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Assimilation Patterns in Cities

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Abstract

We develop a model in which ethnic minorities can either assimilate to the majority's norm or reject it by trading off higher productivity and wages with a greater social distance to their culture of origin. We show that "oppositional" ethnic minorities reside in more segregated areas, have worse outcomes (in terms of income) but are not necessarily worse off in terms of welfare than assimilated ethnic minorities who live in less segregated areas. We find that a policy that reduces transportation cost decreases rather than increases assimilation in cities. We also find that when there are more productivity spillovers between the two groups, ethnic minorities are more likely not to assimilate and to reject the majority's norm. Finally, we show that ethnic minorities tend to assimilate more in bigger and more expensive cities.

Keywords: Identity, agglomeration economies, cities, ethnic minorities, welfare.

JEL Classification: J15, R14, Z13.

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1 Introduction

In 2017, in Michigan, an Indian-American emergency-room doctor who belongs to the Dawoodi Bohra community, a Shiite Muslim sect, was charged with performing female genital mutilation on several young girls. In Minnesota, a black police officer, the first Somali-American cop in his precinct, shot an unarmed Australian woman. Both incidents were immediately seized upon by the far right as examples of the inability – or refusal – of Muslims to assimilate. Assimilation of immigrants is indeed a hot debate in the United States but also in Europe. For some, assimilation is based on pragmatic considerations, like achieving some fluency in the dominant language or some educational or economic success. For others, it involves relinquishing all ties to the old country. For yet others, the whole idea of assimilation is wrongheaded, and integration is seen as the better model.

Since, both in the United States and in Europe, ethnic minorities live disproportionately in cities and reside in areas strongly segregated from neighborhoods where individuals from the majority group live, assimilation or the lack of it can only be understood within a spatial framework. What are the costs and benefits of assimilation? Does residential location affect the assimilation process of ethnic minorities? Do people who assimilate to the majority's norm tend to reside in the same areas as the majority group? Is segregation good or bad? Are ethnic minorities better off by assimilating to the majority's values?

In this paper, we investigate these issues by studying how ethnic minorities assimilate or reject the majority's norm and how this impacts on their residential location, housing prices and the size of the city. Surprisingly, at least from a theoretical viewpoint, there is very little research on the relationship between the urban space and the assimilation choices of ethnic minorities.

We develop a model in which ethnic minorities can either assimilate to the majority's norm or reject it. If they assimilate, their productivity and thus their wage will be "pooled" with that of the majority group and they will therefore obtain a higher income than "oppositional" minorities who reject the majority's norm. This, in particular, implies that their economic status (their relative income with respect to that of the society) will be higher. There is also a social cost of assimilation since they need to distance themselves from their culture of origin. However, the higher is the fraction of minorities who assimilate, the lower is the cost of the perceived distance between assimilation and values from the minority group. This means that there are complementarities in assimilation choices since the higher is the fraction of assimilated minorities, the greater are the benefits from assimilation. We assume that all individuals are ex ante heterogenous in terms of the weight α they put on the importance of income in their utility function. This implies that individuals with very high α will tend to assimilate to the majority's norm while, those with very low α will tend to reject the majority's norm.

We show that three types of equilibria may emerge: An Assimilation Social Identity Equilibrium (ASIE), in which all minority individuals choose to totally assimilate to the majority group, an Oppositional Social Identity Equilibrium (OSIE), in which all minority individuals totally reject the social norm of the majority group, and a Mixed Social Identity Equilibrium (MSIE), in which a fraction of minority individuals assimilate while the other fraction choose to be "oppositional". We give the exact conditions under which each equilibrium is unique and stable but also when there are multiple equilibria. We show, in particular, that the fraction of ethnic minorities in the population has to be large enough while the productivity spillover effect has to be low enough for a MSIE to emerge.

In the second part of the paper, we explicitly model the city and, therefore, the location choices of all individuals. The city is assumed to be monocentric and landlords are absentee. Each individual consumes a non-spatial good and decides the size of her housing, the price to pay for it and her location in the city. To keep the model tractable, we now assume that α, the weight they put on the importance of income in their utility function, can take only two values i.e., a high value α_h or a low value α_l. As a result, a MSIE can emerge only with minority individuals with $\alpha_h$being assimilated. We establish under which conditions an Assimilation Social Identity Urban Equilibrium (ASIUE), an Oppositional Social Identity Urban Equilibrium (OSIUE), or a Mixed Social Identity Urban Equilibrium (MSIUE) emerges or when two or more of them can coexist (multiple equilibria). We show that, in the ASIUE, all ethnic minorities assimilate and live together with the majority group while, in the OSIUE, all ethnic minorities reject the majority's norm and segregate themselves at the vicinity of the Central Business District (CBD) while the majority individuals reside at the periphery of the city. In the MSIUE, a part of ethnic minorities assimilate and live together with the majority group in the suburbs, whereas there also exist minorities who reject the majority's norm and live close to the CBD. We find that "oppositional" minorities reside in more segregated areas, have worse outcomes (in terms of income) but are not necessary worse off (in terms of welfare) than assimilated minorities who live in less segregated areas.

Moreover, we find that a policy that reduces commuting costs or increases the supply of land makes the Oppositional Social Identity Urban Equilibrium (OSIUE) more likely to emerge. In other words, these two policies decrease assimilation in cities. We also find that more productivity spillovers between the majority and minority groups makes ethnic minorities more likely to reject the majority's norm while an increase in the fraction of minorities in the population makes multiple more likely to emerge. Finally, we show that ethnic minorities tend to assimilate more in bigger and more expensive cities.

There is a growing literature trying to understand the process of assimilation of ethnic minorities. Different studies have shown distinct significant influences on the assimilation process for immigrants: the quality of immigrant cohorts (Borjas, 1985), country of origin (e.g. Beenstock et al., 2010; Borjas, 1987, 1992; Chiswick and Miller, 2011), ethnic concentration (e.g. Edin et al., 2003; Lazear, 1999) and personal English skill (e.g. Chiswick and Miller, 1995, 1996; Dustmann and Fabbri, 2003; McManus et al., 1983).

There is also an important literature that studies the concept of oppositional cultures among ethnic minorities. In this literature, as in our model, ethnic groups may "choose" to adopt what are termed "oppositional" identities, that is, some actively reject the dominant ethnic (e.g., white) behavioral norms (they are oppositional) while others totally assimilate to it (see, in particular, Ainsworth-Darnell and Downey, 1998).[1] From a theoretical perspective, researchers have put forward the role of cultural identity (Akerlof and Kranton, 2010) in the assimilation patterns of ethnic minorities (see, e.g. Bisin et al., 2011a,b, 2016; Panebianco, 2014; Verdier and Zenou, 2017, 2018) and show how oppositional identities can emerge as an equilibrium outcome (Akerlof, 1997; Austen-Smith and Fryer, 2005; Selod and Zenou, 2006; Battu et al., 2007; Bisin et al., 2011a; De Marti and Zenou, 2017, Eguia, 2017).[2] Finally, some recent papers have highlighted the role

[1]Studies in the United States (but also in Europe for ethnic minorities) have found, for example, that African American students in poor areas may be ambivalent about learning standard English and performing well at school because this may be regarded as "acting white" and adopting mainstream identities (Fordham and Ogbu, 1986; Wilson, 1987; Delpit, 1995; Ogbu, 1997; Battu and Zenou, 2010; Fryer and Torelli, 2010; Bisin et al., 2011b; Patacchini and Zenou, 2016).

[2]In a series of papers, Zimmermann et al. (2007), Constant and Zimmermann (2008), Constant et al.

of cultural leaders and/or social networks as an important aspect of the identity choices and integration of ethnic minorities in Europe and the United States (Hauk and Mueller, 2015; Carvalho and Koyama, 2016; Prummer and Siedlarek, 2017; Verdier and Zenou, 2017, 2018).

Compared to this literature, our contribution is to put forward the role of the urban structure on the assimilation choices of ethnic minorities. In particular, we are able to show why segregation is detrimental in terms of economic outcomes for minorities, how bigger and more expensive cities affect the assimilation choices of minorities and how a transportation policy pushes them not to assimilate because of geographical segregation.

The rest of the paper unfolds as follows. In the next section, we develop the baseline model and provide the conditions under which each equilibrium emerges. In Section 3, we introduce the city structure and show how space affects the assimilation choices of ethnic minorities. In Section 4, we provide empirical evidence of our main results. Finally, Section 5 concludes. All proofs can be found in Appendix A while, in Appendix B, we determine the equilibrium values of the endogenous variables in any urban equilibrium. In Appendix C, we extend our model where we consider two different incomes for the majority group.

2 Baseline model

2.1 Social groups

Consider a city with a continuum of individuals of size 1.[3] Among them a percentage μ are members of group m and a percentage $1-\mu$ are members of group c. We assume that $\mu < 1/2$, implying that the group m is the *minority group* and the group c is the *majority group*. If we think of ethnicity, then the group m is the ethnic minority group while group c corresponds to the native group.

Thus, there are two social groups, m and c, which are "categories" that individuals learn to recognize while growing up. Each individual is inherently a member of group

(2009) have proposed a new measure of the ethnic identity of migrants by modeling its determinants and explores its explanatory power for various types of their economic performance. They have proposed the ethnosizer, a measure of the intensity of a person's ethnic identity, which is constructed from information on language, culture, societal interaction, history of migration, and ethnic self-identification.

[3] We explicitly model the city and the location choices of all agents in Section 3.

m or c. These groups are given and we focus on the assimilation decision (identification process) of the ethnic minority group m, i.e., whether or not they want to assimilate to the majority group c. Quite naturally, we assume that the majority group c is sufficiently large so that they always identify with their own group and we do not deal with their identification decision. In contrast, each minority individual can either choose to identify with her own group m (i.e., rejection of the majority's norm) or to the majority group c (i.e., assimilation). In equilibrium, two different groups of ethnic minorities will emerge: those who choose to *assimilate* to the majority group's identity, referred to as *assimilated ethnic minorities,* and those who choose to *reject* the majority group's identity, referred to as *oppositional ethnic minorities.*

2.2 Production and wages

In the city, the numéraire good is produced by only using labor. The production of this good exhibits constant returns to scale at the firm level but involves agglomeration economies at the city level. Agglomeration economies are positive external effects of population concentration that arise from various factors such as spillovers among people and firms, labor pooling, and love of variety in consumption and production (see Duranton and Puga, 2004, for an overview). Much of them require intensive communication among individuals in the city. When urbanites identify themselves with different social groups, then agglomeration economies are relatively weak since individuals from a certain group do not fully socialize with individuals belonging to other social groups. Hence, the effects of agglomeration economies would be weaker with the lack of interaction of people from different social groups.

To capture this idea, we assume that the productivity of a minority individual identifying herself with groups m (oppositional) and c (assimilated) is respectively given by:

$$\begin{aligned} y_m(\lambda) &= f\left((1-\lambda)\,\mu + \varepsilon\left(\lambda\mu + 1 - \mu\right)\right), \\ y_c(\lambda) &= f\left(\lambda\mu + 1 - \mu + \varepsilon\left(1-\lambda\right)\mu\right), \end{aligned} \tag{1}$$

where y_J represents the output of a minority individual when she identifies with group $J \in \{m, c\}$, λ is the (endogenous) share of minority individuals identifying with the majority group, i.e., the ones who choose to assimilate to the majority's norm (group c) and $\varepsilon \in [0,1]$ is a constant. Because the majority individuals always identify themselves with the majority group, the total mass of people identifying with the majority group is given by $\lambda\mu + 1 - \mu$, while the total mass of people identifying with the minority group m (thus rejecting the majority's norm) is given by $(1-\lambda)\mu$. We assume that $f(\cdot)$ is twice continuously differentiable, $f'(\cdot) > 0$, and $f''(\cdot) < 0$.

The general idea behind (1) is that it is easier for assimilated ethnic minorities to interact and communicate with individuals from the majority group than oppositional ethnic minorities and this is reflected in terms of their productivity and wages. Indeed, by interacting less with the majority group, oppositional minorities may have difficulties in inter-ethnic relationships due to language barriers (see e.g. Lazear, 1999; De Marti and Zenou, 2017) or more generally to different social norms and cultures.

In particular, in (1), ε can be interpreted as the degree of agglomeration economies due to the interaction of individuals from different social groups or the *inter-group productivity spillover effects*. If $\varepsilon = 0$, agglomeration economies hardly spread to different social groups so that the output of a minority individual is only affected by the population she identifies with. In that case, $y_m(\lambda) = f\left((1-\lambda)\,\mu\right)$ and $y_c(\lambda) = f\left(\lambda\mu + 1 - \mu\right)$ and, because $\mu < 1/2$, $y_m(\lambda) < y_c(\lambda)$, $\forall\lambda \in [0,1]$. If $\varepsilon = 1$, agglomeration economies are equally effective across different social groups and $y_m(\lambda) = y_c(\lambda)$. When $0 < \varepsilon < 1$, independently of the value of ε, $y_m(\lambda) < y_c(\lambda)$, $\forall\lambda \in [0,1]$. Moreover, the higher is ε, the lower is the wage difference $y_c(\lambda) - y_m(\lambda)$.[4] We have the following result:[5]

Lemma 1

(i) $\forall\lambda \in [0,1]$ *and* $\forall\varepsilon \in [0,1]$, $y_c(\lambda) \geq y_m(\lambda)$. *Suppose* $\varepsilon \neq 1$ *Then, when* λ *increases,* $y_c(\lambda)$ *increases and is concave in* λ *while* $y_m(\lambda)$ *decreases and is concave in* λ. *Moreover,* $y_c(\lambda)/y_m(\lambda)$ *increases with* λ.

[4]Indeed, since $f'(\cdot) > 0$, $f''(\cdot) < 0$ and $\mu < 1/2$, it is easily verified that $\partial\left[y_c(\lambda) - y_m(\lambda)\right]/\partial\varepsilon < 0$.

[5]We can re-interpret our model in terms of discrimination in the labor market against ethnic minorities who do not assimilate to the majority group. Indeed, majority workers may discriminate against non-assimilated majority workers by not wanting to interact with them (for instance, some majority workers will be reluctant to work with women with hijab or men with Islamic clothes) and, therefore there will be an income penalty of not assimilating. In our model, the discrimination factor will be captured by ϵ: the lower is ϵ, the higher is discrimination and the larger is the wage difference between majority and non-assimilated minority workers. So, in this interpretation, discrimination is done by workers, not by employers.

(*ii*) *When ε increases, both $y_c(\lambda)$ and $y_m(\lambda)$ increase and are concave in ε. Moreover, $y_c(\lambda)/y_m(\lambda)$ decreases with ε.*

(*iii*) *When μ increases, $y_c(\lambda)$ decreases while $y_m(\lambda)$ increases but both are concave in μ. Moreover, $y_c(\lambda)/y_m(\lambda)$ decreases with μ.*

This lemma is important because it provides us with some important properties of the incomes, which will be useful for the equilibrium characterization. First, in (*i*), we look at the effect of an increase of λ, the fraction of ethnic minorities identifying with the majority group (an endogenous variable), on the incomes of both groups. Figure 1(a) depicts the shape of these three curves. When more ethnic minorities choose to assimilate, the income of group c (which includes both the majority group and assimilated minorities) increases while the income of the oppositional ethnic minorities decreases. This implies that the income ratio $y_c(\lambda)/y_m(\lambda)$ between these two groups increases with λ. This captures the fact that there are positive (negative) externalities in production so that the higher is the fraction of assimilated minorities, the higher (lower) is the productivity of an assimilated (oppositional) minority individual. In other words, there are increasing (decreasing) returns to scale in production of the assimilation (oppositional) process of ethnic minorities.

Second, in (*ii*), we analyze the effect of ε, the degree of agglomeration economies, on incomes. Figure 1(b) depicts the shape of these three curves. When ε increases, there are more productive interactions between group c (majority and assimilated minorities) and group m (oppositional minorities). However, since μ, the fraction of ethnic minorities in the population, is less than $1/2$, $y_m(\lambda) < y_c(\lambda)$ because the agglomeration effects are always stronger for the majority group. Interestingly, Lemma 1 shows that both groups benefit from an increase in ε because there are more interactions between the two groups and, therefore, their productivity increases. In other words, more interaction is always better and translates here by an increase in income of both groups. Finally, an increase in ε reduces y_c/y_m because the productivity spillover effects benefit more the "oppositional" group m than the assimilated group c.

Figure 1: Income difference between assimilated and oppositional minorities

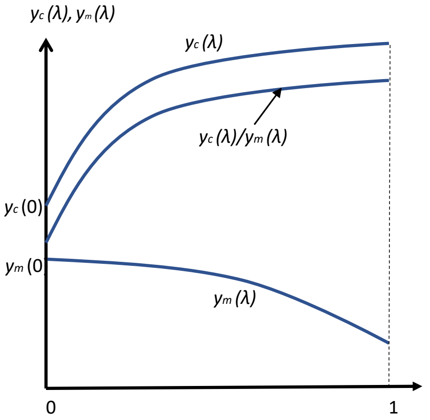


Figure 1(a): Effect of λ on incomes

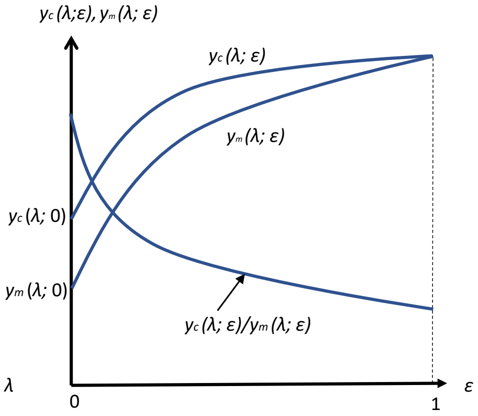


Figure 1(b): Effect of ε on incomes

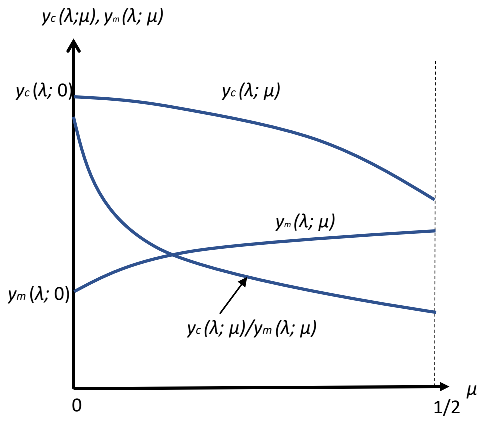


Figure 1(c): Effect of μ on incomes

Finally, in (iii), we examine the impact of the size of the minority group, μ, on incomes. Figure 1(c) depicts the shape of these three curves. We find that, an increase in μ, increases the income of the non-assimilated minority workers $y_m(\lambda)$ while it decreases $y_c(\lambda)$, the income of the majority group and assimilated minority workers. This is because the higher is the fraction of minority individuals in the population, the higher is the productivity of oppositional minority workers (because they work mainly in minority jobs with similar culture or language) and the lower is the productivity of assimilated minority workers and the majority group. As a result, an increase in the size of the minority group, reduces the income ratio y_c/y_m.

In the following, we focus on the case when $0 < \varepsilon < 1$. Each individual is assumed to be endowed with one unit of labor, which she supplies inelastically. Hence, when identifying with group J, an individual receives a wage income of y_J, which constitutes the first part of her utility function. The other parts, which we describe now, are defined in terms of social identity.

2.3 Social identity

Following Shayo (2009) and Sambanis and Shayo (2013), we assume that three main factors affect the social identity and thus the socialization process in terms of assimilation and rejection of each ethnic minority. First, each individual is aware of the different social groups or categories (i.e., groups m and c) that exist in the society. Second, each individual i has an attribute or a quality q_i and she wants to minimize the *perceived distance* between q_i and that of each social group. Third, each individual cares about the *relative status* of each social group so that higher status implies higher utility.

