Human migration and spatial patterns of biodiversity conservation

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Outline

1. Introduction
2. The Fujita-Krugman-Venables economy
3. Biodiversity
4. Equilibrium
5. Results
6. Conclusions

1. Introduction; Migration

- Population-Environment

Mueser and Graves (1995): weather

Hunter (2005): earthquakes

Reuveny (2005): degradation

Marquette and Bilsborrow (1999): land use-migration

Hunter (2000): climate change

Introduction; Migration

- Chu and Yu (2002): migration and biodiversity (but only one way)

Theory

- Hoel and Shapiro (2003): migration and transboundary pollution. Perfect mobility
- Haavio (2007?): imperfect mobility
- Lange and Quaas (2006): NEG and pollution
- Rauscher and Barbier (2007): NEG, biodiversity

Introduction; Biodiversity

Issues:

- Fisheries management. Sanchirico and Wilen (1999, 2001, 2002), Armstrong and Skonhoft (2006). Fixed areas/patches.
- Land use. Polasky et al. (2005): find land use pattern maximizing biological ‘score’ subject to economic return
- Land use, property rights, trade. Taylor (1,2,3,4,........), Smulders et al. (2004)
- Fragmentation (positive and negative)

SLOSS debate

MacArthur/Wilson:

- Theory of Island Biogeography
- Species area curve
- Dynamic equilibrium between immigration and extinction

Better to have one large reserve than many small ones (Terborg, 1974).

Fragmentation (positive and negative)

Objective

- Interaction between population dynamics and habitat loss.
- Vehicle: new economic geography model with biodiversity migration motive.

2. The Fujita-Krugman-Venables economy

If biodiversity is a public good

...then a mobile population may determine the socially optimal level of biodiversity conservation

Tiebout hypothesis

2. Model essentials

- Two regions, two sectors
  - Agriculture
    - immobile unskilled labour; constant returns to scale
  - Manufacturing
    - mobile skilled labour; increasing returns to scale
- ...extended with land as a factor of production
- ...and taxation of manufacturing land by regional governments

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Agriculture

- Unskilled labour: $\bar{l}_a = \bar{l}_a^*$
- Fixed proportions land and labour
- Numeraire on world market
- No transport costs

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Manufacturing

- Varieties $i \in [0, n],\ 0 \le n \le 1$
- Production variety $y(i)$
- Demand for skilled labour $l_m(i) = F + vy(i)$
- Demand for land $s_m(i) = bl_m(i)$

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Preferences representative consumer

$$\max U(c_a, C_m) = c_a^{\mu} C_m^{1-\mu} + \varphi B(.)\,,\ 0 < \mu < 1$$

$$C_m = \left[\int_0^1 c_m(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}$$

$$c_a + \int_0^1 \tilde{p}(i) c_m(i) di \le m$$

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Consumer demand

- Define price index
- $$G=\left[\int_0^1 \tilde{p}(i)^{1-\sigma}\,di\right]^{\frac{1}{1-\sigma}}$$

Then

$$c_a=(1-\mu)m,\ \ c_m(i)=\mu m\frac{\tilde{p}(i)^{-\sigma}}{G^{1-\sigma}}$$

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Transport costs $T\ge 1$

- Price index $G=\left[np^{1-\sigma}+n^*(Tp^*)^{1-\sigma}\right]^{1/(1-\sigma)}$
- Foreign representative demand

$$c_m^*(i)=\mu m^*\frac{(Tp)^{-\sigma}}{(G^*)^{1-\sigma}}$$

- Total demand for domestic product

$$\mu M\frac{p^{-\sigma}}{G^{1-\sigma}}+\mu M^*\frac{T(Tp)^{-\sigma}}{(G^*)^{1-\sigma}}$$

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Profit maximization

- profit

$$\pi(i)=p(i)y(i)-[w+rb][F+vy(i)]$$

$$y(i)=\mu\left[M\frac{p(i)^{-\sigma}}{G^{1-\sigma}}+M^*\frac{(p(i))^{-\sigma}T^{1-\sigma}}{(G^*)^{1-\sigma}}\right]$$

$$\Rightarrow p=v[w+\tau b]\frac{\sigma}{\sigma-1}$$

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Zero profit condition

- Factor demand

$$l_m(i)=\sigma F,\ s_m(i)=b\sigma F$$

$$l_m=n\sigma F,\ s_m=nb\sigma F$$

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Utility

- Skilled labour

$$U_m = \psi G^{-\mu}[w + \frac{\tau s_m}{l_a + l_m}] + \varphi B,\ \psi = \mu^{\mu}(1-\mu)^{1-\mu}$$

3. Biodiversity

- Habitat availability is a determinant of biodiversity
- Species richness dominates in economic models
  - Biodiversity = species richness

