Formal Appendix: Resource Management and Joint-Planning in Fragmented Societies

1 Intuition for results in Section 3.1

<u>*Symmetric Nash equilibrium request*</u>

Per the main text, we have an expression for the expected utility of player i:

$$\mathbb{E}(u_i) = \begin{cases} x_i, & \text{if } x_i + x_{-i} \leq \alpha \\ \frac{x_i[\beta - (x_i + x_{-i})]}{\beta - \alpha}, & \text{if } \alpha < x_i + x_{-i} \leq \beta \\ 0, & \text{else} \end{cases} \tag{A.1}$$

Consider expected utility in the middle case, wherein the total request may be between α and β. After some simplification, the first derivative is:

$$\frac{\beta - 2x_i - x_{-i}}{\beta - \alpha} \tag{A.2}$$

Setting Equation 2 equal to 0 and solving for x_i yields:

$$x_i = \frac{\beta - x_{-i}}{2}$$

To focus on symmetric equilibria, we substitute $(n-1)x_i$ for x_{-i}. After simplifying, we have:

$$x_i^* = \frac{\beta}{n+1}$$

This establishes half of the symmetric Nash equilibrium discussed in the main text.

To see the rest, note that the total symmetric equilibrium request $\frac{n\beta}{\beta-\alpha}$ is only greater than α when it is true that $n\beta > \alpha(n+1)$. Therefore, when that assumption is not met, $\frac{\beta}{n+1}$ *is not* the rational choice for a self-interested decision-maker. Increasing the group-level request to α instead (and dividing it equally given the focus on symmetric equilibria) provides everyone a higher payoff without risking over extraction at all.

While it is in every player's interests to increase her request from $\frac{\beta}{n+1}$ to $\frac{\alpha}{n}$ when $n\beta \leq \alpha(n+1)$, increasing her request any more would be suboptimal. To see this, compare a player's expected utility here from $\frac{\alpha}{n}$ to their expected utility from $\frac{\alpha}{n} + \epsilon$, where ϵ is a small positive term. The expected utility of the former request is higher. In sum, this gives us the other half of the symmetric Nash request presented in the main text.

Symmetric Pareto efficient request

We can express the expected utility of the community as a whole (who requests X) as:

$$\mathbb{E}(u_{comm}) = \begin{cases} X, & \text{if } X \leq \alpha \\ \frac{X[\beta - X]}{\beta - \alpha}, & \text{if } \alpha < X \leq \beta \\ 0, & \text{else} \end{cases} \tag{A.3}$$

Community utility is maximized when $X^* = \frac{\beta}{2}$ (following a similar procedure as above). Note that this will only be greater than α when $\beta > 2\alpha$. In any other situation, the community could maximize it's utility by increasing its request to α instead. As noted above, requesting less than α (the lower bound of the resource's potential worth), would simply yield a loss of utility. Therefore, for a set of players that makes symmetric decisions, the community welfare maximizing requests for each player would be $\frac{\beta}{2n}$ if $\beta > 2\alpha$, or $\frac{\alpha}{n}$ otherwise.

Any outcome that maximizes community welfare is Pareto efficient (because Pareto improvements are not possible). Therefore, those requests must be Pareto efficient. Moreover, because there is no other symmetric outcome that returns as much as or greater utility to the community, they are also the *unique* symmetric Pareto optimal requests.

2 Proposition A

I argue that pessimistic players assume there is as little merging outside their coalition as possible, and optimistic players assume the opposite.

Consider game Γ^1 (see the main text). Presume coalition S_j considers not joining the grand coalition under two extreme expectations. I specify players' steady-state expected utility in equilibrium (given each potential outcome), and then show that one is worse for S_j than the other.

