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**Location of Polluting Activities
in Models of Economic Geography**

Summer School in Resource and Environmental Economics

San Servolo, Venezia (VE), 12th July 2008

Introduction

Geographic space in economic theory

early contributions

- Johann Heinrich von Thünen 1826
- Alfred Marshall 1890
- Harold Hotelling 1929
- Walter Christaller 1933

Contributors to the recent revival of economic geography

- Paul Krugman, 1991, "Geography and Trade"
- Masahisa Fujita
- Paul Krugman
- Anthony Venables

Good textbook

- Richard Baldwin, Rikard Forslid, Philippe Martin, Gianmarco Ottaviano, Frederic Robert-Nicoud, 2003, *Economic Geography and Public Policy*

Agglomeration and the environment

Living in the wrong place (at the wrong time)

- London (1953)
- Seveso (1976)
- Bhopal (1984)
- Chernobyl (1986)
- Beijing (2008) ???

Stylised scenarios of spatial organisation

- concentration
- separation
- dispersion

Related Literature

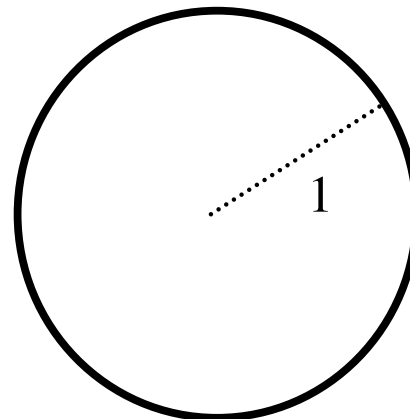
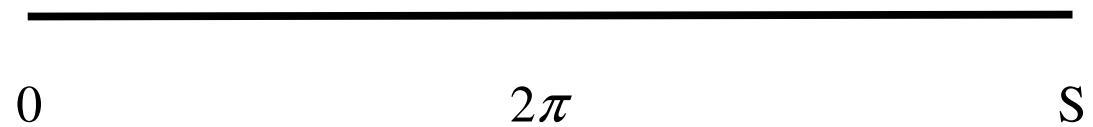
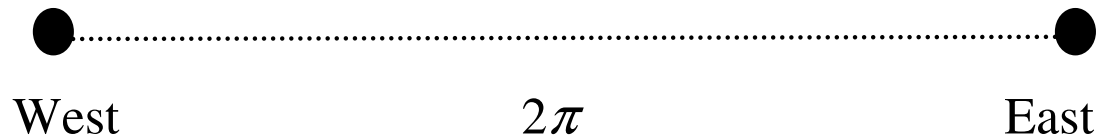
- Rajiv Kanbur, Michael Keen, Sweder van Wijnbergen, 1995
- Michael Rauscher, 1998
- Chris Elbers, Cees Withagen, 2004
- Charles van Marrewijk, 2005
- Edward B. Barbier, Michael Rauscher, 2007
- Andreas Lange, Martin Quaas, 2007
- Efthymia Kyriakopoulou, Anastasios Xepapadeas, 2008
- Michael Rauscher, 2008
- Kenmai Tsubota, 2008

Outline of the talk

1. Types of models of new economic geography
2. A model with footloose capitalists
3. A model with mobile workers
4. Biodiversity and geography
5. Emission reduction in a model with mobile workers
6. Some final remarks

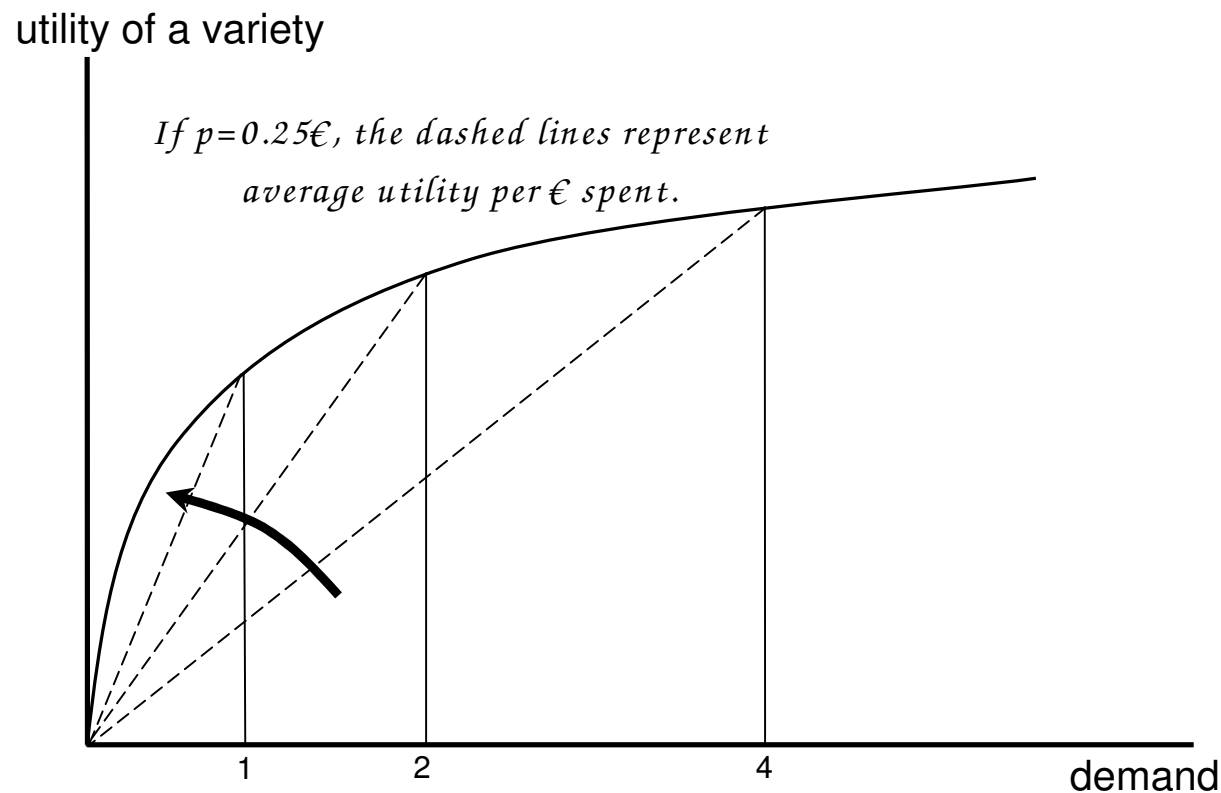
1.Types of models of new economic geography

The modelling of geographic space



The first workhorse of NEG models: Dixit-Stiglitz preferences plus fixed costs

- There are differentiated commodities that are good substitutes.
- The nature of variety remains unspecified.
- Total utility is the sum of utilities of individual varieties.



Consumers/users prefer infinitely many varieties in infinitely small quantities.

However:

Fixed costs make small quantities extremely expensive.

Thus:

Free entry leads to monopolistic competition with limited variety.

And:

Larger markets generate more variety.

Therefore:

Trade is advantageous.

The second workhorse of NEG models: in-kind transportation costs

- von Thünen 1826: horses pull carts with grain and are fed with grain
- Samuelson 1952: icebergs are transported from Antarctica to Africa and Arabia to increase sweetwater supplies

Implications:

- No transportation industry needs to be modelled.
- Price elasticity of demand is unaffected by transportation costs.
- Agglomeration may be advantageous.

Types of two-region NEG models

Models without vertical linkages

- manufacturing uses only primary inputs
- **interregional** mobility of primary factors drives agglomeration

Models with vertical linkages

- manufacturing uses produced inputs (Dixit-Stiglitz type, Ethier)
- **intersectoral** mobility of primary factors drives agglomeration

Who is mobile?

