ability random-float
      1][set ability 1]
       set heading random 360
        while [any? other turtles-here]
       [set heading random 360 fd 1]]
   set income (income - 10)
```

Figure 4.5: Patterns of reproduction - blue turtles

The lines in figures 4.5 and 4.6, belonging to the procedure "reproducing" called by the procedure "go" in figure 4.4, are basically a series of nested conditions regarding how the turtles reproduce and the income they earn. The first

```
 ]][if income >= 10 and
 random 100 < 30
 [hatch 1 [ if no-inheriting
        [set income 0]
    ifelse random-ability [set
    ability random-float
    1][set ability 1]
     set heading random 360
      while [any? other turtles-here]
     [set heading random 360 fd 1]]
 set income (income - 10)
 ]]]][flat-fertility]
end
```

Figure 4.6: Patterns of reproduction - yellow turtles

condition in line two in figure 4.5 simply states that, if the switch "poor-higher-fertility" is on, blue turtles, settled at the beginning on red poorer patches, are going to create one new turtle according to a fertility rate of 50%, holding the income threshold of 10 units discussed above, otherwise they will not be able to reproduce. Once checked that the above condition is met, the turtles are then asked, if the switch "no-inheriting" is on, to transfer no income to the newborn agents; thus both mother and daughter will have 0 units of income soon as they reproduce. Then turtles check whether the "random-ability" switch is on or off, assigning accordingly a random real number, included between 0 and 1, to the ability multiplication factor described previously; if instead the switch is off "ability" will simply assume value 1 for everybody. The figure 4.6 works in the same way with the only difference that this code is referred to yellow turtles, whose group is created on the green and richer part of the world. If the switch "poor-higher-fertility" is on, as in figure 4.5, their natality rate will be only equal to 30%, twenty points lower than the blue group.

```
to flat-fertility
  ask turtles[if income >= 10
      [hatch 1 [
           if no-inheriting [set income 0]
       ifelse random-ability
      [set ability random-float
      1][set ability 1]
       set heading random 360
        while [any? other turtles-here]
       [set heading random 360 fd 1
         ]]set income (income - 10)]]
end
```

Figure 4.7: Flat fertility

In the lines reported in figure 4.7 it is shown how the simulation works when the switch "poor-higher-fertility" is turned off (these codes are in fact called by the procedure "reproducing"). In practice both groups will reproduce simply when the turtles reach the income threshold, implying that the only difference between the two groups is the rapidity in reaching the income level of 10.

The code in the last figure 4.8 shows how the switch "winning-position" works. Whenever an agent gets a location next to (i.e. within a radius of 1 patch) a place where there is already one turtle, this procedure compares the income units of the two rivals. The poorer one is then forced to move away, leaving the richer on her place.

```
to winning-position
  if win-patch [
   ask turtles [
   ifelse any? other turtles in-radius 1
   [ let looser turtles with-min [income]
     ask looser [move-to one-of patches with [not any? turtles-here]]
     ][move-to patch-here]]]
end
```

Figure 4.8: Winning Patcp

It can be now convenient to pass to few experiments through the manipulation of the variables manageable by the observer.

Plan of experiments The following is a summary of the experiments run in the next paragraph.

- no changing of patch, no inheritance, equal fertility, equal ability, no mortality;
- no changing of patch, no inheritance, equal fertility, **random ability**, no mortality;
- no changing of patch, **inheritance allowed**, equal fertility, equal ability, no mortality;
- **changing of patch allowed**, **inheritance allowed**, equal fertility, equal ability, no mortality;
- no changing of patch, no inheritance, **uneven fertility**, equal ability, no mortality;
- no changing of patch, **inheritance allowed**, **uneven fertility**, equal ability, no mortality;
- no changing of patch, no inheritance, equal fertility, equal ability, **mortality rate**.

Experiments It is useful to first start to see, as in 4.9 and in 4.10 respectively, how it looks like the user interface of Model 1 and what happens with all the procedures seen above deactivated (note: to shut down the procedure regarding the possibility of turtles to inherits income from their mother turtle, the switch "no-inheriting" must be turned on).

In figure 4.9, there can be seen the two original mother turtles, created one per area at the same distance from the centre. Once clicked on the button "go", and after a while, the world looks like in figure 4.10, where it can be seen how yellow turtles reproduced themselves much more quickly than the blue ones even when, by expansion, they are located on the red area, which is half as rich as the green area. This effect is due, likely, to the fact that yellow turtles group was already much bigger, thus experimenting more births in absolute terms. Another thing worth to note is how the blue group is mainly concentrated around the first turtle, while few newborn agents are located at the expansion border of

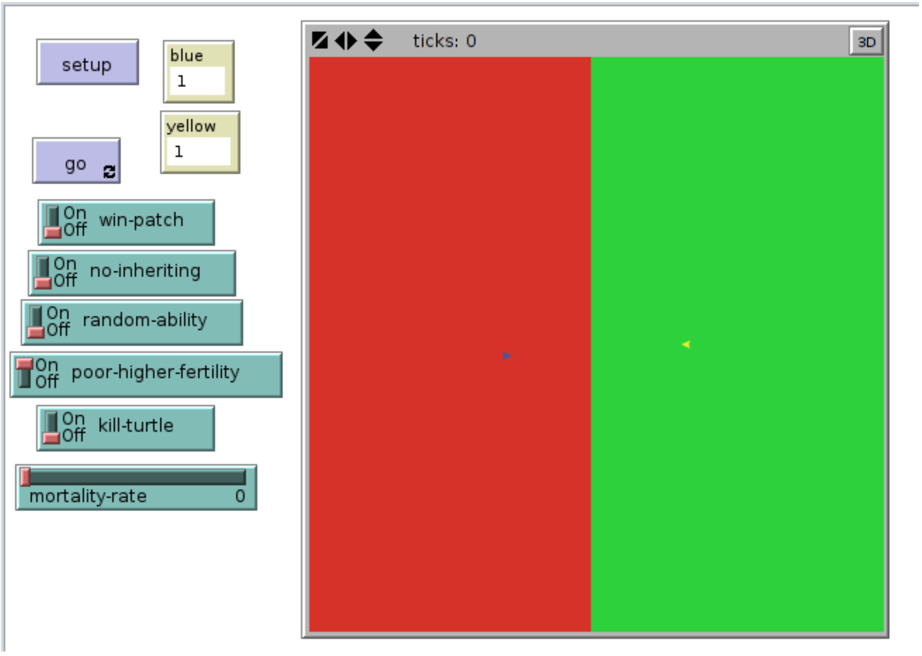

Figure 4.9: The beginning...

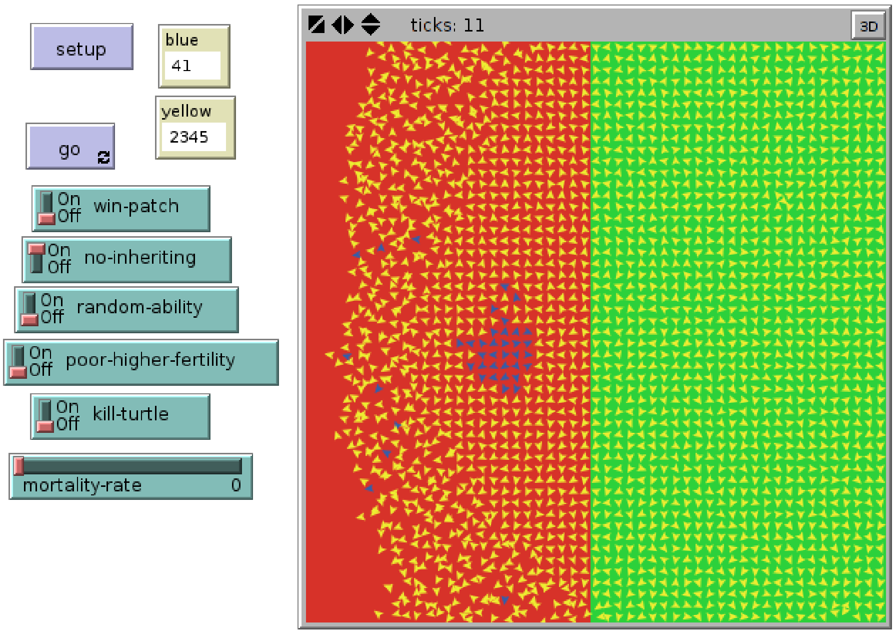

Figure 4.10: ... and after a while.

the whole population, since when they were created all the patches around their mother were already occupied by yellow turtles.

Passing now to manipulate the switches, it will be seen that the activation of a random factor, making the ability of extract income from patches' product casual, does not change too much the situation here, staying the blue population the large minority. Even if the result becomes a little more aleatory, eventually "random ability" seems not able to offset the income gap generated by the difference in product of the two areas.[3]. See figure 4.11.

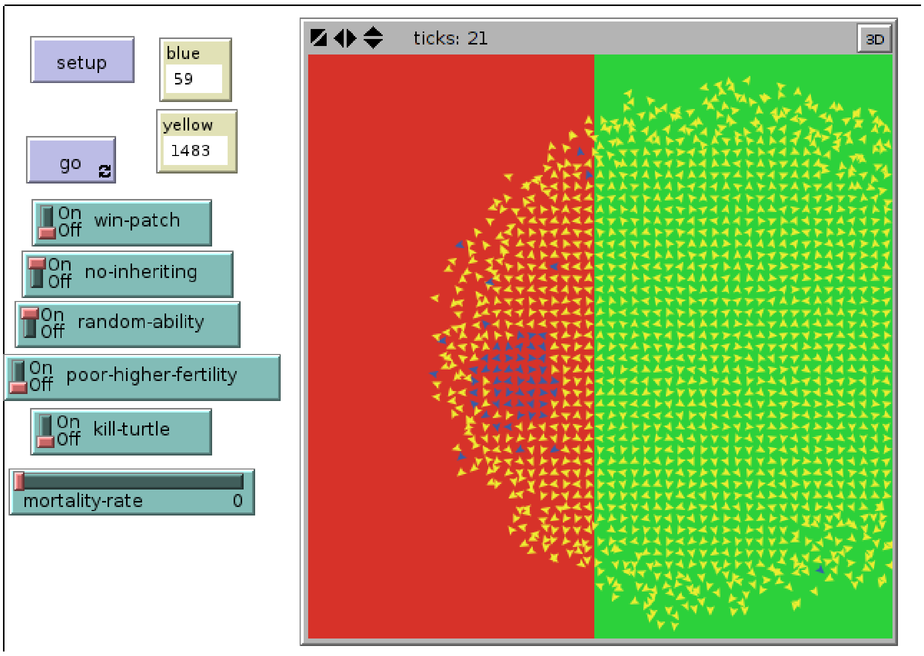

Figure 4.11: Random ability

What happens if, holding parameters equal to those of figure 4.10, the switch "no-inheriting" is turned off (thus allowing the daughters to inherit the income of their mother turtles)? The result is reported in figure 4.12.

It is immediately visible that the blue population reaches a number of units of about ten times greater than that of figure 4.10 in about half the time-steps. In order to try to explain this phenomenon, it can be considered the hypothesis that the poorer part of the population, through a mechanism of inheritance designed as such, gives birth to daughter turtles which are already prepared to reproduce (having inherited 10 units of income), therefore making the generation of new turtles much quicker. What seems to be significant here is that the inheritance dynamics benefits more the poorest part of the population, both in relative and absolute terms, while the richest one takes more advantage from its favourable position in the space.

Figure 4.13 shows the result brought by the activation of the switch "win-patch". It is called in conjunction with "no-inheritance" turned off, since in the

[3]It is not shown here for sake of brevity, but after having run the simulation several times under the same condition and for the same amount of time, the blue group tended to be slightly more numerous, ranging from about 40 members to about 120

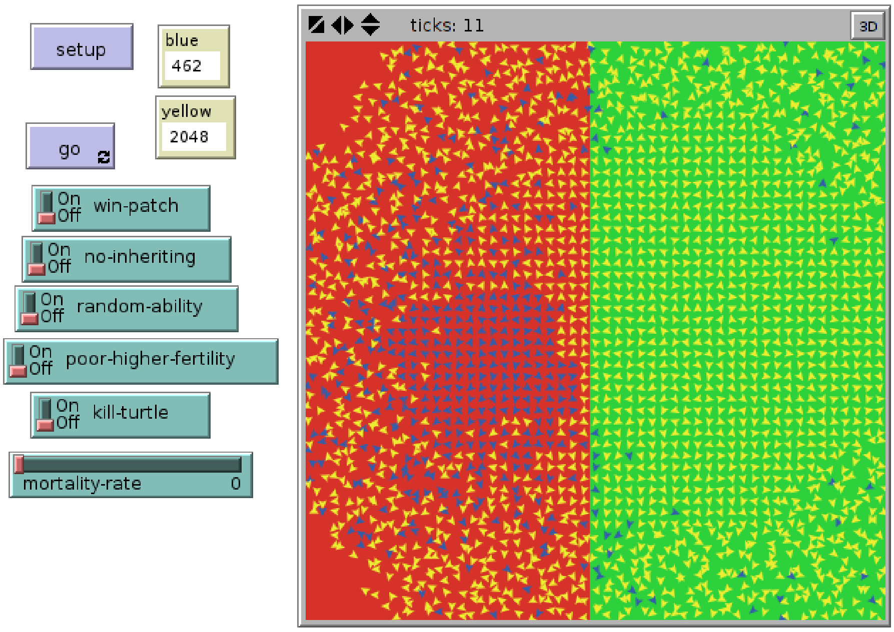

Figure 4.12: Inherit procedure

opposite case (not shown) no outcome is achieved, likely because agents begin to compete since the moment of their creation, when their "income" is zero: the program is not able to decide the winner when the rivals are equal. In case inheritance is allowed, instead, it is more probable that two competing turtles have a different level of "income", hence the simulation gives a neater result. It can be seen how the two groups are now much more fragmented: agents not winning the "duel" have to move to another area of the simulated world, where they settle and start to generate new turtles, which can be a possible explanation to the presence of different blue "islands", probably generated by those agents that lost the challenge against richer rivals.

At this point it can be raised the question on whether the inheriting procedure is an advantage for the poorest group or for the minority group. So far the blue population showed both features, making impossible to distinguish between the two candidate channels of action. Formulating directly the question: does the ability of inheriting income in this specific world, by making quicker the process of reproduction, benefit the blue turtles because they form the least numerous group or because they are the least affluent one?

After having inspected figures 4.14 and 4.15, it seems that the inheriting procedure advantages the blue because they are the poorest. Both images were taken when the program spontaneously stops, i.e. when the global number of turtles is above 2000 , which happens (as expected) sooner in case the switch "no-inheriting" is off; what can be observed is that in figure 4.14, the yellow population is much bigger than in figure 4.15, suggesting that, when an inheritance mechanism is allowed, the poor part of the global population achieves a quicker reproduction speed, *ceteris paribus*, relative to that of the richest group.

Last manipulation that can be interesting to observe is that regarding the

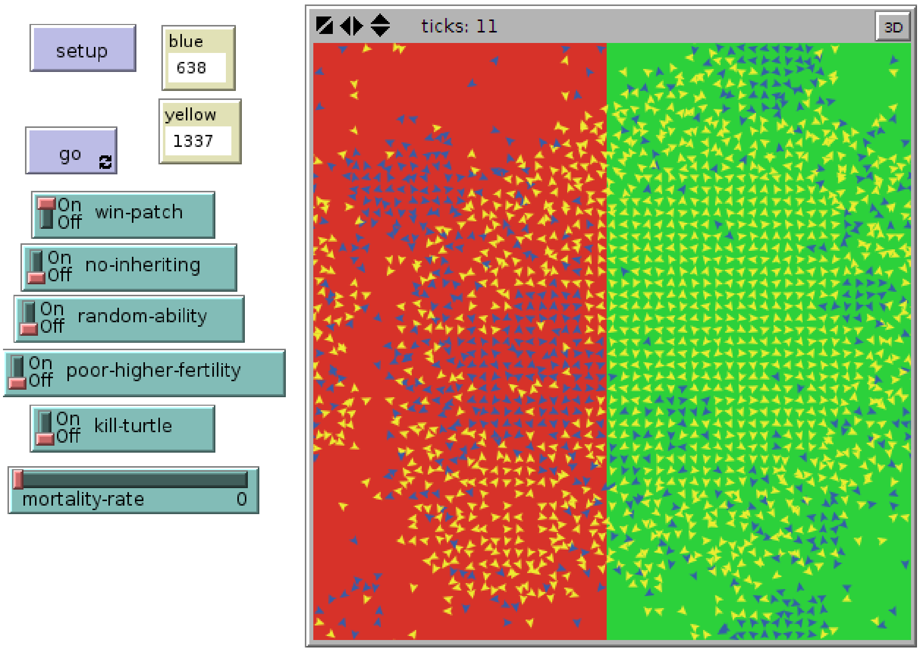

Figure 4.13: Win-patch on with inheritance allowed.

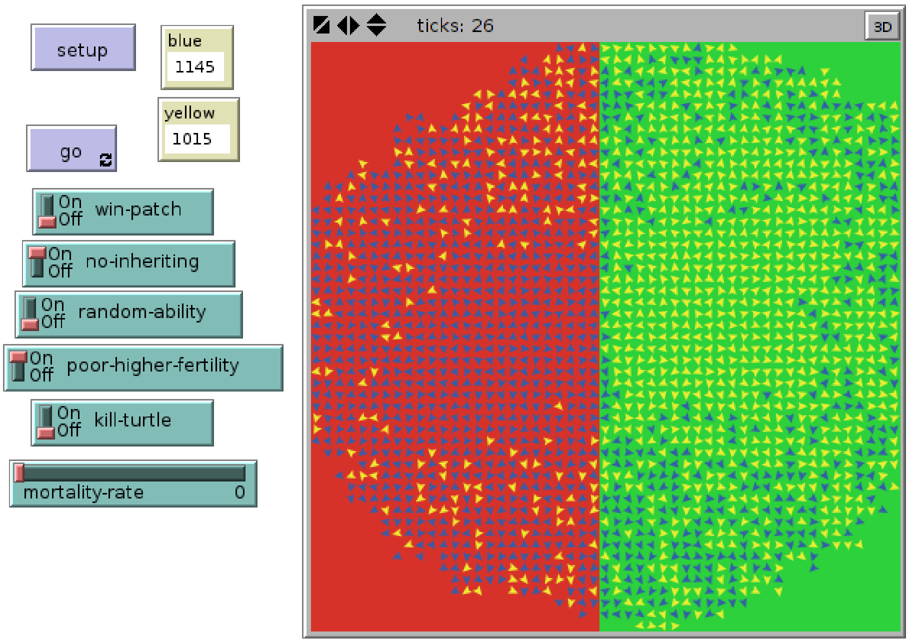

Figure 4.14: High blue fertility with no inheritance ability...

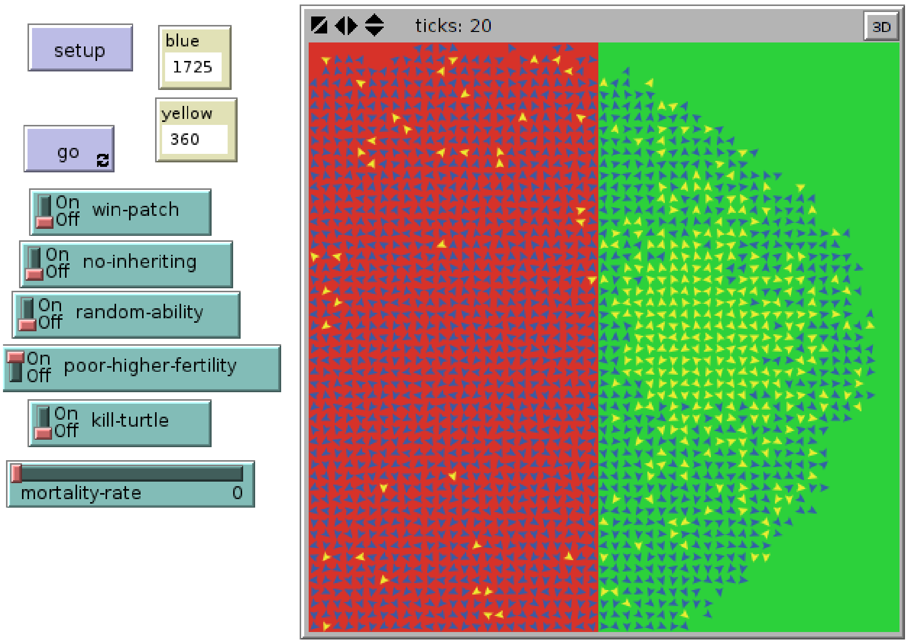

Figure 4.15: ...and with inheritance ability

"kill-turtle" switch and the "mortality-rate" slider. To see what changes, figure 4.16 reports the interface allowing for the inheriting procedure with a 0% mortality rate. After having taken that picture, the rate was increased suddenly to 40%, as in figure 4.17 and run for other four time steps. What can be seen is that the homogeneity of the two groups was weakened, principally that of the blue population, since dead turtles left empty their patches, giving the possibility for newcomers to settle there[4].

4.2 Models 2, 3 and 4

Proceeding with the construction of models, one may wonder what can happen if the product carried by the patches is not so evenly distributed in the space, as it was in the previous model, where every red patches was endowed with the same units of product as well as the patches of the green group. Here a great debt is due to D'Acci [8], who had the idea of analysing the urban space by mean of isobenefit lines, which are here represented by two hypothetical resources unequally distributed across the space. These resources are the main driver for the turtles movements, as they want to reach the spots available with the highest level of the desired variable.

The following three models work as follows. In each of the three there are two different resources, namely "gold" and "coal" (of course the names are

[4]In this case the program has been forced to stop before all turtles finished their round, with the aim of appreciate better the difference between the two situations. If the round was terminated, there would have been simply more empty spaces, but no serious difference in terms of outcome.

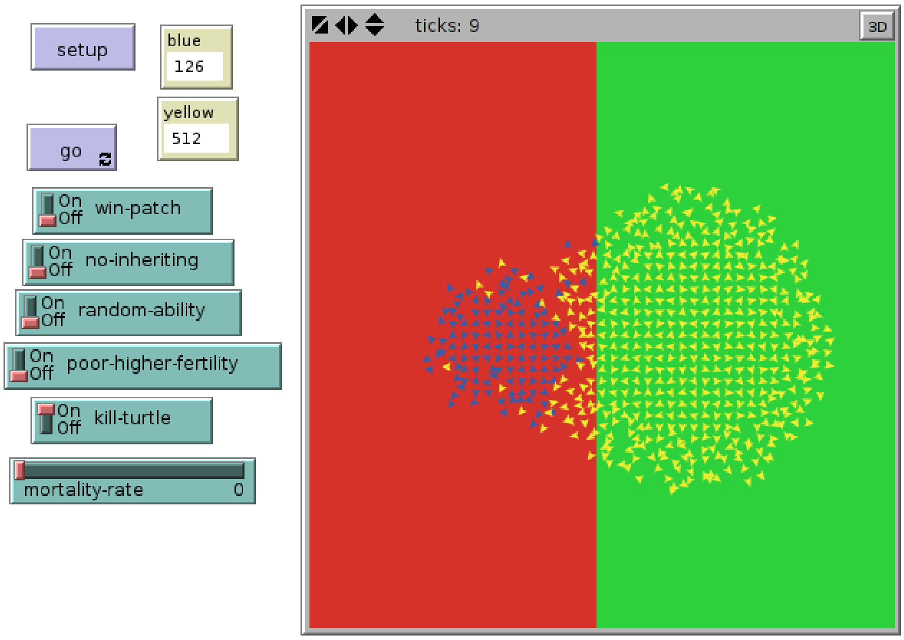

Figure 4.16: Before Switching on “kill-turtles”

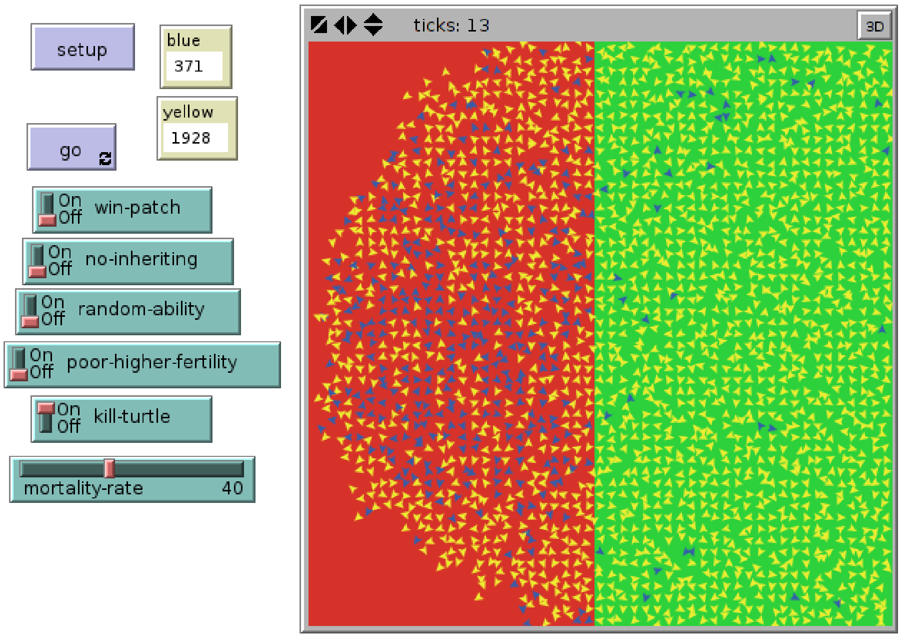

Figure 4.17: After few Ticks at 40% Mortality Rate

simply given to distinguish the two, any other name would work as well) that are diffused across the world around a point of maximum concentration (the lighter shades of colour), then their intensity lowers as the patches are further from the resource core. This pattern of distribution is intended to work as the isobenefit lines of D'Acci [8], since patches equally distant from the maximum concentration spot have more or less the same amount of the specific resource[5] and it will be therefore pretty much indifferent for agents to settle on a specific spot rather than on an adjacent one.

At the beginning of the model, each turtle gives random scores to each of the two resources, providing that they sum up to ten points. Once assigned in this way agents' preferences, every turtle receives as target the patch having the maximum level of the preferred resource and, in case this place have been already occupied, their target becomes the second richest patch free and then proceeding in this manner to less and less affluent spots. If instead a turtle does not show a precise preference, i.e. she assigned five scores to each resource, she is simply asked to move to any unoccupied place.

From a visual perspective, either turtles with no defined preferences or those having a level of wealth (given by the sum of the two resources found on the patch) under a certain threshold have a random and variable orientation, while the satisfied ones, both in terms of wealth and of preferences, point permanently towards their targets.

The main differences concerning the three models are related to turtles movements. In Model 2 agents move directly to the most preferred patch and then they relocate on the best free patches available. In Model 3 instead, turtles move towards their target with a speed proportional to the intensity of their preferences: if an individual has assigned a score of 10 points to the resource "coal", she will move faster to the richest patch than other turtles with a lower level of preference. Finally in Model 4, as in Model 1, only two turtles are created at the beginning, both immediately moving to their favourite richest patch; soon as they reach a level of wealth of fifty or more units, they start to reproduce and their daughters locate on the first and best patch available, where, as again they reach the same wealth threshold, they reproduce newly and so on.

Code explanation: common lines As done before, we are going to look at few lines of code, starting with those that are shared by all the three models.