Singletons

Assume $\mathcal{N} \backslash S_j = \{l_1, ..., l_q\} \; \forall \; l \in \mathcal{N} \notin S_j$

Expected utility of an outcome is based on multiplying a coalition's payoff by the probability it will receive that payoff. With a uniformly distributed resource, we have:

$$\mathbb{E}(u_{S_j}) = x_{S_j} * \frac{\beta - \sum_{i \in \mathcal{N}}^{n} x_i}{\beta - \alpha}$$

And for the case in question here, we have

$$\mathbb{E}(u_{S_j}) = \sum_{i \in S_j}^{m} \frac{x_i[\beta - x_i - x_{-i \in S_j} - q x_{l \notin S_j}]}{\beta - \alpha} \tag{A.4}$$

$$\mathbb{E}(u_{S_j}) = \frac{1}{\beta - \alpha}\Big[\sum x_i \beta - \sum x_i^2 - \sum x_i x_{-i \in S_j} - \sum q x_{l \notin S_j} x_i\Big]$$

Presuming symmetry within coalitions (and among singleton players), this simplifies to:

$$\frac{1}{\beta - \alpha}\Big[\beta x_{S_j} - x_{i \in S_j} x_{S_j} - (m-1) x_{i \in S_j} x_{S_j} - q x_{S_j} x_{l \notin S_j}\Big]$$

and further to:

$$\frac{1}{\beta - \alpha}\Big[\beta x_{S_j} - \frac{1}{m} x_{S_j}^2 - \frac{(m-1)}{m} x_{S_j}^2 - q x_{S_j} x_{l \notin S_j}\Big]$$

Which results in the following first order condition:

$$2 x_{S_j} = \beta - q x_{l \notin S_j} \tag{A.5}$$

A similar procedure yields the first order condition for maximizing $\mathbb{E}(u_{l \notin S_j})$:

$$x_{l \notin S_j} = \frac{\beta - x_{S_j}}{q + 1} \tag{A.6}$$

Based on these, the equilibrium behavior of S_j and each member of $\mathcal{N} \backslash S_j$ come out as:

$$x_{S_j}^* = x_{l \notin S_j}^* = \frac{\beta}{2 + q} \tag{A.7}$$

Interestingly, in equilibrium each singleton outside S_j makes the same request that S_j makes collectively. When the coalition structure is made up of a mix of singletons and coalitions, then, this implies that singletons take advantage of the fact that coalitions tend to request less as a group.

Equation 4 in hand, I flesh out $\mathbb{E}(u_{S_j})$ in Equation 5.

$$\mathbb{E}(u_{S_j}) = \frac{\frac{\beta}{2+q}[\beta - \frac{\beta}{2+q} - \frac{q\beta}{2+q}]}{\beta - \alpha} = \frac{\frac{\beta^2}{(2+q)^2}}{\beta - \alpha} \tag{A.8}$$

Union

Assume $\mathcal{N} \backslash S_j = \{l_1 \cup l_2 \cup ... \cup l_q\} \; \forall \; l \in \mathcal{N} \notin S_j$

Following the same general procedure as above yields this equilibrium behavior whenever there are two decision-makers (regardless of the number of players in either coalition):

$$x_{S_j}^* = x_{-S_j}^* = \frac{\beta}{3} \tag{A.9}$$

And this expression for the expected utility of S_j:

$$\mathbb{E}(u_{S_j}) = \frac{\frac{\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} = \frac{\frac{\beta^2}{9}}{\beta - \alpha} \tag{A.10}$$

Comparison

It is easy to see that S_j is better off when all players in $\mathcal{N} \backslash S_j$ merge together anytime there is more than one player outside S_j.

$$\frac{\frac{\beta^2}{(2+q)^2}}{\beta - \alpha} < \frac{\frac{\beta^2}{9}}{\beta - \alpha}$$

$$\frac{1}{(2+q)^2} < \frac{1}{9}$$

Players with pessimistic expectations assume their coalition faces a structure of singletons, and players with optimistic expectations assume the opposite. ■

3 Proposition B

Positive externalities

Consider Γ^1, where we have Θ_2. I employ proof by induction.

First, I establish that a merge between any two coalitions S_j and S_l improves $v(S_o)$ for some third coalition. I refer to a coalition structure where the first two have merged as $\mathcal{P}_2$, and a structure in which they have not as $\mathcal{P}_1$.