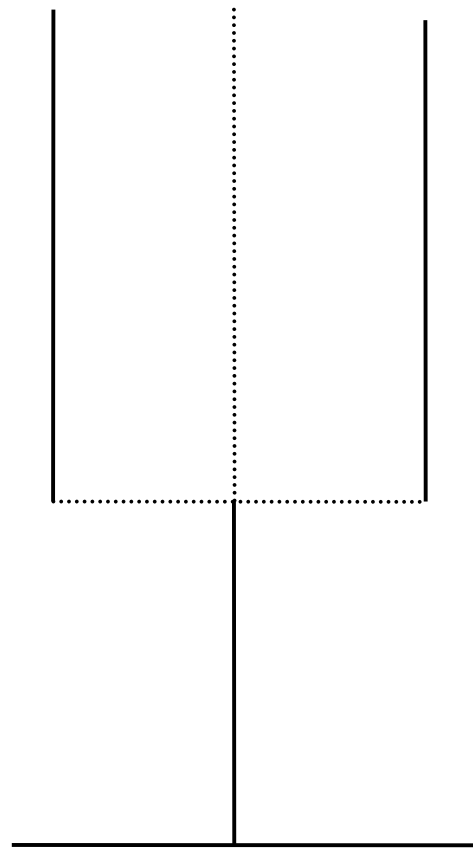
- no one
- only factors of production
- only factor owners (consumers)
- factor owners and factors
 - capitalists
 - workers

Types of utility functions $U(C_A, C_M)$

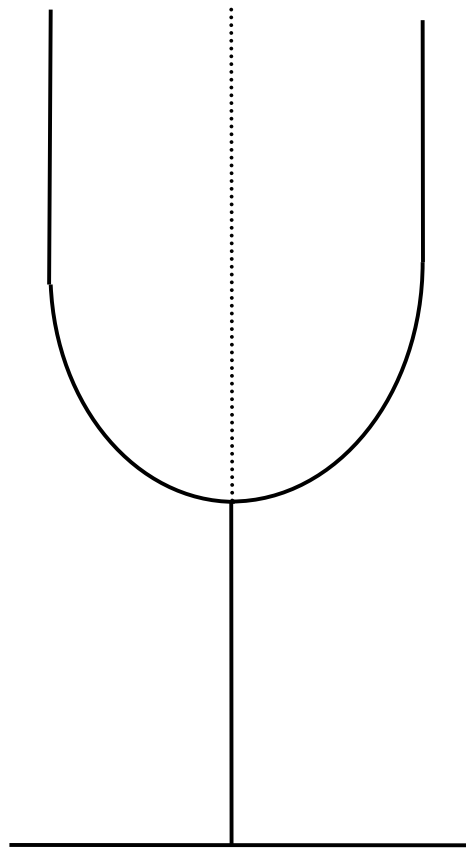
- Pflüger, M., J. Südekum, 2006, A Unifying Approach to the New Economic Geography, Bonn: IZA Discussion Paper 2256. Downloadable from <http://ftp.iza.org/dp2256.pdf>.

The following diagrams are based on Figure 1 of this paper

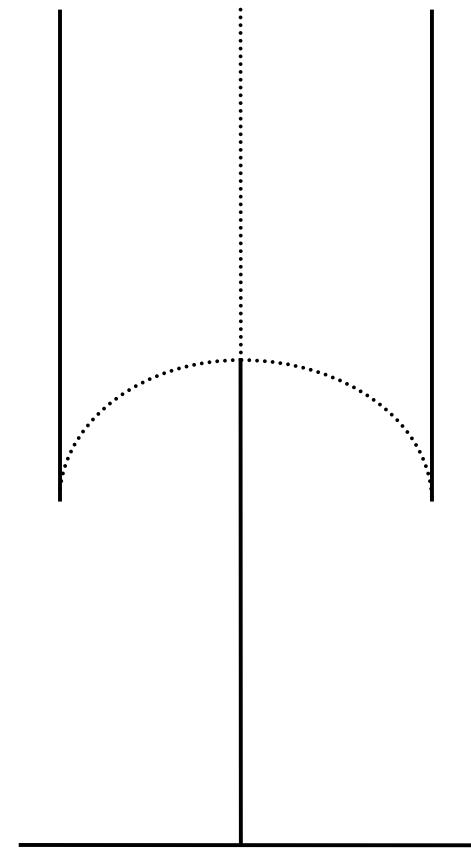
The impact of trade freeness on agglomeration in the core periphery model for different specifications of the utility function



share of firms in the East



share of firms in the East



share of firms in the East

2. A model with footloose capitalists

2.1 The model

2.2 Results under *laissez faire*

2.3 Optimal environmental policies

2.4 Instrument choice

2.1 The model

2 regions: East and West (*)

Private households

Population

- unity, of which β in the east, $(1 - \beta)$ in the west

Endowment

- 1 unit of factor, of which k in the east, $(1 - k)$ in the west
- 1 unit of numéraire ("manna")

Quasilinear utility

$$\int_0^n p(i)c(i)di + \int_0^{n^*} \theta p^*(j)m(j)dj + x = 1 + y. \quad (1)$$

$$u = \frac{1}{\gamma} \left(\int_0^n c(i)^\gamma di + \int_0^{n^*} m(j)^\gamma dj \right) + x - \frac{\delta e^{1+z}}{1+z}, \quad (2)$$

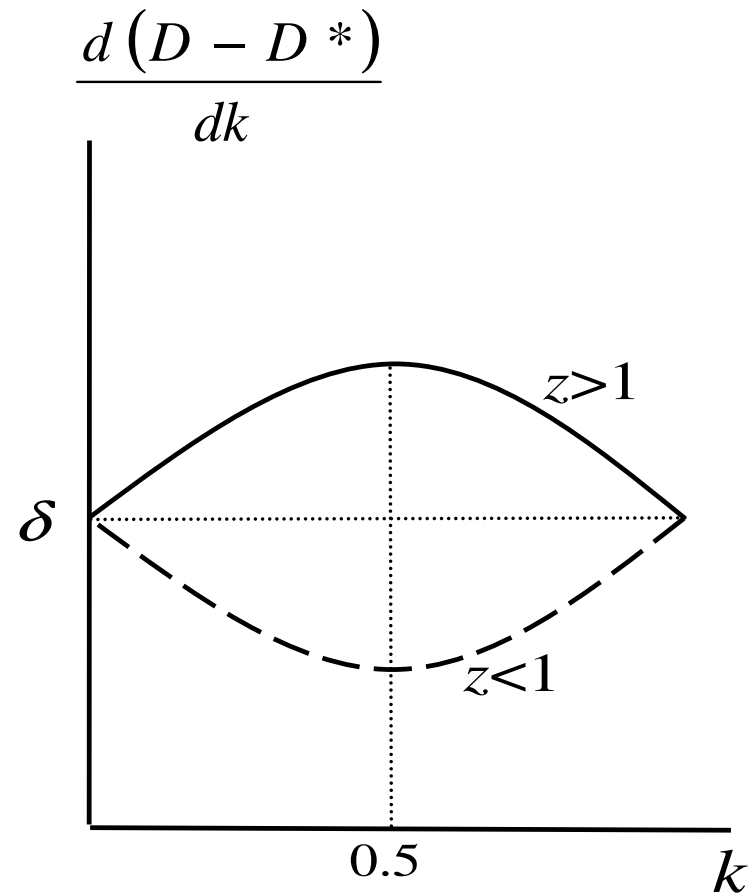
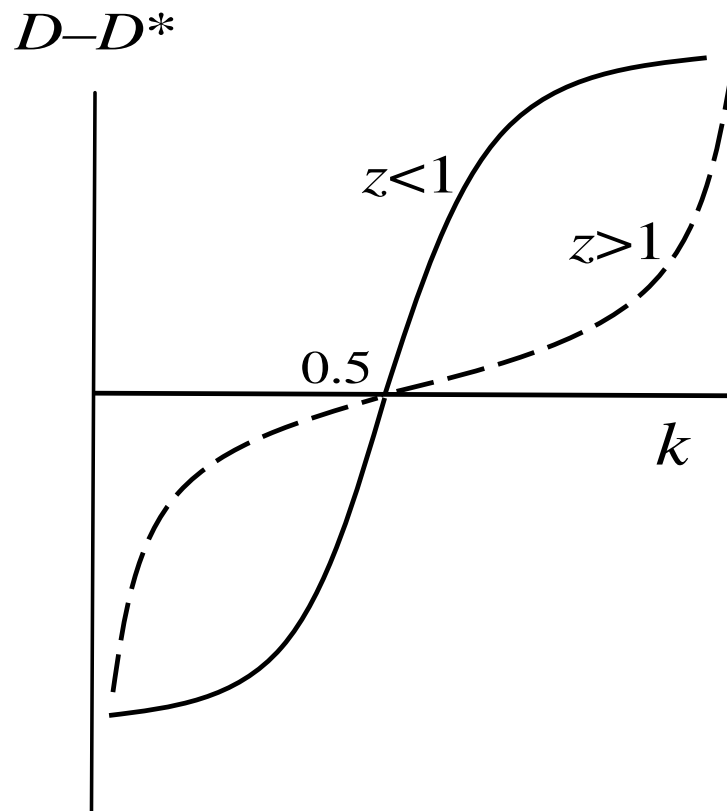
with $\sigma = \frac{1}{1-\gamma}$