2.3.1 Perceived distance

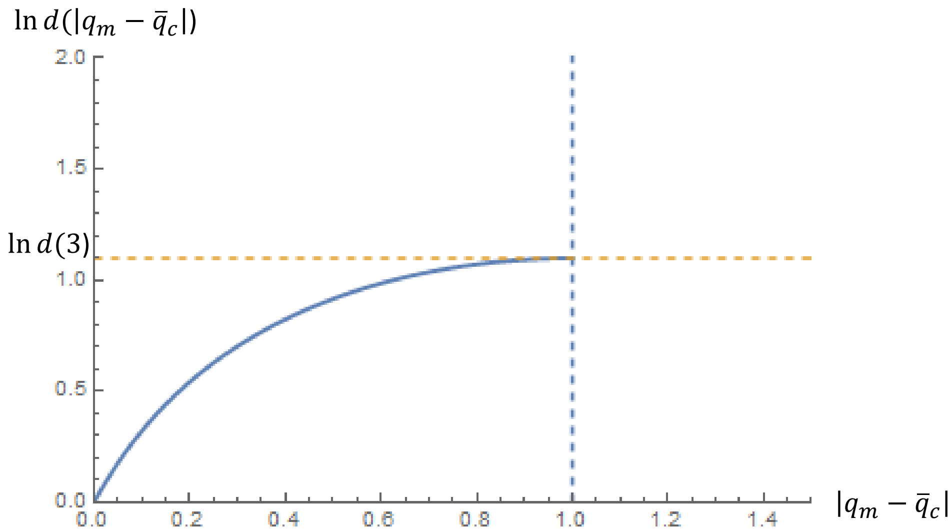
The concept of perceived distance and its adoption to the process of identification originated in the literature of categorization in cognitive psychology (Nosofsky, 1986; Turner et al., 1987). It has also been modeled by economists where the perceived distance is between the action of each agent and that of her social norm and usually negatively affects her utility (Akerlof, 1997; Shayo, 2009; Patacchini and Zenou, 2012; Sambanis and Shayo, 2013; Liu et al., 2014; Boucher, 2016; Ushchev and Zenou, 2019).

Each individual i is born with an attribute or a quality q_i, which depends on the group i she is associated to ($i \in \{m, c\}$). Ethnic minorities are born with q_m and the individuals from the majority group are born with q_c. Since we focus on the choice of the minority group, we write all the attributes as a single binary variable: $q_m = 1$ and $q_c = 0$. The *social norm* of each group $J \in \{m, c\}$ is determined by the "typical" attribute of the group J, which is given by $\overline{q}_J$, the average attribute of the group. Since q_i is a binary variable, $\overline{q}_m$ is equal to 1 while $\overline{q}_c$ is determined by the share of minority individuals who choose to identify themselves with group c, that is:

$$\bar{q}_J = \begin{cases} 1 & \text{if } J = m \\ \frac{\lambda\mu}{\lambda\mu+1-\mu} & \text{if } J = c \end{cases}.$$

where $\lambda\mu/(\lambda\mu + 1 - \mu)$ is the fraction of ethnic minorities among all individuals choosing to identify themselves with group c, i.e., those who assimilate to the majority group's identity. The perceived distance between each minority individual's attribute and the social norm of group J is then given by: $\ln D_J(\lambda) = \ln d(|q_m - \bar{q}_J|)$, where $d(\cdot)$ is an increasing function of $|q_m - \bar{q}_J|$. We also assume that: $d(0) = 1$, $d(1) = \bar{d} > 1$, and $d'(1) = 0$, which, in particular, implies that there is a maximum perceived distance at $\bar{d}$. Figure 2 depicts such a function for $J = c$:[6]

Figure 2: Perceived distance function



[6]In Figure 2, the perceived distance function is equal to: $\ln d(x) = \ln[3 - 2(x-1)^2]$, which satisfies all our assumptions, i.e., $d(0) = 1$, $d(1) = \bar{d} = 3$, and $d'(1) = 0$.

Hence, $D_J(\lambda)$ can be written as

$$D_J(\lambda) = \begin{cases} d(0) = 1 & \text{if } J = m \\ d\left(\frac{1-\mu}{\lambda\mu+1-\mu}\right) & \text{if } J = c \end{cases} . \tag{2}$$

This formulation thus assumes that, if an ethnic minority chooses to reject the majority's norm and thus lives in accordance to her own culture, her perceived distance is the lowest and equal to $\ln d(0) = 0$. On the contrary, if an ethnic minority chooses to assimilate to the majority's norm, there is a perceived distance between her norm and that of her group, which is always greater than $\ln d(0) = 0$ and which is increasing with $(1-\mu) / (\lambda\mu + 1 - \mu)$, the fraction of individuals from the majority group among all individuals adopting the social norm of the majority group. In particular, the higher is μ, the fraction of ethnic minorities in the population, the higher is $\ln D_c(\lambda)$, the perceived distance for assimilated ethnic minorities.

2.3.2 Group status

The last part of the utility function includes a component related to the *status* of the identified group as well as the perceptions of similarity to other group members. The status of the group is determined through comparisons to other groups (Tajfel and Turner, 1986). In our framework, the utility obtained from the group status is determined by the difference between $\overline{y}_J(\lambda) := y_J(\lambda)$, the average income of group J and $\overline{y}(\lambda) := (1-\lambda)\mu y_m(\lambda) + (\lambda\mu + 1 - \mu)\, y_c(\lambda)$, the average income of the population. Thus, an individual obtains a higher utility as her group members obtain higher incomes compared to the population (city) average level.

2.4 Utility function

Let us put the three parts of the utility function together. The utility function of an individual belonging to group m and identifying herself with group J is then equal to:

$$U_J(\lambda) = \alpha \ln \underbrace{y_J(\lambda)}_{\text{individual income}} - \delta \underbrace{\ln D_J(\lambda)}_{\text{perceived distance}} + \sigma \ln \underbrace{\frac{\overline{y}_J(\lambda)}{\overline{y}(\lambda)}}_{\text{relative status of group } J} \tag{3}$$

The first term of (3) represents the utility from own income, the second term captures the disutility from deviating from the social norm of the group (the perceived distance between each individual and the identified group) and the last term is the payoff from the relative status of the identified group. Moreover, α represents the weight put by each individual on her own income. We assume that α differs among minority individuals and is distributed over $[\underline{\alpha}, \overline{\alpha}]$; its cumulative distribution function (cdf) by $G(\alpha)$ and its density function is given by $g(\alpha)$. Thus, when an ethnic minority m considers to assimilate to the majority's norm, she will trade off a higher income, a higher perceived distance, which negatively affects her utility, and a higher status since $\overline{y}_c(\lambda) > \overline{y}_m(\lambda)$. This choice will also be affected by her α, i.e., the weight she put on her income in her utility function. Clearly, ethnic minorities with low (high) α will be less (more) likely to assimilate.

2.5 Equilibrium

Let us determine the equilibrium, which is referred here to as a *Social Identity Equilibrium*. We are looking here at a (pure-strategy) Nash equilibrium where the strategy of each player is her identity choice. Different equilibria can emerge.

Definition 1

(i) *An Assimilation Social Identity Equilibrium (ASIE) is when all minority individuals choose to totally assimilate to the majority group, i.e., all choose the identity of group c and $\lambda = 1$.*

(ii) *An Oppositional Social Identity Equilibrium (OSIE) is when all minority individuals totally reject the social norm of the majority group, i.e., all choose the identity of group m and $\lambda = 0$.*

(iii) *A Mixed Social Identity Equilibrium (MSIE) is when a fraction of minority individuals choose to identify themselves to group m while the other fraction choose to identify themselves to group c, i.e., $0 < \lambda < 1$.*

Since we study Nash equilibrium in identity choices, it is sufficient to check whether each individual decision is consistent with the social environment. In other words, an ethnic minority individual identifies herself with group c, i.e., assimilates to the majority's norm, if and only if $U_c(\lambda) > U_m(\lambda)$ and with group m, i.e., rejects the majority's norm, if and only if $U_m(\lambda) \geq U_c(\lambda)$. From (3), the condition $U_c(\lambda) > U_m(\lambda)$ can be written as:[7]

$$(\alpha + \sigma)\ln\frac{y_c(\lambda)}{y_m(\lambda)} > \delta \ln\frac{D_c(\lambda)}{D_m(\lambda)}. \tag{4}$$

We see here clearly the trade off she faces: by assimilating, she improves her relative income ($y_c(\lambda)/y_m(\lambda) > 1$) but also increases her relative (cultural) distance ($D_c(\lambda)/D_m(\lambda) > 1$). Because the left-hand side (LHS) of (4) is increasing in α while its right-hand side (RHS) is independent of α, any minority individual with a larger α is more likely to assimilate to the majority group than the one with a smaller α.[8] Define $\Gamma(\lambda;\alpha)$ as

$$\Gamma(\lambda;\alpha) \equiv (\alpha + \sigma)\ln\frac{y_c(\lambda)}{y_m(\lambda)} - \delta \ln\frac{D_c(\lambda)}{D_m(\lambda)}. \tag{5}$$

Proposition 1 *For a given λ, a minority individual will choose to identify herself with the group c and thus assimilates to the majority group if and only if $\Gamma(\lambda;\alpha) > 0$, and will identify herself with her own group, i.e., reject the majority's social identity, if and only if $\Gamma(\lambda;\alpha) \leq 0$*

In order to characterize the different possible equilibria, we need to determine the unique endogenous variable of this model, that is λ. For that, we differentiate $\Gamma(\lambda;\alpha)$ with respect to λ.

Lemma 2 *The higher is λ, the higher is $\Gamma(\lambda;\alpha)$, i.e. $\partial\Gamma(\lambda;\alpha)/\partial\lambda > 0$. Moreover, $\lim_{\mu\to 0}\partial\Gamma(\lambda;\alpha)/\partial\lambda = 0$.*

The first result implies that the higher is λ, the fraction of ethnic minorities who choose to assimilate to the majority's norm, the more likely ethnic minorities will assimilate to the majority's norm. In other words, there are *complementarities* in assimilation choices since someone is more likely to assimilate the higher is the fraction of individuals in the population that assimilate. This is because, when λ, the fraction of ethnic minorities who assimilate, increases, the relative income of assimilation, $y_c(\lambda)/y_m(\lambda)$, increases

[7] Observe that, in (4), $\overline{y}(\lambda)$, the average income of the population, disappears because it appears of both sides on the inequality.

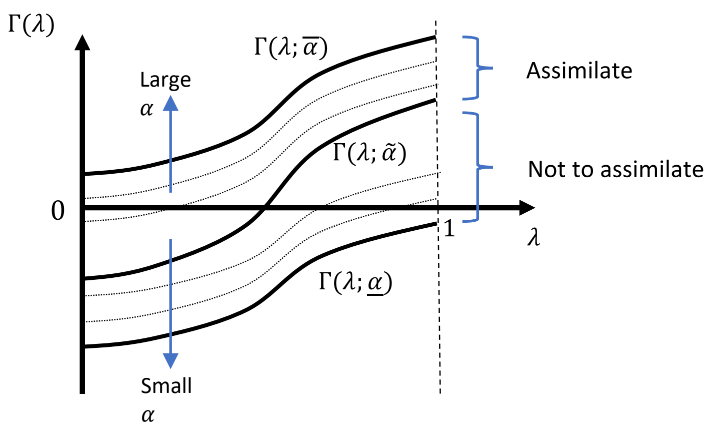
[8] All our results would be qualitatively the same if, instead of α, the heterogeneity of the ethnic minorities would have been in terms of δ or σ.

and $\ln D_c(\lambda) = \ln d(|q_m - \overline{q}_c|)$, the perceived distance between minority and majority groups decreases. The second result, $\lim_{\mu\to 0} \partial\Gamma(\lambda;\alpha)/\partial\lambda = 0$, means that λ has no impact on the decision to assimilate when the fraction of ethnic minorities becomes zero. This result hinges on the assumption that $d'(1) = 0$, i.e., the perceived distance reaches its lowest value when the perceived distance of assimilating is maximal.

This result is related to the cultural transmission literature (Bisin and Verdier, 2000, 2001), which shows that the higher is the fraction of children adopting a certain trait, the higher is the effort of their parents in transmitting this trait. Here, we have something that has the same flavor since the higher is λ, the fraction of individuals adopting the $c-$trait, the higher is the fraction of individuals adopting the $c-$trait. In the cultural transmission literature, this is referred to as *cultural complementarity.* Empirically, Bisin et al. (2016) have confirmed this positive relationship between λ and $\Gamma(\lambda;\alpha)$.

Because we readily know that $\partial\Gamma(\lambda;\alpha)/\partial\alpha > 0$, Proposition 1 implies that for a given λ, there exists a threshold value of α, denoted by $\widetilde{\alpha}$, such that a minority individual with α larger (smaller) than $\widetilde{\alpha}$ chooses to assimilate (not to assimilate) to the majority's norm. Figure 3 represents the assimilation decision.

Figure 3: Assimilation decision



Hence, the share of minority individuals who assimilate to the majority's norm is given by $1 - G(\widetilde{\alpha})$, which, in turn, determines λ. From (5), we have:

$$\begin{aligned}\Gamma(0;\alpha) &= (\alpha+\sigma)\ln\frac{f\left(1-\mu+\varepsilon\mu\right)}{f\left(\mu+\varepsilon\left(1-\mu\right)\right)} - \delta\ln\overline{d},\\ \Gamma(1;\alpha) &= (\alpha+\sigma)\ln\frac{f(1)}{f(\varepsilon)} - \delta\ln d\left(1-\mu\right).\end{aligned}$$

We can therefore summarize the equilibrium conditions as follows:

Proposition 2

(i) An Assimilation Social Identity Equilibrium (ASIE) is a 3-tuple $(\alpha^*, \lambda^*, \Gamma)$ *that satisfies* $\alpha^* = \underline{\alpha}$, $\lambda^* = 1$, *and* $\Gamma(1;\underline{\alpha}) > 0$.

(ii) An Oppositional Social Identity Equilibrium (OSIE) is a 3-tuple $(\alpha^*, \lambda^*, \Gamma)$ *that satisfies* $\alpha^* = \overline{\alpha}$, $\lambda^* = 0$, *and* $\Gamma(0;\overline{\alpha}) < 0$.

(iii) A Mixed Social Identity Equilibrium (MSIE) is a 3-tuple $(\alpha^*, \lambda^*, \Gamma)$ *that satisfies* $\lambda^* = 1 - G(\alpha^*)$ *and* $\Gamma(\lambda^*;\alpha^*) = 0$.

Moreover, we impose a stability condition in the sense that a small perturbation yields incentives that restore the economy to the original equilibrium. From the above proposition, the ASIE and OSIE are stable. However, in order for a MSIE to be stable, we need another condition. Because we readily know that both $\Gamma(\lambda;\widetilde{\alpha}) = 0$ and $\lambda = 1 - G(\widetilde{\alpha})$ are downward sloping in the λ–$\widetilde{\alpha}$ plane and $\Gamma(\lambda;\widetilde{\alpha}) = 0$ determines $\widetilde{\alpha}$ for a given λ whereas $\lambda = 1 - G(\widetilde{\alpha})$ determines λ once $\widetilde{\alpha}$ is given, MSIE is stable if and only if $\lambda = 1 - G(\widetilde{\alpha})$ is steeper than $\Gamma(\lambda;\widetilde{\alpha}) = 0$ at the intersection of these two curves. Moreover, such an intersection is unique if $\lambda = 1 - G(\widetilde{\alpha})$ is globally steeper than $\Gamma(\lambda;\widetilde{\alpha}) = 0$, that is

$$-\frac{1}{g(\widetilde{\alpha})} < -\frac{\partial\Gamma(\lambda;\widetilde{\alpha})/\partial\lambda}{\partial\Gamma(\lambda;\widetilde{\alpha})/\partial\widetilde{\alpha}}, \qquad \forall(\lambda,\widetilde{\alpha}) \in [0,1]\times[\underline{\alpha},\overline{\alpha}], \tag{6}$$

where the left-hand side is the slope of $\lambda = 1 - G(\widetilde{\alpha})$ while the right-hand side is the slope of $\Gamma(\lambda;\widetilde{\alpha}) = 0$ in the $\lambda - \widetilde{\alpha}$ plane. Note here that if the two curves have multiple intersections, there exist multiple (stable) equilibria.

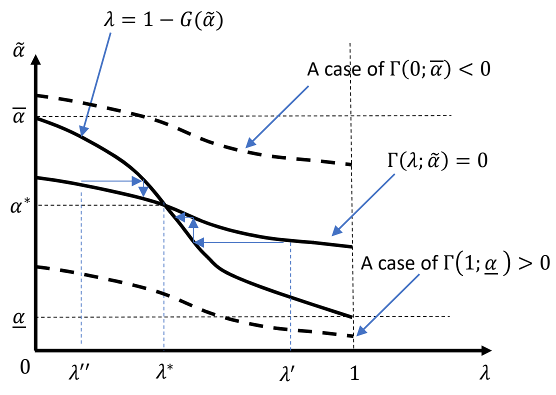
Given this result, in Figure 4, we are now able to describe all the possible equilibria. Figure 4(a) displays the case where condition (6) holds true so that there always exists a unique stable equilibrium. The two solid downward sloping curves are $\Gamma(\lambda;\widetilde{\alpha}) = 0$ and

$\lambda = 1 - G(\widetilde{\alpha})$ when $\Gamma(1;\underline{\alpha}) \le 0 \le \Gamma(0;\overline{\alpha})$, where the steeper one represents $\lambda = 1 - G(\widetilde{\alpha})$. We have positive $\Gamma(\lambda;\widetilde{\alpha})$ in a region above $\Gamma(\lambda;\widetilde{\alpha}) = 0$ and negative $\Gamma(\lambda;\widetilde{\alpha})$ in a region below $\Gamma(\lambda;\widetilde{\alpha}) = 0$. The intersection of the two curves, (λ^*, α^*) is a MSIE.

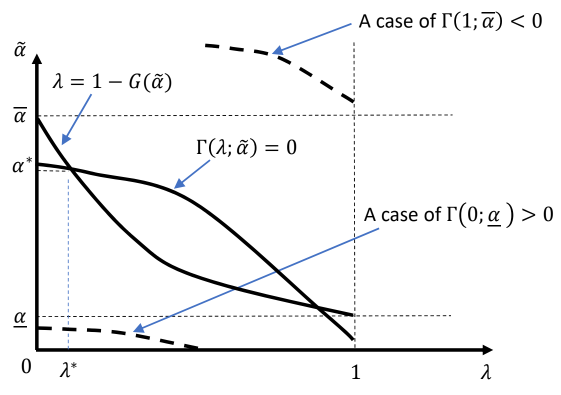
Now suppose the economy is hit by a shock and λ changes from λ^* to λ' (or λ''). Then, this leads to the fact that $\widetilde{\alpha}$ is determined by $\Gamma(\lambda;\widetilde{\alpha}) = 0$, which, in turn, pins down λ via $\lambda = 1 - G(\widetilde{\alpha})$. Such movements are represented by arrows in Figure 4(a). We can confirm that a perturbation induces changes that restore the original equilibrium. In Figure 4(a), we also describe the two other equilibria, ASIE and OSIE. The upper dashed curve represents the case of $\Gamma(0;\overline{\alpha}) < 0$, which results in an OSIE whereas the lower dashed line describes the case of $\Gamma(1;\underline{\alpha}) > 0$, which yields a ASIE.

Figure 4(b) depicts the case where condition (6) does not hold. Again, the two solid downward sloping curves are $\Gamma(\lambda;\widetilde{\alpha}) = 0$ and $\lambda = 1 - G(\widetilde{\alpha})$ when $\Gamma(0;\underline{\alpha}) \le 0 \le \Gamma(1;\overline{\alpha})$. The upper dashed-line curve represents the case when $\Gamma(1;\overline{\alpha}) < 0$, which results in an OSIE, whereas the lower dashed-line curve depicts the case when $\Gamma(0;\underline{\alpha}) > 0$, which yields a ASIE. If $\Gamma(0;\underline{\alpha}) \le 0 \le \Gamma(1;\overline{\alpha})$, there might exist multiple (stable) equilibria. In the figure, (λ^*, α^*) and ASIE are (stable) equilibria.