Consider an initial structure of singletons, wherein two of those singletons (aside from S_o) decide to merge. Recalling Equation 8 in Proposition A and the base model as outlined in section 3.1 of the main text, after some simplification we have:

$$v_{\mathcal{P}_2}(S_o) > v_{\mathcal{P}_1}(S_o)$$

$$\frac{\frac{\beta^2}{(2+q)^2}}{\beta - \alpha} > \frac{\frac{\beta^2}{(n+1)^2}}{\beta - \alpha}$$

This is true in the hypothetical case under consideration, where there are 2 players in the merged coalition and therefore $q = n - 2$.

Consider now a scenario where all players but S_o and some other singleton have merged. If this other singleton and the coalition merge, leaving S_o as a holdout, recalling Proposition A we have the inequality:

$$\frac{\frac{\beta^2}{9}}{\beta - \alpha} > \frac{\frac{\beta^2}{(2+q)^2}}{\beta - \alpha}$$

Here, $q = 2$, which renders this statement true.

Finally, what if we consider a slightly different situation? What if a coalition of all other players (S_o) witnesses a merge between two singleton holdouts (S_j and S_l)? Some reflection reveals that the same inequality as above will result. In sum, merges in this game generate positive externalities for uninvolved players no matter how many others are involved in the merge. Because positive externalities hold in all these extreme circumstances, I argue that they hold in general. ■

Efficiency

No coalition structure aside from the grand coalition will make the efficient (in this parameter space) community-level request of $\frac{\beta}{2}$. This follows, in part, from the fact that this game is not subject to negative externalities.

However, we can verify that this community-level request is efficient more directly. Presume we manipulate the behavior of players to introduce a tremble: we either increase or decrease the net request by some amount ϵ. How does the community-level expected value of this outcome with a tremble compare to that of a unitary player requesting $\frac{\beta}{2}$?

$$\frac{\frac{\beta}{2}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{(\frac{\beta}{2} + \epsilon)[\beta - \frac{\beta}{2} - \epsilon]}{\beta - \alpha}$$

$$\frac{\frac{\beta}{2}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{(\frac{\beta}{2} - \epsilon)[\beta - \frac{\beta}{2} + \epsilon]}{\beta - \alpha}$$

Each reduces to the clearly true expression:

$$0 > -4\epsilon^2$$

The inefficiency introduced by this tremble increases with ϵ. This indicates that a community's net expected utility becomes strictly worse the farther that community's total request gets from $\frac{\beta}{2}$.

To see that only the grand coalition will make this Pareto efficient community level request in Γ^1, consider players' behavior in two other circumstances: (1) when there is a coalition structure of singletons; and (2) when the entire community has merged into two coalitions. The net requests in these cases are $\frac{n\beta}{n+1}$ and $\frac{2\beta}{3}$ respectively (per section 3.1 in the main text and Equation 4 above).

$\frac{\beta}{2}$ is less than each of these, but $\frac{2\beta}{3}$ is closer than $\frac{n\beta}{n+1}$. As the coalition-structure concentrates, then, community-level behavior approaches efficient levels, but does not reach them in this parameter space except through the grand coalition. ■

4 Proposition C

Pessimism

Presume that players in Γ^1 have pessimistic expectations about those outside their coalition. Under pessimism, I show that players will determine that remaining in the grand coalition is more valuable than defecting as a singleton or some subcoalition $S_j \subset \mathcal{N}$.

First, imagine some coalition of players that is considering acting separately from the grand coalition. The value of remaining in the grand coalition for any $i \in S_j$ is on the left (following from Proposition B, and research cited in the main text), and the value of acting separately from other players is on the right (drawn from Proposition A).

$$\frac{\frac{\beta}{2n}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{\frac{\beta}{m(2+q)}[\beta - \frac{\beta}{2+q} - \frac{q\beta}{2+q}]}{\beta - \alpha} \tag{A.11}$$

This becomes:

$$\frac{1}{4n} > \frac{1}{m(2+q)^2}$$

Which simplifies further to:

$$mq + 4m > 4$$

This is always true since m and q are positive integers. But what if a player with pessimistic expectations considers acting alone, rather than diverging from the grand coalition with other players? The term on the right is now drawn from section 3.1 of the main text, since under pessimism a player acting alone simply expects to play a non-cooperative game.

$$\frac{\frac{\beta}{2n}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{\frac{\beta}{n+1}[\beta - \frac{n\beta}{n+1}]}{\beta - \alpha} \tag{A.12}$$

This reduces to the following inequality, which returns true so long as $n > 1$.

$$\frac{1}{4n} > \frac{1}{(n+1)^2}$$

Under pessimistic expectations, each player's expected utility in the grand coalition dominates their expected utility in any possible $S_j \subset \mathcal{N}$. ■

Optimism

The same claims do not always hold when players are optimistic about the behavior of the rest of the coalition-structure outside their own coalition.