Emissions and environmental damage

Emissions from production: proportional to output (and factor input)

Environmental damage

$$D = \frac{\delta k^{1+z}}{1+z} \quad \text{and} \quad D^* = \frac{\delta(1-k)^{1+z}}{1+z} \quad \text{with } z > 0.$$



The differential in environmental damages across regions and its change

Note that all pollution is local in this model.

2.2 Results under laissez faire

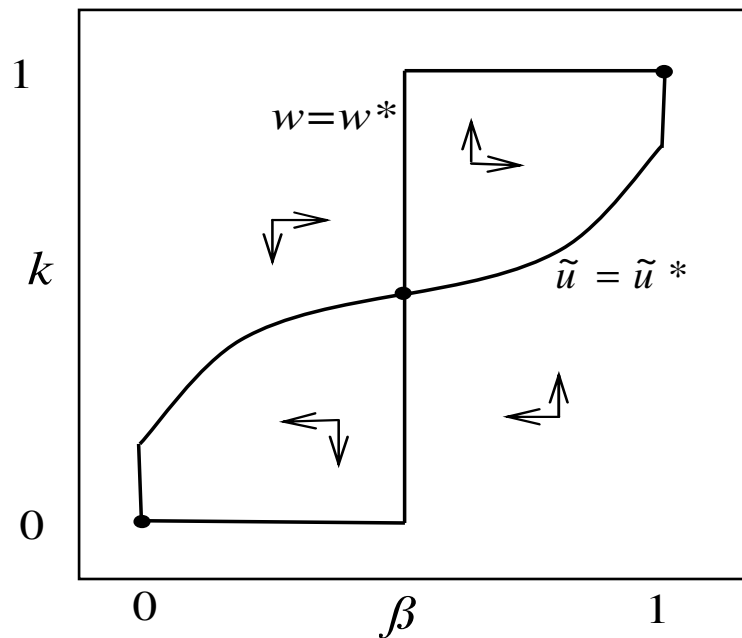
No environmental damage

Centripetal forces

- Firms love large markets
- Consumers like to live close to producers

Centrifugal force

- Consumers do not like to live close to other consumers



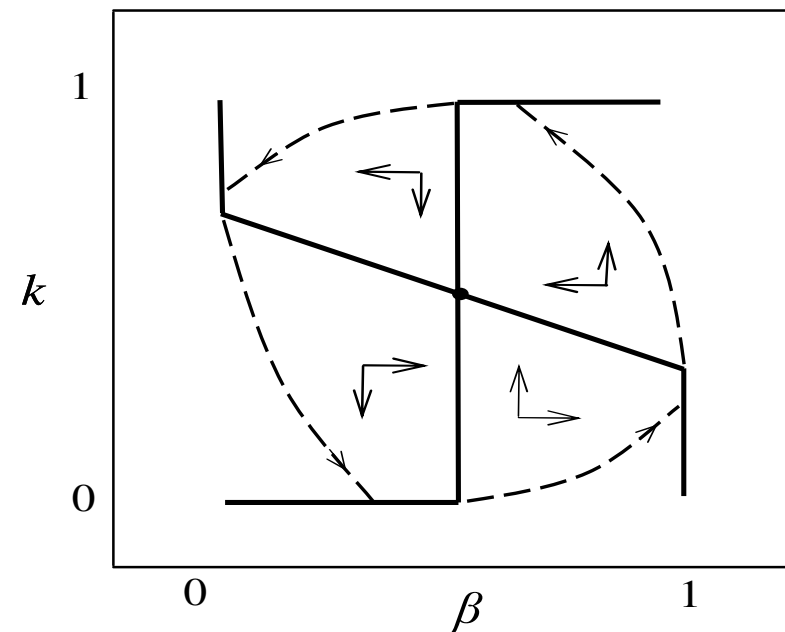
Large environmental damage

Centripetal force

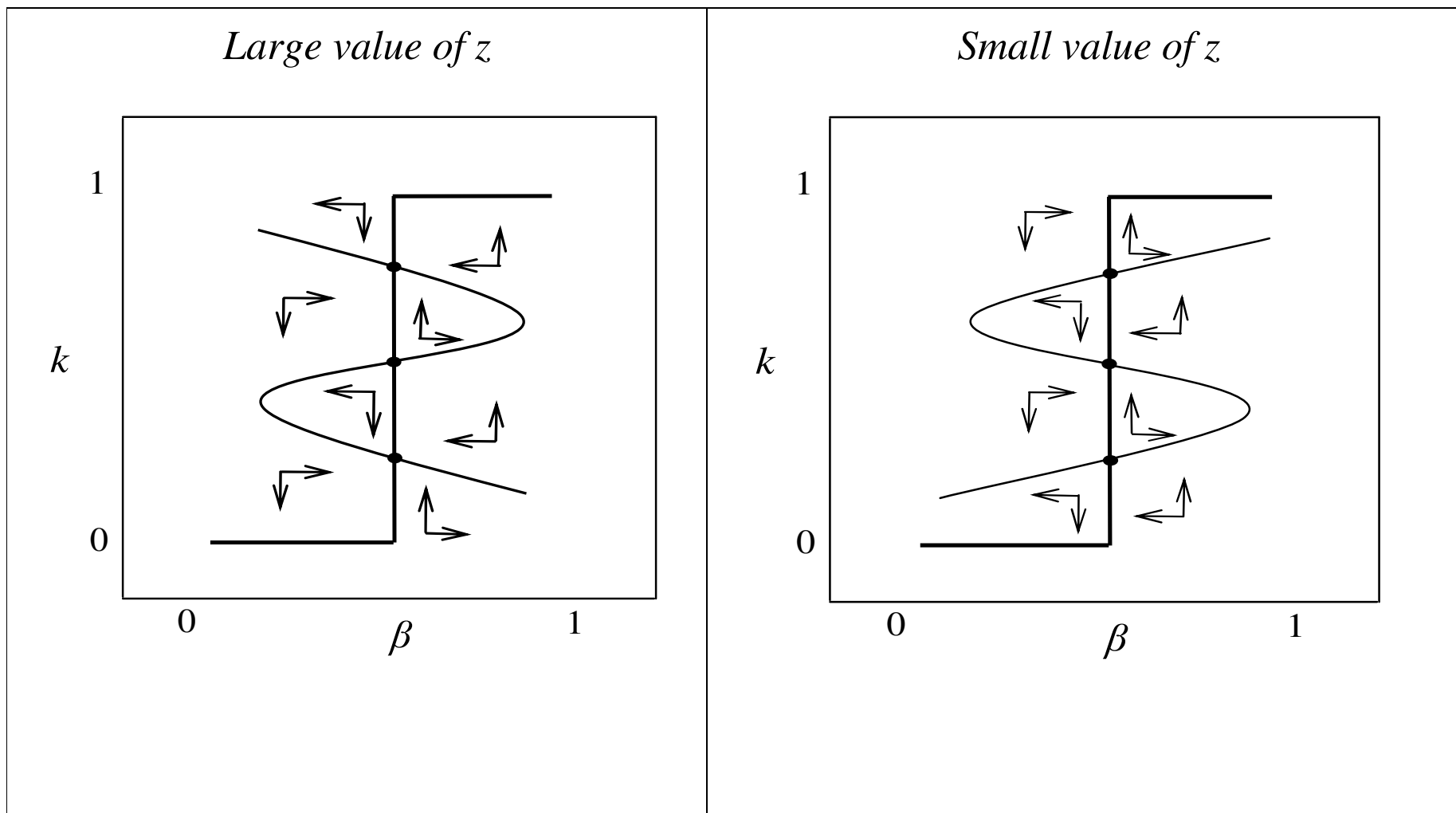
- Firms love large markets

Centrifugal forces

- Consumers do not like to live close to producers
- Consumers do not like to live close to other consumers



Additional scenarios are possible if z is very large or close to zero



2.3 Optimal environmental policy

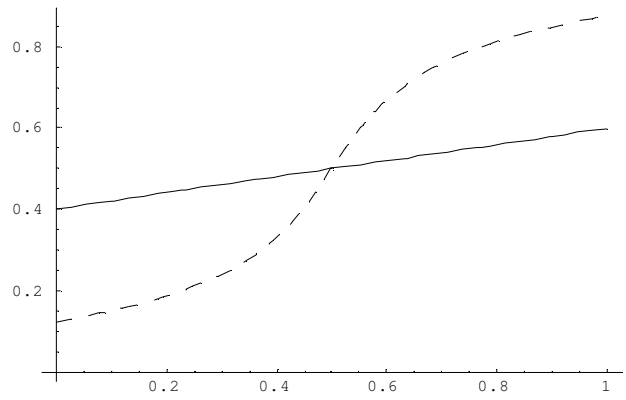
Two simple cases

- $\delta=0$: Full agglomeration.
- δ very large: Perfect separation

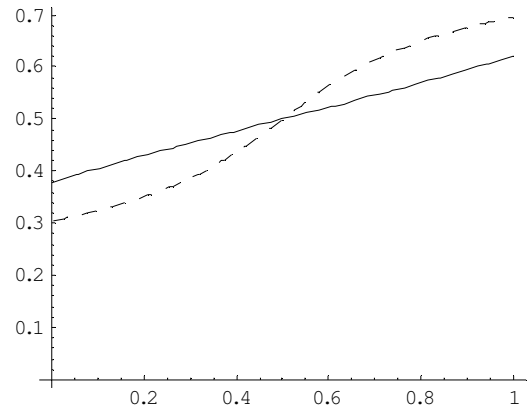
Intermediate cases can be solved numerically