Figure 4: Different possible equilibria



(a) The condition (6) holds true.



(b) The condition (6) does not hold true.

The following proposition summarizes these findings.

Proposition 3

(i) *Suppose (6) holds true.*

- (ia) *If* $\Gamma(1;\underline{\alpha}) > 0$*, there exists a unique stable Assimilation Social Identity Equilibrium (ASIE) where all minority individuals totally assimilate to the majority group.*
- (ib) *If* $\Gamma(0;\overline{\alpha}) < 0$*, there exists a unique stable Oppositional Social Identity Equilibrium (OSIE) where all minority individuals identify themselves with their own group and reject the majority's norm.*
- (ic) *If* $\Gamma(1;\underline{\alpha}) \leq 0 \leq \Gamma(0;\overline{\alpha})$*, there exists a unique stable Mixed Social Identity Equilibrium (MSIE) in which the ethnic minorities with* $\alpha > \widetilde{\alpha}$ *assimilate to the majority group's norm whereas the ethnic minorities with* $\alpha < \widetilde{\alpha}$ *adopt the identity norm of their own group.*

(ii) *Suppose (6) does not hold true.*

- (iia) *If* $\Gamma(0;\underline{\alpha}) > 0$*, there exists a unique stable Assimilation Social Identity Equilibrium (ASIE) where all minority individuals totally assimilate to the majority group.*
- (iib) *If* $\Gamma(1;\overline{\alpha}) < 0$*, there exists a unique stable Oppositional Social Identity Equilibrium (OSIE) where all minority individuals identify themselves with their own group and reject the majority's norm.*
- (iic) *If* $\Gamma(0;\underline{\alpha}) \leq 0 \leq \Gamma(1;\overline{\alpha})$*, there exist multiple stable equilibria.*

This proposition provides the conditions under which each possible equilibrium can arise. In particular, we show under which conditions *oppositional cultures* among ethnic minorities can emerge, i.e., they may "choose" to adopt "oppositional" identities, that is, some actively reject the dominant majority behavioral norms while others totally assimilate to it. The novel aspect of this proposition is that these conditions crucially depend on five key parameters: α, σ, δ, μ and ε. In the next proposition, we focus on the impact of μ and ε on the emergence of each of these equilibria.

Proposition 4

(*i*) *When μ is sufficiently small, only an Oppositional Social Identity Equilibrium (OSIE) or an Assimilation Social Identity Equilibrium can (ASIE) emerge. As μ becomes larger, a Mixed Social Identity Equilibrium (MSIE) can also arise.*

(*ii*) *When ε is sufficiently small, all types of equilibrium can emerge. As ε increases, a unique Oppositional Social Identity Equilibrium (OSIE) is more likely to exist.*

The first result shows the importance of the size of the minority group (μ) on the assimilation process of ethnic minorities. When μ is very small, then either all minorities assimilate or they reject the majority's norm. However, as μ increases, more individuals assimilate (higher λ) and because there are positive spillovers between λ and the productivity of group c, a mixed equilibrium is more likely to emerge.

To understand the second result about ε (the productivity spillover effect), remember that when deciding their identity choice, ethnic minorities trade off the income gain of assimilation against its cultural cost in terms of perceived distance. When ε is very small, there is no much interaction between the two groups, but there is an important income gain of assimilation since $y_c(\lambda; \varepsilon = 0) > y_m(\lambda; \varepsilon = 0)$ but still a cost in terms of cultural distance. As a result, the ethnic minorities assimilate or reject the majority's norm depending on the income gains from assimilation and their α. When ε increases, this is not anymore true since the income ratio y_c/y_m decreases (see Lemma 1 and Figure 1(b)) but the perceived distance remains constant as it is not affected by ε. As a result, the ethnic minorities are more likely not to assimilate and thus to reject the majority's norm. At the limit, when $\varepsilon \to 1$, the income between the two groups becomes the same, i.e., $y_m = y_c$, and, thus, there is no benefit from assimilating to the majority's norm and, as a result, all ethnic minorities become "oppositional".

3 City structure and identity choices

3.1 The city

So far, we referred to the "city" in an abstract way. In this section, we formally model the city and its structure and analyze its impact on the assimilation process of ethnic minorities. Consider a linear monocentric city where all jobs are located in the unique Central Business District (CBD) and where housing areas are spread over the right-hand side of the CBD (located at zero).[9] We assume that each location is endowed with H units of land and that landlords are absentee.

All residents in the city must commute to the CBD in order to work and obtain a wage income, $y_{iJ}(\lambda)$, where i denotes the group the individual i belongs to ($i \in \{m, c\}$) and J represents her identity choice ($J \in \{m, c\}$). Because we only consider the assimilation choice of the minority group m, there are two incomes $y_{mm}(\lambda)$ and $y_{mc}(\lambda)$ for the minority group m and only one income $y_{cc}(\lambda)$ for the majority group c. Note here that we assume only one income level of majority individuals and minority individuals can obtain this income once they assimilate only for the expositional simplicity.[10]

From (1), we know that $y_{mc}(\lambda) = y_{cc}(\lambda) = \overline{y}_c(\lambda) = y_c(\lambda)$ and $y_{mm}(\lambda) = \overline{y}_m(\lambda) = y_m(\lambda)$. Remember that

$$y_c(\lambda) \geq y_m(\lambda),\ \forall\lambda \in [0,1] \text{ and } \forall\varepsilon \in [0,1]\,, \tag{7}$$

where the equality holds true if and only if $\varepsilon = 1$. In the following, we again focus on the case when $0 < \varepsilon < 1$.

3.2 Utility

In order to keep the analysis tractable, we assume that α takes only two values, α_h and α_l with $\alpha_h > \alpha_l$ for minority individuals and normalize the majority's α, which we denote by α_c, to one.[11] The share of minority individuals with α_h is exogenously fixed at $\gamma \in (0, 1)$. It should be clear that, if condition (4) holds for one minority individual with α_k, i.e., $\Gamma(\lambda; \alpha_k) > 0$, then it will hold for all minorities with α_k in the city, which implies that all minority individuals with α_k will choose to assimilate. Thus, if (4) holds true for

[9] For the detailed literature on the monocentric city models, see Fujita (1989) and Zenou (2009) among others.

[10] In Appendix C, we extend our model where we consider two different incomes (low and high-skilled) for the majority group while minorities obtain the same income as the low-skilled majority individuals only when they assimilate. We show that all our results remain unchanged. Because with two incomes, the formulas and the math become very messy, we have kept the analysis with one-income level from the majority group in the main text.

[11] We could have assumed that, even for the majority individuals, α takes two values. This would not change any of our main results.

both α_h and α_l at $\lambda = 1$, i.e., $\Gamma(1; \alpha_h) > 0$ and $\Gamma(1; \alpha_l) > 0$, there always exists a stable Assimilation Social Identity Urban Equilibrium (ASIUE) where all minority individuals totally assimilate to the majority group in the city.[12] Similarly, if the opposite is true for both α_h and α_l at $\lambda = 0$, i.e., $\Gamma(0; \alpha_h) < 0$ and $\Gamma(0; \alpha_l) < 0$, there always exists a stable Oppositional Social Identity Urban Equilibrium (OSIUE) where all minority individuals identify themselves with the minority group. Finally, because we will show below that $\Gamma(\lambda; \alpha_h) > \Gamma(\lambda; \alpha_l)$ and focus on the case where $\Gamma(\lambda; \alpha_k)$ is increasing in λ, a stable Mixed Social Identity Urban Equilibrium (MSIUE) with $\lambda^* = \gamma$ will exist if $\Gamma(\gamma; \alpha_h) \geq 0$ and $\Gamma(\gamma; \alpha_l) < 0$.[13] Of course, we might obtain multiple equilibria, i.e., for the same set of parameters, among the ASIUE, the MSIUE, and the OSIUE, at least two of these equilibria coexist simultaneously and are stable. From now on, we only focus on stable equilibria. Hence, for the ease of the presentation, we omit the expression "stable", i.e., whenever we write "ASIUE", "MSIUE" or "OSIUE", it means that these are stable equilibria.

Let us extend the baseline model by introducing the monocentric city structure. Because of consumption and commuting costs, there is a budget constraint for each individual iJ given by

$$y_{iJ}(\lambda) - tx = z_{iJ} + R(x)h_{iJ} \tag{8}$$

where z_{iJ} is a non-spatial composite good taken as the numéraire (whose price is normalized to 1), h_{iJ} is the housing consumption of each individual iJ in the city, $R(x)$ is the price of housing at each location x from the CBD, and t is the commuting cost per unit of distance.

The utility function (3) can now be written as a direct utility function that incorporates the non-spatial and the housing consumption. We have:

[12] We now add "Urban" in the definition of each equilibrium because we focus on the impact of the location of each agent on her assimilation choice.

[13] There may exist a MSIUE under other conditions but such a MSIUE is unstable. Indeed, since all ethnic minorities with the same α_k are identical ex ante in terms of α, then, at a MSIUE with $\Gamma(\lambda'; \alpha_h) = 0$ for a certain $\lambda' < \gamma$, a slight increase (decrease) in λ will push all ethnic minorities with α_h to assimilate to (to reject) the majority's norm and to converge to the stable MSIUE with $\lambda^* = \gamma$ (stable OSIUE). Furthermore, at a MSIUE with $\Gamma(\lambda'; \alpha_l) = 0$ for a certain $\lambda' > \gamma$, a slight increase (decrease) in λ will push all ethnic minorities with α_l to assimilate to (to reject) the majority's norm and to converge to the stable ASIUE (stable MSIUE with $\lambda^* = \gamma$). Similarly, at a MSIUE with $\Gamma(\lambda'; \alpha_l) = 0$ for a certain $\lambda' \leq \gamma$, a slight increase (decrease) in λ will push all ethnic minorities with α_l to assimilate to (to reject) the majority's norm and to converge to the stable ASIUE (stable OSIUE). We will not study such an unstable equilibrium. Note finally that a MSIUE with $\Gamma(\lambda'; \alpha_h) = 0$ for a certain $\lambda' > \gamma$ does not exist because the share of minority individuals with α_h is γ.

$$U_{iJ}(\lambda;\alpha_k) = \alpha_k\left[A + a\ln z_{iJ} + (1-a)\ln h_{iJ}\right] - \delta\ln D_{iJ}(\lambda) + \sigma\ln\frac{\overline{y}_J(\lambda)}{\overline{y}(\lambda)}, \tag{9}$$

where $\alpha_k = \alpha_h$ or α_l for a minority individual and $\alpha_k = \alpha_c = 1$ for a majority individual. $0 < a < 1$ is a constant and determines the weight put on the non-spatial composite good. We normalize $A := -[a\ln a + (1-a)\ln(1-a)]$ in order to simplify the exposition. Each individual iJ chooses h_{iJ} and z_{iJ} that maximize $U_{iJ}(\lambda)$ under the budget constraint (8). We obtain the following demand functions:

$$z_{iJ}(x,\lambda) = a(y_{iJ}(\lambda) - tx) \qquad \text{and} \qquad h_{iJ}(x,\lambda) = (1-a)\frac{(y_{iJ}(\lambda) - tx)}{R(x)} \tag{10}$$

We see, in particular, that, for a given income, if $R'(x) < 0$, i.e., housing prices decrease with the distance to the CBD, then individuals consume more housing the farther away they reside from the CBD. Plugging these demand functions into the direct utility function (9), we obtain the following indirect utility function:[14]

$$V_{iJ}(x,\lambda;\alpha_k) = \alpha_k\left[\ln\left(y_{iJ}(\lambda) - tx\right) - (1-a)\ln R(x)\right] - \delta\ln D_{iJ}(\lambda) + \sigma\ln\frac{\overline{y}_J(\lambda)}{\overline{y}(\lambda)}. \tag{11}$$

As it is standard in urban economics, city residents are assumed to relocate costlessly within the city. Therefore, there is no incentive for workers to relocate in equilibrium and all individuals of the same type should obtain the same (indirect) utility function. As a result, in equilibrium, all individuals of type mJ ($J \in \{m, c\}$) with α_k enjoy the same utility level: $V_{mJ}(x,\lambda;\alpha_k) = V_{mJ}(\lambda;\alpha_k)$, and all individuals of type c obtain the same utility level equal to: $V_{cc}(x,\lambda) = V_{cc}(\lambda)$.

3.3 Urban equilibria

In order to determine the equilibrium location of all individuals in the city, we use the standard concept of *bid rents* (Fujita, 1989; Zenou, 2009), which is defined as the maximum housing price each individual is willing to pay at each location x in order to obtain her equilibrium utility level. From (11), we obtain the bid rent $\Phi_{iJ}(x,\lambda)$ of an

[14] We defined A in a way that it cancels out the constant.

individual iJ as follows:

$$\Phi_{iJ}(x, \lambda; \alpha_k) = \exp\left[\frac{\alpha_k \ln(y_{iJ}(\lambda) - tx) - \delta \ln D_{iJ}(\lambda) + \sigma \ln(\overline{y}_J(\lambda)/\overline{y}(\lambda)) - V_{iJ}(\lambda)}{\alpha_k(1-a)}\right], \tag{12}$$

where again $\alpha_k = \alpha_h$ or α_l for a minority individual and $\alpha_k = \alpha_c = 1$ for a majority individual. The bid rent $\Phi_{iJ}(x, \lambda; \alpha_k)$ determines the location pattern in the city since absentee landlords will allocate land to the highest bidder at each location x. The market land rent $R(x)$ can then be written as:

$$R(x, \lambda) = \max\left[\Phi_{mm}(x, \lambda; \alpha_k), \Phi_{mc}(x, \lambda; \alpha_k), \Phi_{cc}(x, \lambda), \overline{R}\right], \tag{13}$$

where $\overline{R}$ is the agricultural land rent outside the city, which we normalize to one without loss of generality. Note that, because we normalize $\alpha_c = 1$, we don't explicitly express it in $\Phi_{cc}(x, \lambda)$. For a given λ (the fraction of minority individuals choosing to assimilate to the majority group), the five different equilibrium utility levels are determined by the bid rent equalization at the borders between the locations of the different types of agents. Moreover, the location of the edge of the city, $\bar{x}$, is determined by the population constraint condition:

$$\int_0^{\bar{x}} \frac{H}{h_{iJ}(x, \lambda)} dx = 1 \tag{14}$$

By denoting $\Gamma_{mon}(\lambda; \alpha_k) \equiv V_{mc}(\lambda; \alpha_k) - V_{mm}(\lambda; \alpha_k)$,[15] we can summarize the equilibrium conditions as follows.

Proposition 5

(i) *An Assimilation Social Identity Urban Equilibrium (ASIUE) is a 5-tuple* $(V_{iJ}^*, R^*(x), \bar{x}^*, \lambda^*, \Gamma_{mon}^*)$ *that satisfies (11), (13), (14),* $\lambda^* = 1$, *and* $\Gamma_{mon}^*(1; \alpha_k) > 0, \forall k$.

(ii) *An Oppositional Social Identity Urban Equilibrium (OSIUE) is a 5-tuple* $(V_{iJ}^*, R^*(x), \bar{x}^*, \lambda^*, \Gamma_{mon}^*)$ *that satisfies (11), (13), (14),* $\lambda^* = 0$, *and* $\Gamma_{mon}^*(0; \alpha_k) < 0, \forall k$.

(iii) *A Mixed Social Identity Urban Equilibrium (MSIUE) is a 5-tuple* $(V_{iJ}^*, R^*(x), \bar{x}^*, \lambda^*, \Gamma_{mon}^*)$ *that satisfies (11), (13), (14),* $\lambda^* = \gamma$, $\Gamma^*(\gamma; \alpha_h) \geq 0$, *and* $\Gamma^*(\gamma; \alpha_l) < 0$.

[15] The subscript "*mon*" refers to the "monocentric" city.

In order to derive $\Gamma_{mon}(\lambda;\alpha_k)$, we need to solve the land market equilibrium for a given λ. From (12), the slope of the bid rent with respect to the distance from the CBD, x, is

$$\frac{\partial \Phi_{iJ}(x,\lambda;\alpha_k)}{\partial x} = -\frac{t\Phi_{iJ}(x,\lambda;\alpha_k)}{(1-a)\,(y_{iJ}(\lambda)-tx)} < 0.$$

Indeed, we can see from (12) that the only variable that varies with distance is the commuting cost. Thus, individuals residing further away from the CBD need to be compensated in terms of housing prices. As a result, housing prices decrease with the distance x from the CBD.

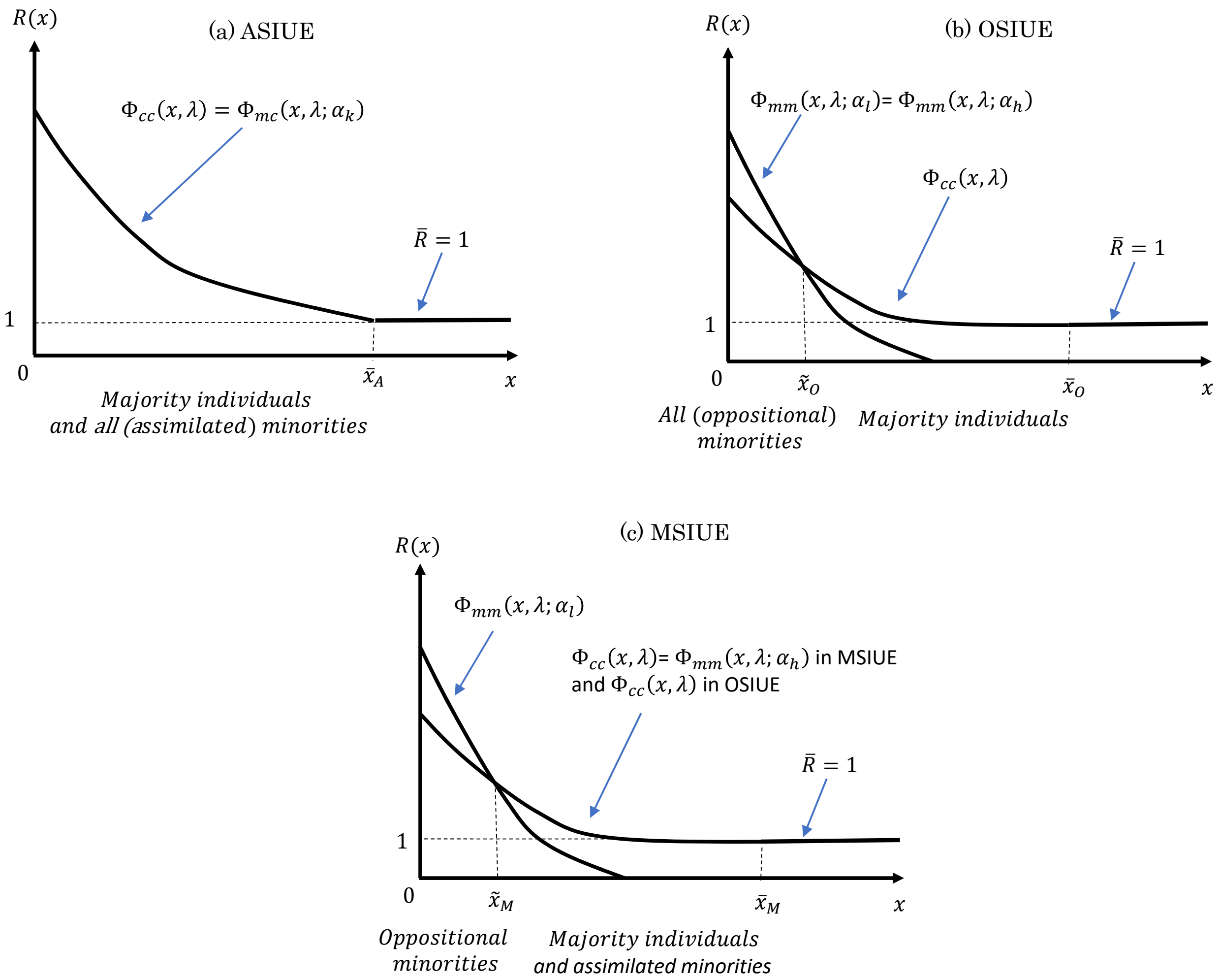
Proposition 6 *In any urban equilibrium, assimilated ethnic minorities and individuals from the majority group have the same bid rent, which means that they will reside in the same area of the city. Moreover, "oppositional" ethnic minorities will have a different and steeper bid rent and therefore will reside closer to the CBD than the majority individuals or the assimilated minorities.*

We show that, in any urban equilibrium, "oppositional" ethnic minorities (i.e., those who choose *not* to assimilate to the majority's norm) will reside close to the city center while assimilated ethnic minorities and majority individuals will reside in the same area of the city. Indeed, when an ethnic minority becomes assimilated, then, in terms of income, housing consumption, bid rent and thus location choice she is "identical" to someone from the majority group: their bid rents are exactly the same. As a result, they live together in the same area of the city. Moreover, since assimilated ethnic minorities and majority individuals have higher incomes than "oppositional" ethnic minorities (see (7)), they will consume more housing (see (10)) and thus will have flatter bid rents. As a result, they prefer to reside farther away from the center because the land is cheaper and they can live in larger houses.

