Hedonic Independence and Taste-homogeneity†
of Organizations with Crowding Types

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Abstract

We consider a model of a local public goods economy with differentiated crowding that distinguishes between the tastes and crowding characteristics of agents. *Crowding characteristics* are those aspects of an agent that have a direct external effect on other members of the coalition to which he belongs. In such an economy, it is possible to form completely taste-homogeneous organizations while still taking advantage of the full array of possible crowding effects (labor complementarities, for example). We find, however, that it is nevertheless possible for taste-heterogeneous organizations to be strictly superior to taste-homogeneous organization with the same distribution of crowding types. We introduce a notion of *hedonic independence*, which stipulates that the values of an agent's characteristics (his taste type and his crowding type) are independent. We show that if hedonic independence is satisfied, then organizations in core and equilibrium states of the economy are essentially taste-homogeneous. A number of examples illustrate the application of our approach to several sorts of organizations. We conclude by discussing how hedonic independence might arise from market interactions.

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1. Introduction

Tiebout's (1956) great contribution to public economics was his hypothesis that if public goods were local, competition between jurisdictions would induce agents to reveal their preferences.[1] Tiebout reasoned that jurisdictions would offer competing bundles of local public goods and tax liabilities. Consumers, acting in their own best interests, would then choose jurisdictions offering public goods and tax combinations that most closely agreed with their preferences. Tiebout concluded that the resulting competitive forces would lead to a near-optimal outcome and the free rider problem discussed by Samuelson would disappear.

Tiebout also speculated that there would be a tendency for optimal jurisdictions to consist of agents with similar tastes. Mixing different types of agents together requires compromises between conflicting tastes. Segregating agents according to tastes, therefore, would seem to be Pareto improving.

If true, this insight has significant implications for a wide range of real world problems. Various kinds of coalitions or organizations are pervasive in our economy and include such things as countries, cities, firms, academic departments, schools, private clubs, partnerships, sets of co-authors, family units, and even groups of friends.[2] Understanding the optimal structures of such organizations and the factors that are important in determining these structures have significant implications from both a descriptive and prescriptive standpoint. For example, many new suburban developments consist of essentially identical houses. Is this an attempt by developers to accommodate the desire of agents with similar tastes to live together, or is it driven by economies of scale in mass production, inefficient zoning regulations or some other factor? Colleges and universities are increasingly focusing their recruiting efforts on students with specific interests or tastes. Does this allow them to concentrate on providing a higher quality education of a specific type, or is everybody worse off from the resulting loss of diversity

[1] By a local public good we mean a public good subject to exclusion and crowding.

[2] For other interpretations see also Cartwright (2000) and Cartwright and Wooders (2001).

in the student body? Corporate cultures differ widely across companies. Does this improve both profits and employee's welfare by allowing workers to choose a culture that suits their tastes, or is this just a random reflection of the CEO's personality that may end up discouraging otherwise qualified employees from seeking employment? Private clubs often concentrate on providing highly specific types of amenities – fitness clubs, country clubs, and sports clubs, for example. Others offer an array of services in order to appeal to a variety of people, the YMCA, labor unions, and churches, for example. What drives this difference? In a similar vein, is it a good idea to force service clubs (Rotary, Lions, Elks) to stop excluding women or others who, for whatever reason, they would prefer not admit? At a more tender level, one might think that one's marriage would be happier if one shared the same tastes with one's spouse. Should this principle guide young lovers?

The literature comes to various conclusions on the question of taste-homogeneity of optimal organizations. For local public goods economies with anonymous crowding (crowding only by the number of individuals sharing a public good) the intuition that taste-homogeneous jurisdictions are optimal is essentially correct. In this case, core states will always consist of agents with the same *demands* for public goods and crowding (Wooders 1978).[3] Since the core is equivalent to the set of price-taking equilibrium states of the economy, the same result applies to equilibrium outcomes.[4]

The situation is much less clear when crowding is differentiated. When agents care not only about the total size of the jurisdiction in which they reside, but also about the s of each particular type of agent, it may indeed be beneficial for agents of different types to live together in the same jurisdiction. Optimal symphony orchestras,

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[3] Note that this is not equivalent to proving that taste-homogeneity of jurisdictions is a *necessary* property of core/equilibrium jurisdictions since, given prices, agents with different preferences may demand the same quantities of crowding characteristics and public goods. The fact that core and equilibrium jurisdictions in anonymous crowding economies must be demand-homogeneous does imply, however, that taste-heterogeneous jurisdictions can never Pareto dominate taste-homogeneous jurisdictions. In other words, while in some circumstances it does no harm to mix agents with different tastes together, there is never any benefit from doing so. (This is independantly noted in Berglas and Pines 1981.)

[4] See also Hamilton (1975), who argues that equilibrium jurisdictions will consist of individuals with the same demands for public goods in an economy where all agents have identical utility functions. A survey of related works and some additional results appears in Barham and Wooders (1998).

for example, employ many types of musicians, not just violinists. Although in general taste-homogeneity may not be optimal, it is still possible to make some progress by narrowing the question. For example, Brueckner (1994) investigates whether mixing different types of agents is optimal when crowding effects are positive and take the form of labor complementarities in production. He shows that if complementarities between types are sufficiently weak, then optimal jurisdictions will consist of individuals with the same demands. De Bartolome (1990) finds a similar tension between the benefits of segregating by taste in order to enjoy first best levels of local public good and taxes, and integrating in order to take advantage of beneficial peer group effects. Also see Benabou (1996) for an interesting study of how the sorting or mixing of agents in communities affects growth rates.

A reason that homogeneity results have been difficult to obtain in the standard differentiated crowding model is that this model forces a link between the external effects agents have on one another and their preference mappings. In some sense, these models seem to be saying that all violinists have the same tastes. While there may be correlation between crowding effects and tastes in many cases (e.g. violinists probably enjoy string music and smokers probably enjoy smoking), there are many situations in which such linkage is hard to justify (e.g. men and women crowd each other very differently yet some of each gender prefer the city to the suburbs). Nevertheless, there is still a strong intuition that optimal orchestras should contain musicians with many different talents (crowding effects), but all with the same preferences. For example, it seems quite plausible that it would be better for musicians who prefer to practice in the morning to join one orchestra and those who prefer to practice in the evening to join another.