```
globals [target1 target2
  second-choice1 second-choice2
  vacancies]
turtles-own[wealth coal-scores gold-scores
  wealth-from-coal wealth-from-gold]
patches-own [coal gold]
```

Figure 4.18: Globals

Those reported in figure 4.18 are the global variables, which are going to be soon defined. They specify what told before, i.e. that the world is divided in

[5]The expression "more or less" is needed because of the NetLogo procedure, since it diffuse the variable first to the four patches vertically and horizontally touching the core, and then on the diagonal ones, which means that these last ones will have a slightly lower level of the considered variable. Eventually the diffusion is not perfectly linear.

two parts, according to the variables “coal” and “gold” (name chosen just for narrative purposes) owned by the patches, and that each agents can refer to two variables “target” to be defined by the single agent’s preferences, as we shall see. The only differences among the three models here is the fact that in models 3 and 4, the variables “second-choice1 ”, “second-choice2 ” and “vacancies” are defined locally trough the command “let” in the procedure “move”, later described in Figures 4.21 and 4.22.

```
to color-patches
repeat 80
[diffuse coal 0.25
  diffuse gold 0.25
  ask patches [if coal > 0.01 [ set pcolor scale-color red coal 0 20]
   if gold > 0.01 [ set pcolor scale-color yellow gold 0 20]]]
end
```

Figure 4.19: World’s shape

Figure 4.19 is referred to the procedure “color-patches“, called by the procedure ”setup“. In the latter, not reported here, it has been asked to two particular patches to set one of the variables ”coal“ and ”gold“ equal to 2000. The code of figure 4.19 makes the surrounding patches to acquire part of those variables according to their distance (which is how the command ”diffuse” works by default in NetLogo) from the source. In particular, the code states that each patch will acquire a fraction of 0.25 (i.e. the 25%) of the resource of her neighbours. Then the patches are proportionately coloured in yellow, if the predominant variable is “gold“, or in red, if the predominant variable is ”coal“: the more the patch owns the variable, the lighter the shade of the colour.

```
to preferences
  set target1 max-one-of patches [coal]
  set target2 max-one-of patches [gold]
  ask turtles [set coal-scores random 10
    set gold-scores (10 - coal-scores)]
end
```

Figure 4.20: Preferences and targets

What is reported in figure 4.20 instead, are the lines of code, again called by the procedure ”setup“, that assign to the turtles the level of preferences towards the two resources. What the program does, is simply to ask the turtles to give a random discrete value, labelled ”coal-scores” and ”gold-scores” and included between 0 and 10, to one of the two variables. The difference between 10 and the number actually picked is then assigned to the other resource [6]. Model 4 has an exception here, as it will be described later, since a default value of 6, to one or the other resource, is given to all the turtles (see figure 4.24). The other two lines simply specify the global variables ”target1“ and ”target2“, which are respectively the patch having the highest value of the variable ”coal”, and the one showing the highest value of ”gold“.

[6]For instance: the turtle 13 chooses randomly a value of 7 assigned to “coal-scores“. Her value of ”gold-scores“ will be then 3.

```
to move
  set vacancies patches with [not any? turtles-here]
  set second-choice1 max-one-of vacancies [coal]
  set second-choice2 max-one-of vacancies [gold]
ask turtles [
  set wealth (gold + coal)
  move-to patch-here
  ifelse coal-scores = gold-scores [set heading random 360][
    ifelse coal-scores > gold-scores[ set color blue
       face target1
    if not any? turtles-on patch-ahead 1 [
    move-to target1]]
  [set color lime
    face target2
    if not any? turtles-on patch-ahead 1
  [ move-to target2]]]
```

Figure 4.21: Movements part 1, model 2

```
    if not any? turtles-on patch-ahead 1
  [ move-to target2]]]
   if any? other turtles-here
   [ifelse coal-scores = gold-scores
     [set heading random 360 move-to one-of vacancies]
    [ifelse coal-scores > gold-scores[
   move-to second-choice1]
  [move-to second-choice2]]
  ]]
  ask turtles with [coal-scores = gold-scores][if any? turtles-on neighbors
    [move-to one-of vacancies]]
  ask turtles with [wealth < 3][set heading random 360]
end
```

Figure 4.22: Movements part 2, model 2

Code differences Figures 4.21 and 4.22 are taken from the code of model 2: they work as basis for all the other models. They report the procedure ”move”, which is called by procedure ”go” also in models 3 and 4. The first lines, reported in figure 4.21, define the global variables “vacancies”, “second-choice1 ” and “ second-choice2 ” (remembering that these are locally defined in models 3 and 4) respectively as any patches with no occupier and, among these, the patches having the maximum amount of “coal” or “gold”. After this, agents define their “wealth“ as the sum of the amount of the resources they find on their current position. Then turtles are asked to take a particular orientation according to the scores they assigned in the procedure “setup”. If they prefer the “coal” variable, they will heading towards the patch having the highest value of it; the same if they show higher scores for the “gold” variable. If instead no clear preferences have emerged (meaning that turtles gave 5 scores to each resource), they will simply take a random direction.

After having chosen the orientation, each turtles is asked to move to the point of maximum level of the preferred resource (the core of one of the two areas) [7]. If there they found another turtle already occupying that position, they are asked to move to one of the second choices, as stated in the code of figure 4.22. In this way, no patch will be occupied by more than one turtle. In particular turtles without any clear preference are asked to move to leave room for new turtles: they “look around” and if there are other agents in the 4-patches neighbourhood, they move to a free patch. The last line in figure 4.22 states that turtles with less than three units of “wealth” have to take a random orientation.

```
    if not any? turtles-on patch-ahead 1 [
    fd (0.1 * coal-scores)]]
  [ set color green
    face target2
    if not any? turtles-on patch-ahead 1
  [ fd (0.1 * gold-scores)]]]
   if any? other turtles-here or
   any? vacancies with [gold > 1] or
   any? vacancies with [coal > 1]
   [ifelse coal-scores > gold-scores [move-to second-choice1] [move-to second-choice2]
   if coal-scores = gold-scores
     [set heading random 360 move-to one-of vacancies]]]
  ask turtles with [coal-scores = gold-scores][
   let vacancies
     patches with [not any? turtles-here]
    while [any? other turtles-here][  move-to one-of vacancies
      set heading random 360]   ]
  ask turtles [if wealth < 1 [set heading random 360]]
```

Figure 4.23: Movements, model 3

Here ends the procedure “move” of model 2. Model 3’s “move” procedure is represented in figure 4.23 (here the lines which have been previously explained dealing with model 2 are absent). This model has been built trying, in a very simple way, to tie turtle’s preferences to their speed in reaching their target. As it can be seen from the first lines in image 4.23, once decided their direction, turtles move step by step, by a distance that is one tenth of the length of a patch,

[7]Turtles can do this if there are no other agent standing on the next patch towards the target, but this is done only for sake of order and to avoid the formation of congestion of turtles heading to opposite directions.

multiplied by the score the turtle gave to her preferred resource[8]. Therefore, the higher the score, the greater the speed of the turtle. Another difference with the previous model, is that turtles are asked to check whether, in addition to the presence of other turtles on the same spot, there are available patches with more than 1 unit of "coal“ or of "gold“. Consequently, at the end, if they are found on patches having less than one unit of resource, they will take a random orientation, just as turtles with no preference do. In order to have this effect clearly visible, the number of turtles created at the beginning (in the procedure "setup“, not shown here), is higher than in models 2 and 4. In fact, with a number of 500, the situation does not reach a stability, since the turtles continuously find free patches with 1 unit of wealth, and they accordingly change position at each turn.

```
to preferences
  set target1 max-one-of patches [coal]
  set target2 max-one-of patches [gold]
  ask turtle 0 [set coal-scores 6]
  ask turtle 1 [set gold-scores  6]

end
```

Figure 4.24: Preferences assignation procedure, model 4

Examining at the end model 4, as mentioned earlier, the first difference met regards the preferences assignation procedure. Here the model works in a slightly different way from the previous ones, since at the very beginning only two turtles are created. These original agents will then give birth to all the other turtles that will act in the model; under this perspective, Model 4 is closer to Model 1 than the others. In order to have one original turtle per resource, their preferences are arbitrarily given: turtles 0 will assign 6 scores to the resource "coal", while turtle 1 will have 6 units of "gold-scores". All their daughters will then inherit the same values of those variables. Turtles 0 and 1 are both generated at the core of their chosen areas. The other differences with respect to Model 2 (not shown here, they are just a couple of lines) are that all turtles generate a new turtle once reached the threshold of 50 units of wealth, and that the program stops when a number of 2000 turtles is reached. The rules of movements stay the same, with the result, as shown later on, that all the turtles take a position on the richest patch available (i.e. not yet occupied) closest to their mother's place.

Plan of experiments Passing now to see how Model 2 3 4 look like, it is quite implicit that, given the previous code's description, they can be seen as part of a unique experiment plan: they were built starting from the same ideas and their environment is pretty much the same, only some parts of the turtles' behaviour change from one model to another.

- different preferences, different targets and second choices, **turtles go directly to objectives**, same spatial distribution of "coal" and "gold;

8. As instance: if the turtle 51 assigned 7 scores to "gold“, she will move by a distance of $0.1 * 7 = 0.7$ patches each time step.

- different preferences, different targets and second choices, **turtles have different speed**, same spatial distribution of “coal” and “gold;
- different preferences, different targets and second choices, **different offspring occupying the world**, same spatial distribution of “coal” and “gold;
- different preferences, different targets and second choices, **different offspring occupying the world**, **different quantity of ”coal“ and ”gold“**;
- different preferences, different targets and second choices, **different offspring occupying the world**, **more concentrated distribution of ”coal“**.

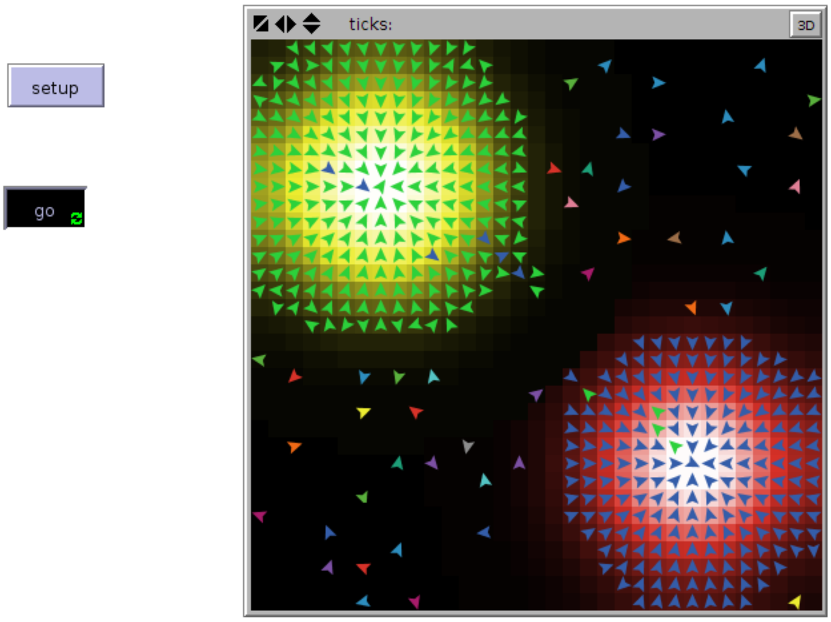

Figure 4.25: Model 2 look

Experiments Figure 4.25 shows the look of Model 2. The yellow area gathers the patches having more than 0.01 units of the “gold” variable, while those having more than 0.01 units of “coal” are coloured in red (remark: the lighter the nuance, the higher the value of the variable). Turtles take different colours and positions according to their features and condition. Those having no clear preferences have a random orientation and a random colour. They tend to be found on black areas, on patches too distant from the core of the two resources distribution to have any significant level of those variables. Turtles showing a precise preference instead, are coloured in blue (in case of a higher value of “coal-scores”) or in green (in the opposite case). The main patterns, visible in figure 4.25, found performing the simulation several times, are that:

1. turtles, as predictable, tend to locate themselves on patches having the highest possible level of their preferred resource, holding the requirement that no more than one turtle per patch is allowed;

2. again as expected, peripheral blue and green turtles do not meet the threshold of 3 units of wealth, therefore they take a random orientation;

3. there are cases of agents "trapped" in their least preferred areas (e.g. the six blue turtles among green ones of figure 4.25), since the "move" procedure does not allow them to move further, because of the agents standing on the next patch they are heading to.

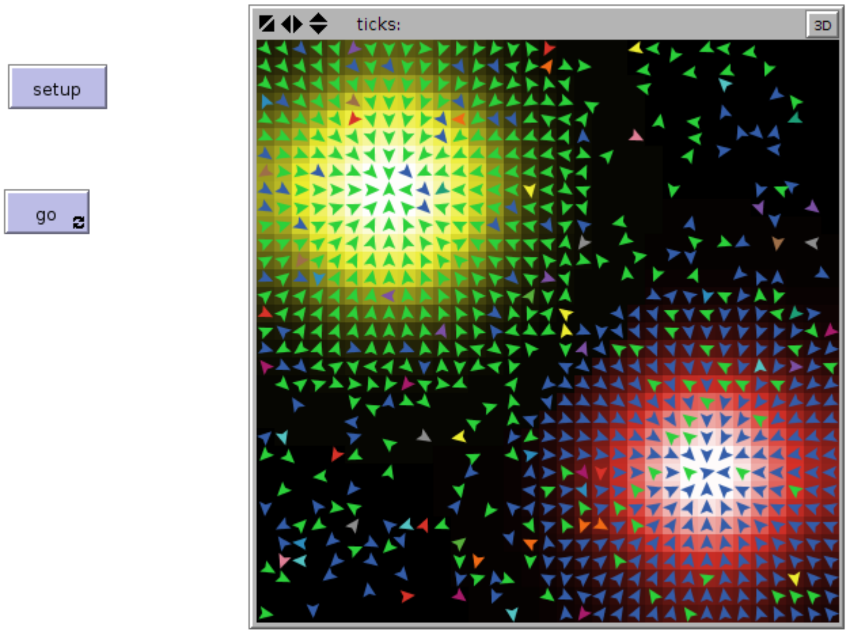

Figure 4.26: Model 3: initial setup.

The simulation of model 3 is reported, at its initial stage, in figure 4.26. As previously told, the density of turtles in the space is greater than in model 2, and 4 as well, in order to have a more stable outcome, otherwise agents will continuously move among patches having more than one unit of resource. It can be seen that the large majority of turtles are already on a satisfying place. The dynamic of model 3 is more relevant for peripheral turtles, figures 4.29 and 4.30 focus on two of them: turtle 287 and turtle 13 respectively, whose characteristics are displayed in figures 4.27 and 4.28. They are found outside their preferred areas. Given the code instruction, they are asked to move towards patches rich in "gold"(turtle 13) or "coal" (turtle 287) according to a speed directly linked to the intensity of their preferences. Therefore turtle 13 will move by 0.9 patch each turn, while turtle 287 by 0.6 patch (see note 8). Figures 4.31 and 4.32 report the situation after the same number of turns for both agents: it can be seen that turtle 13 has moved further than turtle 287, getting closer to her

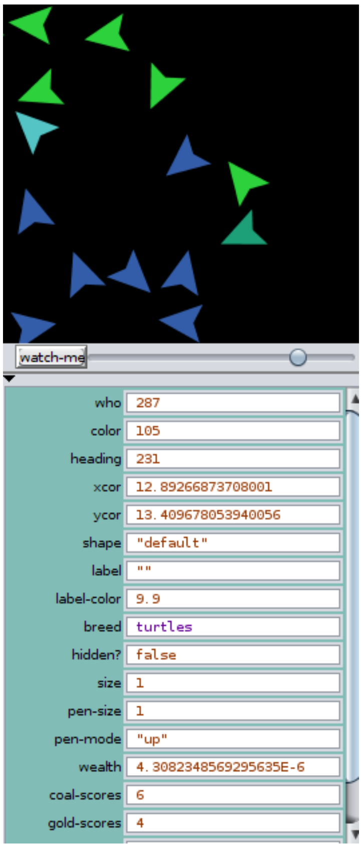

Figure 4.27: Model 3: turtle 287's features.

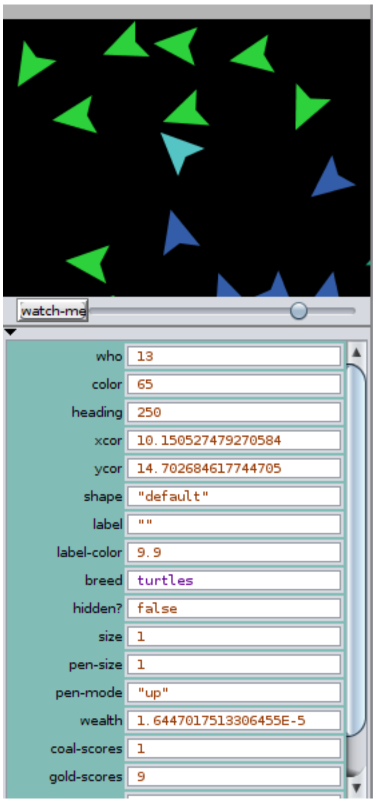

Figure 4.28: Turtle 13's features.

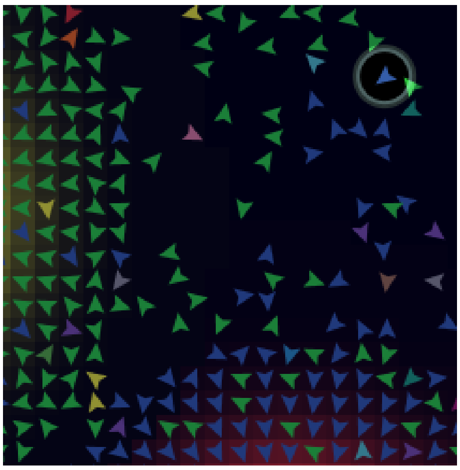

Figure 4.29: Turtle 287: initial position.

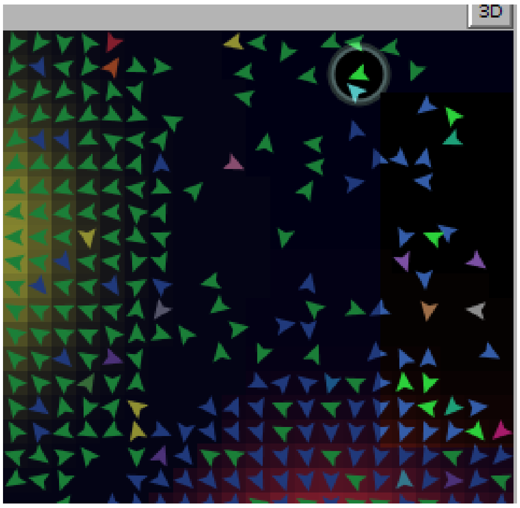

Figure 4.30: Turtle 13:initial position.

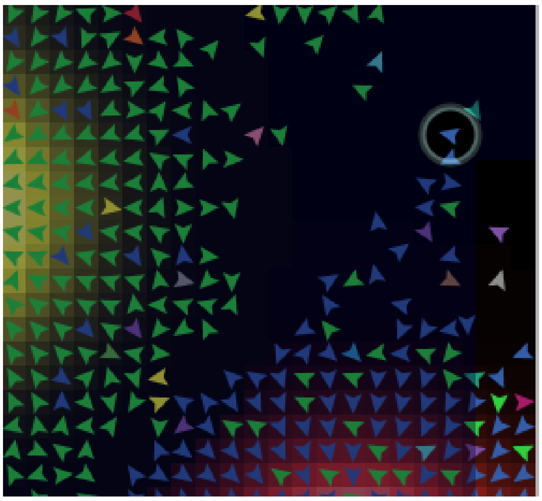

Figure 4.31: Turtle 287: final position.

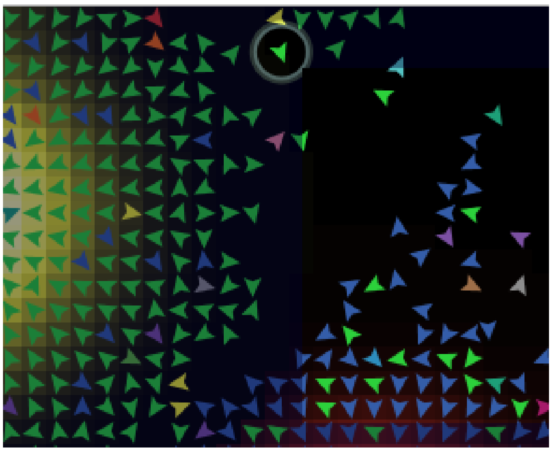

Figure 4.32: Turtle 13: final position.

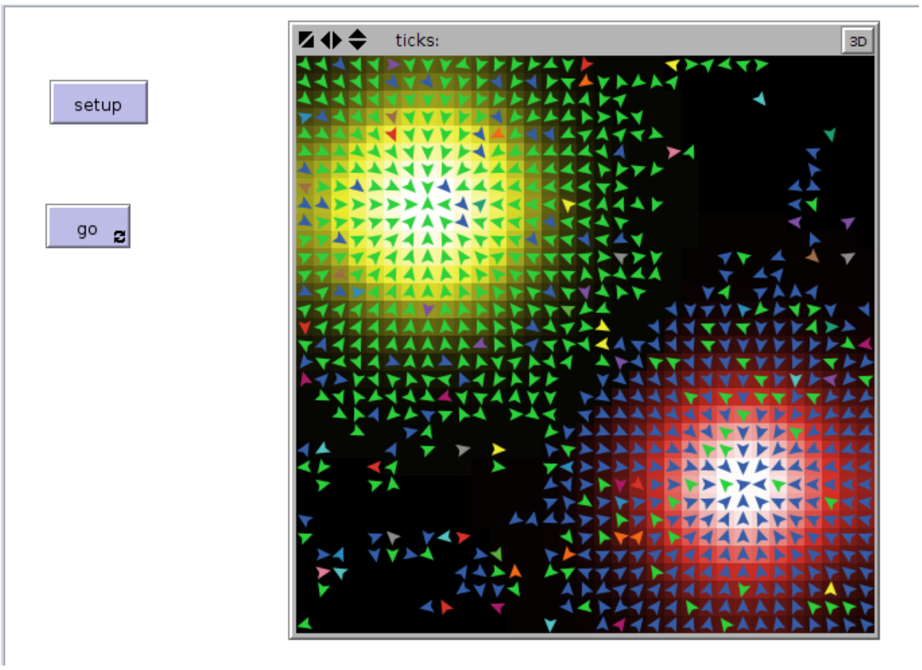

Figure 4.33: Model 3's final outcome.

preferred area. Figure 4.33 displays instead the whole situation at the end of the simulation, i.e. when no turtle will change her position. It can be seen there how turtle 287 has no further moved, since she is embedded in a column of other agents, while turtle 13 has gone closer to the yellow area.

In model 3 still persists the presence of turtles trapped in a area which is not their favourite, just as in figure 4.25 of Model 2. Here their number is higher than before, fact due to the greater density of agents, which is an obstacle to the free movement of turtles. If the path to their target is blocked by other agents, they are simply forced to stay where they are, a phenomenon that causes also different areas of congestion.

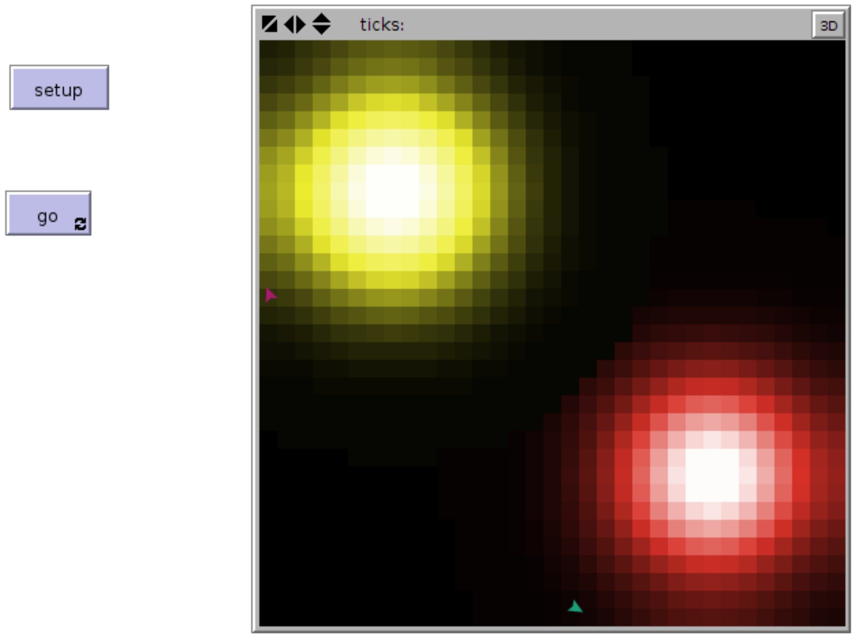

Figure 4.34: Model 4: setup.

Figure 4.34 shows eventually how model 4 looks at its first step, with only two turtles in a randomly chosen position, and with a random colour [9].

Figure 4.35 reports the final outcome of the simulation. As it can be seen, the two groups of turtles perfectly divide the space. Each one is on a position that is the nearest possible to her preferred resource, since every daughter, once born, looked instantly for the closest available patch having the biggest amount of her favourite variable.

As expected, if the observer halves the amount of "coal" of the patch at the core of the red area before the diffusion procedure, the final result is a space occupied by a far larger number of turtles preferring "gold", since they will reproduce at a speed higher than their counterparts (see Figure 4.36). What if "coal" is more concentrated? It can be seen from Figure 4.37 (where the

[9] There is no need here to give a particular colour following turtles' preferences. As previously explained, one of the two prefers "gold" and the other "coal", then their daughters will inherit all the mothers features.

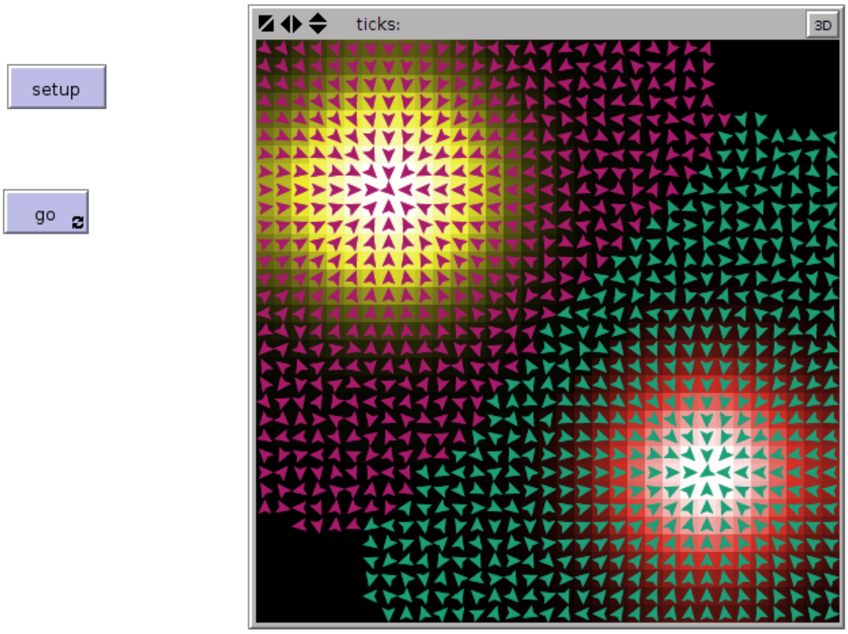

Figure 4.35: Model 4: final outcome.

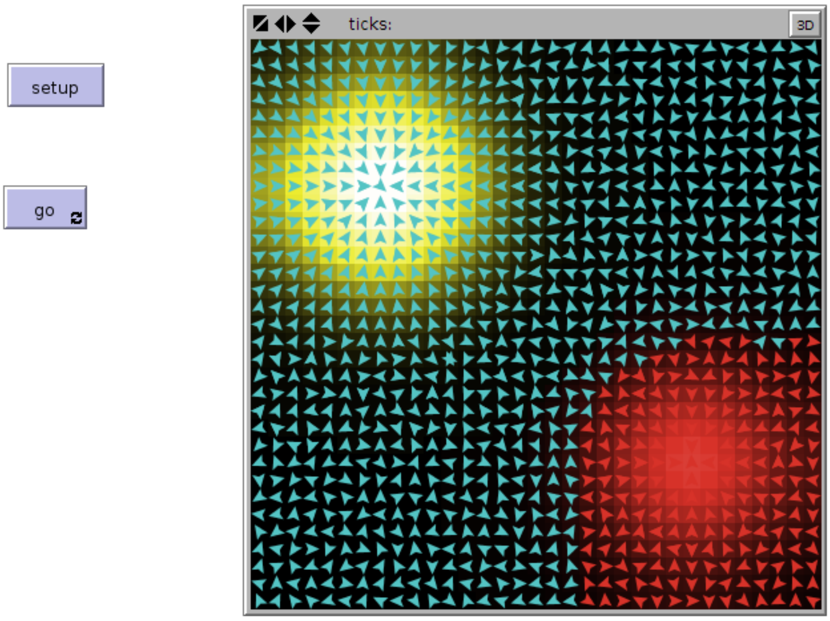

Figure 4.36: Half the level of "coal".

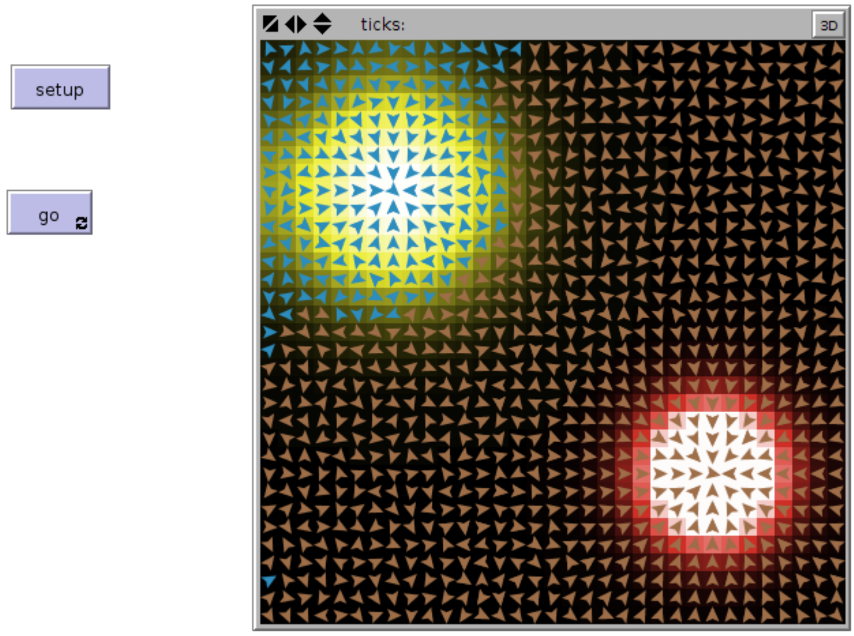

Figure 4.37: Higher "coal" concentration.

rate of diffusion has been lowered from 0.25 to 0.10, see the Code Explanation Paragraph), that this helps turtles preferring that resource to reproduce faster, likely because the first mother has a larger amount available of wealth (noticing that the core quantity before the diffusion is of to 2000 units for both "coal" and "gold"[10]).

4.3 Model 5

Using previous models' findings, integrating old features and adding new ones (see figures 4.1 and 4.2), a new model can be built, in which turtles are more directly subjected to the observer's will. The main rules according to which agents move are kept pretty much the same, but newer, or at least clearer, emergent behaviours may arise.

With respect to the previous ones, a first glance to model 5 shows that the spatial representation of resources has changed: now there is a central area in which patches take the colour red, while all around they are green. This reflects the distribution of two different variables, namely "resource" and "amenity": red patches own a greater concentration of the first one, while green areas are those where the second is more present. As before, the lighter the shade, the greater the presence of one of the two variables (see figure 4.38). The observer can act in order to modify the concentration of the red variable, operating on a slider named "resource-distribution", while the distribution of the green variable

[10]These modifications were made directly modifying the program's code, not shown here.

is given in the code and is more evenly spread with no great variations from patch to patch.

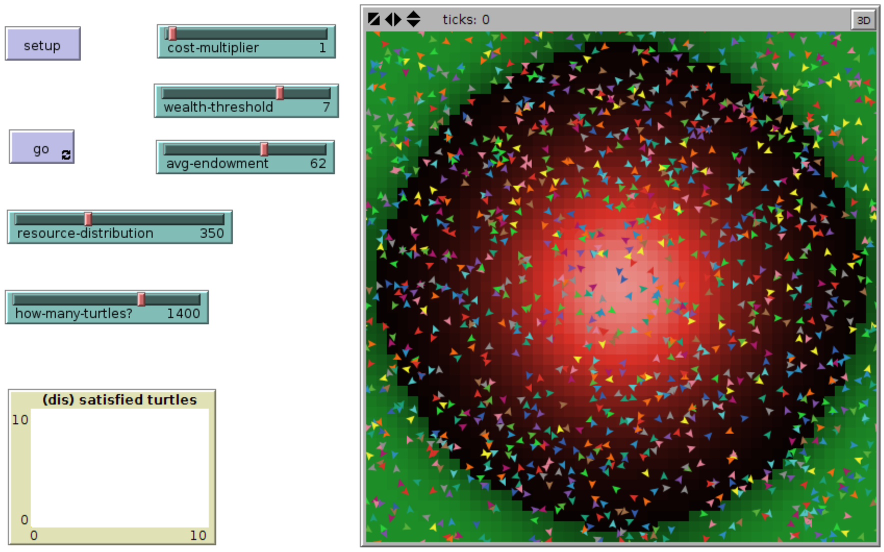

Figure 4.38: Model 5 initial aspect.

Each turtle, then, receives a random and exogenous amount of a variable named " endowment " according to a normal distribution. They own also another variable labelled "wealth" which is composed by the sum of the quantity of "resource" and "amenity" they find on their current patch. This sum, moreover, gets multiplied by a constant named "cost-multiplier" that is decided by the observer through the corresponding slider. The product of this multiplication is named "cost", which is a patches owned variable. As in the previous models, turtles can be "satified" or not about where they are: there is a threshold of wealth above which turtles are happy about their position. The observer can manipulate the slider "wealth-threshold" in order to set the level of wealth. Turtles satisfying this level and having a wealth greater than the patches' cost become green, take an orientation towards their preferred patch, according to an assignation of preferences similar to that of model 2 , and do not change position any longer. If this is not the case, agents become yellow and keep on moving till they find a suitable place (if there is one).

Code explanation. Beginning the explanation of the main lines of the program's code, figure 4.40 reports the procedure "color-patches", called by the procedure "setup" (partially shown in figure 4.39). It works pretty much as the procedure displayed in figure 4.19: it diffuses the variables "reources" and "amenity" across the space, and recolours the patches accordingly, as alredy told: the lighter the shade, the richer the patch. What is to be known here, is that the patch with the highest level of "resource" is the central one, with a maximum value of 6000 (if no diffusion takes place), while a maximum of 10 of the variable "amenity" is given to patches standing outside a circle of a radius of 2 patches, and then spread around (see figure 4.39). The number