From Proposition 5, we see that there are three possible urban equilibria, which are depicted in Figure 5.[16] In the Assimilation Social Identity Urban Equilibrium (ASIUE), all individuals (from the majority and minority groups) have the same bid rent and reside together (Figure 5 (a)). They all obtain the same utility level $V_{cc}^{*}=V_{mc}^{*}$ and all minorities assimilate to the majority's norm. There is no geographical segregation.

[16]The subscripts A, M, and O refer, respectively, to the ASIUE, the MSIUE, and the OSIUE.

Figure 5: Urban equilibria



In the Oppositional Social Identity Urban Equilibrium (OSIUE), all minorities who are oppositional reside close to the city center while all individuals from the majority groups live at the outskirts of the city (Figure 5 (b)). There is complete geographical segregation. Finally, in the Mixed Social Identity Urban Equilibrium (MSIUE), a fraction $1-\gamma$ of ethnic minorities, who have chosen to be oppositional, reside at the vicinity of the CBD while a fraction γ of ethnic minorities, who have chosen to be assimilated, live at the periphery of the city with individuals from the majority group (Figure 5 (c)). There is thus partial segregation.[17]

[17]Observe that, in our model, the (perceived) distance to the social norm does *not* depend on where an individual chooses to live. For example, in the 19th and 20th century in America, it was very common for different ethnic groups to live in different neighborhoods (Polish, Italian, Greek, etc.; see e.g. Biavaschi et al., 2019), but they would all work together on the factory floor. In such an environment,

Let us now study the process of identity choices (assimilation to or rejection of the majority's norm). Let us derive $\Gamma_{mon}(\lambda;\alpha_k) = V_{mc}(\lambda;\alpha_k) - V_{mm}(\lambda;\alpha_k)$. Since the urban structure is relatively simple with only two different areas in the city, in Appendix B, we are able derive the equilibrium values of all endogenous variables defined in Proposition 5. Now, by using (B.2), we can write $\Gamma_{mon}(\lambda;\alpha_k)$ as

$$\begin{aligned} \Gamma_{mon}(\lambda;\alpha_k) &= V_{mc}(\lambda;\alpha_k) - V_{mm}(\lambda;\alpha_k) \\ &= \alpha_k \ln\left(\frac{y_c(\lambda) - t\tilde{x}}{y_m(\lambda) - t\tilde{x}}\right) + \sigma \ln \frac{y_c(\lambda)}{y_m(\lambda)} - \delta \ln D_{mc}(\lambda). \end{aligned} \quad (15)$$

where, as shown by (B.1), $\tilde{x}$ is a function of λ. As λ, the share of the minority individuals who assimilate increases, $y_c(\lambda)$ increases whereas $y_m(\lambda)$ decreases (see Lemma 1). Note first that $\Gamma_{mon}(\lambda;\alpha_k)$ is increasing in α_k, implying that $\Gamma_{mon}(\lambda;\alpha_h) > \Gamma_{mon}(\lambda;\alpha_l)$. We know from (B.1) that when λ increases, the residential area $\tilde{x}$ of the "oppositional" ethnic minorities becomes smaller, resulting in a decrease in total commuting costs, $t\tilde{x}$. As a result, the effect of an increase in λ on the relative net income $\ln\left(\frac{y_c(\lambda)-t\tilde{x}}{y_m(\lambda)-t\tilde{x}}\right)$ is ambiguous. Thus, we assume that the effect of an increase in λ on income is larger than that on commuting costs, and the net income of the minority individuals who do not assimilate, $y_m(\lambda) - t\tilde{x}$, is decreasing in λ.[18] Under this assumption, we obtain

$$\frac{\partial \Gamma_{mon}(\lambda;\alpha_k)}{\partial \lambda} > 0,$$

which leads to the following proposition:

an individual could face a different social norm in the neighborhood (smaller perceived distance) and at work (larger perceived distance). In other words, an individual could integrate professionally but segregate residentially. In our model, there is a *social norm in the workplace* since when someone decides to assimilate, she interacts more with the majority group and thus gets a higher income compared to someone who does not assimilate. It is a social norm because it means that your assimilation decision affects with whom you interact in the workplace. There is also another social norm, which is the perceived distance between your identity choice (assimilate or not) and the average identity decision of your ethnic group. However, in our model, the latter is not spatially localized and thus it is not a *social norm in the neighborhood*.

[18] Sufficient conditions for this to hold true depend on the specification of the production function $f(\cdot)$. If we specify it as $f(x) = x^\sigma, 0 < \sigma < 1$, a sufficient condition is given by

$$t(1-a)[\varepsilon + (1-\varepsilon)(1-\lambda)\mu] < \sigma(1-\varepsilon)[H + t - t\mu(1-\lambda)],$$

which requires that the land endowment H is sufficiently large.

Proposition 7

(*i*) *If (a)* $\Gamma_{mon}(1;\alpha_l) > 0$*, there exists an Assimilation Social Identity Urban Equilibrium (ASIUE) where all minority individuals totally assimilate to the majority group. In that case, there is "urban integration" since both minority and majority individuals have the same bid rent and reside in the same areas of the city (Figure 5 (a)).*

(*ii*) *If (b)* $\Gamma_{mon}(0;\alpha_h) < 0$*, there exists an Oppositional Social Identity Urban Equilibrium (OSIUE) where all minority individuals identify themselves with their own group and reject the majority's norm. In that case, there is "urban segregation" since all ethnic minorities reside close to the CBD while all majority individuals reside at the periphery of the city (Figure 5 (b)).*

(*iii*) *If (c)* $\Gamma_{mon}(\gamma;\alpha_h) \geq 0$ *and* $\Gamma_{mon}(\gamma;\alpha_l) < 0$*, there exist a Mixed Social Identity Urban Equilibrium (MSIUE) where minority individuals with* α_h *assimilate to the majority group and minority individuals with* α_l *identify themselves with their own group and reject the majority's norm. In that case, there is "partial urban segregation" since a part of ethnic minorities reside close to the CBD while all majority individuals and assimilated minority individuals reside at the periphery of the city (Figure 5 (c)).*

(*iv*) *If at least two of (a), (b), and (c) hold true, then there exist multiple equilibria where, among the ASIUE, the MSIUE, and the OSIUE, at least two of these equilibria coexist simultaneously.*

This proposition characterizes the conditions under which each urban equilibrium exists. Figure 6 describes these equilibria, where the horizontal and vertical axes represent λ and Γ_{mon}, respectively. Figure 6 (0) shows the loci of $\Gamma_{mon}(\gamma;\alpha_h)$ and $\Gamma_{mon}(\gamma;\alpha_l)$ while Figures 6 (1) to 6 (10) describe all the possible equilibrium patterns. In particular, Figures 6 (1) and (2) display the case of a unique OSIUE, Figure 6 (4) depicts the case of a unique MSIUE, and Figures 6 (9) and (10) show the case of a unique ASIUE. Multiple equilibria prevail in the remaining figures.

Observe that, in Proposition 7, case (*iv*), multiple equilibria can prevail and it is unclear which ethnic group obtains the highest utility level. Indeed, if we compare the equilibrium utility of "oppositional" minorities (Figure 5 (b)) with that of assimilated minorities Figure 5 (a)), the former have a lower social or cultural distance with respect to their culture of origin but obtain a lower income than the latter. Moreover, the land rents are different and the total commuting costs are lower for the "oppositional" than the assimilated minorities. In other words, in this model, it is unclear if urban segregation is harmful or beneficial to ethnic minorities.

Note here that Proposition 7 does not deal with uniqueness of equilibrium. If we impose additional conditions, we can then obtain the uniqueness of equilibrium as follows:

Remark 1 *Consider Proposition 7.*

$(i)'$ *If, apart from (a),* $\Gamma_{mon}(0;\alpha_h) > 0$ *and* $\Gamma_{mon}(\gamma;\alpha_l) > 0$ *also hold in* (i)*, then there exists a* ***unique*** *Assimilation Social Identity Urban Equilibrium (ASIUE).*

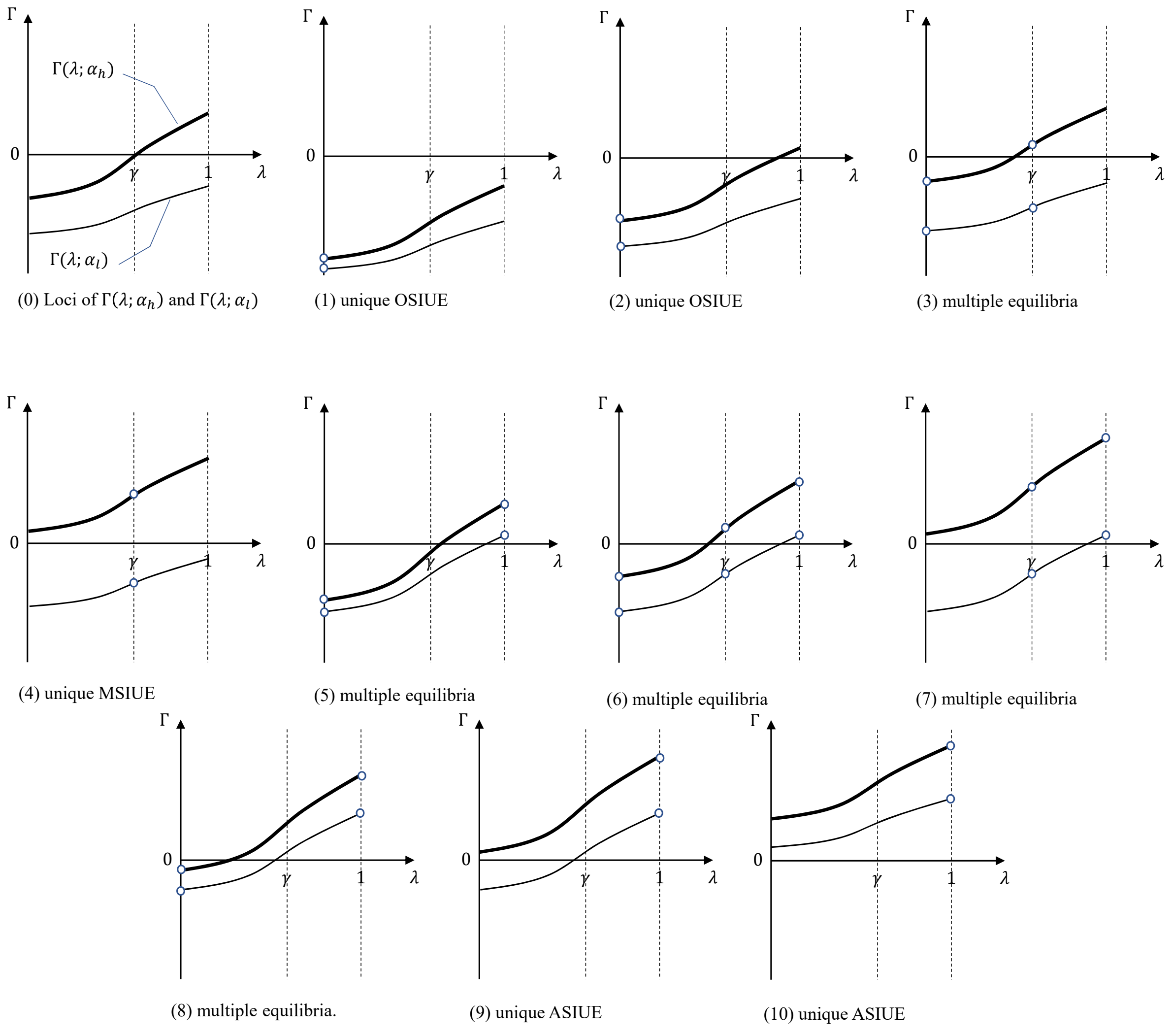
$(ii)'$ *If, apart from (b),* $\Gamma_{mon}(\gamma;\alpha_h) < 0$ *and* $\Gamma_{mon}(1;\alpha_l) < 0$ *also hold in* (ii)*, then there exists a* ***unique*** *Oppositional Social Identity Urban Equilibrium (OSIUE).*

$(iii)'$ *If, apart from (c),* $\Gamma_{mon}(0;\alpha_h) > 0$ *and* $\Gamma_{mon}(1;\alpha_l) < 0$ *also hold in* (iii)*, then then there exists a* ***unique*** *Mixed Social Identity Urban Equilibrium (MSIUE).*

Our model also shows that ethnic minorities in segregated areas (the OSIUE) perform worse in terms of outcomes such as income than in less segregated areas (the ASIUE). We show that this is due to the fact that, when they reject the majority's norm, they reside in segregated areas and are paid a lower income because of lower productivity due to the lack of interaction with the majority group. However, as discussed above, this does not imply that "oppositional" minorities have a lower utility. In Section 3.5 below, we will investigate in detail this issue.

In our framework, urban factors are agglomeration economies described by the function representing productivity, $f(\cdot)$, and the monocentric city structure. The former determines the nominal income of ethnic minorities given the ethnic minority's assimilation decision whereas the latter determines the disposable income given the nominal income. Assimilation decision is based on three terms: the utility from the numéraire and housing consumption, the disutility from the perceived distance, and the utility from the social status. The first term is determined by the disposable income, and the third term

Figure 6: Equilibrium possibilities



is determined by the nominal income. The second term depends on the share of assimilated minority individuals. Hence, the urban factors affect the ethnic minority's incentive to assimilate via the first and third terms, the assimilation decision then determines the nominal income via $f(\cdot)$, and the disposable income via the monocentric city structure. Put differently, the urban factors and the assimilation decision depend on each other and must be simultaneously determined.

3.4 City structure and comparative statics results

Let us now investigate how the city structure affects the two different equilibria, ASIUE and OSIUE. In particular, we study the effect of the commuting cost t and housing supply H on $\Gamma_{mon}(1;\alpha_k)$ and $\Gamma_{mon}(0;\alpha_k)$. We focus on the effects on ASIUE and OSIUE because the effects on MSIUE are mostly ambiguous. The ambiguity comes from the fact that $\Gamma_{mon}(\lambda;\alpha_h)$ and $\Gamma_{mon}(\lambda;\alpha_l)$ move in the same direction. Indeed, suppose, for instance, that a particular parameter change shifts them upwards in the $\lambda - \Gamma$ plane. Then, from Figure 6, we know that the possibility of $\Gamma_{mon}(\gamma;\alpha_h) > 0$ increases, which increases the likelihood of the MSIUE, but the possibility of $\Gamma_{mon}(\gamma;\alpha_l)$ also increases, which decreases the likelihood of the MSIUE and increases the likelihood of the ASIUE. Hence, although we can state that such a change induces the minority individuals to assimilate, we are not sure about the effect on the MSIUE.

Proposition 8 *The commuting cost t and the space available for housing H in the city do not affect the Assimilation Social Identity Urban Equilibrium (ASIUE) where all minority individuals totally assimilate to the majority group in the city (Figure 5 (a)). On the contrary, a lower t or a higher H makes the Oppositional Social Identity Urban Equilibrium (OSIUE) more likely to emerge (Figure 5 (b)).*

A lower commuting cost t increases the net income of workers whereas a higher H enables individuals to consume land at a more reasonable price. Both decrease the utility difference between the assimilated and "oppositional" minorities. This, in turn, decreases the ethnic minority's incentive to assimilate, making the OSIUE more likely to emerge. This is an interesting and counterintuitive result showing that a policy that reduces transportation cost decreases rather than increase assimilation in cities.

The following proposition provides some comparative statics results for the other parameters of the model.

Proposition 9 *A higher ε (spillover effects in production) or δ (weight on perceived distance) makes the OSIUE more likely to emerge whereas a higher σ (weight on relative income) makes the ASIUE more likely to emerge. Moreover, a higher μ (fraction of minorities in the population) makes multiple equilibria more likely to emerge. Finally, a (weight on non-spatial good) neither affects the ASIUE nor the OSIUE.*

The effects of ε, the productivity spillover effect and μ, the fraction of ethnic minorities in the population on equilibrium are similar to those shown in Proposition 4. When ε increases, the income ratio y_{mc}/y_{mm} decreases but the perceived distance remains constant as it is not affected by ε. As a result, ethnic minorities are more likely *not* to assimilate and to reject the majority's norm. As μ increases, more individuals assimilate (higher λ) and because there are positive spillovers between λ and the productivity of group c, multiple equilibria are more likely to emerge. A higher δ implies higher costs from perceived distance, making ethnic minorities less likely to assimilate. In contrast, a higher σ implies higher gains from belonging to a social group with high income, which raises the incentive to assimilate.

3.5 Assimilation versus non-assimilation

We know from Proposition 7 that, under some condition (see part (*iv*) of this proposition), there exist multiple equilibria where at least two of the ASIUE, the MSIUE, and OSIUE coexist. We need, therefore, to better understand the differences between these three equilibria. As shown in Figure 5 (a), in the Assimilation Social Identity Equilibrium (ASIUE), the minority and majority individuals live together in mixed areas whereas, in the Mixed Social Identity Equilibrium (MSIUE) and Oppositional Social Identity Equilibrium (OSIUE), oppositional minority and majority individuals reside in segregated areas (Figures 5 (b) and (c)). These very different urban structures lead to distinct city sizes and land rents. Define the total land rent TLR in a city as the sum of all housing prices paid by the residents of the city times the supply of land H. We have the following result:

Proposition 10 *The city in the Assimilation Social Identity Equilibrium (ASIUE; Figure 5 (a)) is larger, i.e., $\bar{x}_A > \bar{x}_O$, and the total land rent is higher, i.e., $TLR_A > TLR_O$, than in the city in the Oppositional Social Identity Equilibrium (OSIUE; Figure 5 (b)). Moreover, the city in the ASIUE is larger, i.e., $\bar{x}_A > \bar{x}_M$, and the total land rent is higher, i.e., $TLR_A > TLR_M$, than in the city in the Mixed Social Identity Equilibrium (MSIUE; Figure 5 (c)). In other words, integrated cities are bigger and more expensive than segregated cities.*

We obtain these results because the total income of ethnic minorities and majority individuals are higher in the ASIUE than in the OSIUE (or in the MSIUE). This is due, in particular, to the fact that assimilated minorities obtain a larger income than "oppositional" minorities. As a result, these individuals are able to pay higher housing prices, which increase total land rent in the ASIUE. Also, since land is a normal good, because of higher income, assimilated minorities consume more land, which increases the size of the city. Hence, the city size and the total land rents are larger in the ASIUE than in the OSIUE (or in the MSIUE). Note, however, that we cannot obtain a clear-cut result when comparing the MSIUE and the OSIUE because, even if the majority and assimilated minority individuals obtain a higher income in the MSIUE compared to the OSIUE, the oppositional minority individuals earn less in the MSIUE than in the OSIUE.