The purpose of this paper is to explore the question of taste-homogeneity in the context of the *crowding types model* introduced in Conley and Wooders (1996, 1997). The utility of this model in approaching the homogeneity issue is that it sets up a formal distinction between the tastes and crowding effects of agents. This assumption makes it possible to explore economies in which it is feasible for agents to form taste-homogeneous jurisdictions and yet still take advantage of the full array of crowding characteristics (in contrast to Brueckner 1994, and De Bartolome 1990, for example).

Our first result demonstrates that even when taste-homogeneous coalitions are feasible, it may nevertheless be optimal for agents with different tastes to join together in the same organization or club. This result holds regardless of whether crowding is seen on the production side (labor complementarities, for example) or the consumption side (preferences to share the company of particular types of people, for example), and directly contradicts Tiebout's original speculation in this regard.

This naturally begs the question of whether there are reasonable conditions under which taste-homogeneous coalitions will in fact be optimal. We consider a condition we call *hedonic independence* that provides a partial answer. The idea of hedonic independence comes from the hedonic pricing literature initiated by Lancaster (1966) and Rosen (1976) and its recent formulations in the context of characteristic function games by Spulber (1986,1989), Moulin (1988), and Wooders (1992), for example.[5] Hedonic independence requires that the value of the contribution of an agent to an economy equals the sum of the values of the attributes owned by that agent. In particular, hedonic independence means that the value of these characteristics is not affected by the pattern of ownership.

Our second result demonstrates that hedonic independence is sufficient (but not necessary) to ensure that all core states will be essentially taste-homogeneous. By way of explanation, it is worth noting that hedonic independence is always satisfied in a quasi-linear private goods economy. Here, the payoff received by an agent is equal to the sum of the values of the goods in his endowment bundle (see Shapley and Shubik 1975, for example). In contrast, we show that hedonic independence is not always satisfied in a generic crowding types economy. We argue, however, that market forces tend to push such economies in a direction that will cause this condition to be satisfied.

[5] We note that the approach of market-game equivalence of Shapley and Shubik (1969) and Wooders (1994a) is quite distinct. Market-game equivalence shows that there is *some* representation of a commodity space for which a competitive price-taking equilibrium exists and for which core-equilibrium equivalence holds. One such market is the market where the players themselves are the commodities.

The plan of this paper is as follows. In section two, we formally describe the crowding types model. In section three, we discuss the homogeneity properties of this model. In section four, we show that hedonic independence will not generally be satisfied in the crowding types model. We also demonstrate that hedonic independence is sufficient for the core to satisfy taste-homogeneity. Section five concludes.

2. The Model

While our examples encompass a variety of situations, as a specific framework we present a model of an economy with local public goods provided by jurisdictions. This could equally well be described as a model of an economy with clubs or with production.

Agents are defined by two characteristics. There are T different sorts of tastes or preference maps, denoted by $t \in \{1, \ldots, T\} \equiv \mathcal{T}$, and C different sorts of crowding types, denoted $c \in \{1, \ldots, C\} \equiv \mathcal{C}$. We assume no correlation between c and t. The tastes of an individual are assumed to be private information and not to directly affect the welfare or production possibilities of others. Crowding type is publicly observable and enters into jurisdictional production functions and other agents' preference mappings. Note that crowding effects are unrestricted and could be negative or positive.

The population of agents is denoted by $N = (N_{11}, \ldots, N_{ct}, \ldots, N_{CT})$, where N_{ct} is interpreted as the total number of agents with crowding type c and taste type t in the economy. A *jurisdiction* is a group of agents who collectively produce and consume a common level of public good. A jurisdiction is represented by a vector $m = (m_{11}, \ldots, m_{ct}, \ldots, m_{CT})$, where m_{ct} is interpreted as the number of agents with crowding type c and taste type t in the jurisdiction m. The set of all feasible jurisdictions is denoted by $\mathcal{N}$. We shall say that two jurisdictions, m and $\hat{m}$, have the *same crowding profile* if for all $c \in \mathcal{C}$, $\sum_t m_{ct} = \sum_t \hat{m}_{ct}$. That is, two jurisdictions have the same crowding profile if the number of agents of any given crowding type is the same in both jurisdictions. A *partition* $n = \{n^1, \ldots, n^K\}$ of the population is a collection of jurisdictions such that $\sum_k n^k = N$. It will sometimes be necessary to refer to individual agents $i \in \{1, \ldots, I\} \equiv \mathcal{I}$. Observe that $I = \sum_{c,t} N_{ct}$. Let $\theta : \mathcal{I} \to \mathcal{C} \times \mathcal{T}$ be a function that indicates the types of a given individual. Thus, if agent i is of crowding type c and taste type t, then $\theta(i) = (c, t)$. With a slight abuse of notation, if individual i is a member of a jurisdiction represented by a vector m, we shall write $i \in m$. We will also write $n^k \in n$ when a jurisdiction of n^k is in the partition n.

We consider an economy with one private good and L public goods. We assume that agents can be members of only one jurisdiction at a time.[6] Each agent $i \in \mathcal{I}$ of taste type t is endowed with $\omega_t \in \Re_+$ of the private good, and has a complete and transitive preference ordering[7] $\succeq_t$ over $\Re_+ \times \Re^L_+ \times \mathcal{N}$. The strong preference relation $\succ_t$, and the indifference relation $\sim_t$ are induced in the usual way from $\succeq_t$. We do not require preferences to satisfy convexity, monotonicity, and continuity. We only need the relation to satisfy a condition called *taste anonymity in consumption* (TAC):

TAC: For all $m, \hat{m} \in \mathcal{N}$, if for all $c \in \mathcal{C}$ it holds that $\sum_t m_{ct} = \sum_t \hat{m}_{ct}$ then for all $x \in \Re_+$, all $y \in \Re^L_+$, and all $t \in \mathcal{T}$ it holds that $(x, y, m) \sim_t (x, y, \hat{m})$.

This is a formal statement of the idea that agents care only about the crowding types and not the taste types of the agents in their jurisdiction. Given that tastes are unobservable by assumption, it is hard to see any alternative. Our view is that TAC, and TAP below, are more in the spirit of defining the meaning of crowding types rather than as a restriction on preferences or production, respectively.

The set of feasible production plans is given by a set

$$P \subset \Re_- \times \Re^L_+ \times \mathcal{N}.$$

[6] This assumption has been relaxed in a number of papers. See Kovalenkov and Wooders (2003) and references therein.

[7] Formally, this implies that agents with the same tastes but different crowding characteristics have the same endowments. This is without loss of generality since there is no requirement that agents of taste type t have different preferences from agents of type t'. Thus, we can consider agents of the same crowding type with the same preferences but different endowments to be different taste types. Completeness and transitivity are probably not required for the results that follow, but they make the theorems more transparent.