Example $z=4$

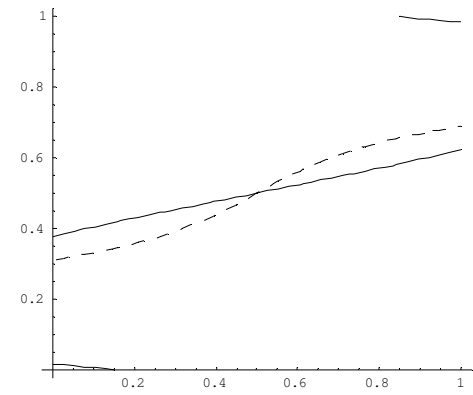
$z=4, \delta=1$



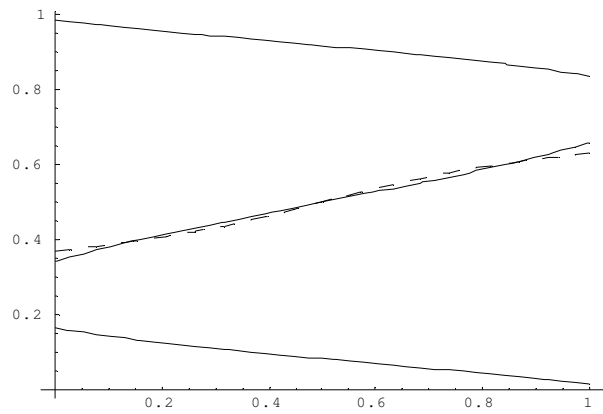
$z=4, \delta=2.5$



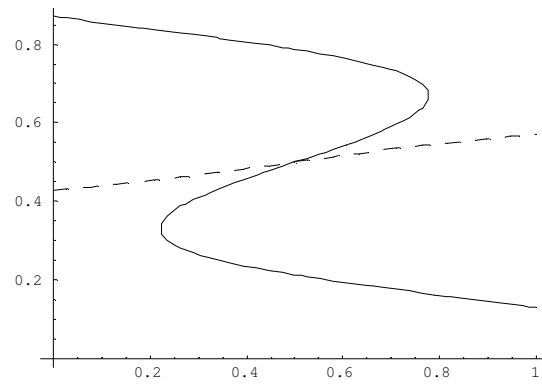
$z=4, \delta=2.6$



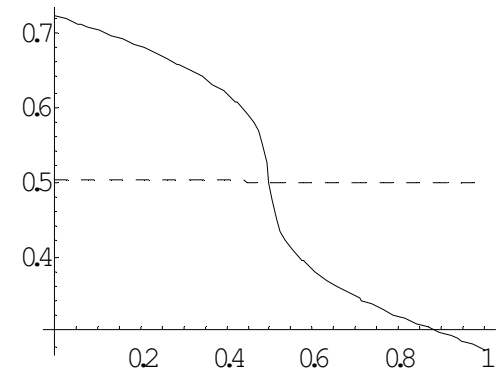
$z=4, \delta=3.7$

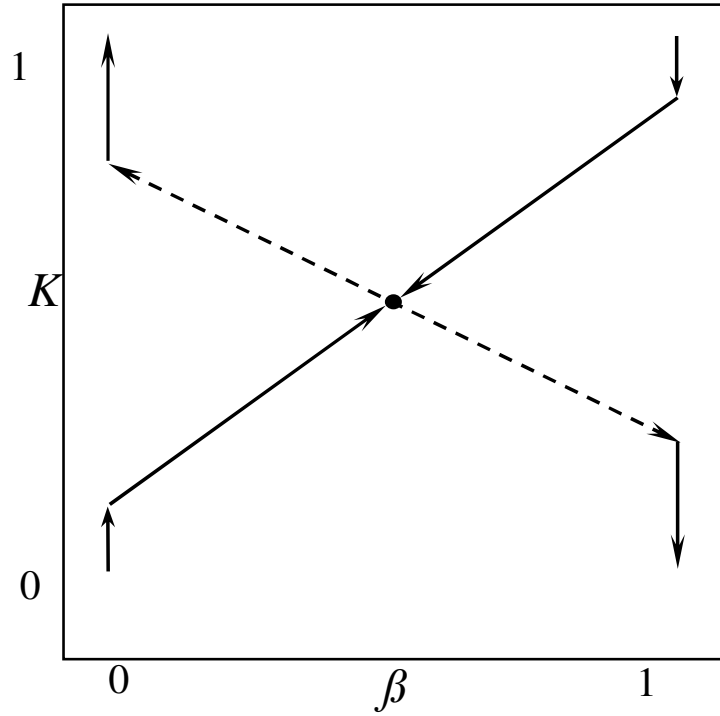


$z=4, \delta=5.5$

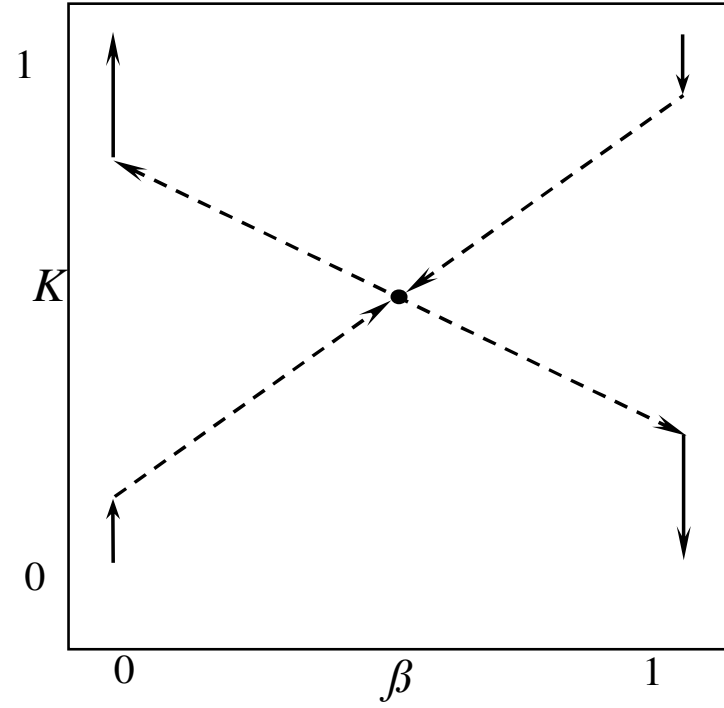


$z=4, \delta=9.5$

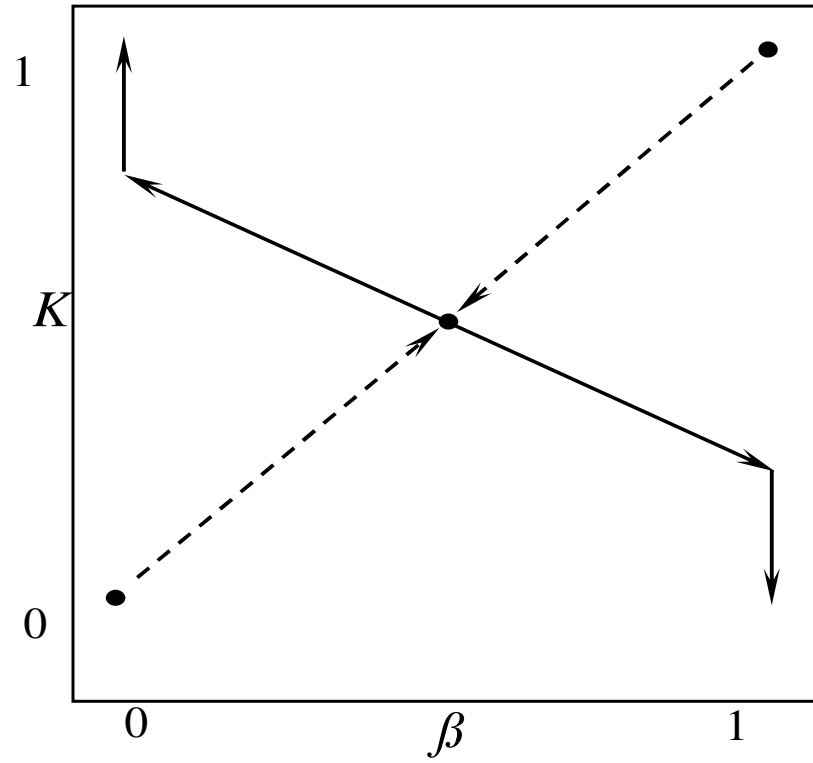




Effects of increasing δ for $z=4$



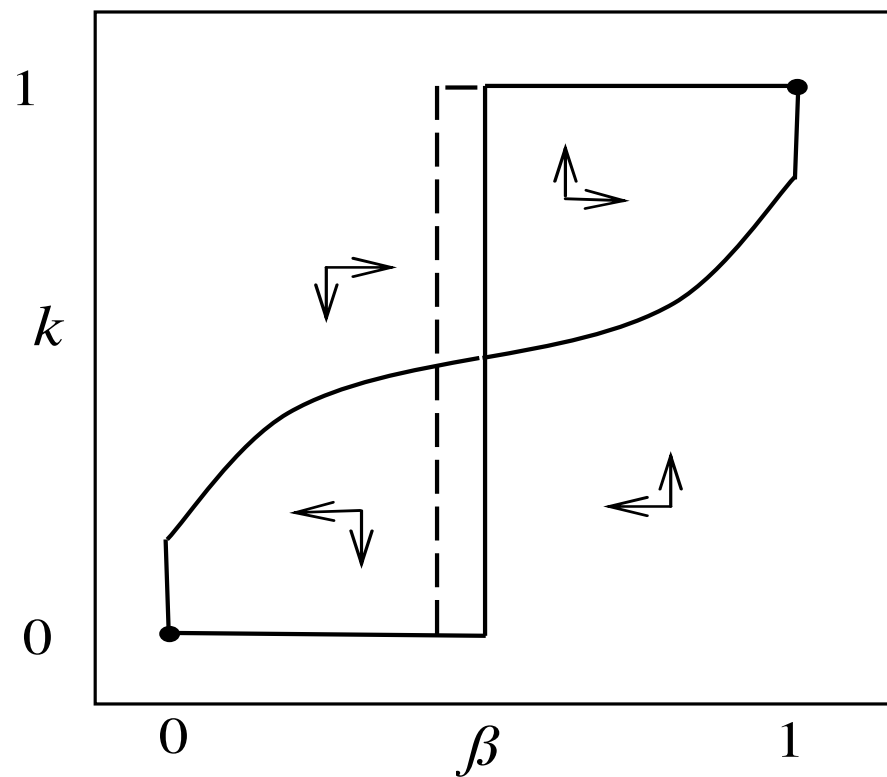
Effects of increasing δ for $z=1$



Effects of increasing δ for $z=0.2$

2.4 Policy Instruments

effect of an emission tax



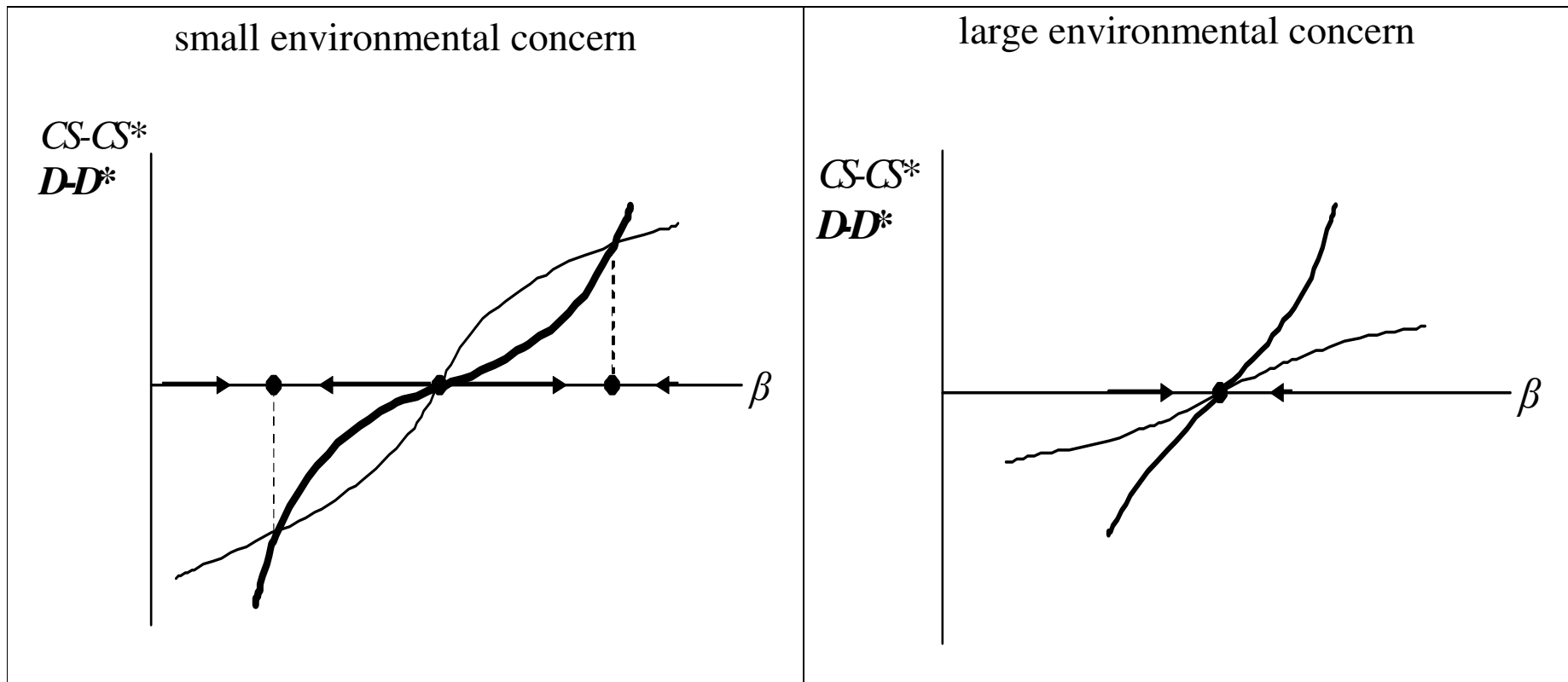
The impact of factor taxation in the East

3 A model with mobile workers

Factors and their owners cannot be separated

$$k=\beta \quad \text{and} \quad 1-k = 1-\beta$$

Centripetal forces dominate



4 Biodiversity and Geography

Simplification: biodiversity = species richness

Number of species s and s^* (real numbers)

$$\frac{ds}{dN} < 0 (= -1), \quad \frac{ds}{dK} < 0 (= -1).$$

Biodiversity $d(s, s^*)$

$$d_s > 0, \quad d_{s^*} > 0,$$

$$d(s, 0) = s, \quad d(0, s^*) = s^*,$$

$$d(s, s^*) \leq s + s^* \text{ for } s \neq 0 \text{ and } s^* \neq 0$$

$$d(s, s^*) \geq \max(s, s^*)$$

$$d(s, s^*) = \left(s^{1+\rho} + s^{*1+\rho} \right)^{\frac{1}{1+\rho}} \quad \text{with } \rho > 0$$

Modified utility function

$$u = \frac{1}{\gamma} \left(\int_0^n c(i)^\gamma di + \int_0^{n^*} m(j)^\gamma dj \right) + x + \omega(d(s, s^*)).$$