When there are multiple equilibria, we would now like to know under which equilibrium the ethnic minorities and the majority individuals are better off. Because this is in general ambiguous, we now resort to numerical analysis. We specify the productivity and perceived distance function, $f(\cdot)$ and $d(\cdot)$ as follows:

$$\begin{aligned} f(L) &= \theta L^{\beta}, \\ \ln d(x) &= \ln[\overline{d} - (\overline{d} - 1)(x-1)^2]. \end{aligned}$$

where $\theta > 0$ and $\beta > 0$ capture the baseline productivity level in the city and the degree of agglomeration economies, respectively. For the baseline case, we set the parameter values as follows: $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$. It is easily verified that, under these parameter values, we obtain multiple equilibria, i.e., $\Gamma_{mon}(1; \alpha_l) = 0.015 > 0$, $\Gamma_{mon}(0; \alpha_h) = -0.067 < 0$, $\Gamma_{mon}(\gamma; \alpha_h) = 0.020 > 0$, and $\Gamma_{mon}(\gamma; \alpha_l) = -0.029 < 0$

(Proposition 7, part (iv)).

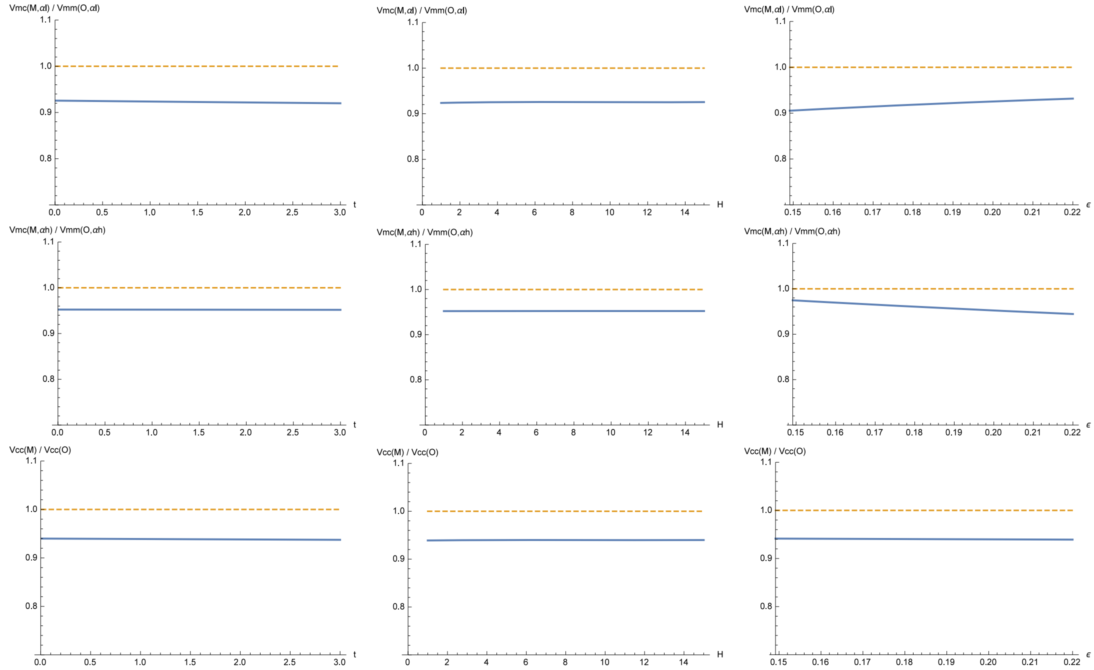
Also, if we compare the equilibrium utilities, we find that, in the ASIUE, $V_{mc}(A;\alpha_h) = 0.882$, $V_{mc}(A;\alpha_l) = 0.608$, and $V_{cc}(A) = 0.988$, and in the OSIUE, $V_{mm}(O;\alpha_h) = 0.922$, $V_{mm}(O;\alpha_l) = 0.687$, and $V_{cc}(O) = 1.075$, whereas, in the MSIUE, $V_{mc}(M;\alpha_h) = 0.878$, $V_{mm}(M;\alpha_l) = 0.635$, and $V_{cc}(M) = 1.010$.[19] So, basically, in this example, both the majority individuals and ethnic minorities are better off in the segregated equilibrium OSIUE. This shows, in particular, that, even if they obtain a lower income, ethnic minorities can be better off by rejecting the majority's norm and spatially segregating themselves from the majority group because their cultural distance with their own group is quite small

Let us now perform some comparative statics exercises by changing a parameter within a range under which the above inequalities regarding Γ_{mon} hold true and examine how it affects the equilibrium utility difference between the two equilibria.

In the *upper panel* of Figures 7a and 7b, we evaluate how a change of a given parameter affects $V_{mc}(M;\alpha_l)/V_{mm}(O;\alpha_l)$, which is the utility difference for ethnic minorities with α_l between assimilating in the MSIUE (where the utility is $V_{mc}(M;\alpha_l)$ and $\lambda^* = \gamma$) and rejecting the majority's norm in the OSIUE (where the utility is $V_{mm}(O;\alpha_l)$ and $\lambda^* = 0$).

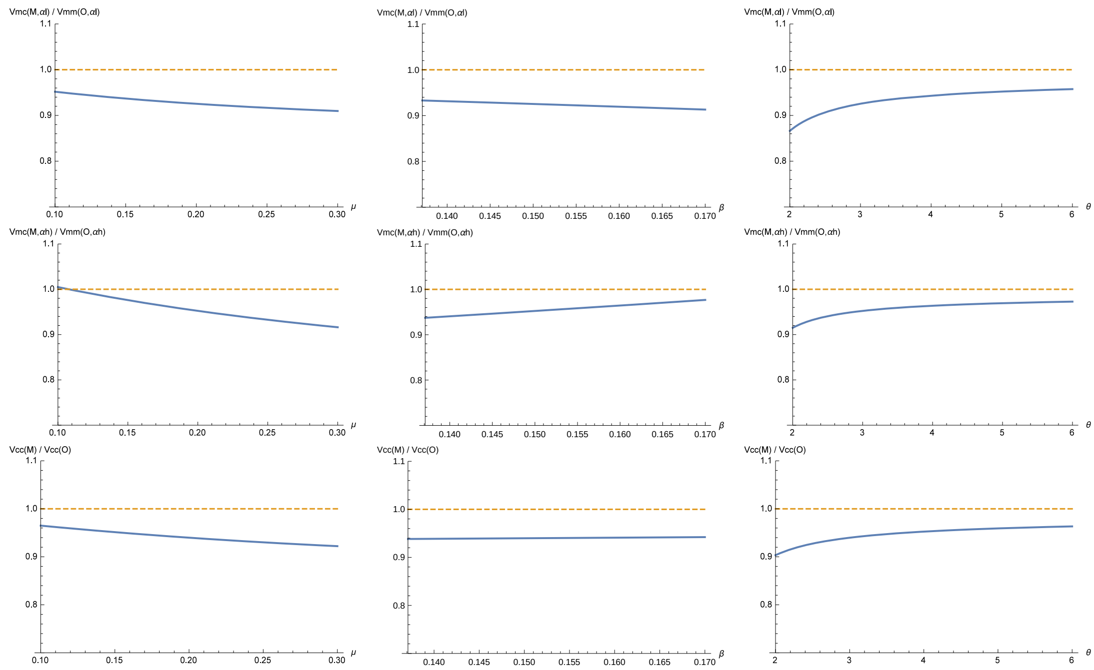
[19] For the sake of the presentation, $V_{mc}(\lambda^A;\alpha_h) := V_{mc}(A;\alpha_h)$, $V_{mm}(\lambda^O;\alpha_h); = V_{mm}(O;\alpha_h)$, $V_{mc}(\lambda^M;\alpha_h) := V_{mc}(M;\alpha_h)$, etc., where A refers to equilibrium ASIUE, O refers to equilibrium OSIUE and M refers to equilibrium MSIUE.

Figure 7a: Utility difference between MSIUE and OSIUE



(1) Effects of changes in t (2) Effects of changes in H (3) Effects of changes in ε

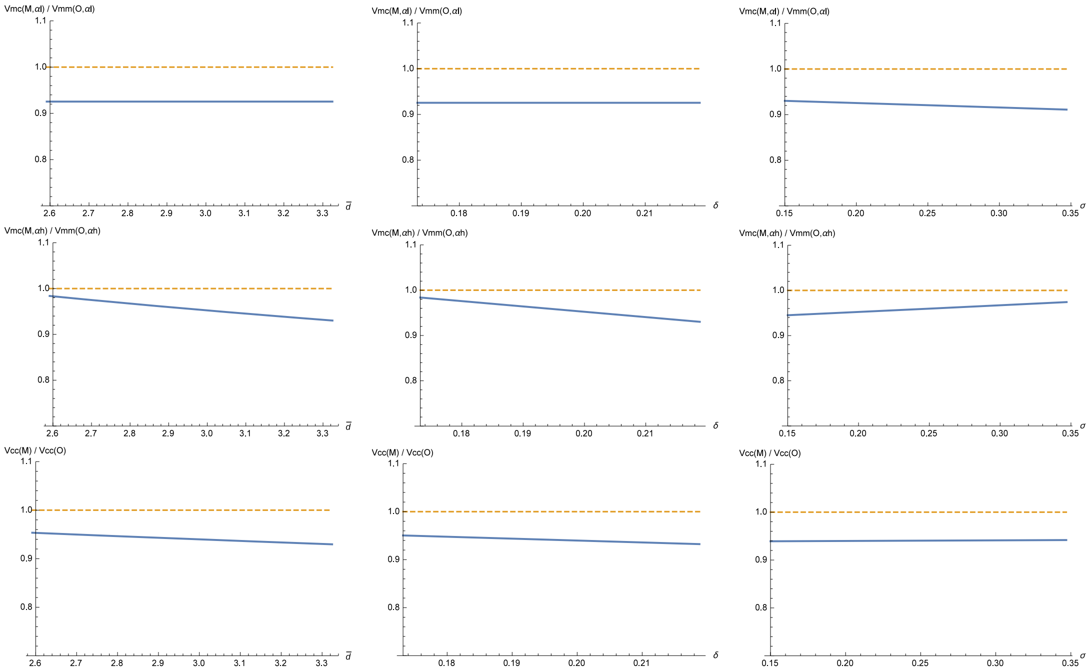
Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.



(4) Effects of changes in μ (5) Effects of changes in β (6) Effects of changes in θ

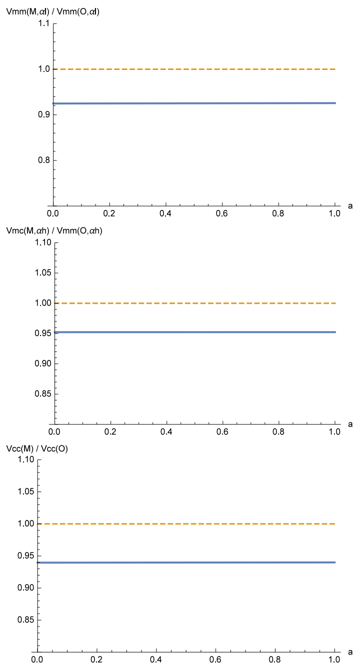
Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.

Figure 7b: Utility difference between MSIUE and OSIUE



(7) Effects of changes in $\overline{d}$ (8) Effects of changes in δ (9) Effects of changes in σ

Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.



(10) Effects of changes in a

Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.

In the *upper panel* of Figures 8a and 8b, we evaluate how a change of a given parameter affects $V_{mc}(A; \alpha_l)/V_{mm}(M; \alpha_l)$, which is the utility difference for ethnic minorities with α_l between assimilating in the ASIUE (where the utility is $V_{mc}(A; \alpha_l)$ and $\lambda^* = 1$) and assimilating in the MSIUE (where the utility is $V_{mc}(M; \alpha_l)$ and $\lambda^* = \gamma$), respectively. The dashed (yellow) line corresponds to a value of $V_{mc}(M; \alpha_l)/V_{mm}(O; \alpha_l)$ or $V_{mc}(A; \alpha_l)/V_{mm}(M; \alpha_l)$ equal to 1 so that ethnic minorities with α_l are indifferent in terms of utility between the two equilibria. The solid (blue) curve represents the real value of $V_{mc}(M; \alpha_l)/V_{mm}(O; \alpha_l)$ or $V_{mc}(A; \alpha_l)/V_{mm}(M; \alpha_l)$. Therefore, if the solid curve is above (below) the dashed line, then $V_{mc}(M; \alpha_l) > V_{mm}(O; \alpha_l)$ or $V_{mc}(A; \alpha_l) > V_{mm}(M; \alpha_l)$ ($V_{mc}(M; \alpha_l) < V_{mm}(O; \alpha_l)$ or $V_{mc}(A; \alpha_l) < V_{mm}(M; \alpha_l)$), and ethnic minorities with α_l in the MSIUE are better off (worse off) than in the OSIE or ethnic minorities with α_l in the ASIUE are better off (worse off) than in the MSIE. In the *middle and lower panels*, we perform the same exercise, but for the ethnic minorities with α_h and majority individuals, respectively.[20]

In Figures 7a(1) and 8a(1), we consider changes in the commuting cost t, and in Figures 7a(2) and 8a(2), we consider changes in the space available for housing H in the city. First, as in the baseline model, both ethnic minorities and individuals from the majority group are always better off in the segregated equilibrium OSIE than in the mixed equilibrium MSIUE whatever the values of t and H. Second, while the minority individuals with α_h is indifferent between the assimilated equilibrium ASIUE and the MSIUE, the other two groups of individuals are better off in the MSIUE than in the ASIUE. Third, a higher t always yields a lower utility for both minorities and majority individuals whereas a higher H raises utility for both of them. In Proposition 8, we showed that a lower t or a higher H makes the OSIE more likely to emerge. Hence, a decrease in t or an increase in H decreases the minorities's and majorities' utility in the OSIUE compared to that in the ASIUE although it increases the possibility of the OSIUE. These results suggest that investment in transportation infrastructure or land development might induce spatial and social segregation between ethnic minorities and individuals from the majority group despite the fact that it increases the desirability for integration.

Figures 7a(3) and 8a(3) perform the same exercises for ε, the productivity spillover

[20] We do not compare the difference in utility between the OSIUE and the ASIUE because it can be deduced from the difference in utility between the OSIUE and the MSIUE and between the MSIUE and the ASIUE.

parameter, and Figures 7a(4) and 8a(4) do it for μ, the fraction of ethnic minorities in the population. A larger ε implies that there are more productive interactions between members of group c (i.e., majority and assimilated minorities) and group m (oppositional minorities). This reduces the productivity gains from assimilation of ethnic minorities and results in a lower relative utility for both ethnic groups. If we consider Figures 7a(3) and 8a(3), for low values of ε, ethnic minorities are better off by assimilating while, for higher value of ε, they are better off by rejecting the majority's norm. For the individuals from the majority group, they are always better off in the segregated equilibrium since spillover effects only affect the assimilation decision of the ethnic minorities.

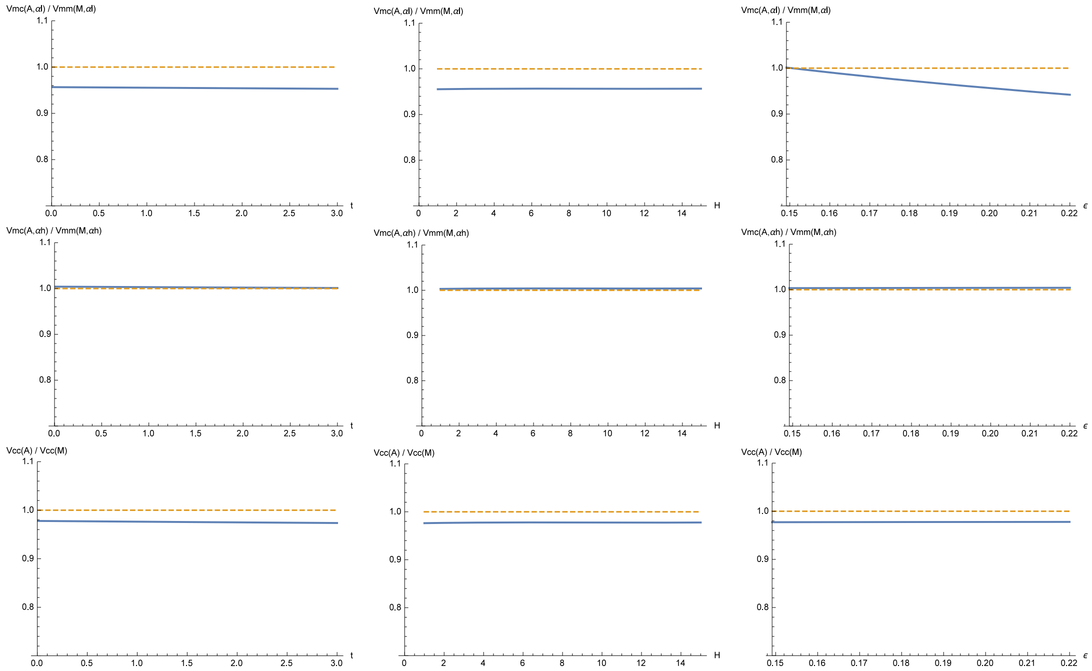
When μ increases, the size of ethnic population becomes larger, which implies that ethnic minorities face smaller disutility from perceived distance. Moreover, productivity gains from minorities's assimilation becomes smaller for minorities and larger for majority individuals. Hence, an increase in μ decreases the minorities' relative utility. This is why for low value of μ, ethnic minorities are better off assimilating while the opposite is true when μ becomes larger.

Figures 7a(5) and 8a(5) look at the change in β, the degree of agglomeration economies and Figures 7a(6) and 8a(6) look at the change in θ, the baseline productivity level in the city. A higher β or θ increases the benefits from minorities' assimilation and thus increases the relative utility for both ethnic groups. Also, as we know from (A.2) and (A.3), a higher β or θ makes the ASIUE more likely to emerge.

Figures 7b(7) and 8b(7), 7b(8) and 8b(8), and 7b(9) and 8b(9) study how a change in $\overline{d}$, the upper bound of the perceived distance, δ, the level of disutility for a given perceived distance, and σ, the level of utility for a given relative status of one's group, affects the utility difference between the two equilibria. When $\overline{d}$ or δ increases, the utility difference between the ASIUE and OSIUE increases because the benefits from assimilation is reduced. On the contrary, an increase in σ, increases the gains from social status for minorities but decreases them for the majority group, yielding a higher relative utility for minorities but a lower relative utility for the majority group.