If $(z, y, m) \in P$ we will say (z, y) is a feasible plan for a jurisdiction with composition m where z is interpreted as an input of private good. Again, we do not impose any conditions of convexity, closedness or monotonicity on the production set. In keeping with the spirit of the model, we assume that only the crowding profile of agents in a jurisdiction affects the cost of producing public goods. We call this *taste anonymity in production* (TAP):

TAP: for all $m, \hat{m} \in \mathcal{N}$, if for all $c \in \mathcal{C}$ it holds that $\sum_t m_{ct} = \sum_t \hat{m}_{ct}$ then for all $z \in \Re_+$, and all $y \in \Re_+^L$ such that $(z, y, m) \in P$ it holds that $(z, y, \hat{m}) \in P$.

The assumptions TAC and TAP are maintained in all that follows and no further mention of them will be made.

A *feasible state of the economy* (X, Y, n) is a partition n of the population, an allocation $X \equiv (x_1, \ldots, x_I) \in \Re_+^I$ of the private good, and public goods production plans $Y \equiv (y^1, \ldots y^K) \in R_+^{KL}$ such that for each $n^k \in n$ there exists $z^k \in \Re_-$ satisfying[8]

$$(z^k, y^k, n^k) \in P$$

and

$$\sum_k \sum_{c,t} n_{ct}^k \omega_t + \sum_k z^k = \sum_i x_i.$$

We denote the set of feasible states by F.

A jurisdiction $\bar{m} \in \mathcal{N}$ producing a feasible plan $(\bar{z}, \bar{y}, \bar{m}) \in P$ *improves upon* a feasible state $(X, Y, n) \in F$ if there exists some $\bar{x} \equiv \{\bar{x}_i\}_{i \in m}$ such that

1. $\sum_{c,t} \bar{m}_{ct} \omega_t + \bar{z} = \sum_{i \in \bar{m}} \bar{x}_i$,
2. for all $i \in \bar{m}$ it holds that $(\bar{x}_i, \bar{y}, \bar{m}) \succeq_t (x_i, y^k, n^k)$, where $\theta(i) = (c, t)$ for some $c \in \mathcal{C}$ and agent $i \in n^k \in n$ in the state (X, Y, n), and,
3. for some $j \in \bar{m}$ it holds that $(\bar{x}_j, \bar{y}, \bar{m}) \succ_{\hat{t}} (x_j, y^{\hat{k}}, n^{\hat{k}})$ where $\theta(j) = (\hat{c}, \hat{t})$ for some $\hat{c} \in \mathcal{C}$ and, in the state (X, Y, n), agent $j \in n^{\hat{k}} \in n$

[8] Note we use the convention that inputs are negative.

A feasible state $(X, Y, n) \in F$ is in the *core* of the economy if it cannot be improved upon by any jurisdiction.

We focus on economies in which small groups are effective. An economy satisfies *strict small group effectiveness*, (SSGE) if the following is true:

SSGE: There exists a positive integer B such that:

1. For all core states (X, Y, n) and all $n^k \in n$, it holds that $\sum_{c,t} n^k_{ct} \leq B$.
2. For all $c \in \mathcal{C}$ and all $t \in \mathcal{T}$ it holds that either $N_{ct} = 0$ or $N_{ct} > B$.

The first condition says that any state that includes at least one jurisdiction with more than B agents can be improved upon. In other words coalitions larger than B do strictly worse than coalitions with B agents or fewer. The second condition says that if there are any agents at all of a type (c, t), in an economy then there must least B of these agents. In other words, no agent type that exists is scarce. This has sometimes been called a "thickness" assumption.

SSGE is a relatively strong formalized version of the sixth assumption in Tiebout's original paper.[9] A weaker version, *small group effectiveness, SGE,* would require that small groups be able to do almost as well on a per capita basis as large groups:

SGE: Given $\epsilon > 0$ there exists a positive integer B_ϵ such that for all feasible states (X, Y, n) there exists another feasible state $(\bar{X}, \bar{Y}, \bar{n})$ where, for all $\bar{n}^{\bar{k}} \in \bar{n}$, it holds that $\sum_{c,t} \bar{n}^k_{ct} \leq B_\epsilon$. and

$$u_t(\bar{x}_j, \bar{y}^{\bar{k}}, \bar{n}) > u_t(x_j, y^k, n^k) + \epsilon,$$

where agent j is of taste type t and resides in jurisdictions $\bar{k}$ and k in the two states, respectively, and u_t is a utility representation of $\succ_t$.

The difference between SSGE and SGE is essentially only an ϵ per person of strict improvement. Other alternatives include assuming that blocking opportunities are ex-

[9] Tiebout assumes that "For every pattern of community services set by, say a city manager who follows the preferences of older residents of a community, there is an optimal community size. This optimum is defined in terms of the number of residents for which this bundle of services can be produced at the lowest average cost." In other words, there is a point at which the benefits of sharing the costs of the LPG over a large number of agents is offset by the cost of negative crowding effects.

hausted by groups bounded in size, there is a minimum efficient scale in the production technology, and so on.

The concept of SSGE for general cooperative games was introduced in Wooders (1983), where it was called "minimum efficient scale" and was also used in earlier working papers. SGE was suggested in Wooders (1980, 1983), where the techniques of proof indicate the relationship between the mild conditions of boundedness of per capita payoffs and SSGE. The precise definition of small group effectiveness as the condition that all or *almost* all gains to collective activities can be realized by groups bounded in size appears in Wooders (1992, 1994a,b) and earlier papers by the same author. With a thickness assumption bounding the percentages of players of each type away from zero, SGE is equivalent to boundedness of per capita payoffs (Wooders 1994a,b).

Informally, SSGE and SGE for games and economies are all very much in the same spirit. In fact they are asymptotically equivalent as the bound on group size in the definition of SSGE grows large, but remains small relative to total population of the economy. Given this, our view is that the particular formalization of Tiebout's assumption six employed does not matter very much and so we choose a version that contributes to simplicity of our proofs.[10]

In practical terms, SSGE is satisfied when optimal coalitions are small compared to the size of the total population of agents. For example, most people would argue the optimal marriages consist of two agents. Even in polygamous societies, it is seldom that anyone marries more than a few spouses. Clearly then, given a population of several billion, the "mating game" satisfies SSGE. Similarly, firms typically can achieve minimum efficient scale while employing only a fraction of the total workforce. Thus, the "firm formation game" satisfies SSGE. Similar examples include departments of economics, public schools, country clubs, and so on. In contrast, a "pure public goods game" may violate SSGE because the optimal way to provide a pure public good is to include the entire population in the coalition so as to spread the costs as widely

[10] See Wooders (1994b) for a detailed discussion of the relationships between the various types of assumptions limiting returns to group size.

as possible. A similar situation would occur with firms if returns to scale increased indefinitely. A boundary case is a private goods exchange economy. Here replicating the economy does not increase or decrease equilibrium utilities but does provide more opportunities for trade, thus shrinking the core.