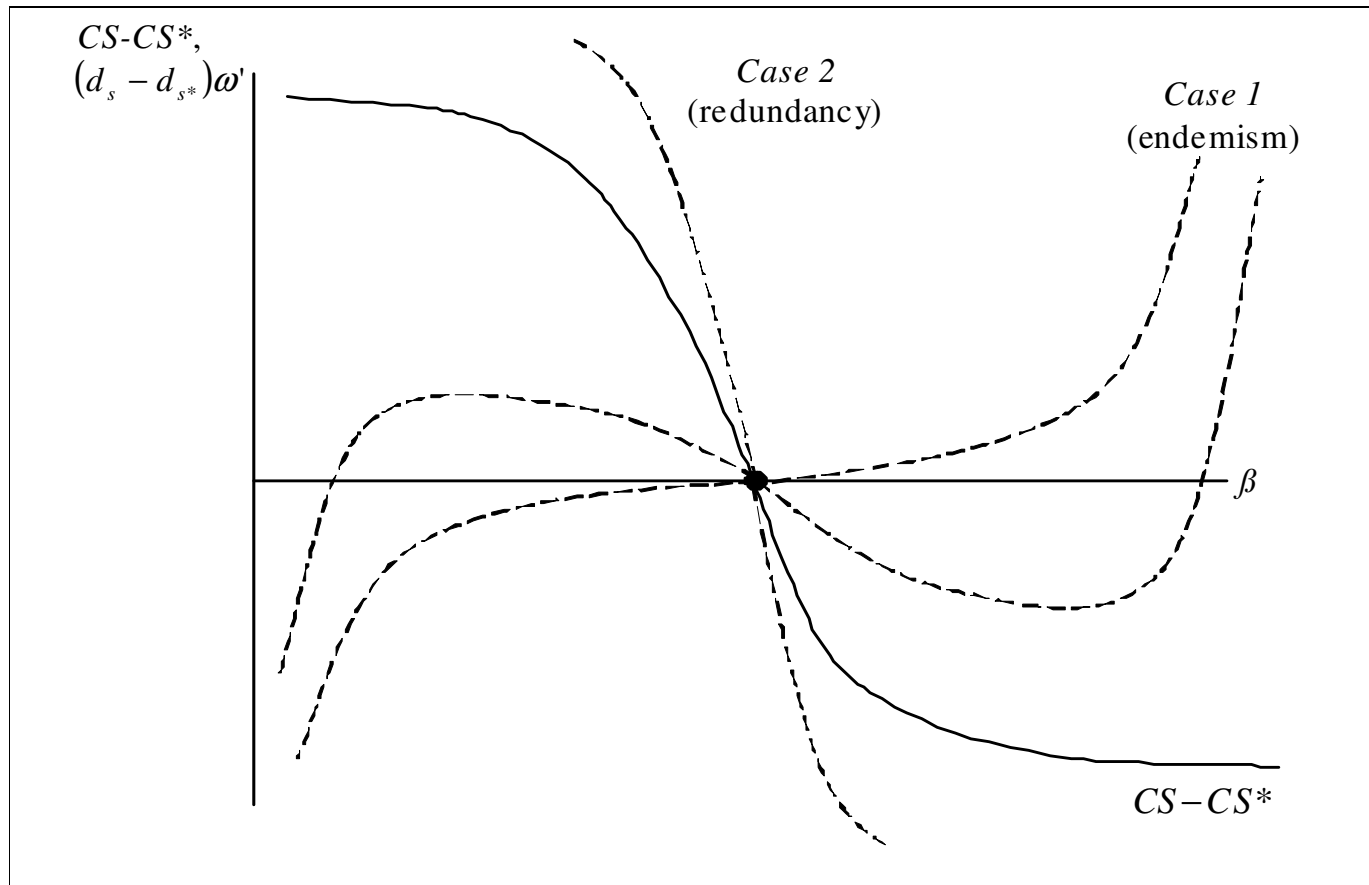
4.1 Immobile factors, mobile people

Assume that factors are equally distributed

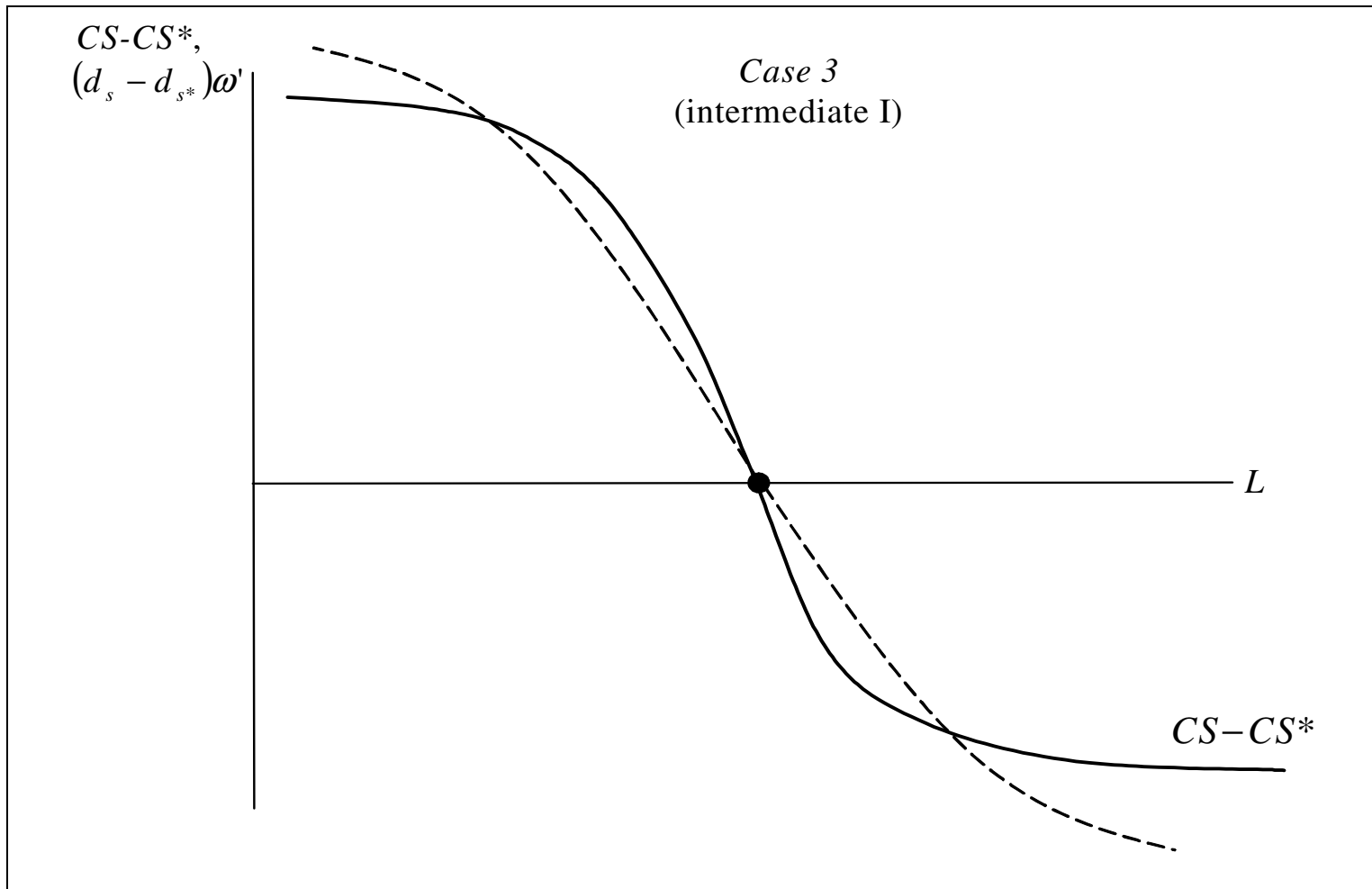