First, consider the value of acting alone to any optimistic player, drawn from the behavior deduced in Proposition A.

$$\frac{\frac{\beta}{2n}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{\frac{\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} \tag{A.13}$$

$$\frac{1}{4n} > \frac{1}{9}$$

The grand coalition only dominates here in trivial cases where there are two or less players. Lastly, consider the value of remaining outside the grand coalition for individual, optimistic members of some coalition S_j.

$$\frac{\frac{\beta}{2n}[\beta - \frac{\beta}{2}]}{\beta - \alpha} > \frac{\frac{\beta}{3m}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} \tag{A.14}$$

$$\frac{1}{4n} > \frac{1}{9m}$$

When the proportion of the community considering acting apart from the grand coalition is greater than $\frac{4}{9}$, the grand coalition dominates. When the proportion of the community is lower than this threshold, this subset of optimistic players *will not* join the grand coalition. ■

5 Proposition D

Consider Γ^2, which is identical to Γ^1 except that the social structure of the community prevents the grand coalition from forming. Players are divided into h equally sized identity groups s.t. $h < n$.

Presume that players are weighing the merits of some focal outcome $(z, \mathcal{P}_h)$, wherein they coordinate as much as the fabric of their community allows. I claim that any alternative outcome $(z, \mathcal{P}_{k>h})$ will decrease the net utility accruing to this community.

I argue this inductively, showing: (1) that when even one player diverges from maximal coordination, this decreases the expected utility of the community writ large; and (2) that a similar difference in community-level expected utilities still appears in the extreme case where we compare the value of $(z, \mathcal{P}_h)$ to the value of a coalition structure of singletons $(z, \mathcal{P}_{k=n})$.

First, per (1), compare the expected utility of the community as a whole under maximal coordination and optimistic expectations (on the left) to its expected utility when one player acts separately from her social group (on the right). For $h = 2$, then we have:

$$\frac{\sum_{j\in\{1,2\}} \frac{\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\sum_{j\in\{1,2,3\}} \frac{\beta}{4}[\beta - \frac{3\beta}{4}]}{\beta - \alpha} \tag{A.15}$$

The term on the right follows from the utility maximizing behavior of the two coalitions (S_1 and S_2) and a “defecting” player (who has stayed outside S_2), derived the same way as the behavior derived in Proposition A:

$$x^*_{S_1} = x^*_{S_2} = x^*_{l \notin S_2} = \frac{\beta}{4}$$

Equation 15 simplifies to:

$$\frac{\frac{2\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\frac{3\beta}{4}[\beta - \frac{3\beta}{4}]}{\beta - \alpha}$$

And further to the truism that 32 > 27.

I now turn to (2). The term on the left stays the same as Equation 15, but now the term on the right becomes the sum of the expected utility of every player acting alone in the base game. Once again, I presume $h = 2$, although this same point holds under more restrictive coalition structures.

$$\frac{\sum_{j\in\{1,2\}} \frac{\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\sum_{j=1}^{n} \frac{\beta}{n+1}[\beta - \frac{n\beta}{n+1}]}{\beta - \alpha} \tag{A.16}$$

Equation 16 becomes:

$$\frac{\frac{2\beta}{3}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\frac{n\beta}{n+1}[\beta - \frac{n\beta}{n+1}]}{\beta - \alpha}$$

Which is true so long as we are not in a trivial case where $n < 3$.

Finally, observe that the difference in values applied by (2) is greater than the difference in values implied by (1) so long as $n \geq 4$ (when $n = 3$, these differences are equivalent). Maximal coordination cannot be Pareto improved by fracturing the coalition structure. ■

6 Proposition E

The previous Proposition argues that maximal coordination is more valuable to the community *as a whole* than any more fractured coalition structure. I now argue that no sub-coalition can gain by diverging from maximal coordination under pessimistic expectations. Again, I rely on proof by induction.