At a more formal level, we show in Conley and Wooders (1997) that SSGE implies that the core and the set of anonymous Tiebout equilibrium allocations are equivalent even for finite economies, and that the core has the equal treatment property (that is in any core state of the economy, all agents who are identical must have the same utility levels). An immediate corollary to this is that price taking equilibria are Pareto efficient. Other forms of equilibrium, Nash and related noncooperative equilibrium notions in particular, may not be optimal in all cases. See Conley and Konishi (2002) for a more complete discussion of the optimality of game-theoretic notions of Tiebout equilibrium.

3. Homogeneity

The central concern of this paper is the degree to which we can expect to see taste-homogeneous coalitions in core states of a local public goods economy with crowding types. It is easy to point to circumstances under which this would clearly fail to be the case. Most obviously, this might be due to "shortages" of agents of the certain types. For example, even if all men like jazz and all women like rock, we would still expect them to go to dances together. Mixed gender taste-homogeneous dances are simply not feasible given this population of agents. Thus, taste-homogeneity of the core can only be reasonably conjectured to hold when the population of agents is capable of supporting the formation of taste-homogeneous jurisdictions that can take advantage of the full array of crowding types. Formally, we say an economy with population N satisfies *full support* (FS) if it includes at least one agent of each taste and crowding combination:

FS: For all $c \in \mathcal{C}$ and all $t \in \mathcal{T}$, it holds that $N_{ct} > 0$.

Note that in combination with SSGE this implies that $N_{ct} > B$ for all $c \in \mathcal{C}$ and all $t \in \mathcal{T}$. Even under conditions of full support the core may not be taste-homogeneous. As we remarked in the introduction, it is always possible that taste-heterogeneous jurisdictions do *exactly* as well as taste-homogeneous ones. To see this in a very elementary case, consider an economy with only one taste and crowding type (all agents are identical). By construction, all jurisdictions are necessarily taste-homogeneous. Now suppose that we arbitrarily divided the agents into two groups and call the tastes of the first group type t and the tastes of the second group type $\hat{t}$. Thus, all agents have the same *preferences*, but we have randomly assigned this preference type one of two index numbers. Obviously, jurisdictions with agents of each taste type do just as well as jurisdictions that are taste-homogeneous. Since in general we cannot see below the index numbers to the underlying preferences in our model we should not expect to be able to demonstrate that taste-homogeneous jurisdictions do strictly better than taste-heterogeneous ones, and so are the only type of jurisdiction seen in the core states.[11] Observe, however, that in the example there is no advantage to mixing across tastes and no disadvantage to forming taste-homogeneous jurisdictions in the example. In this case we say that the core state is *essentially taste-homogeneous*. Thus, the real question is what conditions are sufficient to guarantee that the core states are all essentially taste-homogeneous?

To state this idea formally we will need to know which taste types are represented in a given jurisdiction. The function $\tau : \mathcal{N} \to \mathcal{T}$ gives a list of these types:

$$\tau(m) \equiv (t \in \mathcal{T} \mid \exists\ i \in m \text{ such that for some } c \in \mathcal{C}, \theta(i) = (c, t)).$$

An economy is said to satisfy *strong essential taste-homogeneity* (SET) under the following conditions:

[11] This result does not depend on different index numbers being assigned to the same preferences. Agents with quite different preferences can still express the same demand for public goods at particular prices and so might find it just as good to mix as to segregate.

SET: For each core state (X, Y, n), every jurisdiction $n^k \in n$ in the core partition, and every alternative jurisdiction $\bar{m} \in \mathcal{N}$ such that

a. for all $c \in \mathcal{C}$ it holds that $\sum_t n^k_{ct} = \sum_t \bar{m}_{ct}$ ($\bar{m}$ has the same crowding profile as n^k), and

b. $\tau(\bar{m}) \subset \tau(n^k)$ (the set of taste types represented in jurisdiction $\bar{m}$ is a subset of those represented in n^k),

there exists an allocation $(\bar{x}, \bar{y})$ for $\bar{m}$ such that:

1. for all $i \in \bar{m}$ where $\theta(i) = (c, t)$ and the core state $i \in n^{\hat{k}} \in n$ it holds that $(\bar{x}_i, \bar{y}, \bar{m}) \succeq_t (x_i, y^{\hat{k}}, n^{\hat{k}})$, (agents in $\bar{m}$ are at least as well off as they were in the initial core state (X, Y, n)),
2. $(\sum_{i \in \bar{m}} \bar{x}_i - \sum_{c,t} \bar{m}_{ct}\omega_t, \bar{y}, \bar{m}) \in P$ (the plan is feasible for $\bar{m}$).

In the crowding types model there is no tension between the gains from trade motivation to mixing workers with different labor skills, and the gains to agreement in public goods consumption levels motivation to segregating agents by tastes. Given full support, taste-homogeneous jurisdictions containing a full array of crowding types are feasible. Thus, intuition from the existing literature suggests that crowding type economies should satisfy SET. Unfortunately, this intuition turns out to be false. The first counter-example demonstrates this for an economy in which crowding takes place only in consumption.

Example 1. Nonoptimality of taste-homogeneous jurisdictions with crowding in consumption.