  (e.g., Polasky et al., 2004)
- Species-area curve

  $R = \eta S_H^{\kappa}$

  (MacArthur and Wilson, 1967)

Biodiversity

- Assume two mutually exclusive sets of species exist
  - Generalists abundant spatial presence
  - Specialists limited spatial presence
- each set inhabits only its own type of habitat
- and the two types of habitat lose proportionally with loss of total habitat

Biodiversity

$$B = \alpha_r R + \alpha_e E$$

$$E = \chi(s_h)^{\varsigma}\ (\varsigma > 1)$$

$$R = \gamma(s_h)^{\vartheta}\ (0 < \vartheta < 1)$$

$$B = \alpha_r \gamma(\bar{s} - nb\sigma)^{\vartheta}\left[1 + \frac{\chi\alpha_e}{\gamma\alpha_r}(\bar{s} - nb\sigma)^{\varsigma - \vartheta}\right]$$

Equilibrium; normalization

$$v = (\sigma - 1)/\sigma \Rightarrow p = w + \tau b \text{ and } y(i) = l_m(i)$$

$$F = \mu / \sigma \Rightarrow y(i) = \mu$$

$$\bar{l}_a = \bar{l}_a^* = \tfrac{1}{2}(1-\mu), \bar{l}_m = \mu$$

$$\bar{s} = \bar{s}^* = 1 \Rightarrow s_h = 1 - nb\mu$$

Equilibrium characterization 1

$$M = n\mu w + \tfrac{1}{2}(1-\mu) + \tau nb\mu$$

$$G = \left[n[w+\tau b]^{1-\sigma} + n^*\left([w+\tau b]T\right)^{1-\sigma}\right]^{1/(1-\sigma)}$$

$$w = \left[MG^{\sigma-1} + M^* T^{1-\sigma}(G^*)^{\sigma-1}\right]^{1/\sigma} - \tau b$$

$$B = \alpha_r \gamma (\bar{s} - nb\sigma)^{\vartheta}\left[1 + \frac{\chi \alpha_e}{\gamma \alpha_r}(\bar{s} - nb\sigma)^{\varsigma - \vartheta}\right]$$

Equilibrium characterization 2

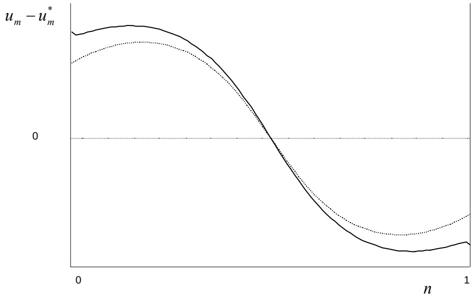
$$U_m(n) = \psi G^{-\mu}\left[w + \frac{2\tau\mu nb}{2n\mu + (1-\mu)}\right] + \varphi B(n)$$

$$U(n) = \psi G^{-\mu}\left[n\mu w + \tfrac{1}{2}(1-\mu) + \tau\mu nb\right] + \varphi\left[n\mu + \tfrac{1}{2}(1-\mu)\right]B(n)$$

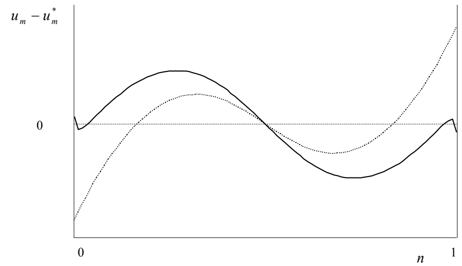
5. Analysis

- Four parts
  - 5.1 Comparison with Fujita et al.
    - Interaction between transport costs and marginal utility of biodiversity
  - 5.2 Role of land use technology
  - 5.3 Role of specialist species
  - 5.4 Analysis of regional policy competition
    - Comparison of coordinated and non-coordinated taxation τ and τ^*

5.1 High transport costs



Intermediate transport costs



Analysis

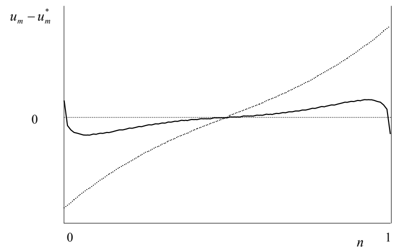
$$B(n) - B(n^*) = \varphi\alpha\gamma(1 - nb\mu)^{\vartheta} - \varphi\alpha\gamma(1 - (1-n)b\mu)^{\vartheta}$$

$$\frac{d(B(n) - B(1-n))}{dn} = -\varphi\alpha\gamma\vartheta b\mu\left\{(1 - nb\mu)^{\vartheta-1} + (1 - (1-n)b\mu)^{\vartheta-1}\right\}$$

$$B(0) - B(1) = \varphi\alpha\gamma - \varphi\alpha\gamma(1 - b\mu)^{\vartheta} > 0$$

$$\frac{d(B(n) - B(1-n))}{dn} \to -\infty$$

Low transport costs



5.2 Land scarcity

$$b\bar{l}_m > \bar{s} \Rightarrow n < 1$$

$$b\bar{l}_m < \bar{s} \Rightarrow s_h > 0$$

5.4 Policy game

- Instrument: land rent
- Objective: welfare inhabitants
- Consider intermediate transport cost