Consider some coalition S_j that remains outside maximal coordination under Γ^2, where $\mathcal{G}^2$ holds (the community is divided in half). Members of S_j are pessimistic, so the expected utility of members of S_j if they diverge from maximal coordination can be drawn from the right-hand side of Equation 11 in Proposition C. Expected utility for any member under maximal coordination is based on Equation 9. Recall that the number of players in S_j is represented by m.

$$\frac{\frac{2\beta}{3n}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\frac{\beta}{m(2+q)}[\beta - \frac{\beta}{2+q} - \frac{q\beta}{2+q}]}{\beta - \alpha} \tag{A.17}$$

$$\frac{2}{9n} > \frac{1}{m(2+n-m)^2}$$

Here, m is logically bound between 2 and $\frac{n}{2} - 1$. This expression is if we plug in any value within this range, so long as we assume a non-trivial case where $n > 3$.

Next, I consider the potential value to a pessimistic player of staying outside maximal coordination alone, again assuming a community is divided in half by some identity division.

$$\frac{\frac{2\beta}{3n}[\beta - \frac{2\beta}{3}]}{\beta - \alpha} > \frac{\frac{\beta}{n+1}[\beta - \frac{n\beta}{n+1}]}{\beta - \alpha} \tag{A.18}$$

$$\frac{2}{9n} > \frac{1}{(n+1)^2}$$

This is true under the same condition as Equation 17.

What if the game is played instead on graph $\mathcal{G}^{n/2}$, where social fragmentation is so severe that players can merge at most once? Only one comparison is needed here. Any pessimistic player assessing the value of diverging from maximal coordination considers the expression below:

$$\frac{\frac{\beta}{n+2}[\beta - \frac{n\beta}{n+2}]}{\beta - \alpha} > \frac{\frac{\beta}{n+1}[\beta - \frac{n\beta}{n+1}]}{\beta - \alpha} \tag{A.19}$$

$$\frac{2}{(n+2)^2} > \frac{1}{(n+1)^2}$$

This is true in any case where $n > 1$. The left-hand side of the above inequality is based on deriving players' behavior in a coalition structure of teams of two (and then simplifying the expression of the expected utility of a member of one of these teams). The end result is equivalent to substituting in $\frac{n}{2}$ for n in the right hand side, dividing $\frac{\beta}{n+1}$ (outside the brackets) by 2, and simplifying. ■

7 Proposition F

Consider Γ^3 and Γ^4, and two outcome pairs $(z, \mathcal{P}_k)$ and $(z, \mathcal{P}_1)$, s.t. $\sum_{i \in z} z = nz_i = \alpha$. A coalition S_j considering diverging from either outcome pair under pessimistic expectations expects to instead receive the value on the left below if it does so.

$$\frac{\frac{\beta^2}{(2+q)^2}}{\beta - \alpha} < \frac{m\alpha}{n} \tag{A.20}$$

This eventually becomes, presuming $\beta = 2\alpha$:

$$4 < 4m + m(n - m)$$

Which is true for any non-trivial number of players and any possible $|S_j|$. Therefore, pessimistic players prefer $(z, \mathcal{P}_k)$ and $(z, \mathcal{P}_1)$.

Readers may be concerned that, as in the base game (see 3.1), perhaps divergence of S_j would lead the community to make a net request less than α. In such a case, they would adjust their behavior, rendering Equation 20 less useful. Luckily, this concern is not pressing.

$$\frac{(q+1)\beta}{(2+q)} > \alpha$$

This reduces to the obviously true expression:

$$2q + 2 > 2 + q$$

Now, I consider the same question for players with optimistic expectations.

$$\frac{\frac{\beta^2}{9}}{\beta - \alpha} < \frac{m\alpha}{n} \tag{A.21}$$

$$4n < m9$$

Similarly to Proposition C, for optimistic players in this parameter space, when the proportion of the community considering acting apart from the grand coalition is greater than $\frac{4}{9}$, $(z, \mathcal{P}_k)$ and $(z, \mathcal{P}_1)$ dominate. Otherwise, the dominant outcome is a mixed coalition structure. ■

8 Proposition G

Consider Γ^5, and four possible network structures $\mathcal{P}_{h^n}$, $\mathcal{P}_h$, $\mathcal{P}_{h'}$, and $\mathcal{P}_{h^1}$, wherein n leads to an outcome in the pessimistic core that is more fractured than h, h leads to an outcome that is more fractured than h', and so forth. I address both claims in Result 6 below.