Suppose there are two crowding types, Smokers and Nonsmokers, denoted S and N, respectively. Also suppose there are two taste types, Lovers and Haters of second hand smoke, denoted L and H, respectively. This gives four possible types of agents: $SL, SH, NL,$ and NH. Public goods production is suppressed in this example and agents care only about the profile of crowding types in their jurisdiction.[12] To simplify

[12] In the interest of transparency, this example is in the form of a simple matching problem. Matching

notation, $U_t(\{\bullet\})$ will be used to denote the utility received by agents of type $t \in \mathcal{T}$ when living in a jurisdiction with a given mix of crowding characteristics. For example, $U_H(\{S, S\})$ is interpreted as the utility received by a hater of second hand smoke when he is a member of a coalition containing two smokers. The utility functions are the following:

$$U_H(\{S, S\}) = 0, \quad U_L(\{S, S\}) = 10,$$

$$U_H(\{S, N\}) = 5, \quad U_L(\{S, N\}) = 5,$$

$$U_H(\{N, N\}) = 10, \quad U_L(\{N, N\}) = 0,$$

and the utility received from being in every other possible type of jurisdiction is zero. This implies the following value function for the associated game:

$$V(\{SL, SL\}) = V(\{NH, NH\}) = 20$$

$$V(\{SH, NL\}) = V(\{SL, SH\}) = V(\{SL, NL\}) = 10$$

$$V(\{SL, NH\}) = V(\{SH, NH\}) = V(\{NL, NH\}) = 10$$

$$V(\{SH, SH\}) = V(\{NL, NL\}) = 0,$$

and zero for every other jurisdiction type. By construction, the core will consist of coalitions with exactly two agents. Thus, if at least three agents of each type appear in the population, SSGE and FS are satisfied. Now consider the case where the population consists of four of each of the four agent types. One core state consists of two jurisdictions each with compositions: $\{SL, SL\}, \{NH, NH\}$, and four jurisdictions with composition: $\{SH, NL\}$, with agents of type SL and NH receiving ten units of utility, and agents of type NL and SH receiving five units of utility. It is easy to check that this state cannot be improved upon.

problems are, of course, a special case of the model presented in this paper. They are simpler in that agents receive utility only through the agent with whom they are partnered, and not explicitly through private or public consumption. The counterexample does not depend on this, however. Note also that utility functions take into account only the feeling of agents about second hand smoke, not the first hand act of smoking. Thus, it does not matter who generates the smoke, only the total number of smokers in the coalition.

We claim that it is not possible to taste-homogenize the mixed jurisdictions without loss of utility. Take a jurisdiction with composition $\{SH, NL\}$ for example. Suppose we tried to taste-homogenize this jurisdiction by replacing the agent of type NL with one of type NH. This coalition receives a total payoff of ten, while the sum of the core payoffs to these agents is fifteen. Thus, it is impossible to make these agents as well off in the taste-homogeneous coalition as they are in the core state. It is easy to check that any other effort to taste-homogenize the mixed jurisdictions fails in the same way. We conclude that when crowding occurs only in consumption, in general the core does not satisfy strong essential taste-homogeneity.

■

Example 1 shows that it is optimal for smoking/haters of second hand smoke, SH, to mix with nonsmoking/lovers of second hand smoke, NL. Taste-homogenizing this jurisdiction, for example by replacing the "nonsmoking/lover" with an "nonsmoking/hater", is not Pareto improving. The "smoking/hater" is made no better off by this change, and clearly it is better to match a smoker with a lover of second hand smoke than to match a smoker with a hater of second hand smoke.

We conclude that the intuition of Tiebout and others that complementarities between agents with the same tastes should make taste-homogeneous jurisdictions optimal is incomplete. It ignores the possibility that there might also be additional complementarities between two different sets of taste and crowding characteristics. In particular a pair of characteristics (c, t) might be complementary to a pair (c', t'). It is simply not sufficient to independently consider complementarities only within a given taste type and between various crowding types. In the example, a smoking/hater would like to find a nonsmoker, and a nonsmoking/lover would like to find a smoker. These two agent types are therefore complementary, and this complementarity outweighs the motivation to find an agent with the same tastes.[13] Epple and Romano (1998) find

[13] Since there is no public good choice and coalition size is fixed at two by construction, there is no motivation to segregate by tastes in this example.

a similar result in their model of optimal school formation. They distinguish between the tastes of agents (proxied by income) and crowding characteristics (the quality of a given student that provides positive "peer-group" effects). They also discover that taste-heterogeneous clubs may be optimal. In particular, they find a complementarity between high-quality low-income students and low-quality high-income students. They show that it is in the best interests of both types of agents for low-quality high-income students to subsidize the education of low-income high-quality students.[14]

Crowding takes place only in consumption in Example 1. In the spirit of Brueckner (1994), it is natural to wonder if a similar result can be obtained when crowding occurs only in production. The following example demonstrates that the answer is yes.

Example 2. Nonoptimality of taste-homogeneous jurisdictions with crowding in production.

Imagine a world composed only of engineers who coalesce into firms to build public projects. Some engineers have good organizational skills and others do not. Having a good organizer in a firm increases productively, thus, organizational skill has positive crowding effects in production. On the other hand, some engineers like building small projects and others like building large one. More formally, engineers can either be organized (O) or disorganized (D), and prefer to build either Little projects (L) or Big ones (B).

There are three possible public projects that a firm might build, a house (H), a theater (T), or a stadium (S). Below we give the private goods cost of constructing each in a coalition not containing any organizer as a function of coalition size.

$$C_H(n) = \begin{cases} 3 & \text{if } |\, n \,| = 1 \\ 100 + |\, n \,|^2 & \text{if } |\, n \,| \neq 1 \end{cases}$$

[14] They also find that the implicit pricing system as reflected by the core contributions of agents to fund schools are asymptotically anonymous for large economies. Specifically, they show that within a given school, all agents with the same tastes (income) pay the same amount in the limit. This reflects the results of Conley and Wooders (1997).

$$C_T(n) = \begin{cases} 6 & \text{if } \mid n \mid \ = 2 \\ 100 + \ \mid n \mid^2 & \text{if } \mid n \mid \ \neq 2 \end{cases}$$

$$C_S(n) = \begin{cases} 21 & \text{if } \mid n \mid \ = 3 \\ 100 + \ \mid n \mid^2 & \text{if } \mid n \mid \ \neq 3 \end{cases}$$

If there is at least one organizer present in a coalition, however, the cost is **halved**. Note that the costs are constructed so that it is only economically viable to construct houses, theaters, and stadia in one, two and three agent firms, respectively.

The two patterns of tastes (L and B) rank the desirability of the projects inversely:

$$u_L(H) = 7 \qquad u_B(H) = 0$$

$$u_L(T) = 6 \qquad u_B(T) = 6$$

$$u_L(S) = 0 \qquad u_B(S) = 10$$

Suppose the population composition is as follows:

$$100 : DL, \quad 100 : DB, \quad 40 : OL, \quad 30 : OB$$

One core state consists of:

$$100 : (DL, H), \quad 40 : (OL, DB, T), \quad 30 : (OB, DB, DB, S)$$

with payoffs:

$$U_{DL} = 4, \quad U_{DB} = 3, \quad U_{OL} = 6, \quad U_{OB} = 13.5.$$

To verify that this is a feasible payoff vector one can calculate the net transferable utility generated in each type of coalition.