Under laissez faire, centrifugal forces dominate

Welfare maximisation:

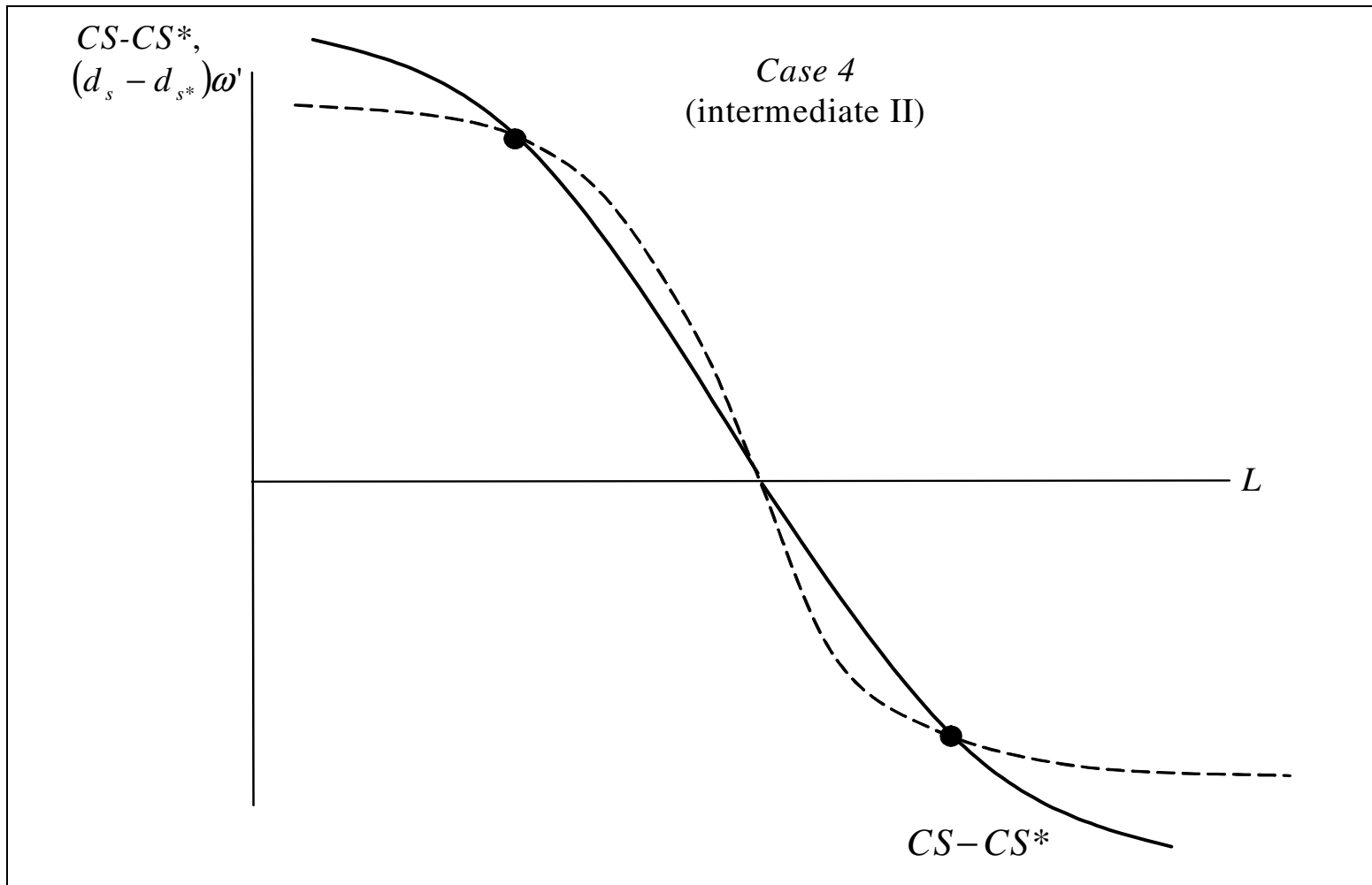
$$\frac{dW}{d\beta} = CS - CS^* - (d_s - d_{s^*}) \omega'$$