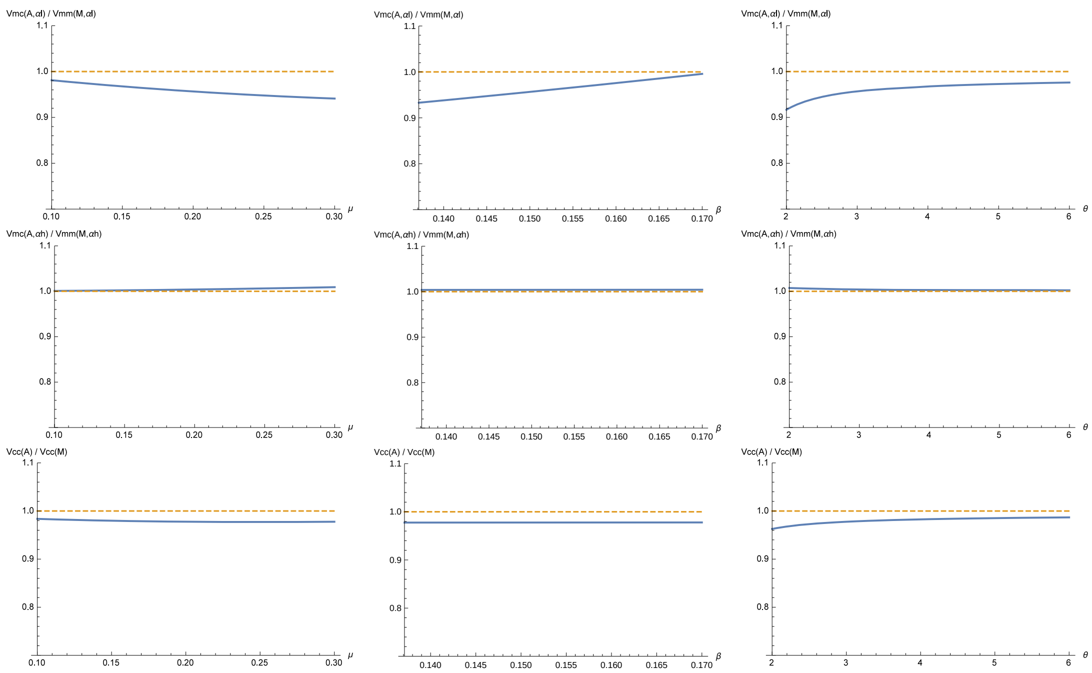
Finally, Figures 7b(10) and 7b(10) display the impact of a, the weight put on the non-spatial composite good, on relative utility. We see that a does not affect the utility difference so that all agents are better off under the segregated equilibrium OSIUE.

Figure 8a: Utility difference between ASIUE and MSIUE



(1) Effects of changes in t (2) Effects of changes in H (3) Effects of changes in ε

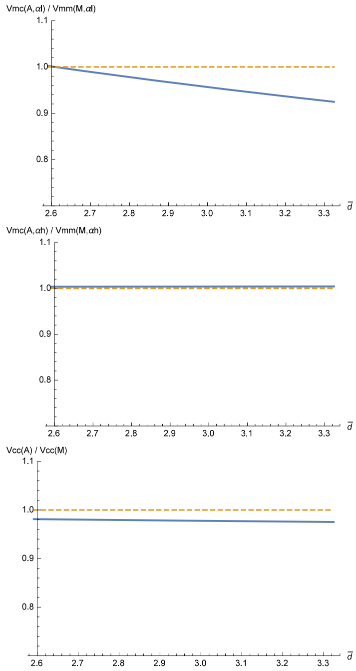
Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.



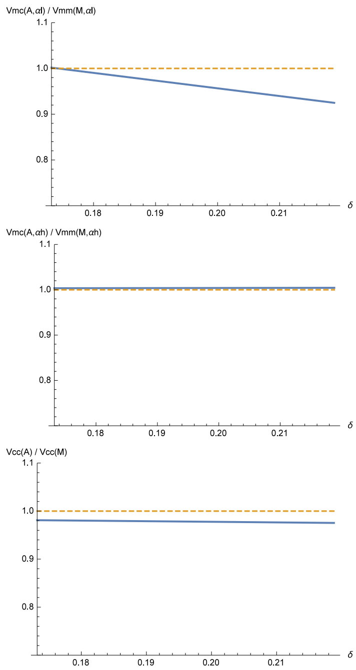
(4) Effects of changes in μ (5) Effects of changes in β (6) Effects of changes in θ

Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.

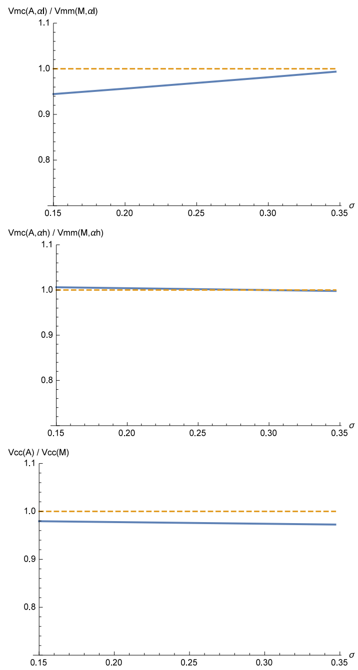
Figure 8b: Utility difference between ASIUE and MSIUE



(7) Effects of changes in $\overline{d}$

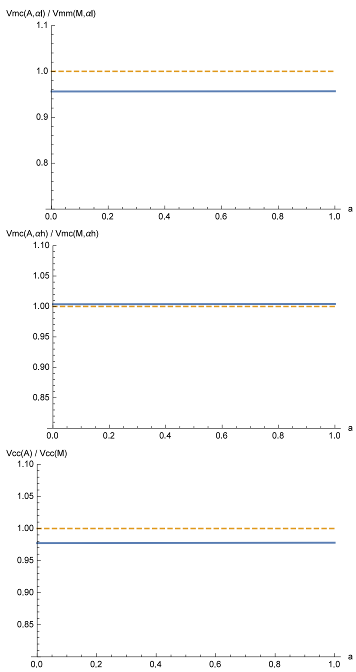


(8) Effects of changes in δ



(9) Effects of changes in σ

Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.



(10) Effects of changes in a

Notes: In the baseline case, we set $a = 0.75$, $\beta = 0.15$, $\overline{d} = 3$, $\delta = 0.2$, $\varepsilon = 0.2$, $H = 10$, $\mu = 0.2$, $\sigma = 0.2$, $t = 0.1$, $\theta = 3$, $\gamma = 2/3$, $\alpha_h = 1$, and $\alpha_l = 3/4$.

4 Evidence of our results

We have different new results in this paper. We would now like to see if we can find some empirical evidence of our main results. Note that, in this paper, our main focus is on the theoretical analysis and not on the empirical analysis. Hence, it is beyond the scope of this paper to conduct a full-fledged empirical analysis, and, therefore, here, we only present the results of existing empirical papers and simple facts (correlations) supporting our results.

Result 1 (Lemma 1): *Assimilated minority workers tend to earn a higher wage than less assimilated minority workers and an increase in the size of the minority group increases the income of the oppositional minority workers and reduces the income of the assimilated minority workers.*

There are different ways of empirically measuring assimilation of ethnic minorities and immigrants. The standard measure is the intermarriage rate, i.e., the fraction of minorities marrying individuals from the native population. Another measure of assimilation is the name change or the name chosen by minorities for their offsprings.[21]

In terms of evidence, Meng and Gregory (2005) have shown that, indeed, intermarried immigrants, earn significantly higher incomes than endogamously married immigrants, even after human capital endowments and endogeneity of intermarriage are taken into account.

Using a different definition of assimilation, in the United States, Biavaschi et al. (2017) find that low-skilled migrants who Americanized their names experienced larger occupational upgrading than those who did not. Similarly, Arai and Skogman Thoursie (2009) examine data on immigrants who changed their surnames to Swedish-sounding or neutral names during the 1990s in Sweden. They find that there is a substantial increase in annual earnings after a name change.

Finally, Li (2013) also provides evidence of Lemma 1. Li defines two markets: the *majority market* where the language of communication is the majority language and the *minority market* where the language of communication is the minority language. In the language of our model, we say that a minority is *assimilated* if he/she chooses to work

[21] For example, Watkins and London (1994) study the name-changing behavior of Jewish and Italian immigrants to the United States in the early 1900s and observe a pattern of assimilation to common American names.

in the majority market and is *oppositional* if he/she chooses to work in the minority market. Using the 2001 Canadian Census Public Use Microdata on individuals, in Table 2, Li shows that assimilated minority workers earn as much as the majority workers while oppositional minority workers earn less than assimilated and majority workers.

Furthermore, in Table 4, Li shows that the income of the oppositional minority group increases with the size of the minority group (μ in our model) but decrease with an increase in the size of the majority group ($1 - \mu$ in our model).

Result 2 (Proposition 6): *Poor minority households (here oppositional minorities who earn low wages) reside close to the city center while richer minority households residing further away from the CBD in the suburbs.*

This is a standard result which is usually observed in American cities where poor African Americans tend to live close to city centers while middle to upper class African Americans as well as white workers reside at the periphery of the city (Fischer, 2003; Glaeser et al., 2008; Ross and Rosenthal, 2015).

Result 3 (Proposition 7): *Ethnic minorities in segregated areas (OSIUE) perform worse in terms of outcomes such as income than in less segregated areas (ASIUE). Moreover, in segregated cities, minorities assimilate less.*

The first result has empirically been investigated by Cutler and Glaeser (1997) who show that segregation is bad for ethnic minorities in the sense that blacks in more segregated areas have significantly worse outcomes (such as economic performance) than blacks in less segregated areas.[22]

There is less systematic evidence for the second result. Cuison Villazor (2018) investigates the link between residential segregation and interracial marriage rates (i.e., assimilation rates) in the United States. There is a lot of variation since some cities have high interracial marriage rates while others fall way below the national rate. For instance, cities with the highest rates of interracial marriage include Honolulu, Hawaii (42 percent), Las Vegas, Nevada (31 percent), and Santa Barbara, California (30 percent) (Livingston, 2017). The cities with the lowest rates of interracial marriage include Birmingham, Alabama (6 percent), and Jackson, Mississippi (3 percent) (Livingston, 2017). Cuison Villazor (2018) performs a comparative analysis of two cities with high interracial

[22]For more recent evidence, see Graham (2018).

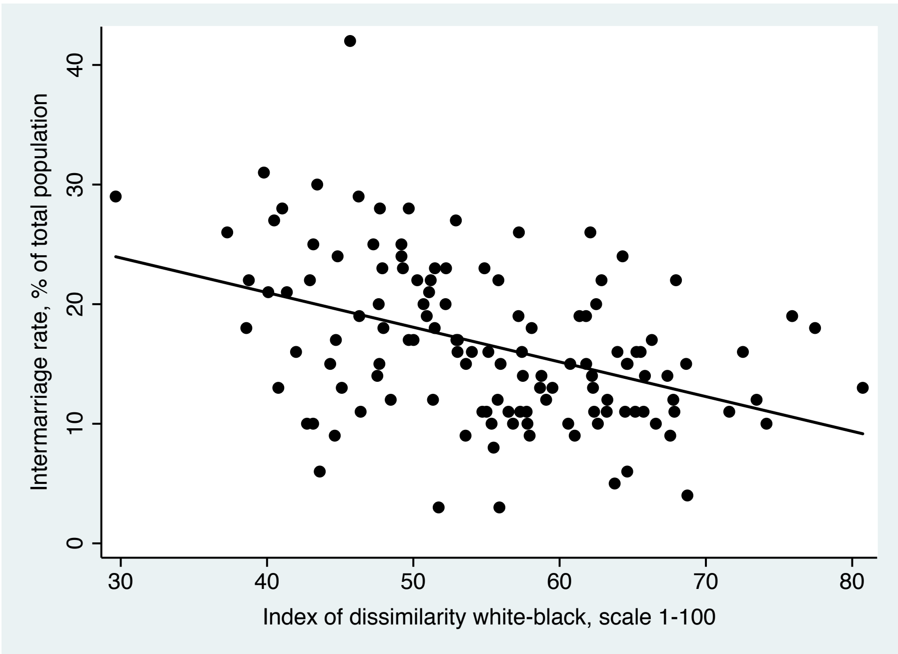
marriage rates— Las Vegas and Santa Barbara—and the cities with the lowest interracial marriage rates—Birmingham and Jackson. The results suggest *a negative correlation between racially segregated neighborhoods and interracial marriage rates.* In other words, *more racial segregation leads to less assimilation.* Indeed, Jackson and Birmingham have more racially segregated neighborhoods and communities, unlike cities with higher rates of interracial marriage than Las Vegas and Santa Barbara.

Because this analysis has only been done for four cities, we have run our own correlations between segregation (measured by the Dissimilarity Index)[23] and inter-marriage rates for 126 metropolitan areas in the United States.[24] Figure 9 displays the results. We see a clear negative correlation between segregation and assimilation. Table 1, column (1) reports the OLS regression between these two variables. We observe that it is negative and significant: an increase of 10% in segregation decreases the intermarriage rate in cities by 2.9% .

[23]The Dissimilarity Index (DI) is a widely used measure of segregation in social science research (Iceland et al., 2002). It varies between 0 and 1. In a perfectly integrated city, each neighborhood's racial composition will mirror that of the city as whole and thus $DI = 0$. In a perfectly segregated city, no minority shares a neighborhood with a White, so that $DI = 1$. More generally, the Dissimilarity Index equals "the city-wide proportion of minority residents who would need to move in order to achieve perfect integration, relative to the proportion that would need to move under a status quo of perfect segregation" (Graham, 2018).

[24]We have the information of the inter-marriage rates for only 126 metropolitan areas. See: https://www.pewsocialtrends.org/interactives/intermarriage-across-the-u-s-by-metro-area/.

Figure 9: Relationship between segregation and assimilation in the United States



Sources: Pew Research Center analysis of 2011-2015 American Community Survey (IPUMS), US Census, and authors' calculations.
Notes: Assimilation is measured by the intermarriage rate, which is defined as the percentage of the population that is married to a person of another race. The measure for Segregation is the Dissimilarity Index between black and white populations across census tracts within a MSA.

Table 1: OLS regression results

Dependent variable	(1) Assimilation$_i$	(2) Segregation$_i$	(3) Segregation$_i$	(4) Segregation$_i$
Segregation$_i$	-0.290***			
	(0.056)			
Ln Land Area$_i$		1.835***		1.468***
		(0.574)		(0.567)
Public transport$_i$			0.928***	0.853***
			(0.193)	(0.194)
Constant	32.563***	37.776***	49.816***	39.070***
	(3.127)	(4.279)	(0.582)	(4.189)
N	126	381	381	381
R^2	0.180	0.026	0.057	0.074

Sources: Pew Research Center analysis of 2011-2015 American Community Survey (IPUMS), US Census, and authors' calculations.
Notes: Assimilation is measured by the intermarriage rate, which is defined as the percentage of the population that is married to a person of another race. The measure for Segregation is the Dissimilarity Index between black and white populations across census tracts within a MSA. Land Area is the total land area of a MSA in square miles. Public transport is defined as the percentage of workers aged 16 years and over use public transport to commute to work. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Result 4 (Proposition 8): *Better transportation (or lower commuting costs) increase the likelihood of segregation, i.e., the equilibrium $OSIUE$ is more likely to emerge.*

To the best of our knowledge, there is no direct empirical test of this result. We have therefore run our own analysis between transportation (measured by the percentage of workers aged 16 years and over use public transport to commute to work) and segregation for all the 381 metropolitan areas in the United States.[25] Figure 10a displays the results. We see a clear *positive* correlation between transportation and segregation. Because of Figure 9 that shows a negative correlation between segregation and assimilation, this means that, in cities with better transportation, minority individuals tend to assimilate less because they are more segregated, as predicted by Proposition 8. Furthermore, Table 1, column (3) reports the OLS regression between transportation and segregation. We observe that it is positive and significant: an increase of 10% in transportation increases segregation in cities by 9.28%. Of course, there is no causal relationship between these two variables but, at least, it indicates that the prediction of our model is not rejected since

[25] As stated above, the intermarriage rate in cities (our measure of assimilation) is only available for 126 MSAs while, the dissimilarity index (our measure of segregation) is available for all the 381 MSAs.

cities with better public transportation (where individuals use more public transportation) tend to be more segregated.

In terms of our model, this negative relationship between transportation and segregation suggest that investment in transportation infrastructure might induce spatial segregation between ethnic minorities and individuals from the majority group, which, in turn, leads ethnic minority individuals to assimilate less.

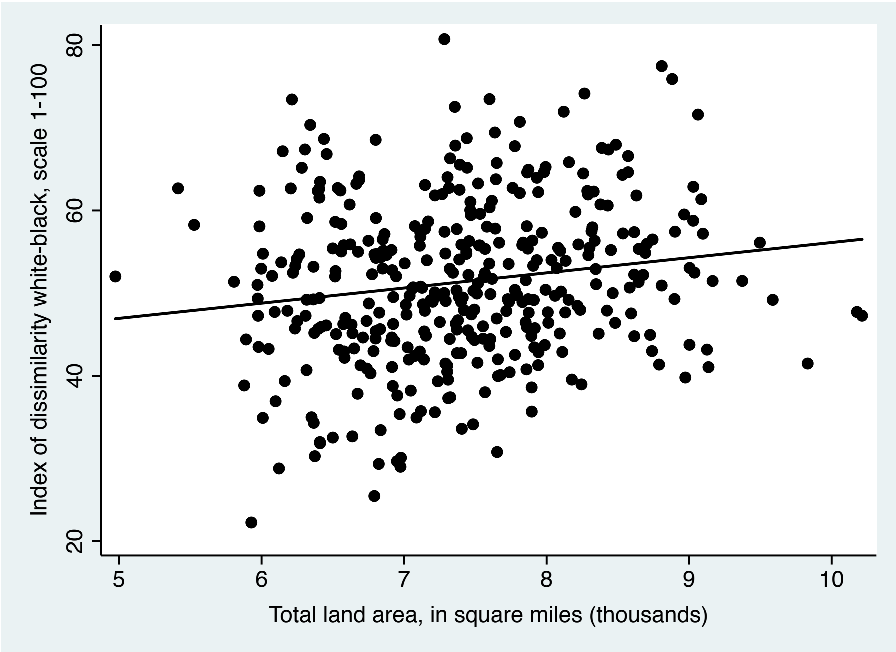
Figure 10a: Relationship between transportation and segregation in the United States

Sources: US Census, and authors' calculations.
Notes: The measure for Segregation is the Dissimilarity Index between black and white populations across census tracts within a MSA. Public transport is defined as the percentage of workers aged 16 years and over use public transport to commute to work.

Result 5 (Proposition 8): *Cities with greater land availability (more supply of land) or larger area tend to have more segregation, i.e., the equilibrium $OSIUE$ is more likely to emerge.*

To the best of our knowledge, there is also no direct empirical test of this result. Therefore, we have again run our own analysis between land area (measured by the total land area of a metropolitan statistical area (MSA) in square miles) and segregation for the 381 metropolitan areas in the United States. Figure 10b displays the results. We see there is a positive correlation between land area and segregation, which is confirmed by Table 1, column (2), which shows that the relationship is positive and significant. In Table 1, column (4), we put both variables (transportation and land area) together and the effects are unchanged.

Figure 10b: Relationship between land area and segregation in the United States



Sources: US Census, and authors' calculations.
Notes: The measure for Segregation is the Dissimilarity Index between black and white populations across census tracts within a MSA. Land Area is the total land area of a MSA in square miles.

Result 7 (Proposition 8): *Ethnic minorities tend to assimilate more in bigger and more expensive cities (higher housing prices).*

There is evidence from Livingston and Brown (2017) that this is true. First, this report documents that about 18% of those living in a metropolitan areas are married to someone of a different race or ethnicity, compared with 11% of those living outside of a metropolitan area. Second, 8% of newlyweds in metropolitan areas were intermarried, compared with 5% of those in non-metropolitan areas.

According to this study, there are likely many reasons that intermarriage is more common in metropolitan areas than in more rural areas. Attitudinal differences may play a role. In urban areas, 45% of adults say that more people of different races marrying each other is a good thing for society, as do 38% of those living in suburban areas. Among people living in rural areas, fewer (24%) share this view.

In our model, this is due to the fact that the total income of ethnic minorities and majority individuals are higher in the spatially integrated Assimilation Social Identity Equilibrium (ASIUE) than in the spatially segregated Oppositional Social Identity Equilibrium (OSIUE). In particular, assimilated minorities earn a higher income than oppositional ones and, thus, are able to pay higher housing prices and consume more land, which increases the size of the city.