For the one-person coalitions with a single DL, the payoff is $u_L(H) = 7$ and the cost is 3 giving a net coalitional payoff of 4.

For the coalitions with one OL and one DB, the payoff is $u_L(T) + u_B(T) = 12$ and the cost is $\frac{6}{2}$ giving a net coalitional payoff of 9.

For the coalitions with one OB and two DB's, the payoff is $u_B(T)+u_B(T)+u_B(T)$ $= 30$ and the cost is $\frac{21}{2}$ giving a net coalitional payoff of 19.5.

It takes some checking of cases, but it is not too difficult verify that this is a core state. The key point to notice is that type OL's form coalitions with type DB's in a core state. Homogenizing this type of coalition by taste would lead to a loss of utility compared to the core. The intuition is that although agents of type OL would prefer to build houses, they lose only a little utility if they build theaters instead. By building theaters as opposed to houses, however, they put their organizational talent to much better use (cutting project construction costs by 3 instead of 1.5). Thus, type OL agents are better off hiring a DB at the prevailing wage and building a theater than staying in a single person coalition and building a house. If follows that the economy does not satisfy SET.

■

Thus, we find that taste-heterogeneous jurisdictions may be able to provide their members with a higher utility level than taste-homogeneous jurisdictions regardless of whether crowding occurs in consumption or production.

As an aside, a weak version of taste-homogeneity (Weak Essential Taste Homogeneity or WET) holds under relatively mild conditions. Specifically, strict small group effectiveness alone implies that there is no advantage in mixing taste types *within a given crowding type.* That is, we might expect to see men who like jazz at a dance with women who like rock, but we would be not expect a dance attended by both women who like rock *and* women who like jazz to be superior to one where all the women liked rock. At any rate, women who like rock would be no better off at such a dance than at one with men who like rock. See Conley and Wooders (2001) for a generalized proof that SSGE implies that economies satisfy WET.

4. Hedonic Prices, Hedonic Independence, and Taste-homogeneity

One property of the examples in the previous section is that it seems to matter how the taste and crowding characteristics are distributed over individuals. The total welfare of the economy would be increased if every lover of second-hand smoke became a smoker, and every hater, a nonsmoker. Note that the total number of lovers, haters, smokers and nonsmokers would not be changed if this took place. There is evidently a bonus for being an agent who has a preference for living with one's own crowding type. Put a different way, the value of characteristics is not independent of how they are bundled.

In this section we explore what happens when the value of characteristics *is* independent of how they are distributed. We consider a special case of the model described in section two in which agents have quasilinear utility functions:

$$u_t(x, y, m) = x + h_t(y, m),$$

where h_t satisfies TAC for all $t \in \mathcal{T}$. It will be convenient to restate the technology in the form of a cost function $f : \Re^n \times \mathcal{N} \to \Re_+$ where

$$f(y, m) = \{z \in \Re_+ \mid (-z, y, m) \in P\}.$$

For simplicity we assume that the cost function is single valued. Formally, we say that an equal treatment state (X, Y, n) satisfies *hedonic independence* (HI) under the following conditions:

HI: There exists a pair of vectors $p = (p_1, \ldots, p_T) \in \Re^T$ and $q = (q_1, \ldots, q_C) \in \Re^C$ such that for all $c \in \mathcal{C}$ and $t \in \mathcal{T}$, $q_c + p_t = U_{ct}$ where U_{ct} is the utility an agent of type (c, t) receives in the equal treatment state (X, Y, n).

As noted earlier, the idea of hedonic decomposition of various attributes of commodities goes back at least as far as Lancaster (1966) and Rosen (1974). It has been restated more recently in the context of characteristic function games by, for example, Spulber (1986,1989), Moulin (1988) and Wooders (1992). These papers present models of abstract economies in which agents are described by a list of characteristics that include tastes, endowments, crowding types and possibly other attributes as well. There is at least a superficial similarity between the models of economies in which agents are valued according to their characteristics, and the crowding types model presented in the current paper. It turns out, however, that even when small groups are effective the value of agent characteristics are *not* necessarily independent in the crowding types model. Consider example one, above. There are four attributes possible, two taste patterns and two crowding types. This gives us four equations and four unknowns of the following form:

$$q_S + p_L = 10$$

$$q_S + p_H = 5$$

$$q_N + p_L = 5$$

$$q_N + p_H = 10.$$

In words, a Smoker who loves second hand smoke receives 10 in the core, and so his attribute wages must sum up to this number, for example. Subtracting the second from the first equation and the fourth from the third equation gives the following:

$$p_L - p_H = 5$$

$$p_L - p_H = -5.$$

Since no set of values can satisfy both of these equations, decentralizing prices for characteristics do not exist. This means that hedonic independence fails. The reason is that there is a bonus for being an agent who likes the type of externality he produces.

The failure of hedonic independence is a fairly intuitive result that we see reflected in everyday life. Consider a national labor market where one's profession is one's crowding type and agents have different preferences over location choice. Suppose, initially, that hedonic independence happened to be satisfied. Now suppose that a much higher than historically average number of new entrants to one profession, say nursing, strongly prefer urban to rural areas, but nothing else in the economy changes. Since city-preferring nurses would be willing to accept smaller wages for the privilege of enjoying the amenities offered by cities, the wages of nurses in urban areas are driven down while their wages in rural areas are driven up. To make matters simple, assume nurses are a small fraction of the total population so that this change does not affect the economy wide hedonic wage for "urban (or rural) preferences". Then the hedonic wage for "nurse" would have to go down if urban nurses get less overall compensation, but would have to go up if rural nurses are to receive more overall compensation. This is clearly impossible so if hedonic independence was satisfied initially, it can't be now. More intuitively, the new situation creates a bonus to being the kind of nurse (rural-preferring) now in short supply and a penalty for being the kind of nurse (urban-preferring) now in more abundant supply. What drives this outcome is the assumption that when an agent moves to a location, he brings his external effects with him. He cannot sell his skills, or transfer his negative external effects outside of the jurisdiction in which he resides. A given nurse may regret he is not the type of person who would enjoy the amenities offered by the high wage rural jurisdictions, but there is little he can do about it. Thus, the requirement that agents must consume the externalities they generate within the jurisdiction in which they live prevents the prices of characteristics from equilibrating across jurisdictions. If this no-trade constraint were non-existent, as it is for private goods, prices of characteristics would equalize.