Since X is uniformly distributed, we have:

$$Pr\Big(\sum x_i > X\Big) = 1 - \frac{\beta - \sum x_j}{\beta - \alpha} \tag{A.22}$$

I claim that, for h and h':

$$1 - \frac{\beta - \sum_{i \in \mathcal{P}_h} x_i}{\beta - \alpha} > 1 - \frac{\beta - \sum_{i \in \mathcal{P}_{h'}} x_i}{\beta - \alpha} \tag{A.23}$$

Which reduces to:

$$\sum_{i \in \mathcal{P}_h} x_i > \sum_{i \in \mathcal{P}_{h'}} x_i$$

Recall that I assume identity groups are all the same size. Therefore, under maximal coordination in the pessimistic core, we have the equilibrium behavior outlined in section 3.1 (where n becomes the number of coalitions k).

It is easy to see that since $k > k'$:

$$\frac{k\beta}{k+1} > \frac{k'\beta}{k'+1}$$

This indicates that social fragmentation here increases the community's net request, which in turn means that it increases the probability of over-extraction.

Consider a comparison now for h^n and h. Some reflection reveals that the result will be the same as above. Finally, consider a comparison for h' and h^1.

$$\frac{k'\beta}{k'+1} > \alpha$$

By assumption here, $\beta > 2\alpha$. Therefore, that statement is true.

Social fragmentation increases the number of decision-makers in a community while n remains constant, and this increased social uncertainty puts more pressure on X. ■

9 Proposition H

Consider a game in the parameter space Θ^2 with pessimistic players and two social structures $\mathcal{G}^h$ and $\mathcal{G}^{h'}$ with $h' > h$. Presume for instance that there was some split in the fabric of local society, which decreased the extent of possible joint-planning. It is in the core for maximal coordination to occur both before and after the split per other results in this study. In effect, the community with $\mathcal{G}^{h'}$ will see more fragmented resource use behavior and therefore a higher probability of over-extraction.

I will now show that an increase in the probability of over-extraction is associated with a decrease in the expected utility of any individual player in this circumstance. An expression for this probability is above in Equation 22. It follows that:

$$Pr\Big(\sum x_i \leq X\Big) = \frac{\beta - \sum x_j}{\beta - \alpha} \tag{A.24}$$

If we multiply this by a coalition's request, we have an expression for their expected joint utility as shown in the main text. Because increases in fragmentation increase Equation 22, it follows that they decrease Equation 24. If a coalition's request somehow remained constant during this process, that would be sufficient justification for my claim.

However, we expect that rational coalitions should adapt to the changing behavior of other players. Below, I show that the expected utility of players under $\mathcal{G}^h$ is higher than that under $\mathcal{G}^{h'}$. To do so, as elsewhere, I assume symmetry across coalitions. The term k^h refers to the number of coalitions under $\mathcal{G}^h$, and other terms are defined similarly.

$$\mathbb{E}u_i|\mathcal{G}^h > \mathbb{E}u_i|\mathcal{G}^{h'}$$

$$x_i^h\Big[\frac{\beta - k^h x_i^h}{\beta - \alpha}\Big] > x_i^{h'}\Big[\frac{\beta - k^{h'} x_i^{h'}}{\beta - \alpha}\Big]$$

Given the equilibrium results that appear at the coalition level under this specific circumstance (see Section 3.1), we can simplify that expression and eventually yield:

$$\frac{\beta^2}{(k^h + 1)^2} > \frac{\beta^2}{(k^{h'} + 1)^2}$$

This is always true because $k^{h'} > k^h$. Fragmenting the structure of society and therefore limiting the potential scope of joint-planning decreases every player's utility.