5 Concluding remarks

In this paper, we develop a model in which ethnic minorities may choose to adopt "oppositional" identities, that is, some actively reject the dominant ethnic norms while others totally assimilate to them. We show that three types of equilibria may emerge: An Assimilation Social Identity Equilibrium (ASIE), in which all minority individuals choose to totally assimilate to the majority group, an Oppositional Social Identity Equilibrium (OSIE), in which all minority individuals totally reject the social norm of the majority group, and a Mixed Social Identity Equilibrium (MSIE), in which a fraction of minority individuals assimilate while the other fraction choose to be "oppositional". We provide conditions under which each equilibrium exists and is unique and investigate the properties of each equilibrium.

We then extend this model by introducing the urban space where all individuals are embedded in. The benefits of assimilation are in terms of higher income while the costs are due to the higher perceived distance between this assimilation choice of ethnic minorities and the norms of their culture of origin. We show how residential location affects the assimilation process of ethnic minorities and why people who are "oppositional" tend to reside in segregated areas around the CBD away from the location of the majority group. We also demonstrate that segregation is bad in terms of economic outcomes but not necessary in terms of welfare.

As highlighted in the Introduction, many people blame immigrants for not assimilating to the majority's norm because they keep some of the values of their culture of origin. In this paper, we tried to fathom the way ethnic minorities assimilate or reject the majority's norm and how these choices affect or are affected by their residential location. This is a first stab at a very complex issue and we hope to see more research on this in the future.

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Appendix

A Proofs

Proof of Lemma 1: The incomes are defined by (1), which we reproduce here:

$$y_m(\lambda) = f\left((1-\lambda)\mu + \varepsilon\left(\lambda\mu + 1 - \mu\right)\right),$$
$$y_c(\lambda) = f\left(\lambda\mu + 1 - \mu + \varepsilon\left(1-\lambda\right)\mu\right).$$

Denote $N_c \equiv \lambda\mu + 1 - \mu + \varepsilon(1-\lambda)\mu$ and $N_m \equiv (1-\lambda)\mu + \varepsilon(\lambda\mu + 1 - \mu)$ and remember that $f'(.) > 0$, $f''(.) < 0$, $0 < \mu < 1/2$ and $0 \leq \varepsilon \leq 1$.

(i) It is easily verified that:

$$y_c(0) = f\left(1 - \mu\left(1-\varepsilon\right)\right) > f\left(\varepsilon + \mu\left(1-\varepsilon\right)\right) = y_m(0),$$

$$y_c(1) = f\left(1\right) > f\left(\varepsilon\right) = y_m(1).$$

For $\varepsilon \in (0,1)$**,** by differentiating (1), we obtain:

$$\frac{\partial y_m(\lambda)}{\partial \lambda} = -f'\left(N_m\right)\mu\left(1-\varepsilon\right) < 0 \text{ and } \frac{\partial^2 y_m(\lambda)}{\partial \lambda^2} = f''\left(N_m\right)\mu^2\left(1-\varepsilon\right)^2 < 0,$$

$$\frac{\partial y_c(\lambda)}{\partial \lambda} = f'\left(N_c\right)\mu\left(1-\varepsilon\right) > 0 \text{ and } \frac{\partial^2 y_c(\lambda)}{\partial \lambda^2} = f''\left(N_c\right)\mu^2\left(1-\varepsilon\right)^2 < 0.$$

Finally,

$$\frac{\partial\left(y_c(\lambda)/y_m(\lambda)\right)}{\partial \lambda} = \frac{f'\left(N_c\right)\mu\left(1-\varepsilon\right)y_m(\lambda) + f'\left(N_m\right)\mu\left(1-\varepsilon\right)y_c(\lambda)}{\left[y_m(\lambda)\right]^2} > 0.$$

(ii) It is easily verified that:

$$y_c(\lambda;\varepsilon=0) = f\left(\lambda\mu + 1 - \mu\right) > f\left((1-\lambda)\mu\right) = y_m(\lambda;\varepsilon=0),$$

$$y_c(\lambda;\varepsilon=1) = f\left(1\right) = y_m(\lambda;\varepsilon=1).$$

For $\varepsilon \in (0,1)$, by differentiating (1), we obtain:

$$\frac{\partial y_m(\lambda)}{\partial \varepsilon} = f'(N_m)(\lambda\mu + 1 - \mu) > 0 \text{ and } \frac{\partial^2 y_m(\lambda)}{\partial \varepsilon^2} = f''(N_m)(\lambda\mu + 1 - \mu)^2 < 0,$$

$$\frac{\partial y_c(\lambda)}{\partial \varepsilon} = f'(N_c)(1-\lambda)\mu > 0 \text{ and } \frac{\partial^2 y_c(\lambda)}{\partial \varepsilon^2} = f''(N_c)(1-\lambda)^2 \mu^2 < 0.$$

We also have:

$$\frac{\partial (y_c(\lambda)/y_m(\lambda))}{\partial \varepsilon} = \frac{f'(N_c)\, y_m(\lambda)\,[(1-\lambda)\mu] - f'(N_m)\, y_c(\lambda)(\lambda\mu + 1 - \mu)}{[y_m(\lambda)]^2}.$$

Since $f'(N_c) < f'(N_m)$[1], $y_m(\lambda) < y_c(\lambda)$, $\forall \lambda \in [0,1]$, and $(1-\lambda)\mu < \lambda\mu + 1 - \mu$, then $\partial (y_c(\lambda)/y_m(\lambda))/\partial \varepsilon < 0$.

(iii) Finally, by differentiating (1), we obtain:

$$\frac{\partial y_m(\lambda)}{\partial \mu} = f'(N_m)(1-\lambda)(1-\varepsilon) > 0 \text{ and } \frac{\partial^2 y_m(\lambda)}{\partial \mu^2} = f''(N_m)(1-\lambda)^2(1-\varepsilon)^2 < 0,$$

$$\frac{\partial y_c(\lambda)}{\partial \mu} = -f'(N_c)(1-\lambda)(1-\varepsilon) < 0 \text{ and } \frac{\partial^2 y_c(\lambda)}{\partial \mu^2} = f''(N_c)(1-\lambda)^2(1-\varepsilon)^2 < 0.$$

Furthermore,

$$\frac{\partial (y_c(\lambda)/y_m(\lambda))}{\partial \mu} = \frac{-f'(N_c)(1-\lambda)(1-\varepsilon)\, y_m(\lambda) - f'(N_m)(1-\lambda)(1-\varepsilon)\, y_c(\lambda)}{[y_m(\lambda)]^2} < 0.$$

This proves all the results. ∎

Proof of Lemma 2: $\Gamma(\lambda;\alpha)$ is defined as:

$$\begin{aligned}\Gamma(\lambda;\alpha) &\equiv (\alpha+\sigma)\ln\frac{y_c(\lambda)}{y_m(\lambda)} - \delta \ln \frac{D_c(\lambda)}{D_m(\lambda)} \\ &= (\alpha+\sigma)\ln\frac{f(N_c)}{f(N_m)} - \delta \ln d(P),\end{aligned}$$

[1] Indeed, since $N_c > N_m$ and $f''(.) < 0$, then $f'(N_c) < f'(N_m)$.

where

$$
\begin{aligned}
N_c &\equiv \lambda\mu + 1 - \mu + \varepsilon(1-\lambda)\mu, \\
N_m &\equiv (1-\lambda)\mu + \varepsilon(\lambda\mu + 1 - \mu), \\
d\left(P\right) &\equiv \frac{D_c(\lambda)}{D_m(\lambda)} \text{ where } P \equiv \frac{1-\mu}{\lambda\mu + 1 - \mu}.
\end{aligned}
$$

Let us differentiate $\Gamma(\lambda;\alpha)$ with respect to λ. We obtain:

$$
\frac{\partial\Gamma(\lambda;\alpha)}{\partial\lambda} = (\alpha+\sigma)(1-\varepsilon)\mu\left(\frac{f'(N_c)}{f(N_c)} + \frac{f'(N_m)}{f(N_m)}\right) + \frac{\delta\lambda d'(P)(1-\mu)}{d(P)\left(\lambda\mu+1-\mu\right)^2} > 0,
$$

and

$$
\lim_{\mu\to 0}\frac{\partial\Gamma(\lambda;\alpha)}{\partial\lambda} = \frac{\delta\lambda d'(1)}{d(1)} = \frac{\delta\lambda}{\overline{d}}d'(1) = 0.
$$

This completes the proof. ▮

Proof of Proposition 4: To prove this proposition, we state the following lemma:

Lemma A3

(i) *The higher is μ, the fraction of minority individuals in the population, the lower is $\Gamma(0;\alpha)$ and the higher is $\Gamma(1;\alpha)$, i.e. $\partial\Gamma(0;\alpha)/\partial\mu < 0$ and $\partial\Gamma(1;\alpha)/\partial\mu > 0$.*

(ii) *The higher is ε, the productivity spillover effect, the lower are $\Gamma(0;\alpha)$ and $\Gamma(1;\alpha)$, i.e. $\partial\Gamma(0;\alpha)/\partial\varepsilon < 0$ and $\partial\Gamma(1;\alpha)/\partial\varepsilon < 0$. Moreover, $\lim_{\varepsilon\to 1}\Gamma(0;\alpha) < 0$ and $\lim_{\varepsilon\to 1}\Gamma(1;\alpha) < 0$.*

Proof of Lemma A3: We know that

$$
\begin{aligned}
\Gamma(0;\alpha) &= (\alpha+\sigma)\ln\frac{f(1-\mu+\varepsilon\mu)}{f(\mu+\varepsilon(1-\mu))} - \delta\ln\overline{d}, \\
\Gamma(1;\alpha) &= (\alpha+\sigma)\ln\frac{f(1)}{f(\varepsilon)} - \delta\ln d(1-\mu),
\end{aligned}
$$

(i): By differentiating these functions, we obtain:

$$
\begin{aligned}
\frac{\partial\Gamma(0;\alpha)}{\partial\mu} &= -(\alpha+\sigma)(1-\varepsilon)\left[\frac{f'(1-\mu+\varepsilon\mu)}{f(1-\mu+\varepsilon\mu)} + \frac{f'(\mu+\varepsilon(1-\mu))}{f(\mu+\varepsilon(1-\mu))}\right] < 0, \\
\frac{\partial\Gamma(1;\alpha)}{\partial\mu} &= \frac{\delta d'(1-\mu)}{d(1-\mu)} > 0.
\end{aligned}
$$

(ii): By differentiating these functions, we obtain:

$$\frac{\partial \Gamma(0;\alpha)}{\partial \varepsilon} = (\alpha+\sigma)\left[\frac{\mu f'(1-\mu+\varepsilon\mu)}{f(1-\mu+\varepsilon\mu)} - \frac{(1-\mu) f'(\mu+\varepsilon(1-\mu))}{f(\mu+\varepsilon(1-\mu))}\right] < 0,$$

since $\mu < 1-\mu$, $\mu+\varepsilon(1-\mu) < 1-\mu+\varepsilon\mu$, $f(\mu+\varepsilon(1-\mu)) < f(1-\mu+\varepsilon\mu)$ and $f'(1-\mu+\varepsilon\mu) < f'(\mu+\varepsilon(1-\mu))$, and

$$\frac{\partial \Gamma(1;\alpha)}{\partial \varepsilon} = -(\alpha+\sigma)\frac{f'(\varepsilon)}{f(\varepsilon)} < 0.$$

Moreover, taking limits, we obtain:

$$\begin{aligned}\lim_{\varepsilon\to 1}\Gamma(0;\alpha) &= -\delta \ln \overline{d} < 0,\\ \lim_{\varepsilon\to 1}\Gamma(1;\alpha) &= -\delta \ln d(1-\mu) < 0.\end{aligned}$$

Using Lemmas 2 and A3, it is then straightforward to prove Proposition 4. ▮

Proof of Proposition 6: As is well known in urban economics, an agent having a steeper bid rent at an intersection of bid rent curves of heterogeneous agents lives closer to the CBD. From (7), we know that at any intersection of Φ_{mc} and Φ_{cc} (i.e., $\breve{x}$ that satisfies $\Phi_{mc}(\breve{x},\lambda;\alpha_k) = \Phi_{cc}(\breve{x},\lambda) \equiv \Phi(\breve{x})$), the slopes of the two bid rent curves are the same:

$$\frac{\partial \Phi_{mc}(\breve{x},\lambda;\alpha_k)}{\partial x} = -\frac{t\Phi(\breve{x})}{(1-a)(y_c(\lambda)-t\breve{x})} = \frac{\partial \Phi_{cc}(\breve{x},\lambda)}{\partial x}.$$

The same result holds true for assimilated minority individuals with different α_k. Hence, the assimilated ethnic minority individuals regardless of α_k and the majority individuals reside in the same area. Moreover, at any intersection of Φ_{mm} and Φ_{cc} (i.e., at any $\tilde{x}$ that satisfies $\Phi_{mm}(\tilde{x},\lambda;\alpha_k) = \Phi_{cc}(\tilde{x},\lambda) = \Phi(\tilde{x})$), we can see that

$$\frac{\partial \Phi_{mm}(\tilde{x},\lambda;\alpha_k)}{\partial x} = -\frac{t\Phi(\tilde{x})}{(1-a)(y_m(\lambda)-t\tilde{x})} < 0, \qquad \frac{\partial \Phi_{cc}(\tilde{x},\lambda)}{\partial x} = -\frac{t\Phi(\tilde{x})}{(1-a)(y_c(\lambda)-t\tilde{x})} < 0, \tag{A.1}$$

which, combined with the fact that $y_c(\lambda) > y_m(\lambda)$ under $0 < \varepsilon < 1$ implies that

$$\left|\frac{\partial \Phi_{mm}(\tilde{x},\lambda;\alpha_k)}{\partial x}\right| > \left|\frac{\partial \Phi_{cc}(\tilde{x},\lambda)}{\partial x}\right|.$$

Hence, the minority individuals who do not assimilate live closer to the CBD than the majority individuals and the minority individuals who assimilate. Note finally that (A.1) implies that oppositional minority individuals with different α_k reside in the same area. This segregation pattern under income heterogeneity is very standard in the urban economics literature (see Fujita, 1989). ∎

Proof of Proposition 8

To prove this proposition, we need to know: *(i)* $V_{mc}(1;\alpha_k)$, the utility level of all ethnic minorities when all of them assimilate to the majority group, *(ii)* $V_{mm}(1;\alpha_k)$, the utility level of the ethnic minorities who reject the majority's norm, *(iii)* $V_{mm}(0;\alpha_k)$, the utility level of all ethnic minorities when all of them decide to reject the norm of the majority group, *(iv)* $V_{mc}(0;\alpha_k)$, the utility level of a some ethnic minorities who decide to assimilate to the majority group, *(v)* $V_{mc}(\gamma;\alpha_k)$, and *(vi)* $V_{mm}(\gamma;\alpha_k)$

From (B.2), we obtain:

$$\begin{aligned}\Gamma_{mon}(1;\alpha_k) &= V_{mc}(1;\alpha_k) - V_{mm}(1;\alpha_k) \\ &= (\alpha_k+\sigma)\ln\left(\frac{y_c(1)}{y_m(1)}\right) - \delta\ln d(1-\mu).\end{aligned} \tag{A.2}$$

where $d(.)$ is the perceived distance defined in Section 2.3.1.

Similarly, we can solve the model when ethnic minorities reject the majority norm to obtain

$$\begin{aligned}\Gamma_{mon}(0;\alpha_k) &= V_{mc}(0;\alpha_k) - V_{mm}(0;\alpha_k) \\ &= \alpha_k\ln\left(\frac{y_c(0)-t\tilde{x}}{y_m(0)-t\tilde{x}}\right) + \sigma\ln\left(\frac{y_c(0)}{y_m(0)}\right) - \delta\ln\overline{d}, \\ t\tilde{x}_m &= \left\{1-\left[\frac{H+(1-\mu)t}{H+t}\right]^{1-a}\right\}y_m(0).\end{aligned} \tag{A.3}$$

By differentiating $\Gamma_{mon}(1)$ and $\Gamma_{mon}(0)$ with respect to t and H, we obtain:

$$\begin{aligned}\frac{\partial\Gamma_{mon}(1;\alpha_k)}{\partial t} &= \frac{\partial\Gamma_{mon}(1;\alpha_k)}{\partial H} = 0, \\ \frac{\partial\Gamma_{mon}(0;\alpha_k)}{\partial t} &= \frac{\alpha_k\left(y_c(0)-y_m(0)\right)}{\left(y_m(0)-t\tilde{x}\right)\left(y_c(0)-t\tilde{x}\right)}\frac{\partial\left(t\tilde{x}\right)}{\partial t} > 0, \\ \frac{\partial\Gamma_{mon}(0;\alpha_k)}{\partial H} &= \frac{\alpha_k\left(y_c(0)-y_m(0)\right)}{\left(y_m(0)-t\tilde{x}\right)\left(y_c(0)-t\tilde{x}\right)}\frac{\partial\left(t\tilde{x}\right)}{\partial H} < 0.\end{aligned}$$

This proves the result. ▮

Proof of Proposition 9

By proceeding as for the proof of Proposition 8, we can differentiate (A.2) and (A.3) to obtain:

$$\frac{\partial \Gamma_{mon}(1;\alpha_k)}{\partial \varepsilon} < 0, \quad \frac{\partial \Gamma_{mon}(1;\alpha_k)}{\partial \mu} > 0 \quad , \frac{\partial \Gamma_{mon}(1;\alpha_k)}{\partial \delta} < 0 \quad , \frac{\partial \Gamma_{mon}(1;\alpha_k)}{\partial \sigma} > 0 \quad , \frac{\partial \Gamma_{mon}(1;\alpha_k)}{\partial a} = 0,$$
$$\frac{\partial \Gamma_{mon}(0;\alpha_k)}{\partial \varepsilon} < 0, \quad \frac{\partial \Gamma_{mon}(0;\alpha_k)}{\partial \mu} < 0 \quad , \frac{\partial \Gamma_{mon}(0;\alpha_k)}{\partial \delta} < 0 \quad , \frac{\partial \Gamma_{mon}(0;\alpha_k)}{\partial \sigma} > 0 \quad , \frac{\partial \Gamma_{mon}(0;\alpha_k)}{\partial a} = 0,$$

This proves the result. ▮

Proof of Proposition 10

For the ASIUE, equations (12) and (B.1) yield:

$$\begin{aligned}
t\bar{x}_A &= \left[1 - \left(\frac{H}{H+t}\right)^{1-a}\right] y_c(1), \\
R_A(x) &= \begin{cases} \Phi_{cc}(x,1) \ (= \Phi_{mc}(x,1;\alpha_k)) & \text{if } x \in [0, \bar{x}_A] \\ 1 & \text{if } x \in (\bar{x}_A, \infty) \end{cases}, \\
\Phi_{cc}(x,1) &= \left(\frac{y_c(1) - tx}{y_c(1) - t\bar{x}_A}\right)^{1/(1-a)},
\end{aligned}$$

For the OSIUE, we have:

$$\begin{aligned}
t\tilde{x}_O &= \left\{1 - \left[\frac{H + (1-\mu)t}{H+t}\right]^{1-a}\right\} y_m(0), \\
t\bar{x}_O &= y_c(0) - (y_c(0) - y_m(0)) \left[\frac{H}{H + (1-\mu)t}\right]^{1-a} - y_m(0) \left(\frac{H}{H+t}\right)^{1-a}, \\
R_O(x) &= \begin{cases} \Phi_{mm}(x,0;\alpha_k) & \text{if } x \in [0, \tilde{x}_O] \\ \Phi_{cc}(x,0) & \text{if } x \in (\tilde{x}_O, \bar{x}_O] \\ 1 & \text{if } x \in (\bar{x}_O, \infty) \end{cases}, \\
\Phi_{cc}(x,0) &= \left(\frac{y_c(0) - tx}{y_c(0) - t\bar{x}_O}\right)^{1/(1-a)}, \\
\Phi_{mm}(x,0;\alpha_k) &= \left(\frac{y_m(0) - tx}{y_m(0) - t\tilde{x}_O}\right)^{1/(1-a)} \left(\frac{y_c(0) - t\tilde{x}_O}{y_c(0) - t\bar{x}_O}\right)^{1/(1-a)},
\end{aligned}$$