Characterisation of optimum solutions



Characterisation of optimum solutions



Characterisation of optimum solutions

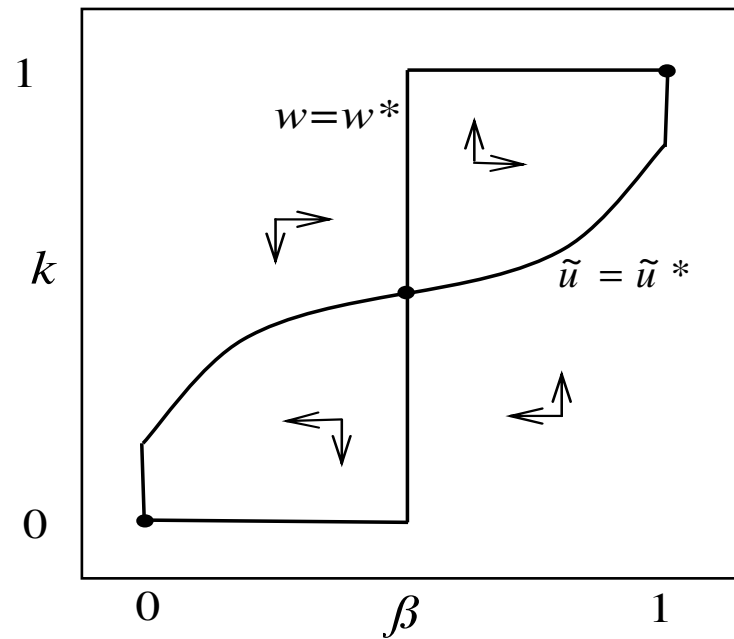
The tax rate implementing the optimum is a Pigouvian tax.

4.2 Mobile Capital

Again: Two centripetal forces and a centrifugal force

- Factors locate where the demand is
- Consumers locate where the production takes place
- Consumers prefer to live in thinly populated regions

The centripetal forces dominate.



Welfare maximisation

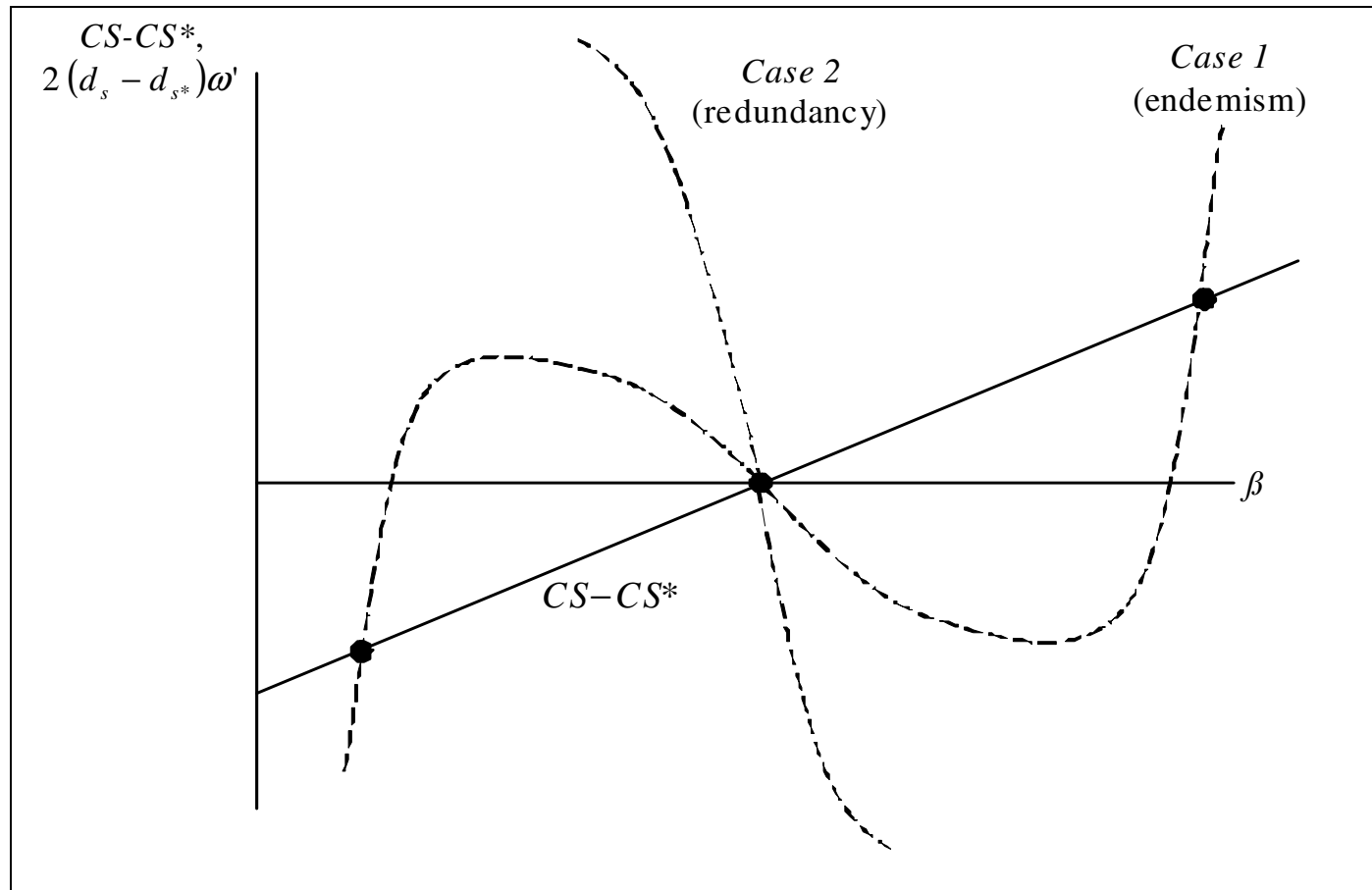
- without biodiversity considerations, agglomeration is optimal
- with high endemism this may change

Interregional transfers and factor-income taxes cannot be used to avoid agglomeration

The optimum combination of instruments:

- Command and control to allocate factors
- Pigouvian tax to allocate consumers

4.3 The Case of Mobile Workers



Optimal solutions in the mobile-factors case: endemism vs. redundancy

5 Reduction in emissions

Emission reduction is costly

It may affect fixed cost

- number of firms/varieties is reduced
- output per firm/variety is increased
- material well-being declines (by more in the regulating region)
- environmental quality is improved in the regulating region

It may affect variable cost

- number of firms/varieties is increased
- output per firm/variety is reduced
- material well-being declines (by more in the regulating region)
- environmental quality is improved in the regulating region

6 Final remarks

Interesting results

Some limitations

- space as distance between two points
- myopic behaviour / simplistic dynamics
- transboundary pollution neglected
- no tall-smokestacks policy

Much remains to be done!