```
to setup
  ca
  reset-ticks
  ask patches [set resource 0 set amenity 0]
  ask patch 0 0
  [set resource 6000]
  ask patches[if distancexy 0 0 > (pi * (2.705 ^ 2))[
      set amenity 10]]
   crt how-many-turtles?
  ask turtles [set endowment random-normal avg-endowment 20
```

Figure 4.39: Setup procedure.

```
to color-patches
  repeat resource-distribution
 [
   diffuse resource 0.25]
  repeat 10
  [diffuse amenity 1 ]
  ask patches
  [if  resource > 0.01
     [ set pcolor scale-color red resource 0 20]
    if amenity > 5
    [ set pcolor scale-color lime amenity 0 30]]
end
```

Figure 4.40: Color patches procedure.

of times that the diffusion of "resource" takes place is decided by the slider "resource-distribution". Turtles own also a variable named "endowment", that is randomly assigned according to a normal distribution with a standard deviation of 20 and mean equal to the value set by the slider "avg-endowment". Finally, the slider "how-many-turtles?" decides the number of turtles that will be created in the system.

```
to patches-costs
  ask patches [set cost cost-multiplier *(amenity + resource )]
end
to preferences
  set city-target
     max-one-of patches [resource]
  set land-target
     max-one-of patches [amenity]
     ask turtles  [set city-scores random 10
    set land-scores (10 - city-scores)]
```

Figure 4.41: Preferences and patches' cost procedure.

Figure 4.41 shows again some lines of code called by the "setup" procedure. In particular, it reports the procedure that assigns the variable "cost" to each patch (as explained before: the cost is equal to the sum of the patches' "resource" and "amenity", times the value of the slider "cost-multiplier"), labelled "patches-costs", and the procedure that gives certain preferences to every turtle. It works as usual, i.e. each agent assigns a random score, named "city-scores" from 0 up to 10. The difference between 10 and this value is then labelled "land-scores". Moreover, in this procedure are also specified the global variables "city-target" and "land-target", defined as the patches carrying the greatest quantity of “resource” and ”amenity“.

```
to move
  ask turtles[
    move-to patch-here
     let vacancies patches with [not any? turtles-here]
     let second-choice-city max-one-of vacancies [resource]
     let second-choice-land max-one-of vacancies [amenity]
      ifelse city-scores = land-scores
     [[ move-to one-of vacancies with [ (resource + amenity) < 3]]
      [ ifelse city-scores > land-scores[
       face city-target
    if not any? turtles-on patch-ahead 1 [
   fd 1]]
  [face land-target
    if not any? turtles-on patch-ahead 1
  [ fd 1]]]
```

Figure 4.42: Movements part 1, Model 5.

```
    if not any? turtles-on patch-ahead 1
  [ fd 1]]]
   if any? other turtles-here
   [ifelse city-scores = land-scores
     [move-to one-of vacancies with [(resource + amenity) < 3]]
    [ifelse city-scores > land-scores[
   move-to second-choice-city]
  [move-to second-choice-land]]
  ]
    if wealth < wealth-threshold or cost > endowment
     [ifelse city-scores = land-scores
       [set heading random 360 move-to one-of vacancies]
       [ifelse city-scores > land-scores [
    set heading random 360 move-to second-choice-city]
    [set heading random 360 move-to second-choice-land]]]
      ]
end
```

Figure 4.43: Movements part 2, Model 5.

Figures 4.42 and 4.43 show the procedure ”move”, contained in turn in the procedure “go”. In these lines are set the main rules of movements of the turtles, rules that are very close to those reported in figures 4.21 and 4.22 for previous models. Here turtles define again few local variables, which are:

1. “vacancies”, that includes all the patches not occupied by any agent;
2. “second-choice-city”, that is the free patch (or ”vacancy”) with the highest level of “resource”;
3. “second-choice-land”, which is the best “vacancy” in term of “amenity”.

All the turtles, then, receive different instructions according to their preference. If they have an equal level of “city-scores” and “land-scores”, they are asked to move to a patch where the sum of the values of “amenity” and “resources” is strictly less than 3. If instead turtles show a clear “preference”, they are asked to heading towards their favourite target and, being no turtles on the next patch, to move step by step in that direction. They are then required to check whether there is another agent on the patch on where they are. If this is the case, turtles are asked to move directly to the preferred "second-choice", or to any free patch if they are indifferent in terms of scores. This action takes place also when turtles do not meet the requirement of having a level of wealth greater than that set by the slider"wealth-threshold", or they do not satisfy the condition of having an "endowment " greater then the patch's "cost". In these latter two cases, they will also take a random orientation.