We conclude that hedonic independence is likely to be one of the factors that influences whether agents mix or segregate across taste type in the core states of the economy. Theorem 1 shows that this intuition is true.

Theorem 1. *Any core state, (X, Y, n) satisfying HI for an economy satisfying SSGE and FS must also satisfy SET.*

Proof/

See appendix.

■

Whether to interpret this result as supporting or attacking the intuition that there is a strong tendency for jurisdictions to be taste-homogeneous is not completely clear. On the one hand, hedonic independence is a special, perhaps even nongeneric, condition in the context of crowding types economies. On the other hand, it is automatically satisfied when crowding is *anonymous* and so the homogeneity results we have for such economies are an immediate corollary of Theorem 1. In addition, hedonic independence may be satisfied in some cases due to market interactions not modeled in the current paper. Several authors, including de Bartolome (1990), Evans *et al.* (1992) and Benabou (1996) have examined models in which parents make residential choices based on peer group effects that influence the educational outcomes for their children. To abstract from this a bit, suppose more generally that agents make educational investment decisions and in so doing choose to acquire a set of skills which then become their crowding type. It seems natural in such a model that no skill/taste combination could possibly receive a bonus or penalty. Otherwise agents would have an incentive to revise their educational choices, and so any rent to particular combinations should be competed way. We investigate this more formally in Conley and Wooders (1996 and 2001). We show that if crowding type is endogenous and all agents are equally adept at acquiring skills, a no-arbitrage condition in education choice will imply that hedonic independence holds. However, when agents have different underlying genetic characteristics that affect the cost of acquiring skills (intelligence, diligence, physical coordination, for example), this result breaks down, hedonic independence may not be satisfied, and optimal coalitions may not be taste-homogeneous.

We close with one more result. Although hedonic independence may be a sufficient condition for taste-homogeneity, it turns out not to be necessary.[15] Thus, the door is still open for the exploration of other conditions that have implications for the form of optimal coalitions.

Example 3: HI is not necessary for SET.

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[15] We thank an anonymous referee for calling our attention to this question.

In the interest of brevity, we provide a bare-bones example. Suppose there are two crowding types A and B, two tastes types, 1 and 2, and no public goods. Let the utility functions be as follows:

$$u_1(A,A) = 10 \quad u_1(A,A,B) = 8, \quad u_1(B) = 4, \quad u_1(\text{ all else }) = 0$$

$$u_2(B,B) = 10 \quad u_2(B,B,A) = 8, \quad u_2(A) = 4, \quad u_2(\text{ all else }) = 0$$

$$100 : A1, \quad 50 : B1, \quad 50 : A2, \quad 100 : B2$$

In any core state, agents of type A1 and B2 can guarantee themselves a payoff of at least 10, and agents of type B1 and A2 can guarantee themselves a payoff of 4. The two ways to achieve this are

$$50 : (A1, A1, B1), \quad 50 : (B2, B2, A2)$$

and

$$50 : (A1, A1) \quad 50 : (B2, B2), \quad 50 : (B1), 50 : (A2).$$

Each of these coalitional structures provides the agents with the following core payoffs:

$$U_{A1} = 10, \quad U_{B1} = 4, \quad U_{A2} = 4, \quad U_{B2} = 10.$$

Note that this means that in the first case, types B1 and A2 are making side-payment of 2 to each of the other two coalition members to be allowed to join.

Observe that both possible core states satisfy SET (the coalitions are already taste-homogeneous).

However:

$$q_A + p_1 = 10$$

$$q_A + p_2 = 4$$

$$q_B + p_1 = 4$$

$$q_B + p_2 = 10.$$

Subtracting the second from the first equation and the fourth from the third equation gives the following:

$$p_1 - p_2 = 6$$

$$p_1 - p_2 = -6.$$

Thus, HI is not satisfied, even though SET is.

■

5. Conclusion

The motivation for this paper is to explore whether or not taste-homogeneous organizations are optimal. Although we focus on a Tiebout economy with crowding types, our approach includes a wide variety of coalitional games as special cases. The literature falls on both sides of the question of taste-homogeneity, and our major objective is to uncover the underlying factors that determine the optimal structure of coalitions in this dimension.

Our first conclusion is that in general it is not the case that optimal jurisdiction will be taste-homogeneous. We show through a pair of counter-examples that this is true regardless of whether crowding takes place in consumption or production. These results are shown for a model in which crowding is differentiated and crowding types are exogenously associated with agents (gender, for example, is an exogenous crowding characteristic). This contrasts with results for economies with undifferentiated crowding and for economies in which equally able agents choose their crowding types endogenously (for example, when otherwise identical agents invest in education to acquire different types of skills). In both of these cases, optimal jurisdictions are taste-homogeneous. If agents have differential abilities that affect the cost of acquiring skills (for example, it might be easier for smart people to finish medical school), however, this result breaks down and taste-heterogeneous jurisdictions may again be optimal.

Our second conclusion is that one factor which may help explain this difference is that taste and crowding effects may have internal complementarities. For example, it may be beneficial to be the type of individual who enjoys the sort of externality one produces. To investigate this issue, we define a condition called hedonic independence that requires, which no such complementarities exist, and so the value of agents' characteristics to an economy is independent to how they are distributed across agents. Hedonic independence is satisfied in anonymous crowding economies and endogenous crowding types economies with equally able agents. It is not satisfied in general in either exogenous crowding type economies or in endogenous crowding type economies with differentially able agents. We show that hedonic independence is sufficient but not necessary for the optimality of taste homogeneity of jurisdictions.

Appendix

In effect, hedonic independence implies that the core may be decentralized by prices with a specific property. In Conley and Wooders (1997), we show that if the core is nonempty, there will also exist a price system that will decentralize the core. Formally, a *Tiebout price system for crowding type c* is a mapping:

$$\rho_c : \Re_+ \times \mathcal{N}_c \to \Re.$$

Less formally, a price system ρ_c for agents of crowding type $c \in \mathcal{C}$ gives an admission price for every jurisdiction containing agents of type c, for every possible public good level. A *Tiebout price system* is simply the collection of price systems, one for each crowding type, and is denoted by ρ. See page 427 of Conley and Wooders (1997) for a more complete motivation and a formal definition of Tiebout equilibrium.

With this preliminary, the next Lemma demonstrates a useful relationship between these two decentralizing price systems.