For the MSIUE, we have

$$
\begin{aligned}
t\tilde{x}_M &= \left\{1 - \left[\frac{H + (\gamma\mu + 1 - \mu)t}{H + t}\right]^{1-a}\right\} y_m(\gamma), \\
t\bar{x}_M &= y_c(\gamma) - (y_c(\gamma) - y_m(\gamma))\left[\frac{H}{H + (\gamma\mu + 1 - \mu)t}\right]^{1-a} - y_m(\gamma)\left(\frac{H}{H+t}\right)^{1-a}, \\
R_M(x) &= \begin{cases} \Phi_{mm}(x, \gamma; \alpha_l) & \text{if } x \in [0, \tilde{x}_M] \\ \Phi_{cc}(x, \gamma) \ (= \Phi_{mm}(x, \gamma; \alpha_h)) & \text{if } x \in (\tilde{x}_M, \bar{x}_M] \\ 1 & \text{if } x \in (\bar{x}_M, \infty) \end{cases}, \\
\Phi_{cc}(x, \gamma) &= \left(\frac{y_c(\gamma) - tx}{y_c(\gamma) - t\bar{x}_M}\right)^{1/(1-a)}, \\
\Phi_{mm}(x, \gamma; \alpha_k) &= \left(\frac{y_m(\gamma) - tx}{y_m(\gamma) - t\tilde{x}_M}\right)^{1/(1-a)} \left(\frac{y_c(\gamma) - t\tilde{x}_M}{y_c(\gamma) - t\bar{x}_M}\right)^{1/(1-a)},
\end{aligned}
$$

Because

$$
\frac{H}{H + (1-\mu)t} > \frac{H}{H + (\gamma\mu + 1 - \mu)t} > \frac{H}{H+t},
$$

we know that

$$
\begin{aligned}
t\bar{x}_O &= \left\{1 - \left[\frac{H}{H + (1-\mu)t}\right]^{1-a}\right\} y_c(0) + \left\{\left[\frac{H}{H + (1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\} y_m(0) \\
&< \left\{1 - \left[\frac{H}{H + (1-\mu)t}\right]^{1-a}\right\} y_c(0) + \left\{\left[\frac{H}{H + (1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\} y_c(0) \\
&= \left[1 - \left(\frac{H}{H+t}\right)^{1-a}\right] y_c(0) \\
&< \left[1 - \left(\frac{H}{H+t}\right)^{1-a}\right] y_c(1) = t\bar{x}_A,
\end{aligned}
$$

and

$$
\begin{aligned}
t\bar{x}_M &= \left\{1-\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a}\right\} y_c(\gamma) + \left\{\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\} y_m(\gamma) \\
&< \left\{1-\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a}\right\} y_c(\gamma) + \left\{\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\} y_c(\gamma) \\
&= \left[1-\left(\frac{H}{H+t}\right)^{1-a}\right] y_c(\gamma) \\
&< \left[1-\left(\frac{H}{H+t}\right)^{1-a}\right] y_c(1) = t\bar{x}_A.
\end{aligned}
$$

Moreover, the total land rents (TLR) are given by

$$
\begin{aligned}
TLR_A &= H\int_0^{\bar{x}_A} \Phi_{cc}(x,1)dx \\
&= \frac{(H+t)(1-a)}{t(2-a)}\left[1-\left(\frac{H}{H+t}\right)^{2-a}\right] y_c(1), \\
TLR_O &= H\int_0^{\tilde{x}_O} \Phi_{mm}(x,0)dx + H\int_{\tilde{x}_O}^{\bar{x}_O} \Phi_{cc}(x,0)dx \\
&= \frac{H(1-a)}{t(2-a)}\left[\left(y_c(0)+\frac{\mu t}{H+(1-\mu)t}y_m(0)\right)\left[\frac{H+(1-\mu)t}{H}\right]\right. \\
&\quad \left. -y_c(0)\left[\frac{H}{H+(1-\mu)t}\right]^{1-a} + y_m(0)\left\{\left[\frac{H}{H+(1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\}\right], \\
TLR_M &= H\int_0^{\tilde{x}_M} \Phi_{mm}(x,\gamma;\alpha_l)dx + H\int_{\tilde{x}M}^{\bar{x}_M} \Phi_{cc}(x,\gamma)dx \\
&= \frac{H(1-a)}{t(2-a)}\left[\left(y_c(\gamma)+\frac{\mu(1-\gamma)t}{H+(\gamma\mu+1-\mu)t}y_m(\gamma)\right)\left[\frac{H+(\gamma\mu+1-\mu)t}{H}\right]\right. \\
&\quad \left. -y_c(\gamma)\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a} + y_m(\gamma)\left\{\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a} - \left(\frac{H}{H+t}\right)^{1-a}\right\}\right].
\end{aligned}
$$

From this, we can show that

$$\begin{aligned}
TLR_O &< \frac{H(1-a)}{t(2-a)}\left[\left(y_c(0)+\frac{\mu t}{H+(1-\mu)t}y_c(0)\right)\left[\frac{H+(1-\mu)t}{H}\right]\right. \\
&\quad \left. -y_c(0)\left[\frac{H}{H+(1-\mu)t}\right]^{1-a}+y_c(0)\left\{\left[\frac{H}{H+(1-\mu)t}\right]^{1-a}-\left(\frac{H}{H+t}\right)^{1-a}\right\}\right] \\
&= \frac{(H+t)(1-a)}{t(2-a)}\left[1-\left(\frac{H}{H+t}\right)^{2-a}\right]y_c(0) \\
&< \frac{(H+t)(1-a)}{t(2-a)}\left[1-\left(\frac{H}{H+t}\right)^{2-a}\right]y_c(1)=TLR_A,
\end{aligned}$$

and

$$\begin{aligned}
TLR_M &< \frac{H(1-a)}{t(2-a)}\left[\left(y_c(\gamma)+\frac{\mu(1-\gamma)t}{H+(\gamma\mu+1-\mu)t}y_c(\gamma)\right)\left[\frac{H+(\gamma\mu+1-\mu)t}{H}\right]\right. \\
&\quad \left. -y_c(\gamma)\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a}+y_c(\gamma)\left\{\left[\frac{H}{H+(\gamma\mu+1-\mu)t}\right]^{1-a}-\left(\frac{H}{H+t}\right)^{1-a}\right\}\right] \\
&= \frac{(H+t)(1-a)}{t(2-a)}\left[1-\left(\frac{H}{H+t}\right)^{2-a}\right]y_c(\gamma) \\
&< \frac{(H+t)(1-a)}{t(2-a)}\left[1-\left(\frac{H}{H+t}\right)^{2-a}\right]y_c(1)=TLR_A.
\end{aligned}$$

B Equilibrium values of all variables in any urban equilibrium

Letting $\bar{x}$ denote the edge of the city, the market land rent is given by

$$R(x,\lambda) = \begin{cases} \Phi_{mm}(x,\lambda;\alpha_k) & \text{if } x \in [0,\tilde{x}] \\ \Phi_{cc}(x,\lambda)\ (=\Phi_{mc}(x,\lambda;\alpha_k)) & \text{if } x \in (\tilde{x},\bar{x}] \\ 1 & \text{if } x \in (\bar{x},\infty) \end{cases}.$$

At the city edge $\bar{x}$, the utility of the majority individuals is equal to:

$$V_{cc}(\lambda) = \ln(y_c(\lambda) - t\bar{x}) - \delta \ln D_{cc}(\lambda) + \sigma \ln \left[\frac{y_c(\lambda)}{\overline{y}(\lambda)}\right].$$

Plugging this into (12) with $i = J = c$ yields the bid rent of the majority individuals:[2]

$$\Phi_{cc}(x,\lambda) = \left(\frac{y_c(\lambda) - tx}{y_c(\lambda) - t\bar{x}}\right)^{1/(1-a)}.$$

At the border $\tilde{x}$ between the residential area of the minority individuals who do not assimilate and that of other individuals, we have $\Phi_{mm}(\tilde{x},\lambda;\alpha_k) = \Phi_{cc}(\tilde{x},\lambda)$, implying that we can write the indirect utility of the minority individuals who do not assimilate as

$$V_{mm}(\lambda;\alpha_k) = \alpha_k \left[\ln\left(y_m(\lambda) - t\tilde{x}\right) - (1-a)\ln \Phi_{cc}(\tilde{x},\lambda)\right] + \sigma \ln \frac{y_m(\lambda)}{\overline{y}(\lambda)}.$$

Plugging this into (12) with $i = J = m$, we obtain the bid rent of the minority individuals who do not assimilate:

$$\Phi_{mm}(x,\lambda;\alpha_k) = \left(\frac{y_m(\lambda) - tx}{y_m(\lambda) - t\tilde{x}}\right)^{1/(1-a)} \left(\frac{y_c(\lambda) - t\tilde{x}}{y_c(\lambda) - t\bar{x}}\right)^{1/(1-a)}.$$

[2]We can obtain the same bid rent function by deriving the utility of the group m individuals who assimilate, and plugging it into (12) with $i = m$ and $J = c$.

Hence, using (10), the housing demands are given by:

$$\begin{aligned} h_{mm}(x,\lambda) &= (1-a)\frac{(y_m(\lambda)-t\tilde{x})^{1/(1-a)}}{(y_m(\lambda)-tx)^{a/(1-a)}}\left(\frac{y_c(\lambda)-t\bar{x}}{y_c(\lambda)-t\tilde{x}}\right)^{1/(1-a)}, \\ h_{mc}(x,\lambda) &= h_{cc}(x,\lambda) = (1-a)\frac{(y_c(\lambda)-t\bar{x})^{1/(1-a)}}{(y_c(\lambda)-tx)^{a/(1-a)}}. \end{aligned}$$

The population constraints (14) are then equal to:

$$(1-\lambda)\mu = \int_0^{\tilde{x}} \frac{H}{h_{mm}(x,\lambda)}dx, \qquad \lambda\mu + 1 - \mu = \int_{\tilde{x}}^{\bar{x}} \frac{H}{h_{cc}(x,\lambda)}dx.$$

We can solve them with respect to $\tilde{x}$ and $\bar{x}$, respectively, and obtain

$$\begin{aligned} t\tilde{x} &= \left\{1 - \left[\frac{H+(\lambda\mu+1-\mu)t}{H+t}\right]^{1-a}\right\} y_m(\lambda), \\ t\bar{x} &= y_c(\lambda) - (y_c(\lambda)-y_m(\lambda))\left[\frac{H}{H+(\lambda\mu+1-\mu)t}\right]^{1-a} - y_m(\lambda)\left(\frac{H}{H+t}\right)^{1-a}. \end{aligned} \tag{B.1}$$

Plugging the above equations into (11), we obtain the indirect utility as

$$\begin{aligned} V_{mm}(\lambda;\alpha_k) &= \alpha_k\left[\ln(y_m(\lambda)-t\tilde{x}) - \ln\frac{y_c(\lambda)-t\tilde{x}}{y_c(\lambda)-t\bar{x}}\right] + \sigma\ln\frac{y_m(\lambda)}{\overline{y}(\lambda)}, \\ V_{mc}(\lambda;\alpha_k) &= \alpha_k\ln(y_c(\lambda)-t\bar{x}) - \delta\ln D_{mc}(\lambda) + \sigma\ln\frac{y_c(\lambda)}{\overline{y}(\lambda)}, \\ V_{cc}(\lambda) &= \ln(y_c(\lambda)-t\bar{x}) - \delta\ln D_{cc}(\lambda) + \sigma\ln\frac{y_c(\lambda)}{\overline{y}(\lambda)}. \end{aligned} \tag{B.2}$$

C Equilibrium with different incomes from the majority group

In this appendix, we will show that our main results are unaltered if we introduce heterogeneity in income among majority individuals. Suppose now that there exists high skilled majority individuals whose income is y_s that is larger than the highest possible income of other agents, i.e., $y_s > y_c(1)$.[3] Hence, we refer to the majority individuals described in the main text as low-skilled majority individuals. We assume that minority individuals can obtain the same income as the low-skilled majority individuals, $y_c(\lambda)$ when they assimilate, but can never obtain the high income y_s, even when they assimilate. This is because of discrimination in the labor market.

Under this additional assumption, we can obtain the same results as those shown in the main text. Put differently, our results hold true if minority individuals can obtain the same income at least as a part of majority individuals.

Denote the number of high-skilled majority individuals as ρ, and their disutility from the perceived distance by $\delta \ln D_s$. Here, for the expositional simplicity, we assume that high-skilled and low-skilled majority individuals belong to different social groups, i.e., groups s and c. We can obtain the same results even if we assume that they belong to one social group. Then, $\delta \ln D_s$ becomes zero and the skilled majority's indirect utility $V_s(\lambda)$ is given by

$$V_s(\lambda) = \ln(y_s - tx) - (1-a)\ln R(x) + \sigma \ln \frac{y_s}{\overline{y}(\lambda)},$$

and their bid rent function is given by

$$\Phi_s(x,\lambda) = \exp\left[\frac{\ln(y_s - tx) + \sigma \ln(y_s/\overline{y}(\lambda)) - V_s(\lambda)}{1-a}\right]. \tag{C.1}$$

Comparing its slope $\partial \Phi_s(x,\lambda)/\partial x$ with those of other individuals' bid rent functions at any intersection, $\widetilde{x}_s$, of $\Phi_s(x,\lambda)$ and other bid rent functions, we know that $\Phi_s(x,\lambda)$ is flatter than other bid rent functions at $\widetilde{x}_s$. Hence, in a similar way to the proof of Proposition 6, we know that high skilled majority individuals will reside at the outskirts of the city.

[3]Here, we consider two levels of majority individuals' income. If we consider three or more income levels, our model does not change qualitatively.

At the city edge, $x = \overline{x}$, and $V_s(\lambda)$ becomes

$$V_s(\lambda) = \ln(y_s - t\overline{x}) + \sigma \ln \frac{y_s}{\overline{y}(\lambda)}.$$

Plugging this into (C.1), we obtain

$$\Phi_s(x, \lambda) = \left(\frac{y_s - tx}{y_s - t\overline{x}}\right)^{1/(1-a)}.$$

In the same way as in the proof of Proposition 6, we can show that the oppositional minority individuals live close to the CBD, and low-skilled majority individuals and assimilated minority individuals live in between the oppositional minority individuals and high-skilled majority individuals. Denote the border between oppositional minority's residential area and low skilled majority's residential area as $\tilde{x}_c$ and the border between low skilled majority's residential area and high skilled majority's residential area as $\tilde{x}_s$. The resulting bid rent functions are then equal to

$$\begin{aligned}
\Phi_{cc}(x, \lambda) &= \Phi_{mc}(x, \lambda; \alpha_k) = \left(\frac{y_c(\lambda) - tx}{y_c(\lambda) - t\tilde{x}_s}\right)^{1/(1-a)} \left(\frac{y_s - t\tilde{x}_s}{y_s - t\bar{x}}\right)^{1/(1-a)}, \\
\Phi_{mm}(x, \lambda; \alpha_k) &= \left(\frac{y_m(\lambda) - tx}{y_m(\lambda) - t\tilde{x}_c}\right)^{1/(1-a)} \left(\frac{y_c(\lambda) - t\tilde{x}_c}{y_c(\lambda) - t\tilde{x}_s}\right)^{1/(1-a)} \left(\frac{y_s - t\tilde{x}_s}{y_s - t\bar{x}}\right)^{1/(1-a)}.
\end{aligned}$$

From these bid rent functions, we obtain the housing demand functions, which, combined with the population constraint (14), yield

$$\begin{aligned}
t\tilde{x}_c &= \left\{1 - \left[\frac{H + (\rho + \lambda\mu + 1 - \mu)t}{H + (\rho + 1)t}\right]^{1-a}\right\} y_m(\lambda), \qquad \text{(C.2)} \\
t\tilde{x}_s &= y_c(\lambda) - (y_c(\lambda) - y_m(\lambda)) \left[\frac{H}{H + (\rho + \lambda\mu + 1 - \mu)t}\right]^{1-a} - y_m(\lambda) \left[\frac{H + \rho t}{H + (\rho + 1)t}\right]^{1-a} \\
t\bar{x} &= y_h - (y_h - y_c(\lambda)) \left(\frac{H}{H + \rho t}\right)^{1-a} - (y_c(\lambda) - y_m(\lambda)) \left[\frac{H}{H + (\rho + \lambda\mu + 1 - \mu)t}\right]^{1-a} \\
&\quad - y_m(\lambda) \left[\frac{H}{H + (\rho + 1)t}\right]^{1-a}.
\end{aligned}$$

Note that if we substitute $\rho = 0$, we can see that (C.2) becomes identical to (B.1) with

$t\bar{x} = t\tilde{x}_s$. With these threshold values, we obtain the following indirect utility functions:

$$
\begin{aligned}
V_{mm}(\lambda;\alpha_k) &= \alpha_k\left[\ln\left(y_m(\lambda) - t\tilde{x}_c\right) - \ln\frac{y_c(\lambda) - t\tilde{x}_c}{y_c(\lambda) - t\tilde{x}_s}\frac{y_s - t\tilde{x}_s}{y_s - t\bar{x}}\right] + \sigma\ln\frac{y_m(\lambda)}{\overline{y}(\lambda)},\\
V_{mc}(\lambda;\alpha_k) &= \alpha_k\left[\ln(y_c(\lambda) - t\tilde{x}_s) - \ln\frac{y_s - t\tilde{x}_s}{y_s - t\bar{x}}\right] - \delta\ln D_{mc}(\lambda) + \sigma\ln\frac{y_c(\lambda)}{\overline{y}(\lambda)},\\
V_{cc}(\lambda) &= \ln(y_c(\lambda) - t\tilde{x}_s) - \ln\frac{y_s - t\tilde{x}_s}{y_s - t\bar{x}} - \delta\ln D_{cc}(\lambda) + \sigma\ln\frac{y_c(\lambda)}{\overline{y}(\lambda)},\\
V_s(\lambda) &= \ln(y_s - t\bar{x}) + \sigma\ln\frac{y_s}{\overline{y}(\lambda)}.
\end{aligned}
$$

Hence, we get:

$$
\begin{aligned}
\Gamma_{mon}(\lambda;\alpha_k) &= V_{mc}(\lambda;\alpha_k) - V_{mm}(\lambda;\alpha_k)\\
&= \alpha_k\ln\left(\frac{y_c(\lambda) - t\tilde{x}_c}{y_m(\lambda) - t\tilde{x}_c}\right) + \sigma\ln\frac{y_c(\lambda)}{y_m(\lambda)} - \delta\ln D_{mc}(\lambda),
\end{aligned}
$$

which is almost the same expression as (15), where $\tilde{x}$ is replaced by $\tilde{x}_c$.

To summarize, when we introduce two different incomes from the majority group, we still have, as in the one-income case, three urban equilibria but with some differences in locations. In the ASIUE, minority and low-skilled majority workers reside close to the CBD while high-skilled majority workers live in the suburbs. In the OSIUE, the urban configuration will be different. The oppositional minority workers will reside close to the CBD, the high-skilled majority workers at the periphery of the city while the low-skilled majority workers will reside in between these two groups. In the MSIUE, the oppositional minority workers will reside close to the CBD, the high-skilled majority workers at the periphery of the city while the low-skilled majority workers and the assimilated minority workers will reside in between these two groups. So, the urban configurations are different since, with one majority income, there is only one border ($\tilde{x}$) and thus only two areas in the city, while, with two majority incomes, there are two borders ($\tilde{x}_c$ and $\tilde{x}_s$) and three areas in the city.

What is remarkable is that, despite these differences, the condition for assimilation decision is basically identical with one and with two incomes from the majority group, so most of the results remain unchanged.