Second-best optimum

- Coordinated policy at intermediate T, φ = 0.006
- ...with $\alpha_E = 0$
  - First-best at n = n* = 0.5
  - Corresponding non-unique τ and τ^* are symmetrical
- ...with $\alpha_E = 0.7$
  - First-best at n = S_H^* = 0.994
  - Corresponding τ and τ^* not unique

Non-cooperative equilibrium

- Non-coordinated policy at intermediate T, φ = 0.006
- ...with $\alpha_E = 0$, solution dependent on initial values
  - Start: asymmetric
    - Second-best stable solution n = S_H^* = 0.985
    - Corresponding τ and τ^* not unique
  - Start: symmetric
    - First-best (symmetric) solution is stable
    - Corresponding $\tau = \tau^* = 0$

Non-cooperative equilibrium

- Non-coordinated policy at intermediate T
- ...with α_E = 0.7
  - Start: asymmetric
    - Second-best cannot be achieved
  - Start: symmetric
    - Second-best stable solution at n = n* = 0.5
    - Corresponding $\tau = \tau^* = 0$

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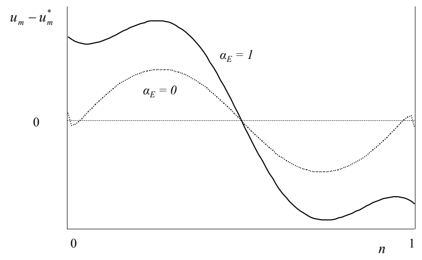
Policy game



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6. Conclusions

- Introduction of biodiversity yields more equilibria than exist in Fujita et al. (2001)
- Optimal level of fragmentation increases with marginal utility of biodiversity
- Optimal level of fragmentation increases with valuation of specialist species
- In certain cases, the Nash equilibrium corresponds to the first-best level of fragmentation

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Appendix 1

$$n = 1, \tau = 0$$

$$M = \mu w + \tfrac{1}{2}(1-\mu)$$

$$G = w$$

$$w = \left[M w^{\sigma-1} + M^* T^{1-\sigma} (G^*)^{\sigma-1} \right]^{1/\sigma}$$

$$w^\sigma = (M + M^*) w^{\sigma-1}$$

$$w = M + M^* = \mu w + \tfrac{1}{2}(1-\mu) + \tfrac{1}{2}(1-\mu)$$

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Appendix 2

$$M = \tfrac{1}{2}(1+\mu), M^* = \tfrac{1}{2}(1-\mu), G = 1, G^* = T$$

$$w^* = \left[\tfrac{1}{2}(1-\mu)T^{\sigma-1} + \tfrac{1}{2}(1+\mu)T^{1-\sigma}\right]^{1/\sigma}$$

$$U_m(1) = \psi, U_m^*((1) = \psi T^{-\mu}\left[\tfrac{1}{2}(1-\mu)T^{\sigma-1} + \tfrac{1}{2}(1+\mu)T^{1-\sigma}\right]^{1/\sigma}$$

$$\{U_m^*((1)\}^{\sigma} = \psi^{\sigma}\left[\tfrac{1}{2}(1-\mu)T^{\sigma-1-\sigma\mu} + \tfrac{1}{2}(1+\mu)T^{1-\sigma-\sigma\mu}\right]$$

$$\frac{\partial U_m{}^*(1)}{\partial T} < 0 \ for \ T = 1$$

Appendix 3

$$n = n^* = \tfrac{1}{2}$$

$$M = \tfrac{1}{2}\mu w + \tfrac{1}{2}(1-\mu)$$

$$G = \left[\tfrac{1}{2}w^{1-\sigma} + \tfrac{1}{2}(w^*T)^{1-\sigma}\right]^{1/(1-\sigma)}$$

$$w = \left[MG^{\sigma-1} + M^*T^{1-\sigma}(G^*)^{\sigma-1}\right]^{1/\sigma}$$

$$M = M^* = \tfrac{1}{2}, w = w^* = 1, G = G^* = \left[\frac{1+T^{1-\sigma}}{2}\right]^{1/(1-\sigma)}$$

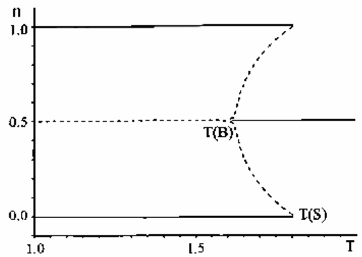

Figure 5.4
Core-periphery bifurcation