```
to colour-turtles
  ask turtles with [ land-scores = city-scores]
  [set color grey]
  ask turtles with [land-scores != city-scores]
  [ifelse wealth >= wealth-threshold and cost <= endowment
    [set color lime]
    [set color yellow]]
end
```

Figure 4.44: Turtles recoloured.

Finally, figure 4.44 shows the piece of code that recolours the turtles according to their "satisfaction", i.e. whether they meet or not the levels of wealth and endowment sufficient to stay on their position. In particular, those not complying with these requirements take the colour yellow, while the other will become green instead. Turtles with an equal level of "city-scores" and "land-scores" will simply have the colour grey.

Plan of experiments.

- Low "wealth" threshold, low "cost-multiplier", "endowment" = 50, "resource-distribution" = 280, 1650 turtles;
- **High "wealth" threshold, high "cost-multiplier"**, "endowment" = 50, "resource-distribution" = 280, 1650 turtles;
- **High "wealth" threshold**, low "cost-multiplier", "endowment" = 50, "resource-distribution" = 280, 1650 turtles;
- Low "wealth" threshold, **high "cost-multiplier"**, "endowment" = 50, "resource-distribution" = 280, 1650 turtles;
- **High "wealth" threshold**, low "cost-multiplier", "endowment" = 50, "resource-distribution" = 280, **300 turtles**;
- Low "wealth" threshold, low "cost-multiplier", "endowment" = 50, **"resource-distribution" = 900**, 1500 turtles;
- Low "wealth" threshold, low "cost-multiplier", "endowment" = 50, **"resource-distribution" = 200**, 1500 turtles;
- Low "wealth" threshold, **high "cost-multiplier"**, "endowment" = 50, **"resource-distribution" = 900**, 1500 turtles;

- Low "wealth" threshold, **high "cost-multiplier"**, "endowment" = 50, **"resource-distribution" = 200**, 1500 turtles;

- Low "wealth" threshold, low "cost-multiplier", **"endowment" = 20, "resource-distribution" = 1000**, 1500 turtles;

- Low "wealth" threshold, low "cost-multiplier", **"endowment" = 20, "resource-distribution" = 50**, 1500 turtles.

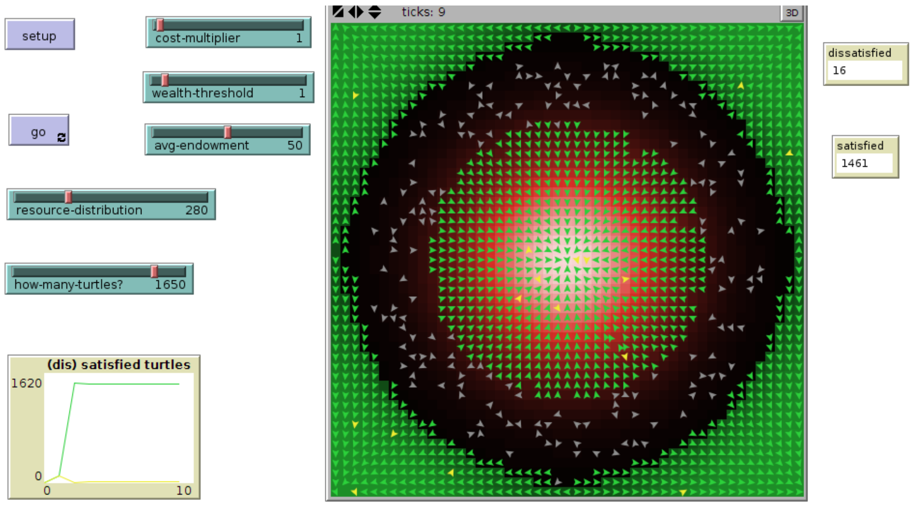

Figure 4.45: Manipulation of thresholds, low requirements.

Experiments Passing now to the execution of a few experiments, figure 4.45 reports the result of a simulation in which the two thresholds are kept very low (one unit each), while a rather large number of turtles operates in the model, resources are quite concentrated (the diffusion procedure is repeated 280 times), and the average endowment given to the agents accounts for 50 units. As it can be seen, almost every agent satisfies the requirements of endowment and threshold of wealth, while only 16 out of 1650 turtles are "dissatisfied" with their position (see top right counters); it can also be observed how yellow turtles are dispersed among the green ones.

Figure 4.46 was obtained keeping all but the threshold sliders equal. As foreseeable, every turtle is now yellow and "dissatisfied", being the endowment and wealth thresholds, respectively at a level of 18 and 8 units, too high for them.

Hopefully more interesting is instead figure 4.47, where, with respects to figure 4.46, only the slider "cost-multiplier" has changed, lowered to 3 units. The result is a core of green turtles around the centre, two peripheral yellow rings at the edge of the red and green zones, and again a compact set of green turtles at the four corners [11]. This happens, likely, because the richest patches are now more affordable in terms of "endowment", being much lower the constant multiplying the "wealth" they are carrying. Peripheral turtles, instead, do not met

[11]It must be remarked that this world is not a square, but indeed it is an open torus , where the four corners are actually connected.

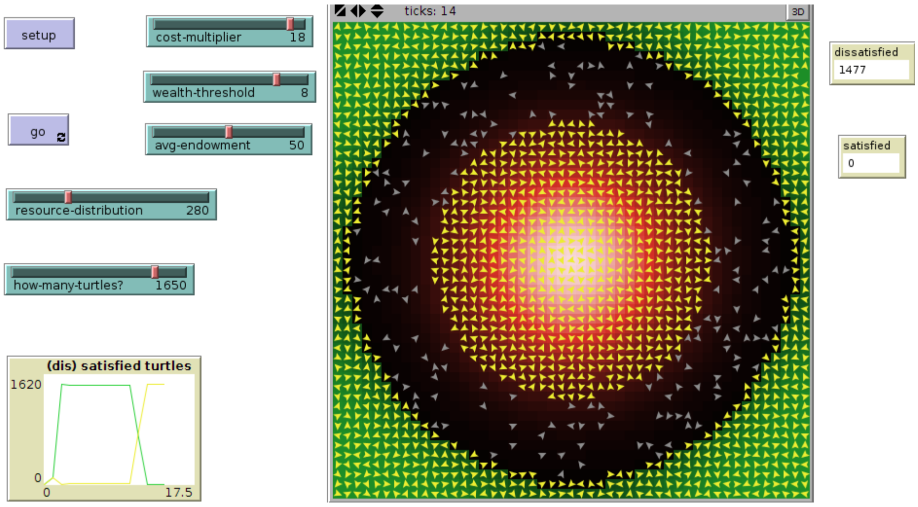

Figure 4.46: Manipulation of thresholds, high requirements.

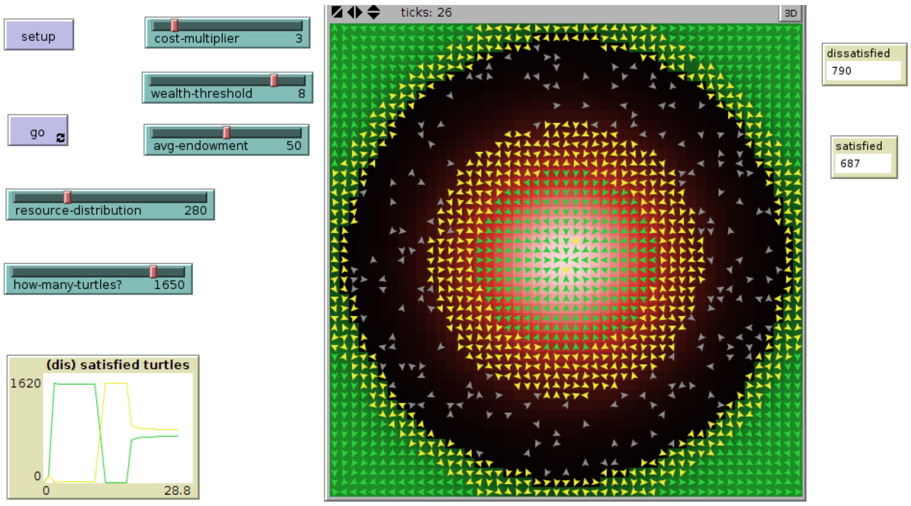

Figure 4.47: Manipulation of thresholds 1: low patches' cost.

the “wealth-threshold” condition, therefore stay “dissatisfied”. It is also worth to notice, looking at bottom left graph, how this result was not instantaneous, but took a few time steps before being reached: though low, not every turtle has enough units of “endowment” to overcome the cost of the richer patches (e.g. the two yellow turtles at the centre of the red area). Therefore, an adjustment took place, during which poor turtles moved (randomly) to the periphery, and the rich ones (again randomly) moved to the centre, where they found a suitable spot. The fact that this adjustment took time to be implemented, raises the question on whether there are turtles that could afford a place in the centre, but are not allowed to move from their unsatisfying positions.

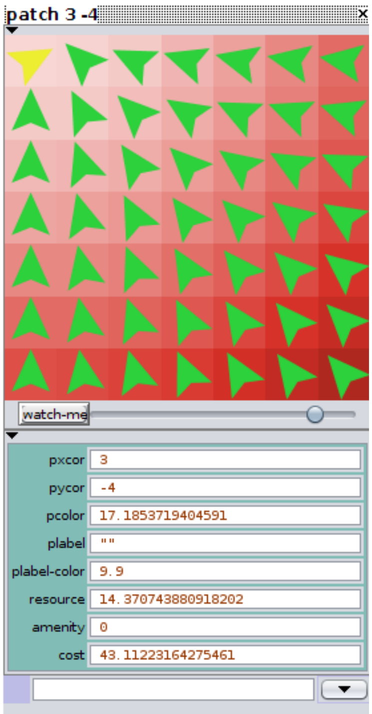

Figure 4.48: Detail of a patch’s cost.

To prove these doubts, figures 4.48 and 4.49 show respectively a focus on a central red patch (whose ”cost“ is greater than 43 units), and a panoramic of the world where all the yellow ”dissatisfied“ turtles, owning more than 45 units of ”endowment“, are coloured in blue (see the ”command center” at the bottom of figure 4.49). Thus, hypothetically, all these turtles could afford the ”cost” of the highlighted patch and, consequently, the cost of many of the most central patches, for what concerns the red area (the highlight could have been on a green one, without altering the substance of the result). Once seen the large number of blue agents, the conclusion seems that, in this particular world, a large number of turtles is dissatisfied because there is no room for them. The capacity of the red area (and of the green as well) of *carrying* agents is, up to certain point, limited.

Figures 4.50, 4.51 and 4.52 are taken running a second time the experiment

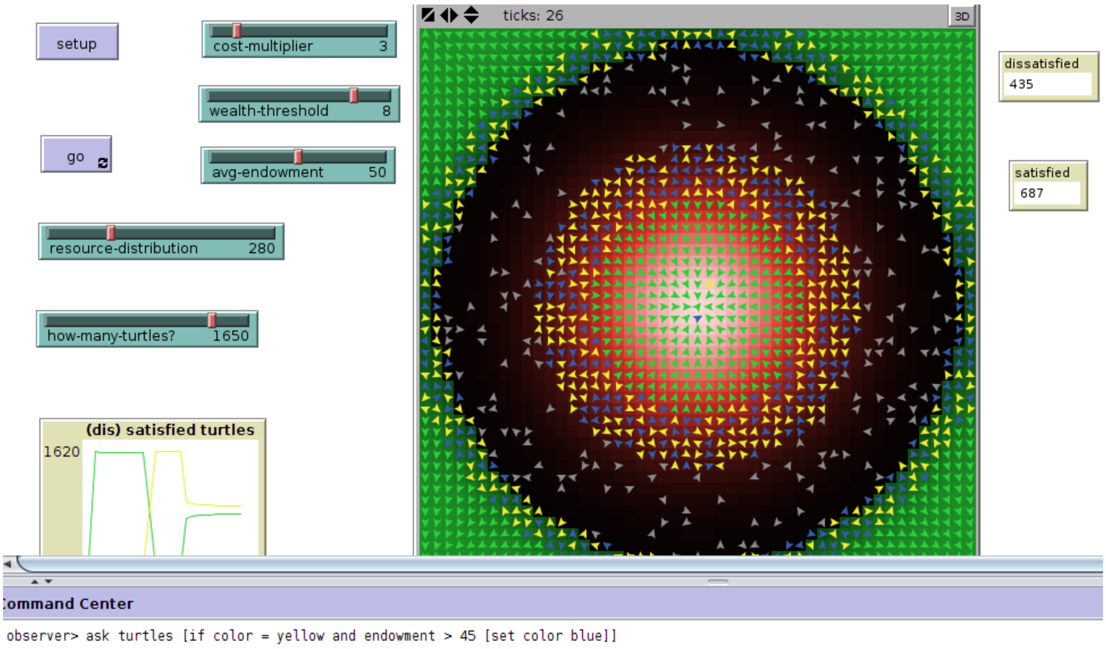

Figure 4.49: Blue rich dissatisfied turtles.

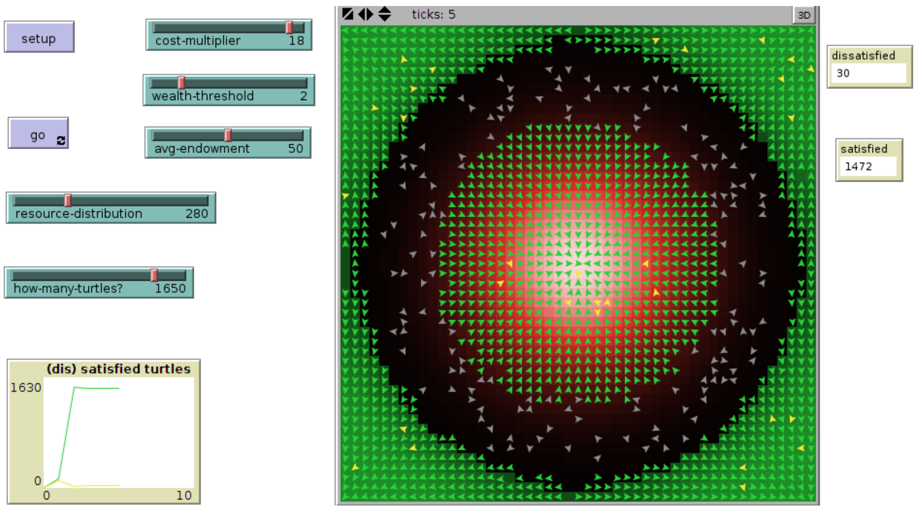

Figure 4.50: Manipulation of threshold 2.

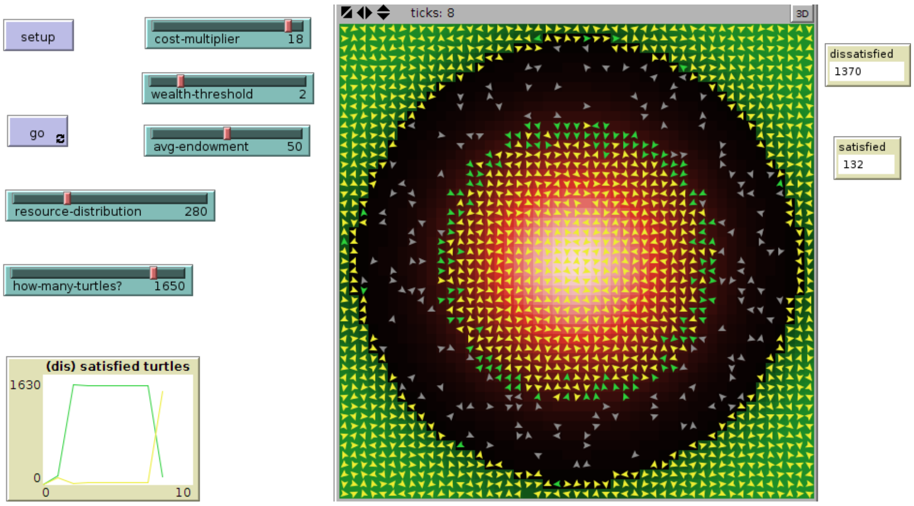

Figure 4.51: Manipulation of threshold 2 : lower “wealth threshold.

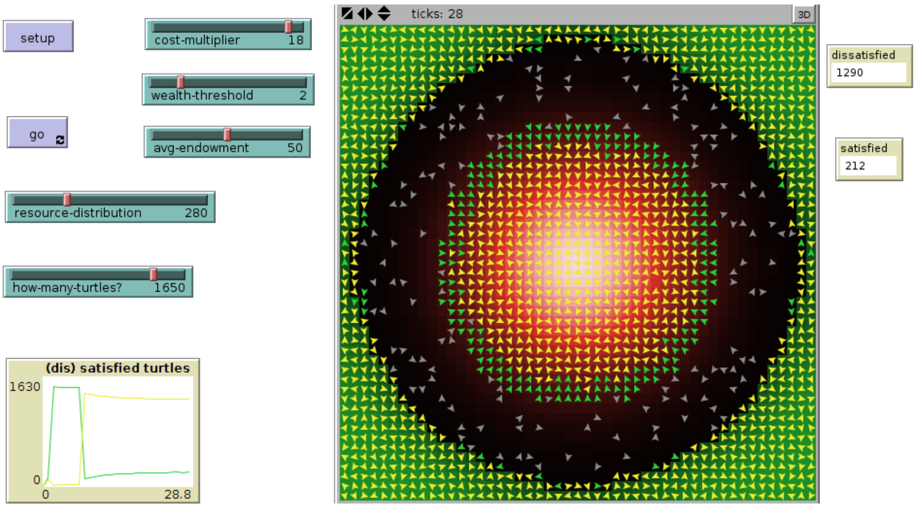

Figure 4.52: Manipulation of threshold 2: ... after few ticks.

with the same initial parameters (figures 4.45 and 4.50 look pretty much equal), but now, instead of lowering the slider "cost-multiplier", the threshold of the satisfying level of "wealth" has been decreased. The initial result of this modification is shown in figure 4.51: only peripheral turtles are now green and satisfied, particularly on red patches, since those area guarantee enough "wealth", higher than 2 units, but a level of "cost" sufficiently low. It can be seen from the bottom left graph how the number of satisfied turtles is still (even if smoothly) increasing, as well as that of the dissatisfied ones is decreasing. Figure 4.52 was taken after few time steps: now the number of green agents has changed, as shown by the counter, and more satisfied turtles can be found on peripheral areas. This phenomenon suggests that there are frictions in the adjustment, due to the high density of turtles, as previously discussed.

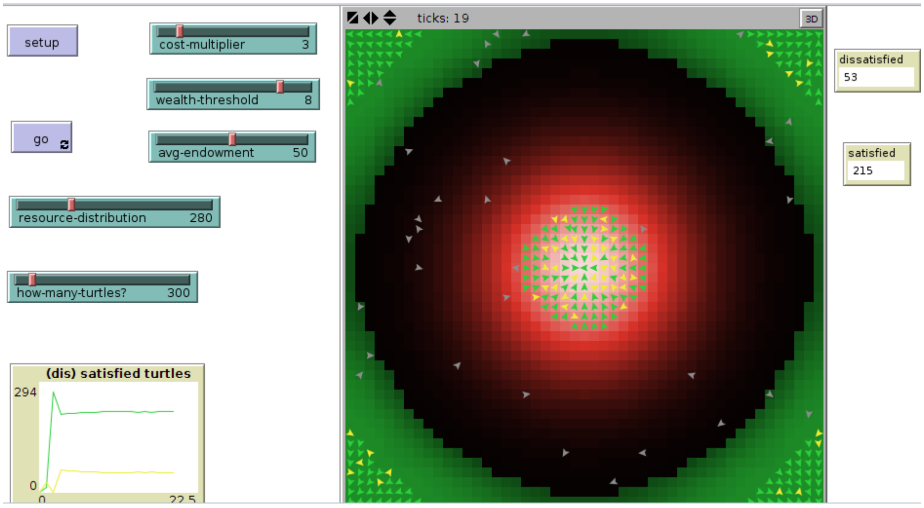

Figure 4.53: Density effect.

To test this hypothesis, it was performed a simulation with a smaller number of agents; figure 4.53 shows the result. The parameters are the same of figure 4.47, except for the number of turtles, which is now of 300. It can be seen, as expectable, that the proportion of "satisfied" is now much higher (65% against the 41.6%). Moreover, through the "command center" it was again asked to "dissatisfied" turtles with an "endowment" greater than 45 units, to become blue: no turtle changed her colour.

In order to better understand the mechanism that collocates turtles in separated neighbourhoods (for what concerns colours) or mixed , figure 4.54 presents a simulation similar to the previous (the slider "endowment" is left at 50 units, the world is populated by 1500 turtles, and "wealth-threshold" and "cost-multiplier" are kept low), with the only significant difference that, now, the variable "resource" is much more spread around the simulation world. Bearing in mind that the total quantity of the variable is always the same, since simply the procedure of diffusion is repeated more times, now red patches carry a level of "resource" which is similar to all them. It can be seen how most of the turtles are green coloured, with just 37 "dissatisfied" turtles out of 1500.

Figure 4.55, instead, shows the specular situation with a higher concentration

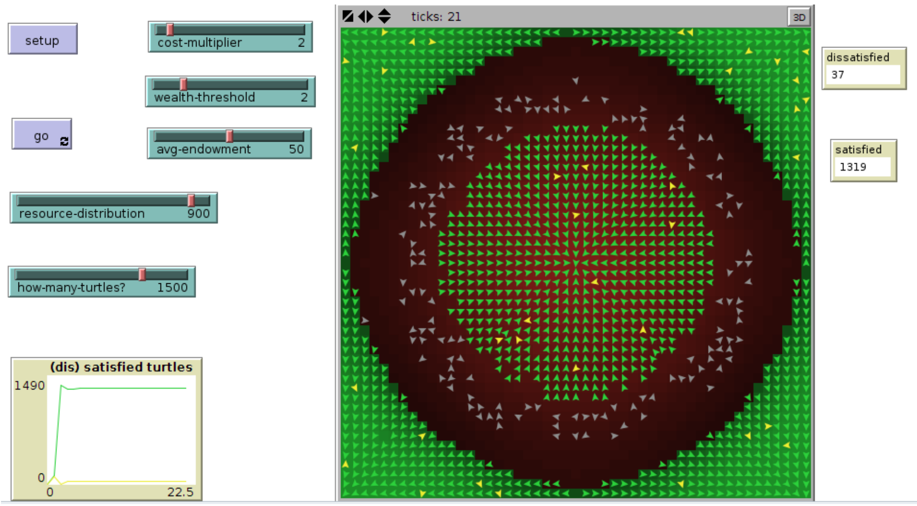

Figure 4.54: More spread “resource”.

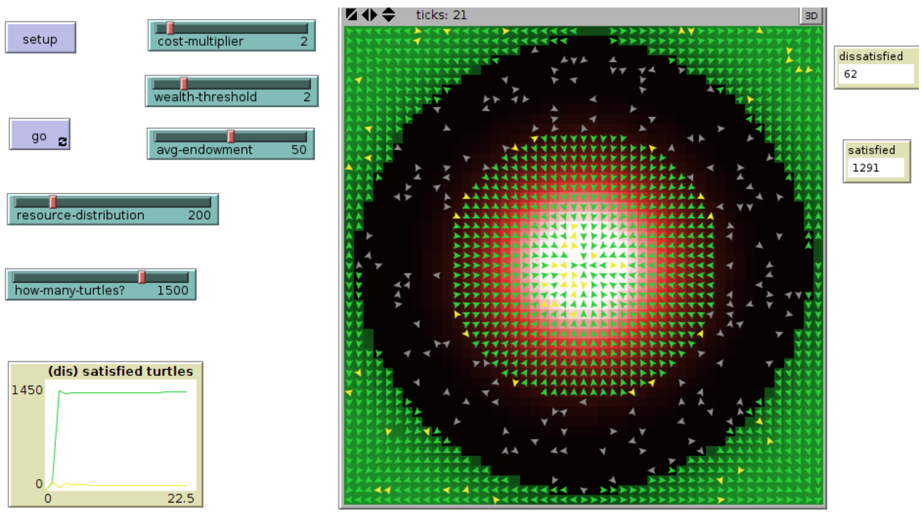

Figure 4.55: More concentrated ”resource“.

of the same variable: now the number of ”dissatisfied“ turtles has doubled (more than 60 agents). Moreover, yellow agents, among other green ones, tend to be found more frequently on central central red patches, since are those that have become relatively more expensive.

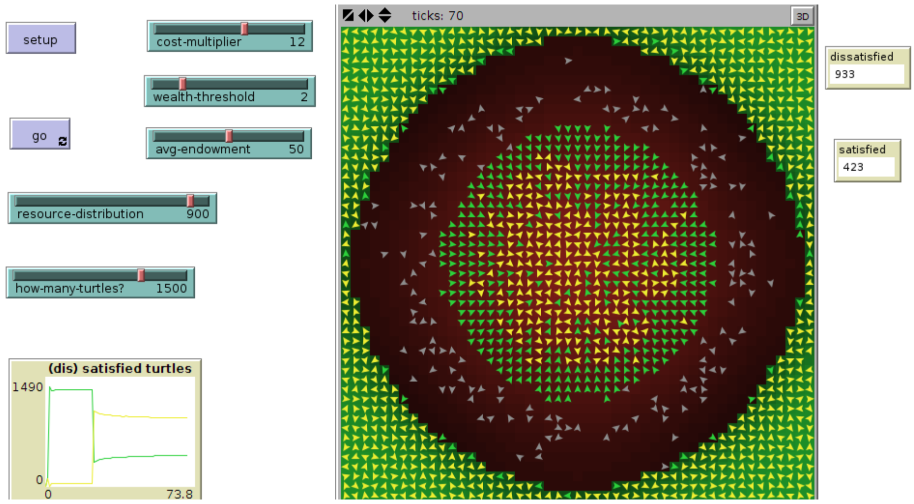

Figure 4.56: Higher cost and diffusion.

What is going to happen, if the cost threshold get to be increased? Figure 4.56 reports the result of this modification on the same simulation of figure 4.54. After around 50 time steps, the situation is that there are, as expected, more ”dissatisfied“ turtles (even if, when the picture was taken, their number was still smoothly increasing), which tend to be located mainly in the centre of the red area (again, those are the most ”expensive” patches), even though also some green turtles may be found among them.

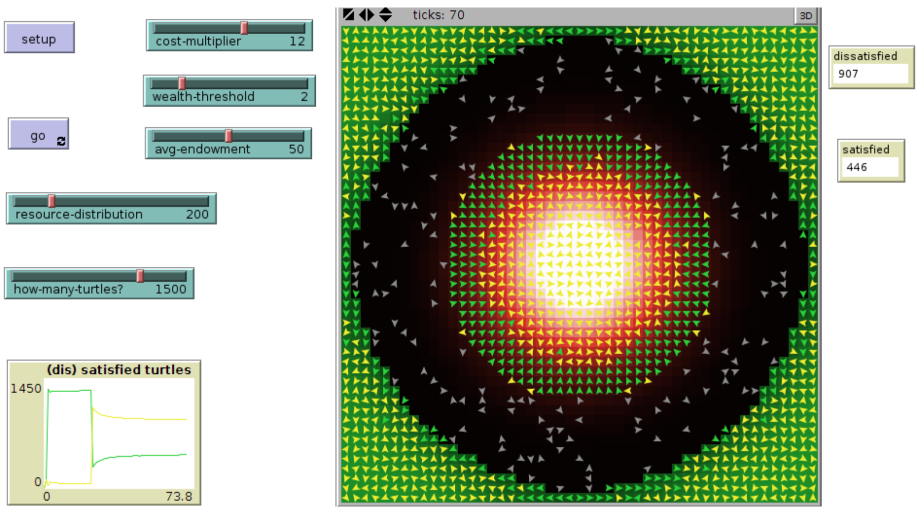

Figure 4.57: Higer cost and concentration.

Figure 4.57 displays the result of an increase of the slider “cost-multiplier” on the same simulation of figure 4.55. As shown, though the number of “satisfied” is a bit lower than that of figure 4.56 (respectively 446 and 423), the spatial collocation of the agents is radically different. Now green peripheral turtles, on red patches, are neatly divided from their yellow counterpart. The lower concentration of the variable “resource” seems to modify the accessibility to suitable position to turtles on red patches. To see the direction of this effect, NetLogo was asked, through the “command center”, to report the number of turtles that are at the same time “satisfied”, i.e. green (“lime“ in the program) and that prefer red patches over the green ones, i.e. with a level of city scores higher than 5. Figures 4.58 and 4.59 show the result: when ”resource“ is more equally distributed, the accessibility to suitable patches is eased, as the number of green turtles if of 100 units.

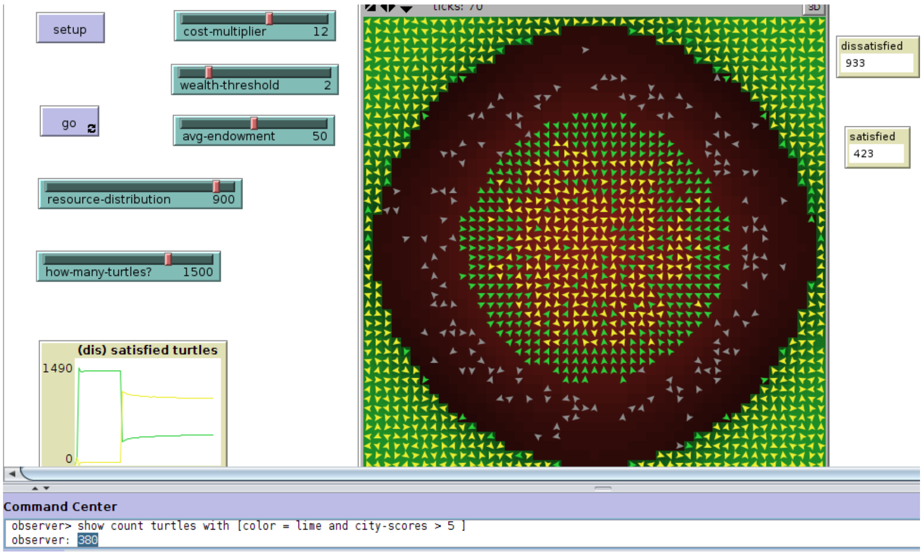

Figure 4.58: Lower concentration: satisfied turtles on red area.

Looking at the whole number of ”satisfied“ and ”dissatisfied“, as already pointed out, the number of green turtles is even a bit larger when ”resource“ is more concentrated [12]. The difference can be explained looking at peripheral green patches, where more ”satisfied“ turtles are found, when the variable ”resource“ is more concentrated. Why is this happening? Figures 4.60 and 4.61 give the answer: when the diffusion procedure of ”resource“ is repeated a larger number of times, an increasing quantity of that variable tends to be found also on green areas, making the ”cost“ of those patches growing. This can explain why the number of ”satisfied“ turtles was, on the whole, greater with more concentrated resource, but on red patches, with a more equal spatial distribution of the variable ”resource“, more green agents were found.

To conclude this set of experiments, it can be interesting to see two extremely opposite cases, in order to make clearer the capacity of the patches to *carry* agents. As seen from the previous experiments, with a more spatially distributed

[12] In other simulations, not shown here, the result was similar most of the times.

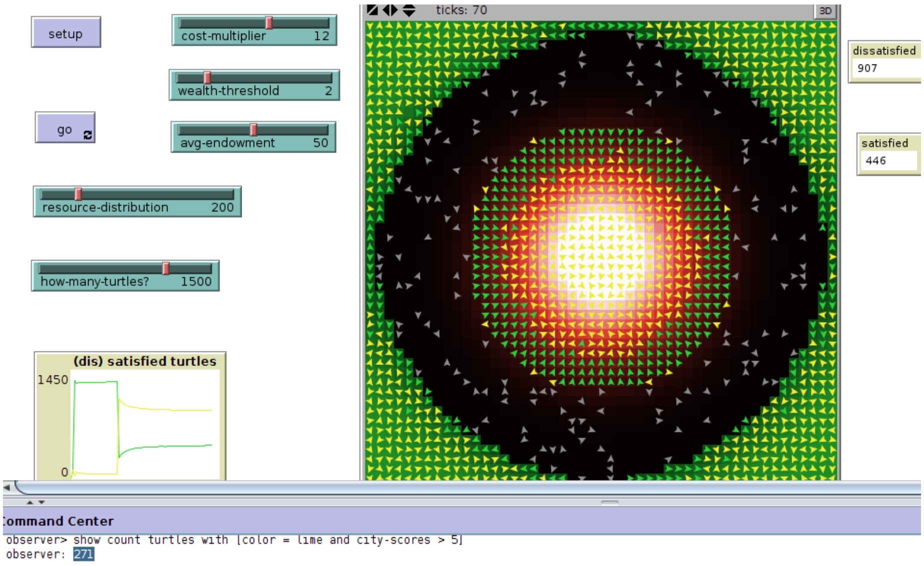

Figure 4.59: Higher concentration: satisfied turtles on red area.

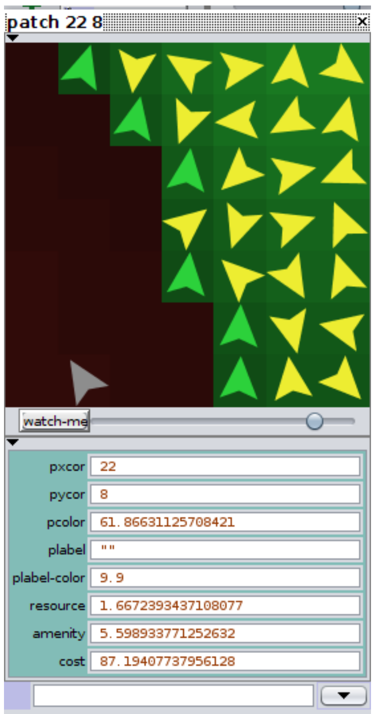

Figure 4.60: Lower concentration: focus on patch 22 8.

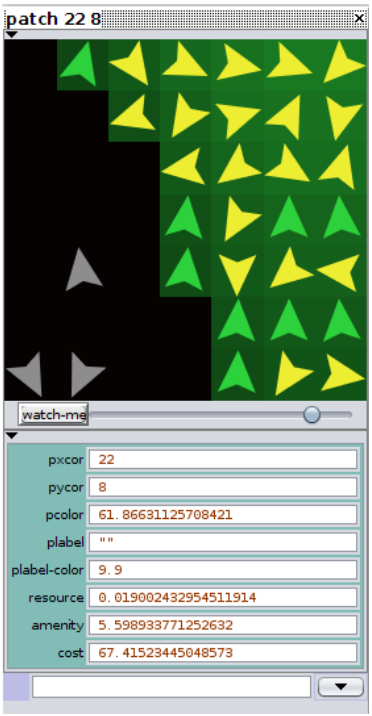

Figure 4.61: Higher concentration: focus on patch 22 8.

"resource", a larger number of turtles can find a satisfying position. On the contrary, a more concentrated diffusion of the same resource seems to advantage those agents having their "target" on green areas.

Figures 4.62 and 4.63 show the results of two simulation, both of them having the same average "endowment" of 20 units, the same number of turtles (1000), and both the thresholds at a level of 1. The only difference is that figure 4.62 has a variable "resource" spread as much as possible, while figure 4.63 reports a situation of a really high spatial concentration. Both simulations were run for the same amount of time (30 time steps). In the case where the resource is extremely diffused, there are some dissatisfied turtles on red areas, which are again mixed with green agents. The overall number of "satisfied" turtles is 1023 in the first case, and 852 in the second. It can be also interesting to see how green turtles, in figure 4.63, form the shape of a ring in the middle of two layers of yellow agents: central patches are now too "expensive", while peripheral red ones do not provide enough "wealth" because of the great concentration of the variable "resource".

In order to have a better comprehension of the comparison between figures 4.62 and 4.63, it can be useful to confront the number of "satisfied" and "dissatisfied" divided by region. Figures 4.64 and 4.65 report, through the "command center" at the bottom, the number of "dissatisfied" turtles preferring red patches and the number of "satisfied" preferring green patches. As shown, there are respectively 109 "dissatisfied" against 349 on the central red area, while the number of satisfied on green areas is 572 to 605: while there is a large difference for agents having a "city-scores" variable greater than 5, this gap reduces when

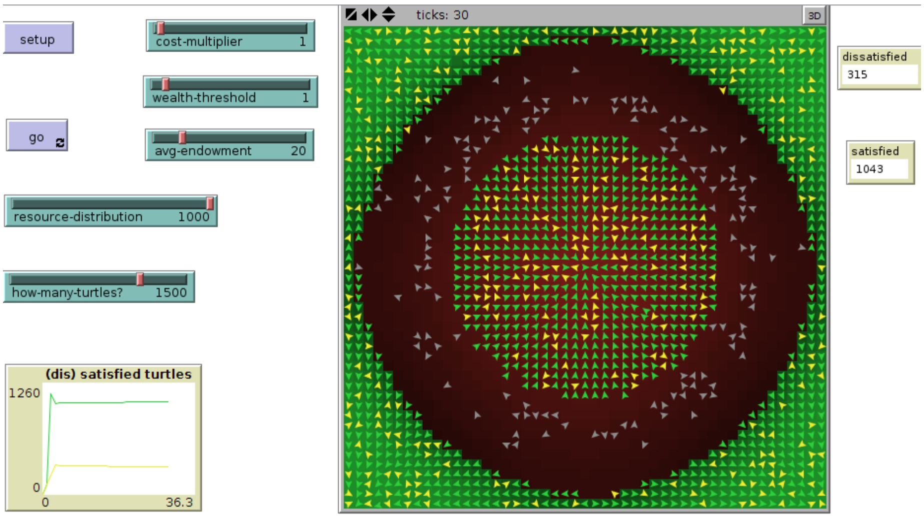

Figure 4.62: High diffusion.

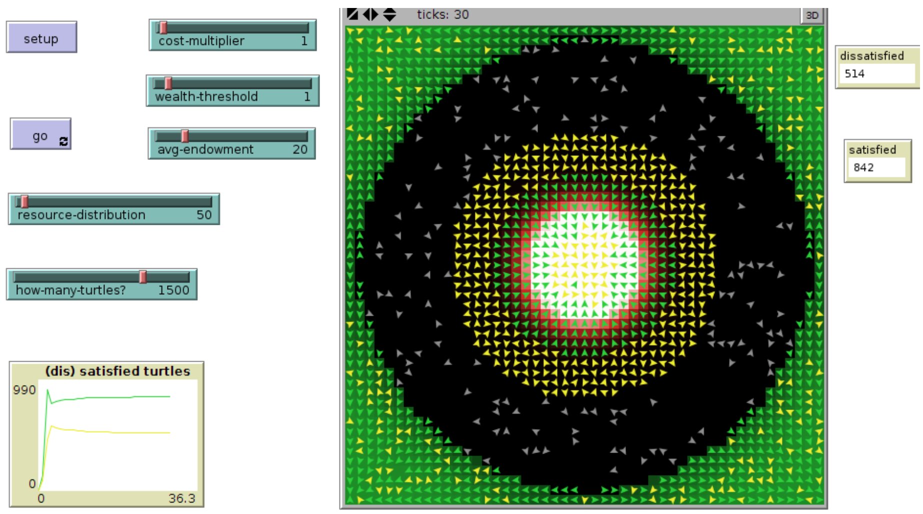

Figure 4.63: High concentration.

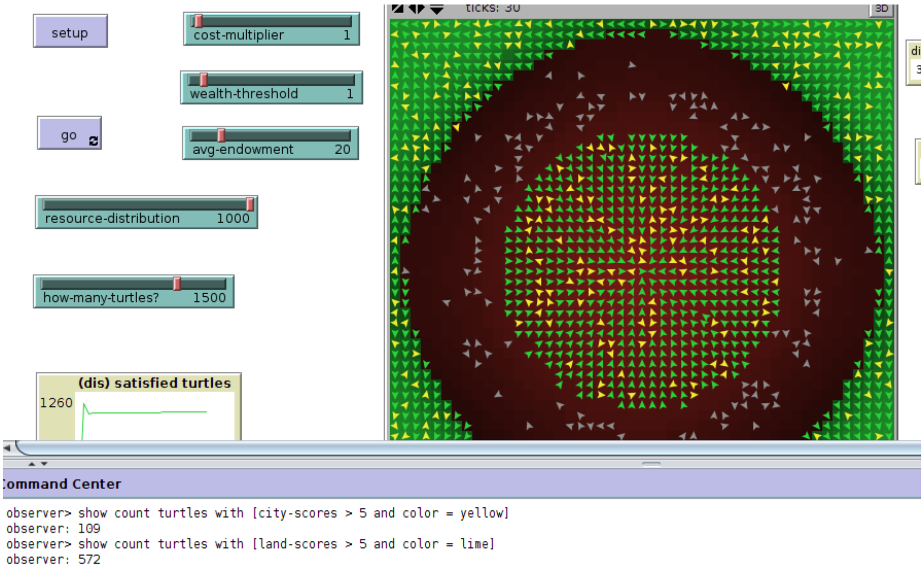

Figure 4.64: High diffusion: yellow turtles on red patches, green turtles on green patches.

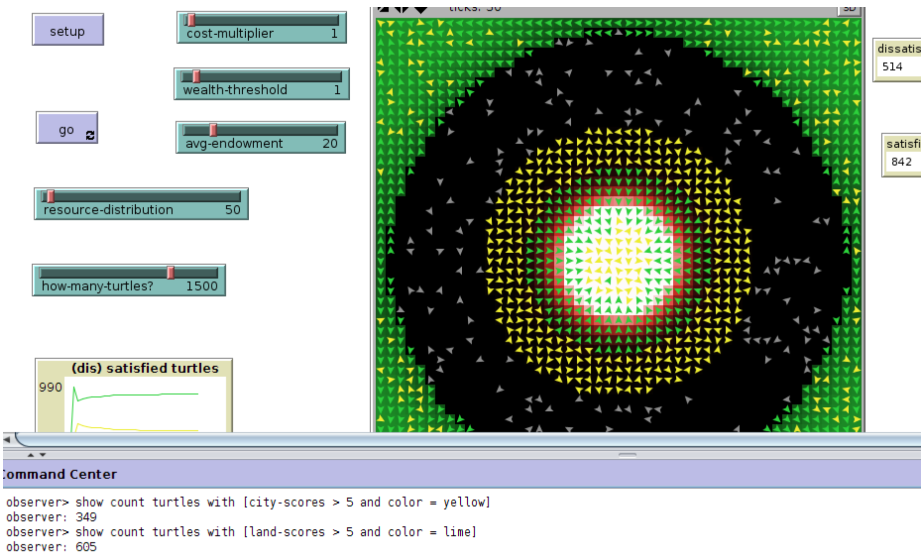

Figure 4.65: High concentration: yellow turtles on red patches, green turtles on green patches.

the analysis is turned to those with “land-scores” again greater than 5.

When compared with figure 4.59, the picture reported in 4.65, looks different also in the fact that there are no longer groups of “satisfied“ turtles on the borders of the green area. This can happen, clearly, because there is a larger number of green turtles now, but it can be worth to check whether, as in the previous cases, the diffusion of the variable ”resource“ get to increase the cost of green patches, as it was in figure 4.56.

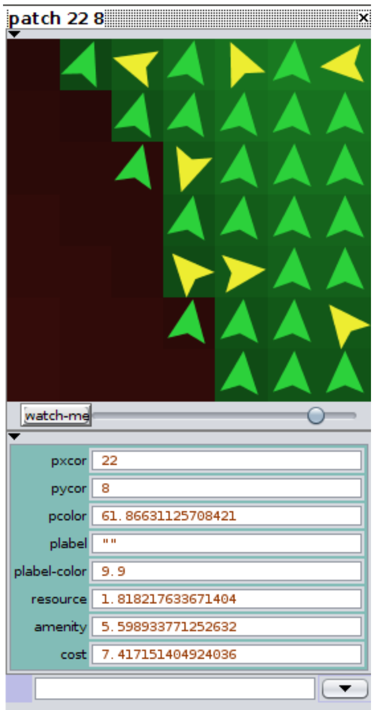

Figure 4.66: Patch 22 8, diffused resource.

To answer these questions, figures 4.66 and 4.67 were taken, in which patch 22 8 is again highlighted. Comparing these images with 4.61 and 4.60, it can be seen how, in the situation of larger diffusion, the cost of the patch is less affected, since a broader distribution makes the quantity of the variable increase by a smaller amount.

4.4 Model 6

The sixth and last model presents new dynamics and further extensions of the previous one. The space is, as usual, separated into two different areas, one with a higher concentration of a variable named ”resource“, the other where the quantity of the variable ”amenity“ is greater. In the first case, again, patches are asked to turn red, while in the second to take the colour green (”lime” in the code). And again the lighter the colour, the more concentrated the variable. On this space, 900 turtles are created: all these belong to a breed named “generic”. As they are collocated on the world, they acquire a certain value of a variable

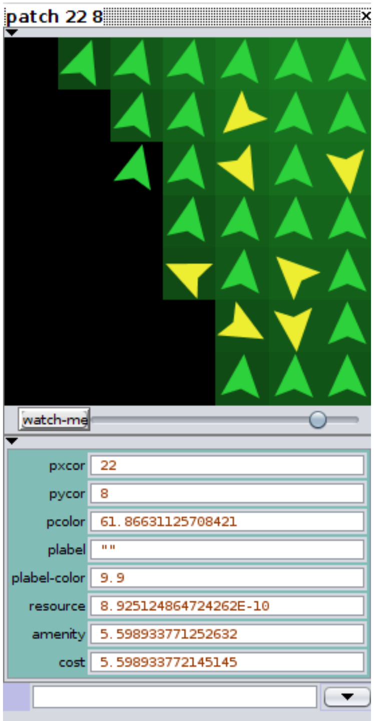

Figure 4.67: Patch 22 8, concentrated resource.

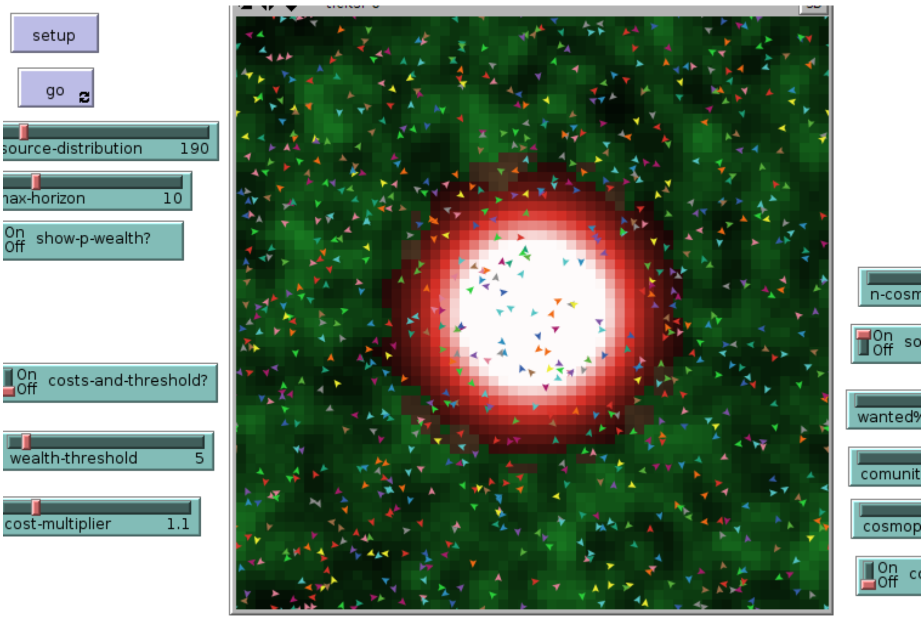

Figure 4.68: Model 6: simulation environment.

named "wealth", which is given by the sum of "amenity" and "resource" of the patch on where they are. One tenth of this quantity is accumulated by the agents under the variable "income". Once stored 20 units of "income", the "generic" creates one turtle of the breed "l-class". Once an "l-class" reaches in turn 40 units of "income", she dies, generating a turtle of the sort named "m-class". Again, once an "m-class" accumulates 60 units of income, she generates a "u–class" agent and then dies. This process goes on until the limit of 300 l-class and 300 m-class is achieved. To each new turtle, a certain amount of a variable "endowment" is assigned, according to a random normal distribution, characterized by a standard deviation of 10 and a mean of 20 units for the "l-class" breed", of 40 units for the "m-class" and of 60 units for the "u-class".

Irrespective of the breed which they belong to, all the turtles follow, by default, the same rules of movement (similar to that of model 5): they are asked to set a "target", i.e. the patch showing the highest level of "wealth"[13] within an area of radius (measured in patches) equal to the "income" owned. In case the chosen place has been already occupied by another agent, they are asked to move to the second richest patch available, and so on until they do not find a unoccupied place. Since the turtles collect income endlessly, it is given to the observer the ability to set up the upper limit of this accumulation process, by operating on a slider created on the programme's interface.

Beside these basic rules, it is possible to activate two further turtles' behaviours through the observer's interface. The first is akin to that of model 5: if called, turtles are asked to change their position if two requirements are not satisfied, i.e. the wealth carried by the patch on which they are must be greater than a threshold, set through a slider on the interface, and the quantity of "endowment" owned must be greater than a variable labelled "cost". Again as in the previous model, this last variable is computed by the programme multiplying the level of wealth times a constant decided by the observer. If one of these two conditions is not met, then the agents are asked to move until they find a new suitable place (it still holds the requirement of one turtles per patch).

The second callable behaviour regards only the "u-class" turtles. The switcher "social-preferences", on the interface, changes the rule of movements of the "u-class" breed, whose members are divided, when they are generated, through a dummy variable into "comunitarian" and "cosmopolitan" (according to proportions decided by the user). Those agents belonging to the first group are asked to move until a satisfying percentage of their neighbours has a level of "endowment" close to that owned by them [14]. On the contrary, "cosmopolitan" turtles change position until they find enough neighbours with a sufficiently different "endowment". Both the percentage of neighbours and the level of "endowment", according to which a turtle is judged similar of different, are under the control of the observer.

One last manipulation is at users' disposal, which does not interfere with the rules described above: using two switches, all the turtles belonging to the "l-class" breed, i.e. those with a general low level of "endowment", can receive

[13] As shown later, in the code the patches have a variable named "p-wealth", which is specular to the turtles' owned variable "wealth" (the second is equal to the first). Similarly, turtles have two variables, namely "t-resource" and "t-amenity", which are equal to the "resource" and "amenity" owned by the patches. These distinctions were set only for practical reasons.

[14] The correspondent lines of code were (a lot) inspired by the model "segregation" built by Uri Wilensky and included in the models library of NetLogo.

an exogenous quantity of 100 units of "endowment“, and, or, the possibility of selecting their targets in a radius of 50 patches.