Lemma 1. *Consider any core state, (X,Y,n) that satisfies HI for an economy that satisfies SSGE and FS, and let (p,q) be the hedonic prices that support this state. If there are two agents $i,\hat{i} \in n^k \in n$ for which $\theta(i) = (c,t)$ and $\theta(\hat{i}) = (\hat{c},\hat{t})$ then*

$$q_c + p_{\hat{t}} = h_{\hat{t}}(y^k, m) + \omega_{\hat{t}} - \rho_c(y^k, n^k).$$

Proof/

By Theorem 4 of Conley and Wooders (1997), there exists an anonymous Tiebout price system that decentralizes the core state (X,Y,n). Since by HI, (p,q) also decentralizes the core state and by assumption, $i,\hat{i} \in n^k$, we know:

$$q_c + p_t = h_t(y^k, n^k) + \omega_t - \rho_c(y^k, n^k) byHIand$$

and

$$q_{\hat{c}} + p_{\hat{t}} = h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_{\hat{c}}(y^k, n^k),$$

Adding these up and rearranging terms gives us,

$$h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_c(y^k, n^k) - q_c - p_{\hat{t}} +$$

$$h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k) - q_{\hat{c}} - p_t = 0$$

Consider the second line of this equation. We claim that

$$h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k) - q_{\hat{c}} - p_t \leq 0.$$

Suppose not, then

$$q_{\hat{c}} + p_t < h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k)$$

By FS and SSGE there must exist an agent j who currently is a member of some jurisdiction $n^{\tilde{k}} \in n$ such that $\theta(j) = (\hat{c}, t)$ and by HI,

$$u_t(x_i, y^{\tilde{k}}, n^{\tilde{k}}) = q_{\hat{c}} + p_t.$$

But then if agent j replaces agent $\hat{i}$ in jurisdiction n^k, while contributing $\rho_{\hat{c}}(y^k, n^k)$ to public goods production, since j is the same crowding type as i by TAC all the remaining agents in n^k are exactly as well off. By TAP the cost of producing y^k is covered. In addition, since

$$u_t(x_j, y^{\tilde{k}}, n^{\tilde{k}}) = q_{\hat{c}} + p_t < h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k),$$

by TAC agent j is better off. Thus, this jurisdiction is able to improve upon (X,Y,n) which contradicts the hypothesis that it is a core state. We conclude that

$$h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k) - q_{\hat{c}} - p_t \leq 0.$$

By an identical argument

$$h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_c(y^k, n^k) - q_c - p_{\hat{t}} \leq 0.$$

Since

$$h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_c(y^k, n^k) - q_c - p_{\hat{t}} +$$
$$h_t(y^k, n^k) + \omega_t - \rho_{\hat{c}}(y^k, n^k) - q_{\hat{c}} - p_t = 0$$

both lines of this equation must equal zero. We conclude that

$$q_c + p_{\hat{t}} = h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_c(y^k, n^k).$$

■

Theorem 1. *Any core state (X, Y, n) satisfying HI for an economy satisfying SSGE and FS must also satisfy SET*

Proof/

Let $n^k \in n$ and let jurisdiction $\bar{m} \in \mathcal{N}$ be such that

a. for all $c \in \mathcal{C}$ it holds that $\sum_t n^k_{c,t} = \sum_t \bar{m}_{ct}$ and
b. $\tau(\bar{m}) \subseteq \tau(n^k)$.

We must show that there exists an allocation $(\bar{x}, \bar{y})$ for $\bar{m}$ such that

1. for all $i \in \bar{m}$ it holds that $u_t(\bar{x}_i, \bar{y}, \bar{m}) \geq u_t(x_i, y^{\hat{k}}, n^{\hat{k}})$, where $\theta(i) = (c, t)$ and, in the initial core state, $i \in n^{\hat{k}} \in n$,
2. $\sum_{i \in \bar{m}} \bar{x}_i - \sum_{c,t} \bar{m}_{ct}\omega_t - f(\bar{y}, \bar{m}) = 0$.

Consider an allocation $(\bar{x}, \bar{y})$ where $\bar{y} = y^k$ and $\bar{x}_j = \omega_{\hat{t}} - \rho_c(y^k, n^k)$ for all $j \in \bar{m}$ where $\theta(j) = (c, \hat{t})$. Since the crowding profiles of jurisdictions $\bar{m}$ and n^k are the same, by Theorem 3 (Conley and Wooders 1997),

$$\sum_{c,t} \bar{m}_{ct}\omega_t - \sum_{i \in \bar{m}} \bar{x}_i = \sum_{c,t} \bar{m}_{ct}\rho_(y^k, n^k) = \sum_{c,t} n^k_{ct}\omega_t - \sum_{i \in n^k} x_i,$$

and by TAP, $f(y^k, n^k) = f(\bar{y}, \bar{m})$. It follows that

$$\sum_{i \in \bar{m}} \bar{x}_i - \sum_{c,t} \bar{m}_{ct}\omega_t - f(\bar{y}, \bar{m}) = \sum_{i \in n^k} x_i - \sum_{c,t} n^k_{ct}\omega_t - f(y^k, n^k) = 0.$$

Thus, the allocation is feasible for $\bar{m}$ and condition (2) is satisfied.

It only remains to show that agents are just as well off in $\bar{m}$ as in their original jurisdictions. Consider an agent $j \in \bar{m}$ such that $\theta(j) = (c, \hat{t})$. By hypothesis (a) and (b) there must exist a pair of agents $i, \hat{i} \in n^k \in n$ such that $\theta(i) = (c, t)$ and $\theta(\hat{i}) = (\hat{c}, \hat{t})$ for some $\hat{c} \in \mathcal{C}$ and $t \in \mathcal{T}$. By Lemma 1,

$$q_c + p_{\hat{t}} = h_{\hat{t}}(y^k, n^k) + \omega_{\hat{t}} - \rho_c(y^k, n^k).$$

Then by construction of $\bar{x}_j$, HI and TAC.

$$q_c + p_{\hat{t}} = h_{\hat{t}}(\bar{y}, \bar{m}) + \hat{x}_j.$$

We conclude that for all $i \in \bar{m}$ it holds that $u_t(\bar{x}_i, \bar{y}, \bar{m}) \geq u_t(x_i^{\hat{k}}, y^{\hat{k}}, n^{\hat{k}})$, where $\theta(i) = (c,t)$ and, in the core state, $i \in n^{\hat{k}} \in n$, and so condition (1) is satisfied.

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