```
to setup
  ca
  reset-ticks
  create-generics 900
  ask turtles [setxy random-xcor random-ycor
  set heading random 360]
  ask patch 0 0 [set resource 10000]
   ask patches [if random 100 < 25 and
     distancexy 0 0 > (pi * (2 ^ 2 ))
    [set amenity 10]]
  ask turtles [ set wealth 1 set income 1]
  color-patches
  preferences
end
```

Figure 4.69: Setup procedure.

```
to color-patches
   repeat 10 [ diffuse amenity 0.25]
   ask patches[ if show-p-wealth? = false
     [set pcolor scale-color lime amenity 0 20]]
  repeat resource-distribution
  [diffuse resource 0.25]
  ask patches [if show-p-wealth? = false and
     resource > amenity
    [set pcolor scale-color red resource 0 20]
     set p-wealth resource + amenity
    if show-p-wealth? = false and resource < 5 and
    resource > 1 and amenity > 3 [
      set pcolor scale-color ( brown   )  p-wealth 0 30]
      if show-p-wealth? = true
       [set pcolor scale-color brown p-wealth 0 20]]
end
```

Figure 4.70: Diffusion of "amenity“ and "resource.

Code explanation. Figures 4.69 and 4.70 report the creation of the starting point of the simulation. 900 turtles are created and randomly distributed around the space. An initial quantity of 10,000 units of "resource" (a patch owned variable), is assigned to the central patch, while a quantity of 10 units of "amenity" (again a patches' variable) is given to the 25% of the patches, with the exclusion of a circle of a radius of 2 patches, around the patch "0 0" (i.e. the central one). Once the programme has assigned the variables, it diffuses them around: all the surrounding patches take the 25% of the variables possessed by their neighbours. This process is repeated 10 times for the variable "amenity“, while for "resource" the repetition is up to the user, which can manipulate a slider on the interface named "resource-distribution“. Then it is asked to the patches to take the colour red or lime with a shade proportional to the amount of "resource“ or "amenity“ respectively owned. For practical reasons of visualization, it is asked to the patches with an amount of "resource“ between 1

```
to preferences
 ask turtles  [if random 100 < (n-cosmopolitan)
   [ set cosmopolitan true
     set comunitarian false]]
 ask turtles with [cosmopolitan != true]
 | [set cosmopolitan false
    set comunitarian true]
end
```

Figure 4.71: Comunitarian and cosmopolitan turtles.

and 5 units and contemporary a level of "amenity" greater than 3, to take the colour brown. Furthermore, in case the switch "show-p-wealth" is called before running the programme, all the patches will turn to brown, according to the amount of "p-wealth" (i.e. the sum of resource and "amenity") owned. Figure 4.71 simply shows that since the beginning the population of turtles is divided through a dummy variable between "comunitarian" and "cosmopolitan", according to a rate decided by the observer through the slider "n-cosmopolitan". The slider decides the percentage of "cosmopolitan", the remaining agents will present instead the variable "comunitarian".

```
to generic-move
  ask generics
    [if income < max-horizon [
    set target max-one-of patches in-radius
     income[p-wealth]
    set vacancies patches in-radius
    income with
    [not any? turtles-here]]
  if income >= max-horizon [
  set target max-one-of patches in-radius
   max-horizon [p-wealth]
    set vacancies patches in-radius
     max-horizon with
     [not any? turtles-here]]
    move-to patch-here
    set second-choice max-one-of  vacancies [p-wealth]
    face target
    if not any? turtles-on patch-ahead 1[
      ifelse t-resource > t-amenity[
        move-to target]
    [fd 1 ]
    ]
   if any? other turtles-here and any? vacancies [
      move-to second-choice
      ]
  if costs-and-threshold? = true [
   if wealth < wealth-threshold or endowment < cost[
   if any? vacancies [ set heading random 360
     move-to second-choice ]]]]
end
```

Figure 4.72: Rules of movement.

Figure 4.72 shows the part of code that gives to the turtles "generic" the instructions on how to move. Basically the same code is then repeated for each other breed (not shown), except for “l-class“ turtles (see figure 4.73). These rules are very close to those of model 5. The turtles are asked first to check whether their income (whose formation in described later) is lower of the value set by the slider “max-horizon”. If is it so, then they are required to select the patch, named “target”, carrying the bigger amount of “p-wealth” among those included in a circle of radius equal to their income. Within this circle they are also asked to look for all the unoccupied patches, called “vacancies”, and among them to select a “second-choice”, i.e. the “vacancy” with the greater amount of “p-wealth”. If instead the “income” owned by the turtles is bigger than the value of the slider, then the agents perform the same tasks, but within a radius equal to the “max-horizon“ given by the user. Once decided targets and second objectives, the programme asks to the agents to turn towards the selected target and to do one step ahead, until they are on the chosen place, or anyway until there is no other agent on the next patch. If the ”target” is already occupied, then the agent moves to her “second-choice“. In addition, if a turtle is found on a patch whose amount of ”resource” is greater than the level of “amenity“ (i.e. roughly the red central area), she is asked to move directly to the target. To this process it can be added that of model 5, i.e. when the switch ”cost-and-threshold“ is activated, the turtles are asked to control if the ”wealth“ they currently own (given by the patch on where they are) is greater than the value of the slider ”wealth-threshold“ and, at the same time, if it is also greater than the ”cost“ of their position. This cost, as already told, is given by the product of ”p-wealth“ times the level of the ”cost-multiplier“ slider (in the procedure ”go”, not shown).

The figure 4.73 reports the slightly different rules that “l-class” turtles use to move. The main difference regards the fact that these turtles compute their radius of action following a variable named “sight”, instead of the value of “income”. This former is made equal with the latter, if the switch “l-class-sight” is deactivated. If this is not the case, “sight” takes the arbitrary value of 50, equal for every “l-class”, allowing them to “see” longer than any other turtle, since the maximum value that the slider “max-horizon” can take is 40. The other difference is that the, once activated the slider “l-class-subsidy”, all the “l-class” turtles show a value of 100 units of “endowment”.

In figure 4.73 is simply shown how income is accumulated, i.e. the turtles take one-tenth of the “p-wealth” (the sum of “amenity” and “resource”) of the patch on which they currently are, and they add it to the amount of the variable already owned.

So far, the only breed to which all the turtles belonged was that named “generics”. Figure 4.75 reports the lines of code which allow the generation of the “l-class” and “m-class” breeds (”u-class“ follows the same pattern), which go under the procedure ”social-classes“. In the first passage, the program asks to ”generics“ turtles, once they have attained a level of ”income“ greater than 20 units, to create one new turtle of the ”l-class“ breed. This turtle will show the colour magenta and a level of wealth again equal to the p-wealth owned by her current patch. She receives also a certain endowment, randomly assigned following a normal distribution with a mean of 20 units and a standard error of 10. Once generated the new turtle, the ”generic“ mother dies and disappears from the system. The second part of figure 4.75 regards the creation of ”m-class“ agents. The procedure is basically the same, with the difference that, in

```
to l-class-move
 ask l-classes
    [ifelse l-class-subsidy [set endowment  100]
      [set endowment initial-endowment]
      if income < max-horizon [ ifelse l-class-sight
        [set sight 50][set sight income]
    set target max-one-of patches in-radius sight [p-wealth]
    set vacancies patches in-radius sight with [not any? turtles-here]
    ]
  if income >= max-horizon [ifelse l-class-sight [set sight 50]
    [set sight max-horizon]
  set target max-one-of patches in-radius sight
   [p-wealth]
    set vacancies patches in-radius sight with [not any? turtles-here]
    ]
    move-to patch-here
    set second-choice max-one-of  vacancies [p-wealth]
    face target
    if not any? turtles-on patch-ahead 1[
      ifelse t-resource > t-amenity[
        move-to target]
    [fd 1 ]
    ]
   if any? other turtles-here and any? vacancies [
      move-to second-choice
      ]
  if costs-and-threshold? = true [
   if wealth < wealth-threshold or endowment < cost[
   if any? vacancies [ set heading random 360 move-to second-choice ]]]]
end
```

Figure 4.73: Rules of movement, “l-class” turtles.

```
to gain
ask turtles [ set wealth p-wealth
  set income income + (0.1 * p-wealth)
  set t-resource resource
  set t-amenity amenity]
end
```

Figure 4.74: Generation of “income”.

```
to social-classes
  ask generics [if income > 20  [ hatch-l-classes 1
      [set color magenta
        set wealth p-wealth
        set endowment random-normal 20 10
        set initial-endowment endowment]
     die]]

  ask l-classes[set n-m-class count m-classes
     if n-m-class < 300  and income > 40 [
    hatch-m-classes 1[
      set color blue
      set wealth p-wealth
      set endowment random-normal 40 10]
    die]]
```

Figure 4.75: Generating new breeds.

order to reproduce, the "l-class" turtle must now satisfy two conditions: her "income" has to be greater than 40 units, and the number of "m-classes" ("l-classes" are asked to set the value of the global variable "n-m-class" equal to that amount) has to be lower than 300. If these requirements are met, then the "l-class" will generate one "m-class", a blue agent with a level of "wealth" equal to the "p-wealth" of the patch. In addition, the new turtles will have an "endowment" drawn from a normal distribution of mean 40 units and 10 of standard error. Finally the "l-class" that generated the new agent dies. The generation of the "u-class" turtles is alike, with the main difference that the newly created agents will receive a random "endowment" from a distribution with mean 60 and standard deviation 10. Moreover their colour is yellow.

```
to comunitarian-movements
   ask u-classes [if social-preferences = true and
   comunitarian = true [
   set n-different count (turtles-on neighbors) with
   [endowment <= ([endowment] of myself) - comunitarian-endowment-tolerance or
   endowment >= ([endowment] of myself) + comunitarian-endowment-tolerance]
   set n-wanted count (turtles-on neighbors) with [
   endowment > ([endowment] of myself) - comunitarian-endowment-tolerance and
   endowment < ([endowment] of myself) + comunitarian-endowment-tolerance]
   set tot-nearby n-wanted + n-different
   set neighbourhood-satisfied n-wanted >= (wanted% * tot-nearby) / 100]]
end
```

Figure 4.76: "Comunitarian" movements rule.

Figures 4.76 and 4.77 shows the rules of movements for those "u-class" turtles with, respectively, the dummy "comunitarian" and "cosmopolitan" set on the value "true". These procedures are activated only if called by the switch "social-preferences". They are almost specular: "u-classes" are asked to count the neighbouring turtles [15] having an endowment equal to that of the agent performing the task, more or less the value set by a slider ("comunitarian-endowment-tolerance" or "cosmopolitan-endowment-tolerance", depending on

[15] As in all the previous case, the neighbours of a specific position are considered the eight surrounding patches.

```
to cosmopolitan-movements
   ask u-classes [
   if social-preferences = true and
   cosmopolitan = true [
   set n-wanted count (turtles-on neighbors) with
   [endowment < ([endowment] of myself) - cosmopolitan-endowment-tolerance or
   endowment > ([endowment] of myself) + cosmopolitan-endowment-tolerance]
   set n-different count (turtles-on neighbors) with
   [endowment >= ([endowment] of myself) - cosmopolitan-endowment-tolerance and
   endowment <= ([endowment] of myself) + cosmopolitan-endowment-tolerance]
   set tot-nearby n-wanted + n-different
   set neighbourhood-satisfied n-wanted >= (wanted% * tot-nearby) / 100]]
end
```

Figure 4.77: "Cosmopolitan" movement rule.

the type of turtle). Then they compute how many neighbours have an "endowment" outside the same thresholds. In the case the "u-class" is a "comunitarian" agent, then the first number will be the value of the turtles owned-variable "n-wanted", while the second is going to be the amount of the "n-different" variable. The converse happens with "cosmopolitan" agents. The "u-classes" are then ask to set the variable "tot-nearby" equal to the sum between "n-wanted" and "n-different". Finally, turtles having a level of "n-wanted" greater than the number given by the ratio between the product of "tot-nearby" times the value of the slider "wanted%" over 100, i.e equation 4.1[16], will present the variable "neighbourhood-satisfied", and will be then happy with their place.

$$\frac{tot - nearby \times wanted\%}{100} \tag{4.1}$$

```
to move-unsatisfied-neighbourhood
   if social-preferences = true[
   ask u-classes with [comunitarian = true]
   [let n-neighbours count (turtles-on neighbors)
   with[color = [color] of myself]
     if not neighbourhood-satisfied
   or n-neighbours < 1
   [new-place]]
   ask u-classes with [cosmopolitan = true]
   [let n-others count (turtles-on neighbors) with[
   color != [color] of myself]
     if not neighbourhood-satisfied
     or n-others < 1
   [new-place]]]
end
```

Figure 4.78: Unsatisfied turtles.

If a turtle does not find a suitable position, in terms of similarity or difference with her neighbours, she is asked to change place according to the code reported by figures 4.78 and 4.79. The procedure "new-place", shown in the second

[16] As already mentioned, this part of code owes a lot to Uri Wilensky's "Segregation" model, available in NetLogo's library.

```
to new-place
  set heading random 360 fd 1
  if any? other turtles-here [new-place]
  move-to patch-here
end
```

Figure 4.79: Finding a new place.

picture, makes the turtles choose a random orientation and to do a step forward. If "social-preferences" is activated, this part of the code is called whenever:

1. "u-classes" do not show the variable "neighbourhood-satisfied";
2. a "comunitarian" turtle has not even one neighbour of her *same* breed ;
3. a "cosmopolitan" turtle has not even one neighbour of a *different* breed ;
4. there is another turtle on the same patch.

The first three conditions are reported in figure 4.78, while the last in 4.79. Conditions 2 and 3 have been added for it seemed reasonable to assume that a "cosmopolitan" prefers to be next to other (different) agents, rather than to be alone. The same thought was formulated for "comunitarian" turtles, with similar agents. More specifically, "comunitarian" and "cosmopolitan" turtles are asked to set a local variable, named respectively "n-neighbours" and "n-others", equal to the number of surrounding turtles with the same colour or with a different one. When this value is less than one, agents are asked to perform the "new-place" procedure. Also for these lines of code holds the remark of note 16.

```
to recolor-turtles
   ask u-classes [if cosmo-vs-comun = true[
       ifelse comunitarian [set color red ]
       [set color cyan]]
   if cosmo-vs-comun = false[set color yellow]]
end
```

Figure 4.80: Recolouring turtles according to their "social preferences".

Finally, "u-class" turtles can be asked to take different colours in order to distinguish them between "comunitarian" and "cosmopolitan". When the user activates the switch "cosmo-vs-comun", "u-classes" are asked to take the colour cyan, if they belong to the "cosmopolitan" group, and to turn to red if they are "comunitarian".

Plan of experiments.

- Average resource distribution, high max-horizon, no social-preferences, no costs and thresholds, no l-class sight, no l-class subsidy.
- Average resource distribution, **low max-horizon**, no social-preferences, no costs and thresholds, no l-class sight, no l-class subsidy.

- **Sparse resource distribution**, **low-high max-horizon**, no social-preferences, no costs and thresholds, no l-class sight, no l-class subsidy.
- Average resource distribution, **low max-horizon**, no social-preferences, **costs and thresholds**, no l-class sight, no l-class subsidy.
- Average resource distribution, **low max-horizon**, no social-preferences, **costs and thresholds**, **l-class sight**, no l-class subsidy.
- Average resource distribution, **low max-horizon**, no social-preferences, **costs and thresholds**, **l-class sight**, **l-class subsidy**.
- Average resource distribution, high max-horizon, **social-preferences** [17], no costs and thresholds, no l-class sight, no l-class subsidy.

Experiments. In order to perform some experiments, it can be useful to illustrate how the model works by default, with different values of the sliders previously described.

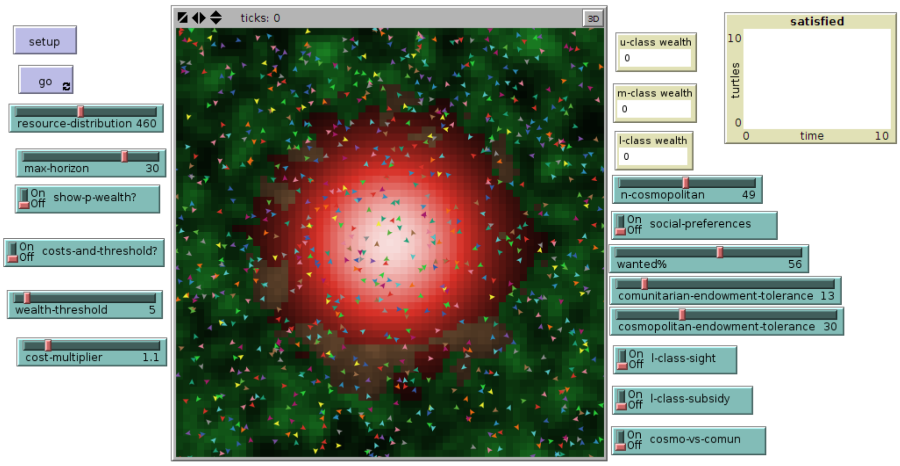

Figure 4.81: Simulation starting point.

Figure 4.81 shows how it looks like the beginning of the experiment (which is pretty much always the same, except for the fact that the variable "resource" can be differently distributed). As it can be seen, all the turtles are randomly collocated over the space. As the top-right slider "resource-distribution" reports, the procedure of diffusion of "resource" is repeated 460 times.

Running the simulation, after few time-steps (23 more precisely) it appears that the majority of the turtles have moved to the centre of the world, as in figure 4.82, where the quantity of "resource" is greater. As set by the slider "max-horizon", turtles are allowed to choose the target up to a distance of 30 patches[18], but the fact that many groups of agents can be found at the periphery of the environment, suggest that many of them have not yet accumulated enough

[17] As it will be further reported, the activation of the switch "social-preferences" will led to a series of simulations in which several possibility of "endowment-tolerance" and "wanted% are explored. See from figure 4.100 on.

[18] The simulation world measures 30x30 patches.

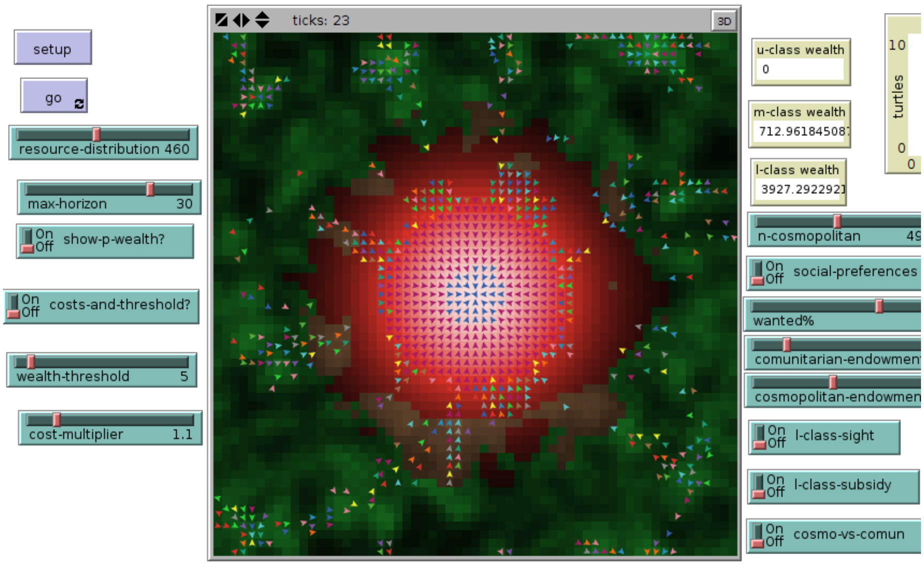

Figure 4.82: The situation after a while.

“income” to notice the more affluent central patches, and therefore the limit of 30 patches is still to be reached. Moreover, it can be seen that central turtles accumulate resources faster, since most of them has already reached the “income” threshold to generate "l-classes“ and “m-classes”. Tough the motion of the agents is not very appreciable from a picture, figure 4.82 shows also how entire groups of turtles “migrate” altogether toward the centre: e.g. one may check out the agents on the right, the majority of which is heading towards the red patches, or the group bottom-left, where turtles in the corner, the furthest from the centre, direct their heads toward a green patch, while there is a sparse set of agent few patches distant which seems to head towards the richest area. Figures 4.83 and 4.84 focus on two of these turtles. The first is the “generic” 445, which has an income of less than 8 units, while the second, i.e. the “generic” 276, passes the level of 10 units. None of them is able, therefore, to select as target the richest central patch of the environment, but they are heading towards different directions: turtle 276 if approximatively facing the red area, while turtles 445 has opposite orientation. The explanation for this phenomenon can be found considering that the variable “income” can lead the turtles to a self-reinforcing process, since the more income you have, the longer you see, and the longer you see, the richer are the patches that you find, leading to the acquisition of a greater income and so on. This hypothesis should explain also why groups migrate progressively.

Figure 4.85 shows the final result of the same simulation. It can be seen how all the turtles now belong to one of the three breeds and that they are all situated around the central area.The top-right counters, namely “l-class wealth“, “m-class wealth“ and “u-class wealth” report the sum of the variable “wealth” owned by the single breed: as it can be expected, the richest is the “u-class”, which occupies the centre of the space, since those are the daughters of the first 300 “generic” turtles that became rich in “income“, reaching first the ability to

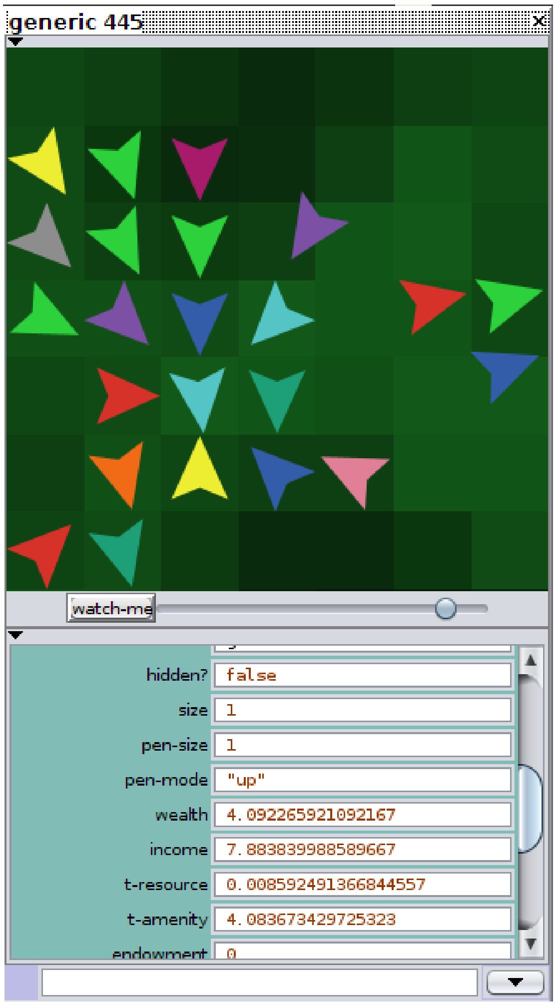

Figure 4.83: Focus on “generic” turtle 445.

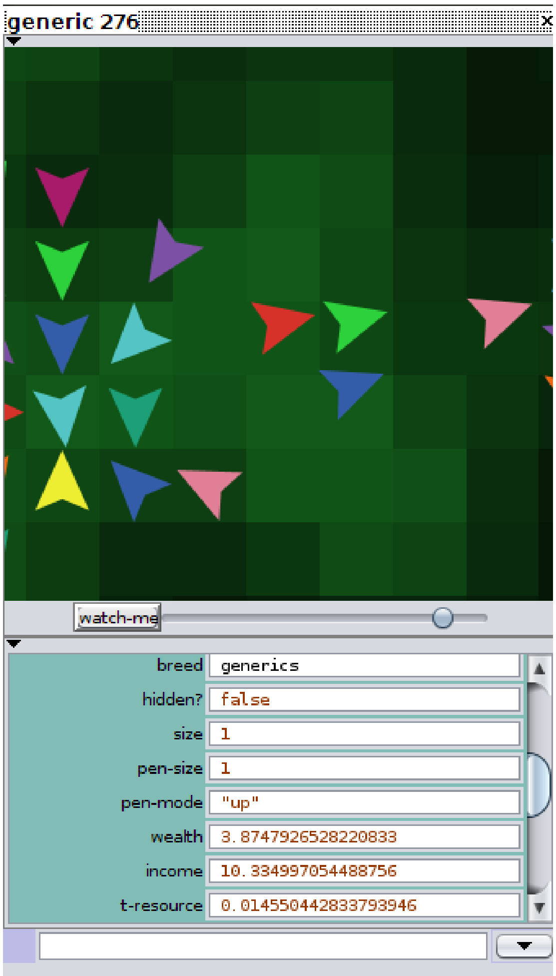

Figure 4.84: Focus on “generic” turtle 276.

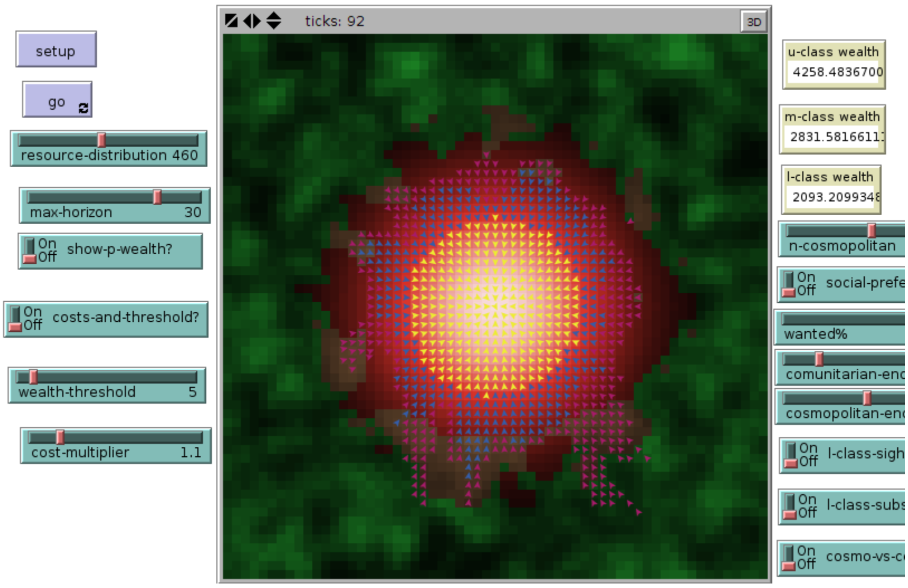

Figure 4.85: Final outcome.

act at a greater distance.

The second richest are then the blue "m-classes". It can be also worth to notice that the turtles are not distributed in a perfectly regular manner. This is due, first, to the fact that the code does not allow multiple agents per patch and that a turtle can move only until she has no other agent on the next patch, and second because the random distribution of the variable "amenity" makes some of the red patches to own more "p-wealth" than others. In fact, some of the most peripheral turtles tend to occupy brown patches, i.e. where "resource" is between 1 and 5 units, and "amenity" is at the same time greater than 3.

Figure 4.86 reports instead the outcome of a simulation run with the same parameters but the value of "max-horizon", which is now only of 3. As predictable, a much lower number of turtles is able to reach the most affluent zones. Furthermore, differently from the previous case, it can be also noticed that some "u-classes" agents can now be found on the periphery of the central red area.

It can be interesting also to inspect how turtles behave in an environment in which the variable "resource" is more evenly distributed among patches, and also how do they react to a rise in the maximum length of "vision" they have. Figure 4.87 reports a situation in which the distribution of "resource" is the most even possible, as indicated by the "resource-distribution" slider, and where turtles can "look" only at a distance of three patches: once all the three new breeds are completely formed and the movements are over, the turtles, according to their radius of action, are irregularly collocated all over the world, forming small groups around the lighter (therefore "richer") areas. Figure 4.88 was instead taken once the slider "max-horizon" was set to a level of 30 (ten times greater than the previous picture) patches, and once all the major agents movements were finished. The comparison between 4.87 and 4.88 reveals that

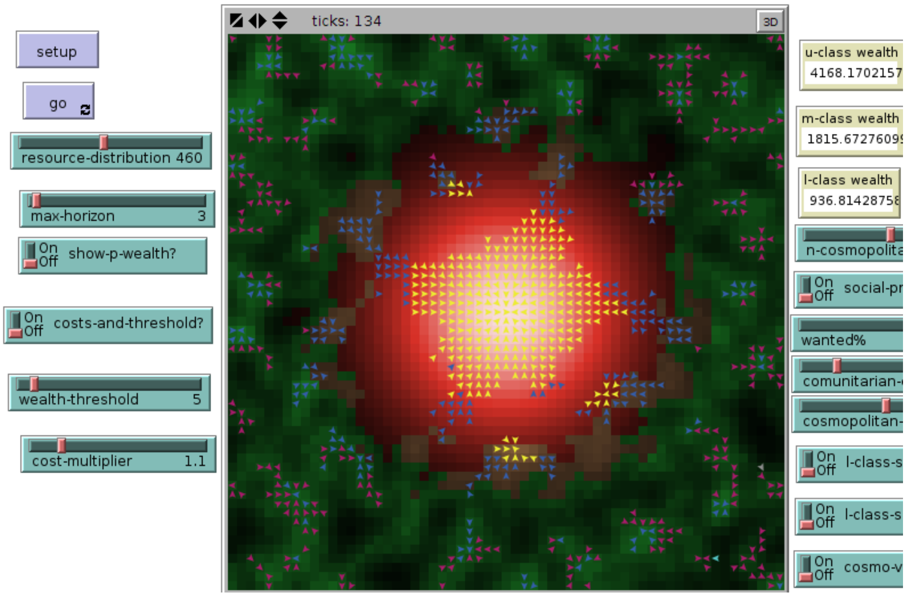

Figure 4.86: Lower level of "max-horizon".

the richest patch in "p-wealth" is no longer the central one (visible in figure 4.90). It can be seen, in fact, how the large majority of the turtles is oriented towards the brown patch 8 12, reported in detail in figure 4.89, which is now the richest (as shown in the command center at the bottom of figure 4.88) and therefore the "target" selected by the agents. In addition, the position of the turtles indicates how, within the red area, the variable "p-wealth" is no longer smoothly distributed as before. As argued previously, turtles are asked to choose always the best unoccupied place within their "vision": *holes* in their spatial distribution indicates the there are areas of overlapping between "amenity" rich and "resource" rich patches which are not always caught by the brown colour. This superimposition causes the existence of red areas less affluent than their neighbours. Anyway, the increase in the "max-horizon" value benefited more the less affluent breeds, as it can be seen confronting the three counters in figure 4.87 and in 4.88: though the total sum of the "wealth" owned by "u-class" turtles has remained unchanged, that of the other two increased, particularly that of the "l-classes". This can be well explained considering that yellow affluent turtles already occupied the best patch available.

In order to better understand this mechanism, figure 4.91 shows how it appears an analogous situation with the switch "show-p-wealth?" turned on. All the patches are coloured in brown according to the level of the variable "p-wealth" they reach (remarking that this value is equal to sum of "amenity" and "resource"). As usual, the lighter the shade, the richer the patch.

Once performed the experiments regarding the different distribution of resources, it is possible to examine how the switch "cost-and-threshold" can change the location of turtles. Figure 4.92 shows the aspect of the environment before turning on the switch and the initial parameters of the simulation: the variable "resource" is quite, though not tremendously, concentrated (the

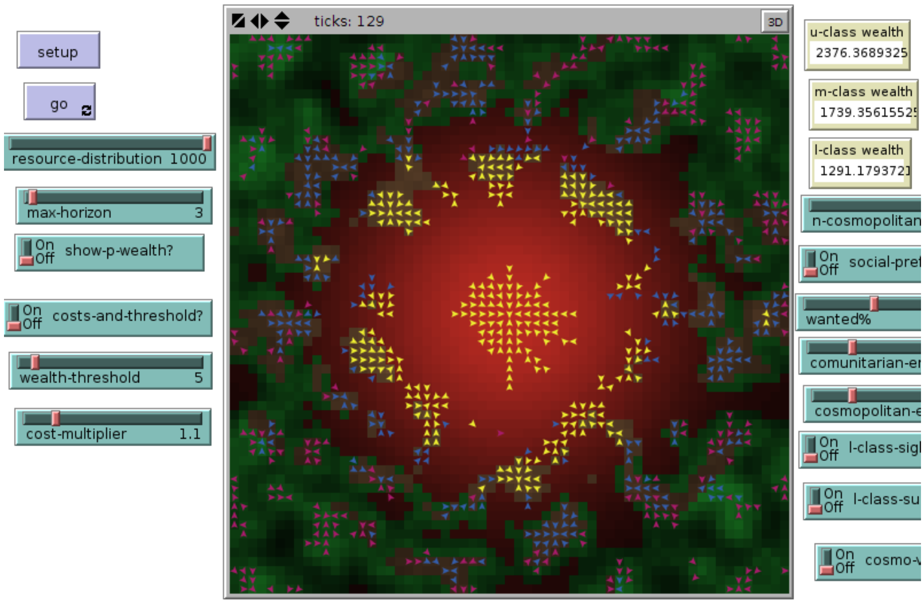

Figure 4.87: Sparse resource and low max-horizon.

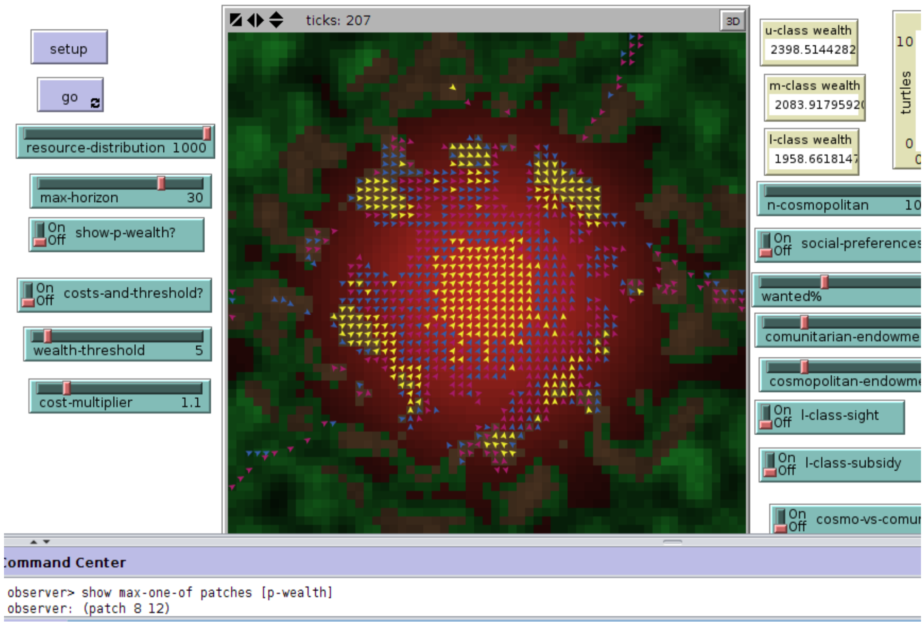

Figure 4.88: Sparse resource and high max-horizon.

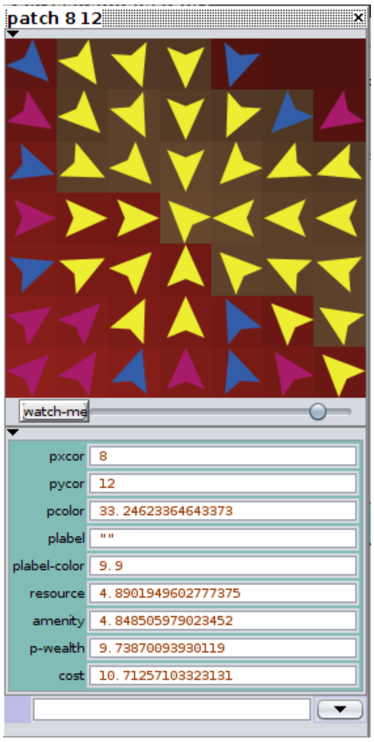

Figure 4.89: Patch 8 12.

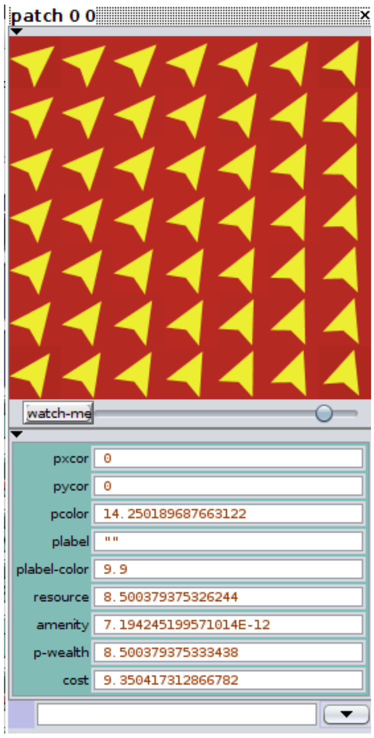

Figure 4.90: Patch 0 0.

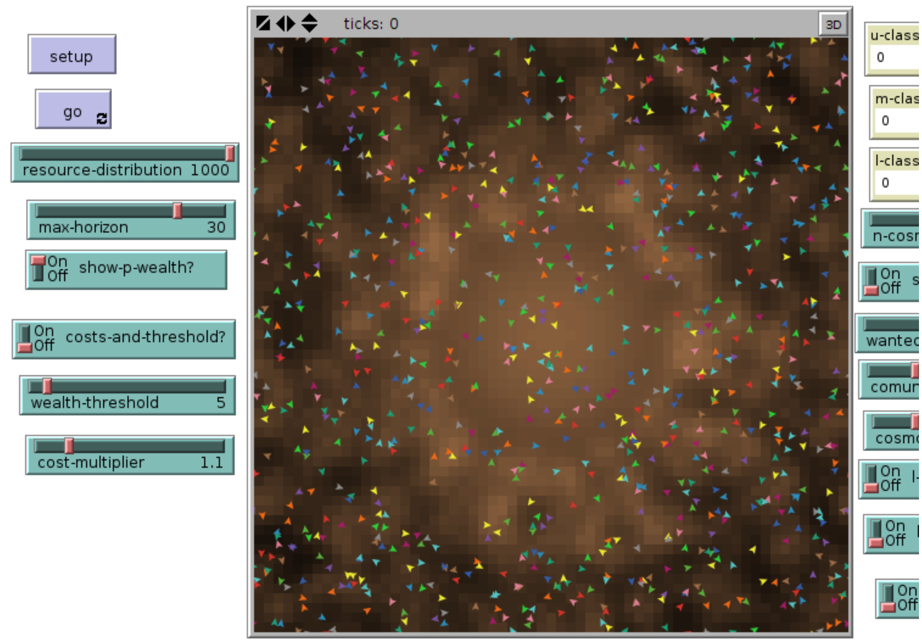

Figure 4.91: Distribution of “p-wealth”.

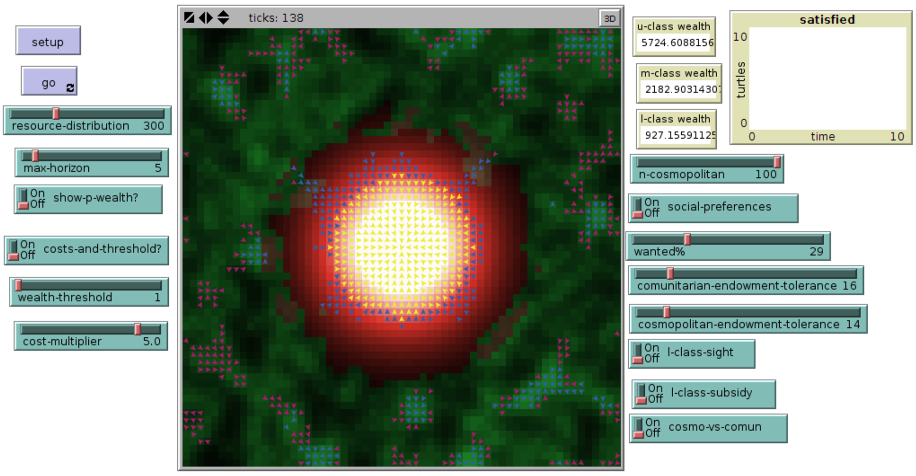

Figure 4.92: Situation before the activation of the switch "cost-and-threshold".

diffusion command is repeated 300 times), while the value of the slider "max-horizon" is 5 patch. From this situation, the activation of the switch, with a level of "wealth-threshold" very low (1 units) and the "cost-multiplier" slider set to 5.0, leads to the outcome reported by figure 4.93[19].

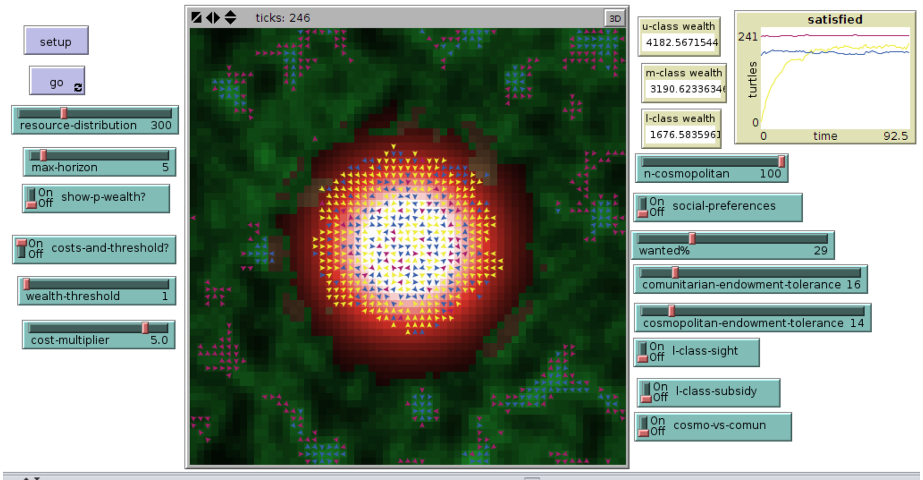

Figure 4.93: The effect of a high level of patches' cost.

The top-right graph [20] measures how many turtles have found a position matching both requirements of wealth and endowment, divided among the different breeds. As visible, the majority of the turtles on a suitable place are the "l-classes", which, spatially, are found mainly on green patches, which carry

[19] As previously explained, the two sliders set the level of "wealth" and the "cost" of patches that should be met by the wealth owned by turtles and their income respectively. It follows that the agents tend to behave as in model 5.

[20] This graph works only if the switch "cost-and-threshold" is activated.

enough “p-wealth” without being too much “expensive”. Central patches, instead, tend to show a high level of “cost” (“p-wealth” times “cost-multiplier”), allowing less yellow and blue agents to be “satisfied“ with their location, which is more likely on red central patches. What if the slider “wealth-threshold” is rapidly increased? Figure 4.94 shows that many agents have moved from outer regions to the central area. This happened likely because unsatisfied turtles tend to move randomly within their radius. By chance, some of them end up near the rich red zone and keep staying around there, attracted by the higher wealth, although they do not seem to own enough “endowment” to find a stable position. Consequently, the lines in the graph drop, and no blue nor magenta turtle satisfies the two conditions set by the sliders, while a part of “u-classes” still does.

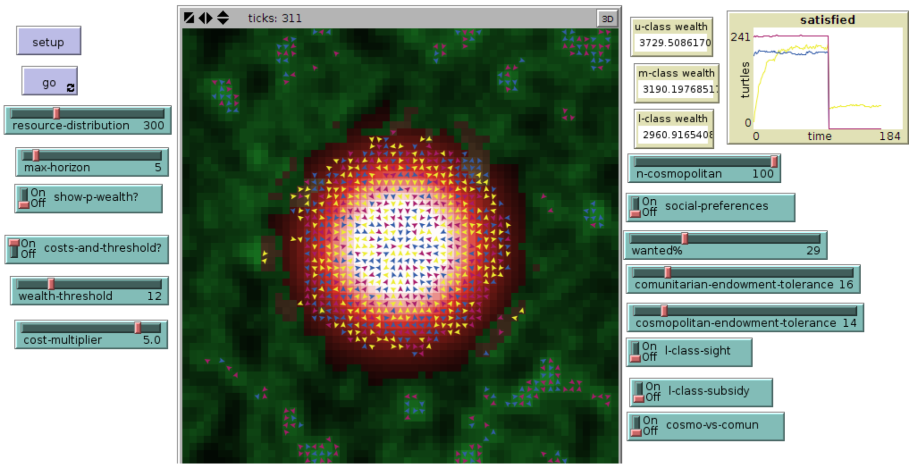

Figure 4.94: The result of an increase in the “wealth-threshold” value.

From this situation, the observer can turn on the switch “l-class-sight”, which gives the ability to all “l-class” turtles to act within a radius of 50 patches. The outcome of this activation is shown in figure 4.95: no magenta turtles can be found on green patches, and the counter of their wealth proves that they tend to be mainly on the most affluent patches. Moreover, some of the “l-classes” is forming a ring around the white core of the central area. Anyway, as can be seen from the graph, none of them is able to afford a place in that area, and yellow turtles are still the most satisfied.

Things change when finally “l-class-subsidy” is activated. The graph in figure 4.96 shows the sharp rise in the number of satisfied “l-class” agents, overcoming that reached by yellow turtles. They tend to occupy central areas, thus the most expensive ones, while “u-classes” are now standing on peripheral red patches. The more stable among them form hence a circle close to the central core.

One last interesting property arising from the activation of “cost-and-threshold” is capacity of the “u-class” breed to respond to an increase in the value of the slider “cost-multiplier”. The figure 4.97 shows a situation in which “cost-and-threshold” is activated and both “wealth-threshold” and “cost-multiplier” are low. As reported by the graph, most of the turtles are satisfied with this pa-

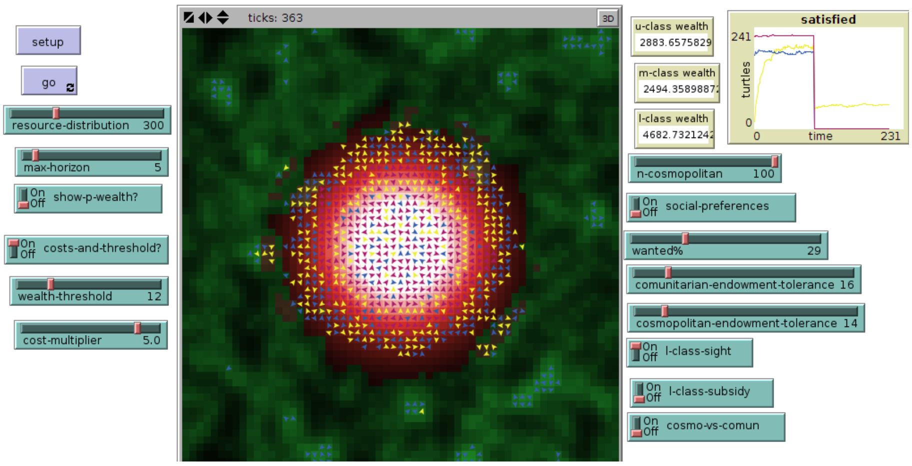

Figure 4.95: Activation of the switch "l-class-sight".

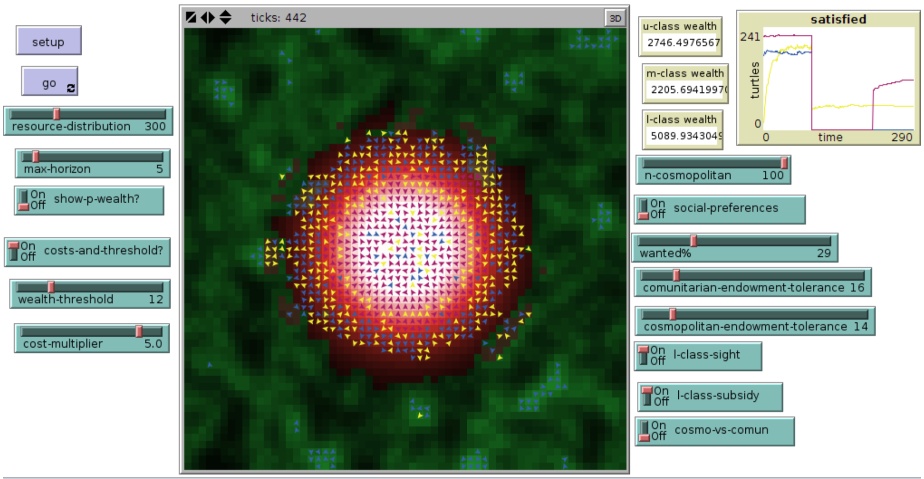

Figure 4.96: Activation of the switch "l-class-subsidy".

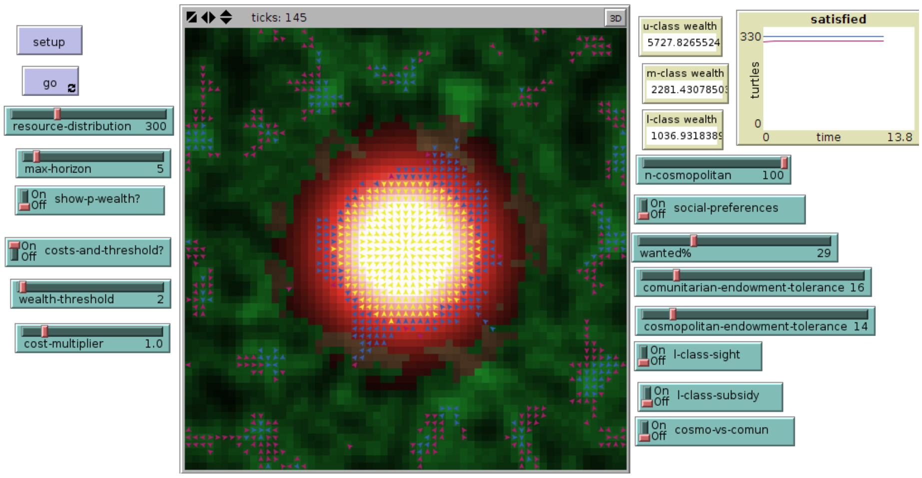

Figure 4.97: Initial situation with low “cost-multiplier”.

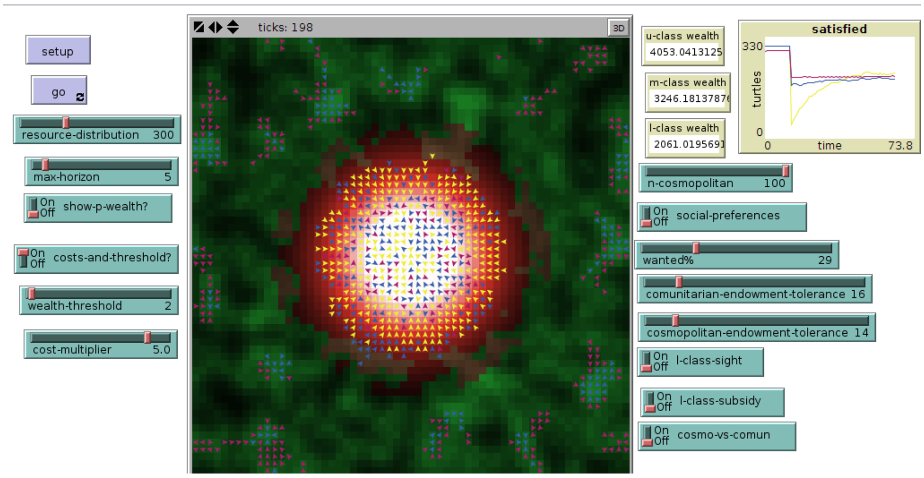

Figure 4.98: Effect of an increase in “cost-multiplier”, and “u-classes” recover.

rameters (the yellow line measuring the “u-classas” is hidden behind the blue one). The graph in the next figure, i.e. 4.98, shows instead what happens once the cost multiplier is brought to a higher level: the breed that suffers more from this rapid rise is the “u-class” whose members, anyway, are also the most able in readjusting their position, finding new satisfying places. As it can be seen, the yellow line drops sharply, reaching the lowest level among the three. But, while the other two stay more or less constant, the “u-class” breed start a gradual recover which ends at a level lower than the previous, but still higher than its counterparts. Likely, they moved towards peripheral, and less expensive, areas, replaced by dissatisfied blue and magenta turtles.

The last additional behaviour that can be called is that activated by the switch “social-preferences”: when it is on, it makes yellow turtles react to the composition of their neighbourhood, evaluated in terms of the variable “endowment” owned. As already explained, the slider “n-cosmopolitan” decide the proportion of turtles preferring a location where a percentage, set by the slider “wanted%“, of turtles has an income greater or lower than the level decided by ”cosmopolitan-endowment-tolerance“. The part of the ”u-classes“ not included among the ”cosmopolitan“, instead, will prefer patches where the same proportion of neighbours has an ”endowment“ included between her own endowment minus or plus the value set by ”comunitarian-endowment-tolerance“. As a first experiment, it can be useful to see how the sliders work, in case all the yellow turtles are ”comunitarian“.

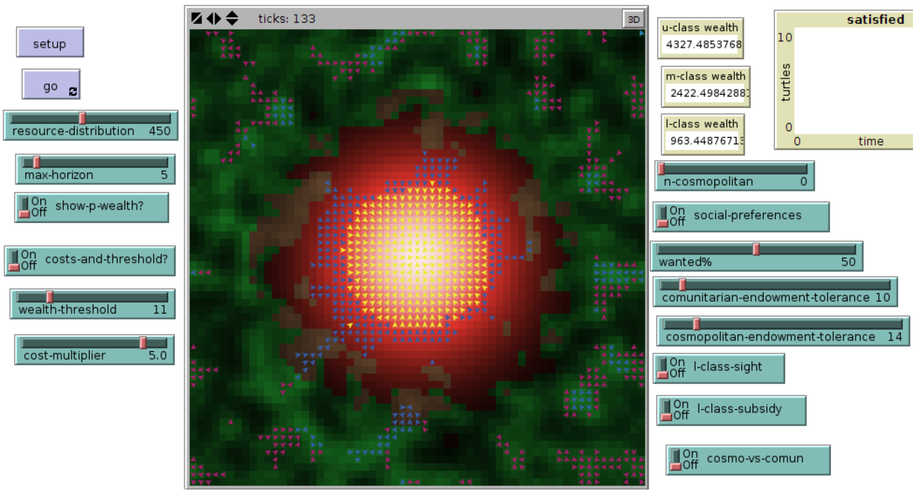

Figure 4.99: The world before the activation of ”social-preferences.

Figure 4.99 shows the situation before the activation of “social-preferences”. As set by the sliders, the diffusion of “resource” was repeated 450 times, while the maximum distance at which agents can act is 5 patches; the switch “cost-and-threshold” is deactivated. All the “u-class” turtles are “comunitarian”, the percentage of similar neighbours satisfying them is the 50%, and the threshold of income outside which other agents are considered different is of 10 units.

Once activated the switch, the simulation produces the outcome of figure 4.100. Some of the yellow turtles that were already confining with “m-class“

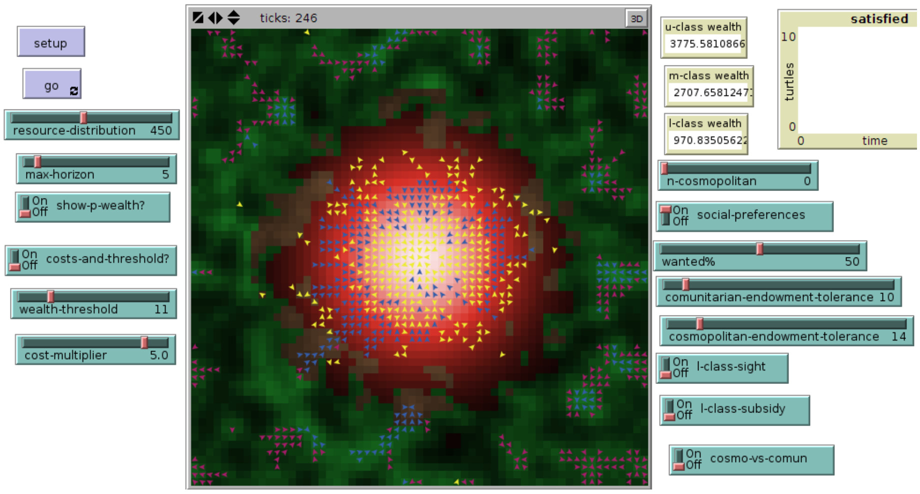

Figure 4.100: The situation after the activation of “social-preferences”.

turtles, has moved towards the periphery of the red core, in some cases replaced by blue agents. Those ”u-classes“ that have moved formed new sparse yellow group in outer areas, except for those few which can be seen already on green patches (in the simulation they are still moving).

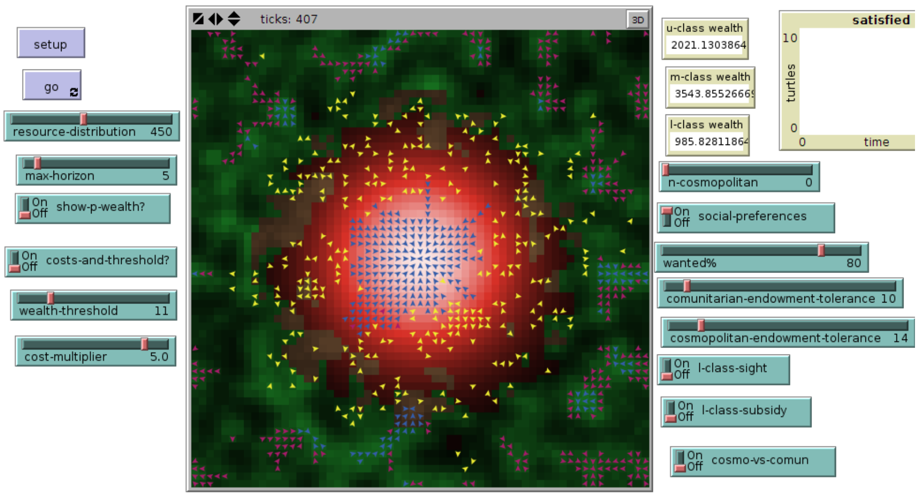

Figure 4.101: What happens after an increase of the ”wanted%“ value.

If the user increases the percentage of ”similar“ neighbours wanted, the result looks as that in figure 4.101, where all the yellow turtles have been replaced by ”m-classes“, searching for a larger and more homogeneous neighbourhood. The mechanism that led from 4.100 to 4.101, is that, once a sufficiently large number of comunitarian has moved, a certain amount of blue turtles replaced them, affecting the neighbourhood composition, hence making more probable that further ”u-class“ were dissatisfied with their position. Again dissatisfied turtles moved away, until all the centre was occupied by "m-classes". Though no appreciable through static images, a large part of the yellows is still moving, except for some groups: the largest of them can be found at the bottom-right of the red area. Holding the threshold of "wanted%" constant and lowering the slider "comunitarian-endowment-tolerance" up to a value of 4 units, the outcome obtained looks pretty much similar, except for a small yellow enclave, as in figure 4.102.

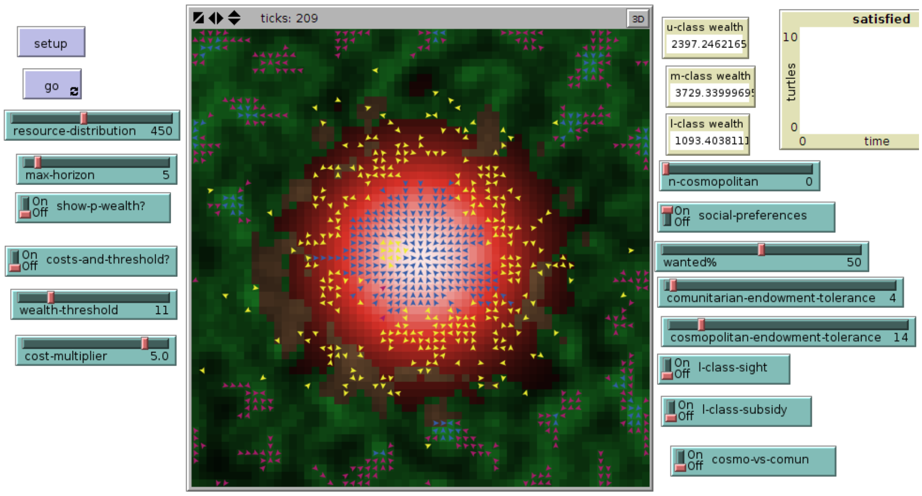

Figure 4.102: Holding "wanted%" constant and lowering "comunitarian-endowment-tolerance".

To the simulation of 4.102, one can also see what happens by causing a migration towards the central zone. Figure 4.103 reports the outcome generated by an increase in the value of the slider "max-horizon", which passed from 5 to 20 patches. It can be seen that the arrive of other turtles (with a likely lower levels of "endowment") generated an even larger marginalisation of the "u-classes". The fact that they can tolerate up to the 50% of neighbours with a level of endowment that cannot be lower or greater than 4 units of their own one, pushes them to chose outer patches, where they can, by chance, find neighbours meeting their requirement (as it can bee also detected, on average, by looking at the counter "u-class wealth"). The only group of yellow turtles that does not seem to have been affected by this migration, is the enclave of "u-turtles" on the central red area.

Now, what if all the turtles have the variable "cosmopolitan" activated? Figure 4.104 shows the outcome of a simulation with the same general parameters regarding the concentration of "resource" and "max-horizon" as before, but with the entire "u-class" population with the dummy "cosmopolitan" activated (as set by the slider "n-cosmopolitan"). It can be seen how sparse has become the spatial distribution of the yellow agents and that blue turtles are now occupying the centre of the world (before switching on "social-preferences", the simulation looked like figure 4.99)[21]. Furthermore, all the turtles that are

[21] A comparison between 4.101 and 4.104 may show how the same kind of centre can be reached both by a population of exigent comunitarians or by a group of "integralist" cos-

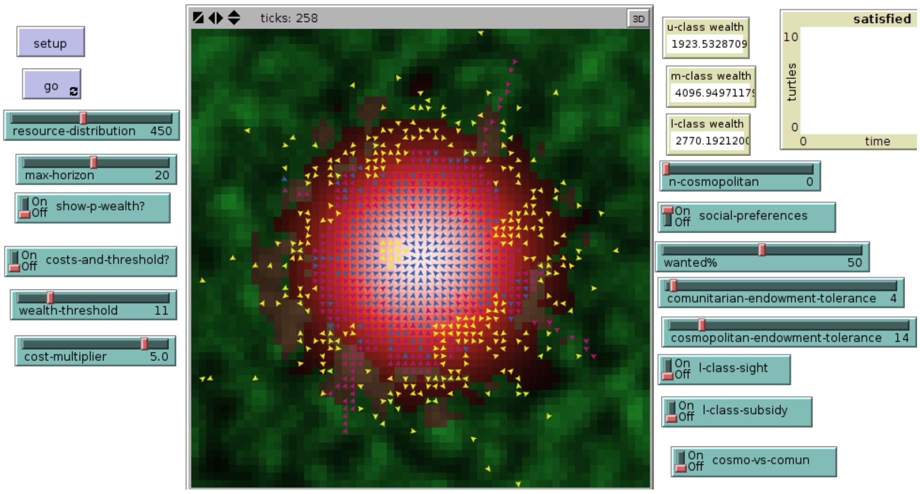

Figure 4.103: Reaction of "comunitarian" turtles to migrations from outer areas.

alone are still moving in the simulation. At the bottom picture, the command centre reports the number of "u-classes" (134) that found a position meeting the requirement set by the sliders "wanted%" and "cosmopolitan-endowment-tolerance", i.e. these agent were able to choose a patch where at least the 50% of their neighbours have an endowment greater or lower than their own, plus or minus 50 units[22].

Figure 4.105 shows the same simulation, but after halving the number of neighbours required. The number of turtles with a satisfying position is now 211, as reported by the command centre. From a visual vantage point, it can be seen how yellow turtles tend to be mainly on the border of the peripheral groups, in particular next to "l-classes", condition that can be explained considering that turtles of this breed are likely to have a much lower endowment than "u-classes". Running again the program with the same level of "wanted%" of picture 4.104, but lowering the level of the slider "cosmopolitan-endowment-tolerance", the result is quite different, as in figure 4.106. Now many yellow turtles can be still found in the central area, since it is now easier for them to find neighbours exceeding (positively or negatively) their own endowment by 20 units. Consequently, the number of "u-classes" with the desired neighbourhood composition has increased, reaching 286 agents: it seems that relaxing the endowment requirement is more effective than reducing the percentage of different neighbours wanted. The difference between 4.105 and 4.106 is that cosmopolitan turtles, in the first case, are not able to find even the 25% of agents with the level of endowment required, therefore they move around leaving the centre, which becomes homogeneously "m-classes" owned. In the latter figure, instead, yellow turtles that, searching for a suitable place, move away leaving room for enough blue turtles, with a sufficiently different endowment, to make

mopolitan, i.e. turtles searching for agents with a large difference in the "endowment" value.

[22]It may be useful to remark that cosmopolitan turtles reacts exactly in the opposite way, with respect to the comunitarian ones: the higher is the value of "cosmopolitan-endowment-tolerance", the harder is for them to find turtles with the desired characteristics, since a large part of the population gets to be excluded.

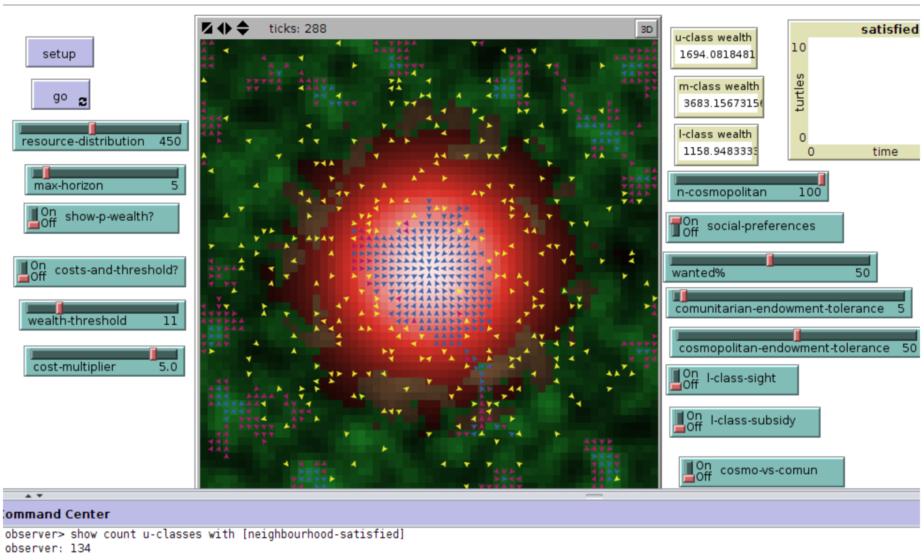

Figure 4.104: “cosmopolitan” u-classes.

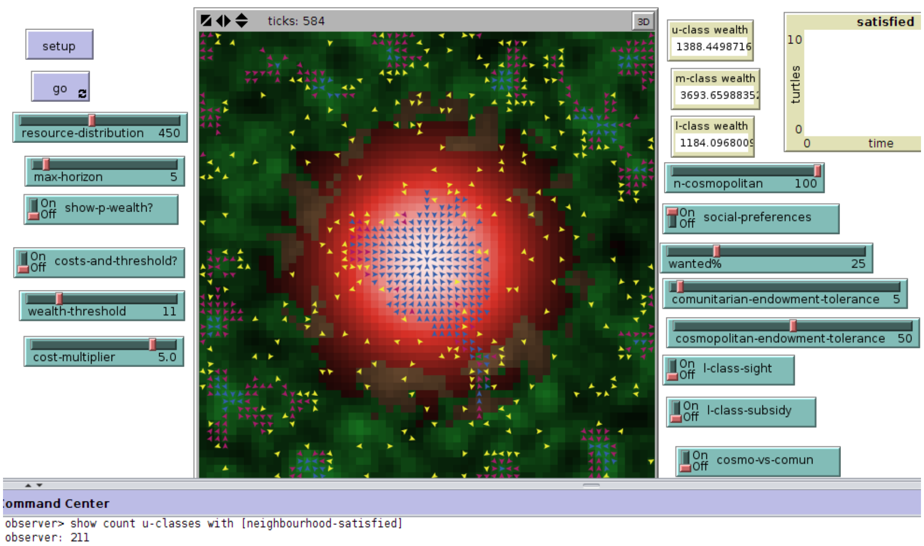

Figure 4.105: A reduction in the value of “wanted%”.

other "u-classes" satisfied with their neighbourhood composition.

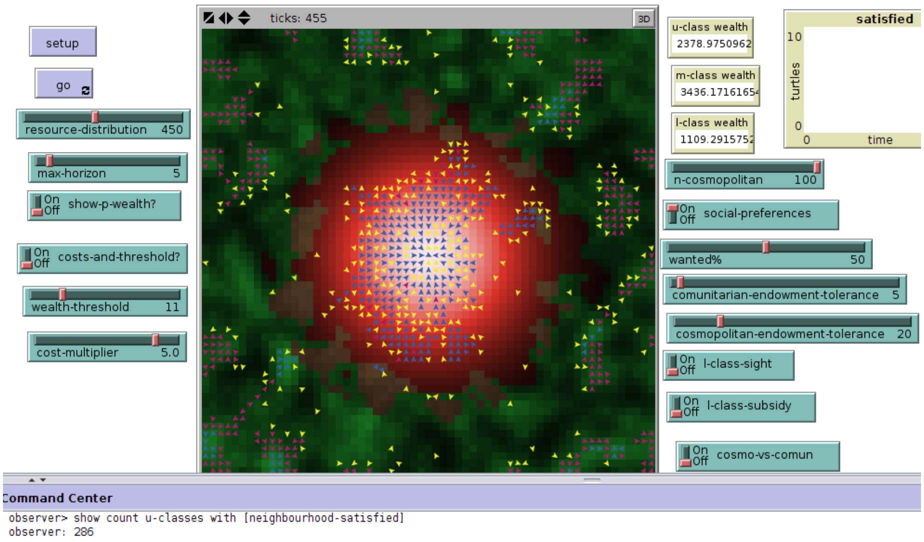

Figure 4.106: A reduction in the value of "cosmopolitan-endowment-tolerance".

So, the settings of the simulation reported in figure 4.106 produce a more variegated centre, which is characterized by the mixed presence of both "u-classes" and "m-classes". Given this result, it should be then possible to find those parameters and dynamics which are able to obtain an integrated spatial distribution of turtles [23].

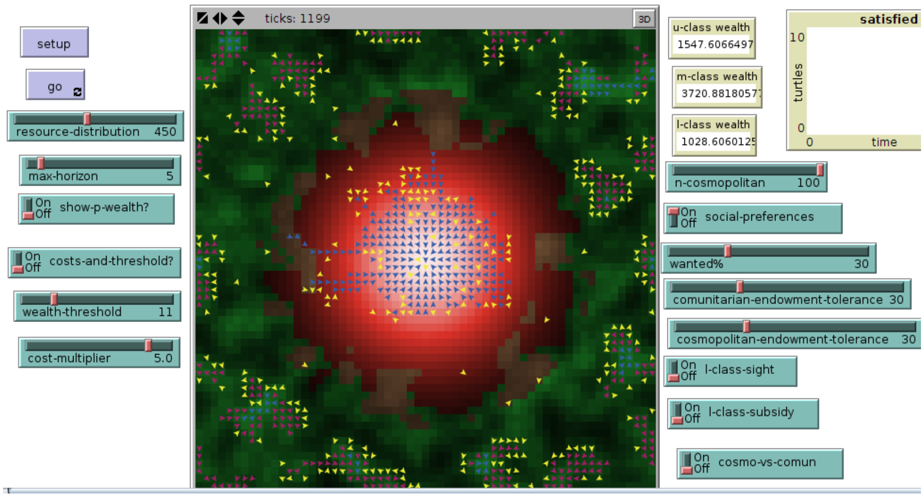

Figure 4.107: Mixing breeds, low max-horizon.

Figures 4.107 and 4.108 shows one possible way, although not the best one, to get the result. In the first, all "u-classes" are cosmopolitan. Moreover they

[23] Of course this achievement required many tries, not shown in the text.

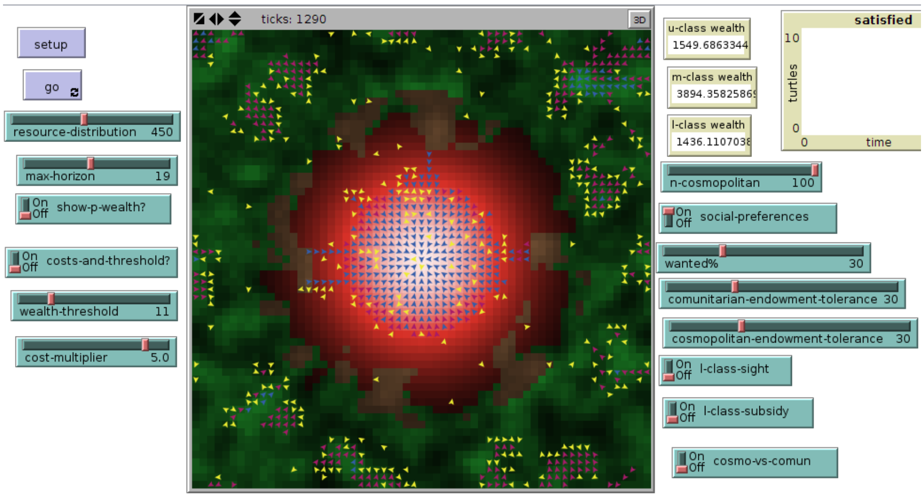

Figure 4.108: Mixing breeds, the result of migrations.

search a place where the 30% of the neighbours are of the desired kind, i.e. with an endowment greater or lower than 30 units of their own one. The picture was taken once almost all the yellow agents had found such a position. Once obtained this outcome, the slider "max-horizon" was increased, in the hope that turtles would move towards the central area. What happened, instead, was that a large part of the "m-classes" and "l-classes" on green areas was not able to move, since it was surrounded by yellow turtles (remark: the program's code states that a turtles faces is target and keep on moving forward, until she does not meet another agent). The easiest way to overcome this problem is to set directly since the beginning a larger "max-horizon", making the turtles move straight to the central area as in figure 4.85. Once achieved this result, the observer can switch on "social-preferences", holding the same parameters as before. The outcome is shown in 4.109, where many yellow turtles can be found amid "m-classes" and "l-classes" (even though not all of them were able to find a suitable place: in the simulation many turtles are still moving, mainly the outer ones).

It can be, finally, interesting to see how the fortune of comunitarian turtles can be tied with the level of tolerance of the cosmopolitan part of the "u-class" breed. The experiment reported by figures 4.110, 4.111 and 4.112 aims to see how this can happen. In the simulation, the yellow population was divided between "comunitarian" and "cosmopolitan", covering each the 50% of the "u-class" breed. The tolerance parameter is set to 5 units by both the sliders, this mean that the comunitarian part is quite intolerant, while the cosmopolitan one can accept as neighbours a rather large part of the "m-class" and "l-class" breeds. Figure 4.110 shows the first result: all the turtles are surrounding the centre (because of the value of the "max-horizon" slider), and yellow turtles can be found both on the core affluent patches, or at the periphery of the central area. In 4.111, it can be seen how they divide between "comunitarian", in red, and "cosmopolitan" in light blue. The former can be found mainly in outer areas, while the latter ones still occupy the inner area. An increase (from 5 to 25

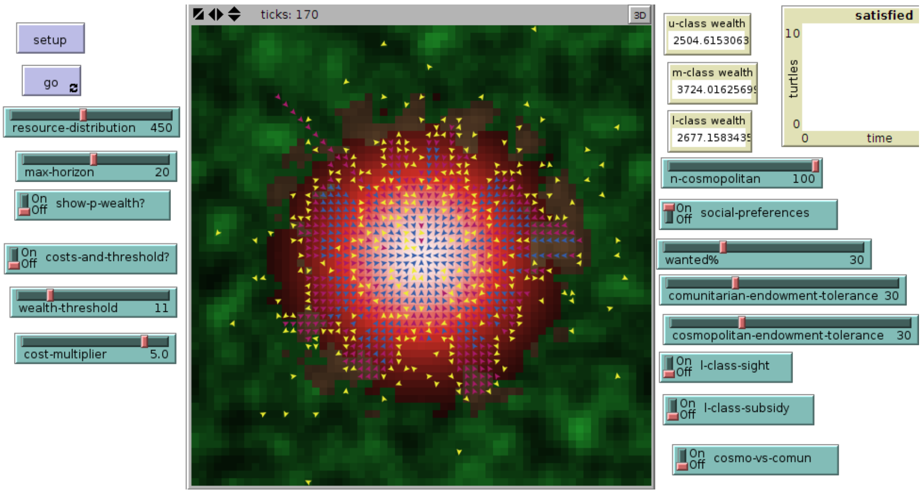

Figure 4.109: The result with an higher value of "max-horizon".

units of "cosmopolitan-endowment-tolerance") produces then the result of figure 4.112: "cosmopolitan" have now become harder to satisfy, since now the strict minority of the population can met the diversity of endowment required. The consequence is that many of them have moved to more peripheral zone searching for a suitable neighbourhood. This mechanism allow many "m-classes" and "l-classes" to access to the red core, forcing then the remained "comunitarian" to leave their patches: the cosmopolitan "intolerance" made "intolerant" turtles go away.

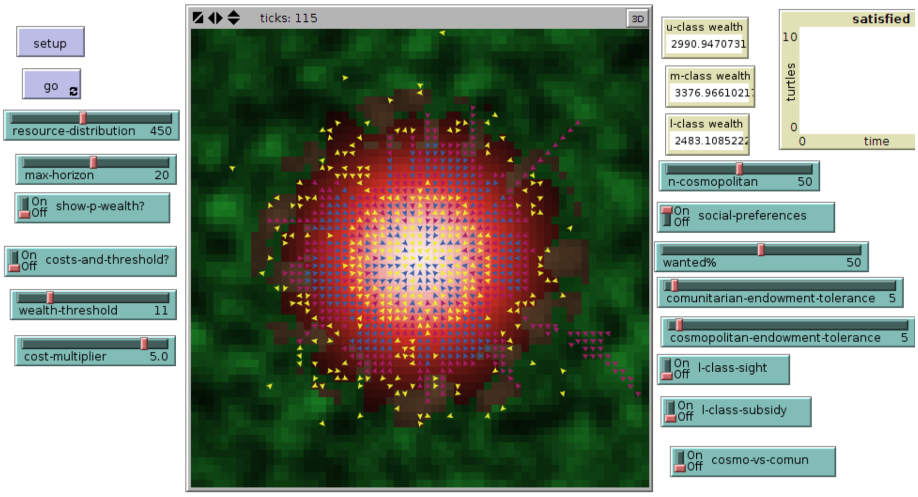

Figure 4.110: Half comunitarian, half cosmopolitan, all coloured in yellow.

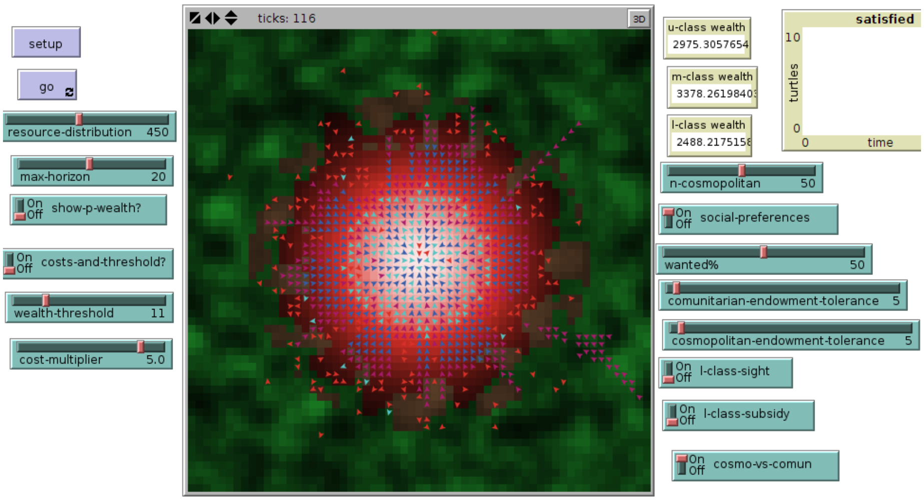

Figure 4.111: Half comunitarian, half cosmopolitan: red and cyan.

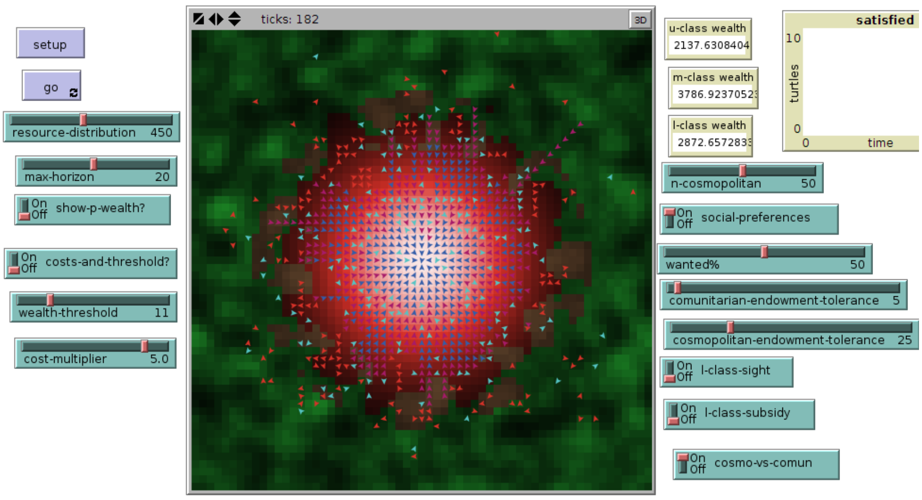

Figure 4.112: The result increasing the level of “cosmopolitan-endowment-tolerance”.

Conclusions

The study of the dynamics through which people position themselves on the space may involve an immense set of reasons: economic, racial, social, cultural, historical, anthropological, psychological, religious, political *etc.*, which are hard to arrange in a uniform project. This variety of factors is studied by an equal (if not greater) number of scientific disciplines: the naive initial idea behind this thesis was that of trying to conjugate contributions coming from different areas of study. Among those not explored in the literature review, some insights could have come from the field of social psychology and from sociology. With respect to the first, chapter 1 made a brief reference to the work of Aronson [1], which would have been helpful in order to look for the psychological motivations to segregation dynamics. In particular, the idea that human groups can be easily divided through the creation of fictive differences could be of a certain help in the analysis of the phenomenon[24].

Another possible intersection among disciplines, could be that of the formation of cultural and ethnic enclaves, as it can involve political geography (as Marcuse in [21], see note 10 in chapter 3), psychological studies showing under which circumstances the sense of belonging to a social group is enforced (as again in Aronson [1]), and sociology, which discusses what can be the social consequences, whether positive or negative (e.g. it has been already quoted the work of Putnam in [23], concerned about the role played by so-called "bonding" social capital[25]). Finally, all these contributions will need to be empirically tested, as done by Ibraimovic in [17] (see again note 10 in chapter 3).

Given the possibility of such interconnection among different disciplines, Agent Based Modelling seemed to be a good option in order to investigate social phenomena (see also appendix A for more details). The purpose of chapter 4 was therefore that of exploring some possibilities in the creation and the consolidation of social differences within a population composed of identical agents. If the agents are created with the same characteristics and with the same behavioural rules (at least at the beginning of the simulations), the source of

[24] For instance, Aronson quotes the so called "Stanford Prison Experiment" conducted by Philip Zanardo in 1971, where a group of people was randomly divided between prisoners and guards: within six days the former ended up displaying passive depressed behaviours, while the latter became cruel and sadistic. The simple fact of having authoritative power, n the basis of an artificial distinction, led the guards to take their role very seriously.

[25] Putnam sees this form of social capital as that arising in closed social groups, sometimes in opposition to negative perceptions coming from the rest of society (which is usually one of the reasons for the emergence of ghettos and enclaves), which suffers from a series of trade-offs: e.g. it enhances cohesion within a community (e.g. a religious confession whose members do not care about reciprocal social status), but at the same time tends to preclude the possibility of the creation of fruitful contacts with the rest of society, thereby weakening it.

inequalities has to come from the environment; contingent forces will do the rest. With this aim in mind, for example, the first model was created with a rough division of the world into two parts, one richer in a variable called "product"[26], the other poorer. Only because of this main difference, turtles reproduce more or less quickly. One interesting fact, as mentioned in the model's description, is that the possibility of inheriting from their mothers enables the less affluent agents to achieve a greater number through reproduction. Another interesting dynamic can be considered that arising from the movement procedure of model 6, where turtles that, by chance, were created on the richest patches are able to reach before the others more and more affluent areas at which point, because of how the program was designed, the privileged position cannot be challenged, unless they start to behave differently (i.e. caring about the composition of their neighbourhoods). It is also interesting to see, again in model 6, how turtles migrate one behind the other, forming longer or shorter lines: they "see" which are the best patches, and they occupy them one by one, since, as their vision gets larger, they choose as target the same position.

In other models, such as models 3 and 5, turtles are exogenously endowed, right from the start, with a certain value of a variable (endowment or rate of preference). Here the aim is to see how the agents may react to different spatial distributions of the resources. Apart from those cases in which the parameters do not allow any turtle to be satisfied with her position (or in the opposite situation, i.e. where each one is happy everywhere), one of the results is that, in crowded situations, it takes time for the agents to adjust to exogenous changes, which is eased by the fact that they select different targets, according to their preferences.

To conclude this short discussion, chapter 3 was included in order to review how, and according to which theoretical arguments, social spatial phenomena (mainly in urban areas) have been judged by some authors. Remarking that the models presented have little to do with the real world, as simulated agents are ontologically different from human beings (and far simpler), it is hard to apply these analyses to the simulations reported. It can be just said that none of the models seems to lead to a "just" outcome, in the different senses expressed by the authors quoted; the worlds described in chapter 4 are rather static and the improvement of the turtles' situations is limited by the rule "one turtle per patch". Moreover, in real society, there are mechanisms at work which are much more internal and spontaneous, affecting the distribution of resources and determining movements on the social ladder: it would be interesting to see which of them push society away from a "just" outcome (according to the acknowledged interpretation of this word...).

[26] The name was chosen merely for narrative purposes; in fact in other models variables with other names are created (e.g. resource, coal, gold or amenity), but with the same function and interacting in the same way with the turtles.

Appendices

Appendix A

On ABM

Is not a mystery that the models described in chapter 4 are abstract and their agents are in no way comparable with actual people or households. And hence: why build such models? and why by mean of Agent Based Modelling (ABM) techniques, such as the visual simulation? An answer to the first question can be found in Epstein [9], who easily replies the following (italics in the original paper):

> The first question that arises frequently-sometimes innocently and sometimes not-is simply, "Why model?" Imagining a rhetorical (non-innocent) inquisitor, my favorite retort is, "You *are* a modeler." Anyone who ventures a projection, or imagines how a social dynamic-an epidemic, war, or migration-would unfold is running *some* model.

The actual issue becomes then:

> ...not whether to build models; it's whether to build *explicit* ones. In *explicit* models, assumption are laid down in detail, so we can study exactly what they entail. On these assumptions, *this* sort of thing happens. When you alter the assumptions *that* is what happens. By writing explicit models, you let others replicate your result

(Epstein [9], italics in the original article.)

If one agrees upon these statements, then she may wonder which set of analytical tools is to be used (and, possibly, which is the most proper among those) to build explicit models. Terna in [31] divides the possibilities among three main areas:

1. *verbal argumentation*, which is a very elastic way to analyse facts (e.g. historical), but has the problem that its hypothesis and conclusions can hardly be verified or testified;

2. *mathematical equations*, such as in statistics or econometrics, which overcome the the problem of the verification and of hypothesis testing, but that are sometimes too rigid to properly deal with the heterogeneity of human action and interaction, as they bind actors' behaviours to specific and fix sets of assumptions and restrictions;

3. *computer simulation*, mainly when linked to ABM, which as Terna writes:

> ... allows us to use the descriptive capabilities of verbal argumentation and the ability to calculate the effects of different situations and hypotheses together. From this perspective, the computer program is a form of mathematics. In addition, we can generate time series from our models and analyze them employing statistics and econometrics. However, reality is intrinsically agent-based, not equation-based.

   Furthermore, this third point leads to a great advantage, which is the ability to build *artifacts* of the social systems to be analysed and than to change their hypotheses and the behaviour of their agents, with the possibility of treating the simulation's results with statistical and econometric instruments (see Terna [31]).

These arguments introduce the answer to the second question made at the beginning of this appendix: why use ABMs? As Epstein and Axtell argue in [10], social processes are complex, and involve many subsystems which interact (e.g. economic, cultural, spatial...) with each other producing certain outcomes. But usually the separate analysis tells to scholars little about the whole process, as it happens that the result is more complex than the mere sum of the single parts. Moreover, part of this complexity lies in the fact that, in the social field, is often hard to design and perform controlled experiments; while another major difficulties, as already noted above, is the heterogeneity of the actors involved in social processes. This diversity, Epstein and Axtell reports, has usually been treated by filtering it out, either explicitly (as macroeconomic models dealing with a supposed representative agent) or implicitly (performing the social analysis by mean of extremely aggregate models). The ABM approach is significantly different from the "traditional" ones and, as it allows to consider jointly and to combine spheres of social behaviour which have been so far treated separately (as explained by Epstein and Axtell in [10]. These considerations make ABM a suitable instrument in the field of the social sciences, as argued by Axelrod and Tesfatsion in [2], since it enjoys:

1. the ability to deal with system composed by interacting agents;
2. it enhance the analysis of emergent properties arising from these interactions.

Given this two properties, ABM allows scholars to better understand how macroscopic effects may *emerge* from the repeated interaction among agents and from their micro-behaviours. As it is reported in [2]:

> ...Why have particular large-scale regularities evolved and persisted, even when there is little top-down control? [e.g. standing ovations, trade networks, mutual cooperation etc.] ABM researchers seek causal explanations grounded in the repeated interactions of agents operating in specified environments. In particular, they ask ask whether particular types of observed global regularities can be reliably generated from particular types of agent-based models.

In addition to this goal (the *empirical understanding* goal, in the text), Axelrod and Tesfatsion see the ABM as a third scientific approach, deduction and induction being the other two. In particular, agent-based simulation start from certain explicit assumptions, just as deduction, but, differently from deduction, it does not prove the generality of the proceeding theorems. ABM generates instead a series of data which can be inductively investigated. But, again differently from induction, these data do not come from real-world measures, they arise instead from a specific list of assumptions regarding a real or imagined system of interest (see Axelrod and Tesfatsion in [2]).

To summarize and conclude, Epstein and Axtell provide a definition of ABM in [11] as follows:

> Compactly, in agent-based [computational] models, a population of data structures representing individual agents is instantiated and permitted to interact. One then looks for systematic regularities, often at the macro-level, to emerge, that is, arise from the local interaction of the agents. The short-hand for this is that macroscopic regularities "grow" from the bottom-up. No Equations governing the overall social structure are stipulated in multi-agent computational modeling, thus avoiding any aggregation or misspecification bias. Typically, the only equations present are those used by individual agents for decision-making. Different agents may have different decision rules and different information; usually, no-agents have global information, and the behavioral rules involve bounded computational capacities-the agents are"simple". This relatively new methodology facilitates modeling agent heterogeneity, boundedly rational behavior, non-equilibrium dynamics, and spatial processes.

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