Fourth Oregon Symposium on Integrating Land Use and Transportation Models

Simulating Firmography

15-17 November 2005

Rolf Moeckel · University of Dortmund

Simulating Firmography

(a) Theory

(b) Business birth

(c) Business death

(d) Change of size

(e) Modelling: State-of-the-art

(f) ILUMASS approach

(g) Conclusions

Firmography includes

Change of businesses by

- Firm entry (birth)
- Growth (e.g. by employees, floorspace, turnover, vehicles)
- Shrinking (e.g. by employees, floorspace, turnover, vehicles)
- Firm exit (death)

In principle includes, too:
Change of business type, fusion, take-over, merger, or splitting off.

Theory of Firmography

Gibrat (1931): Gibrat's Law

Birch (1979): The Job Generation Process

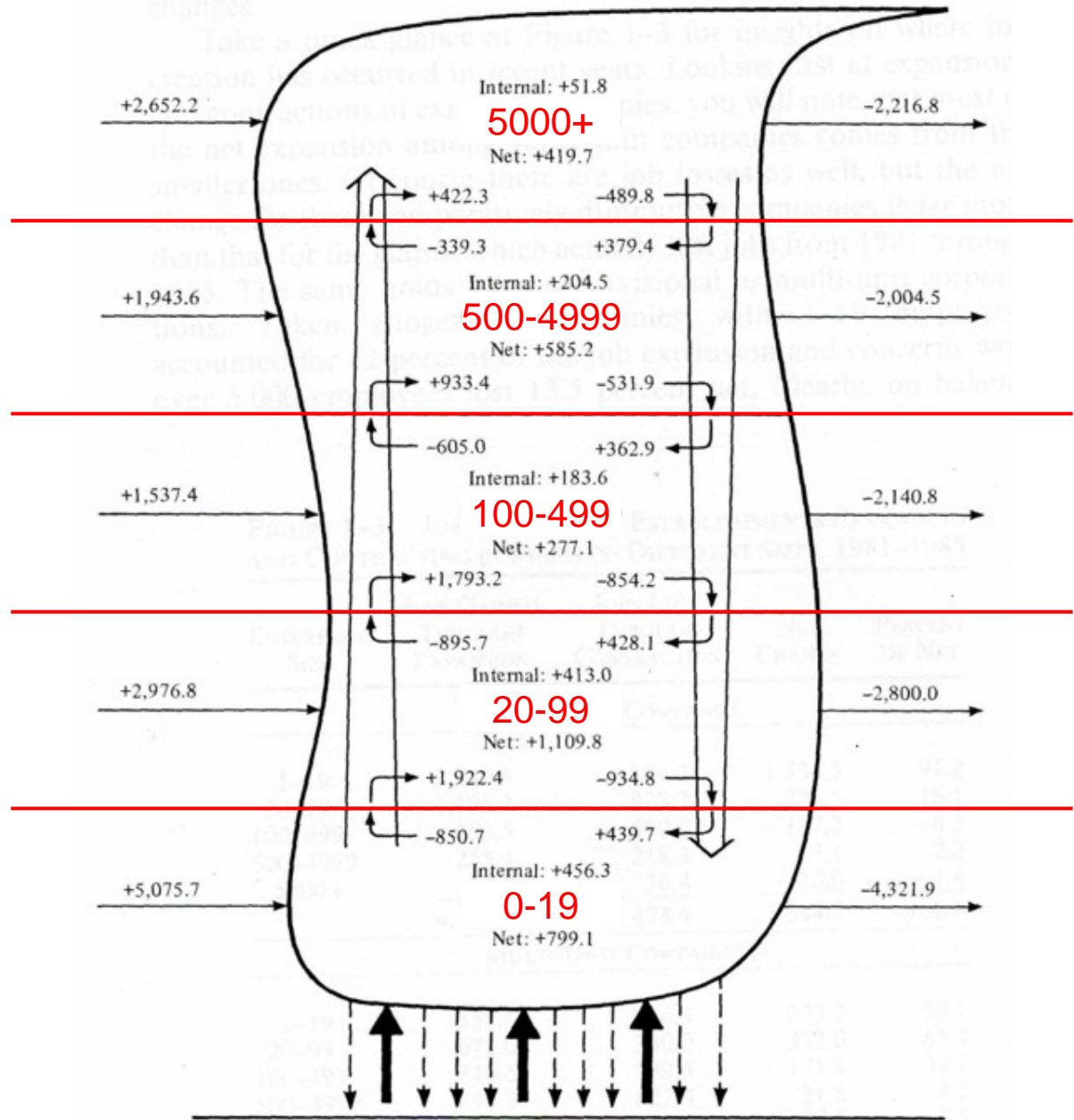**Freeman, Hannan** (1983): Organizational Populations

Hannan, Freeman (1989): Carrying Capacity

Cyert, March (1992): A behavioral theory of the firm

Carroll, Hannan (1999): The Demography of Corporations and Industries

Birch:
The Job
Generation
Process

Birch 1987

Complete Flows in the Economic Thundercloud

Freeman and Hannan: Organizational Populations

Birth and death rates depend on number of firms (density) in the different industries.

The population of businesses and the environment defines birth rates and death rates.

Hannan and Freeman: Carrying Capacity

Carrying Capacity denotes the maximum size of a population in an environment (defined by workforce, market, floorspace).

The capacity is estimated by spatial input-output tables for each business type.

Leads to a higher number of births if the number of existing businesses is below the carrying capacity and vice versa.

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Births

Birth Probabilities

Business births have two origins:

(1) Business creation by a business:
Splitting off or starting a new branch

(2) Business creation by an individual:
Age, gender and education influence
birth probability

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Influence on Birth Probabilities

- Economic prosperity
- Sectoral change
- Johnson, Cathcart (1979): Most business founders worked in the same business type before.
- Beesley, Hamilton (1993): Firms of same business type and higher unemployment fosters firm births.
- Hart & Scott (1994): Government incentives play a major role, especially for R&D firms.

Influence on Birth Probabilities (cont.)

- Garofoli (1994): Clusters, firms' size, social structure and education are most important for births. Unemployment hinders new births.
- Love (1996): Number of firm deaths determines firm birth.
- Berglund, Brännäs (2001): Average income, local unemployment, and higher education.
- Frenkel (2001): Physical infrastructure, governmental incentives and highly skilled labour.
- Maoh (2005): Rich regions have more births because of better access to capital.

Simulating Firmography
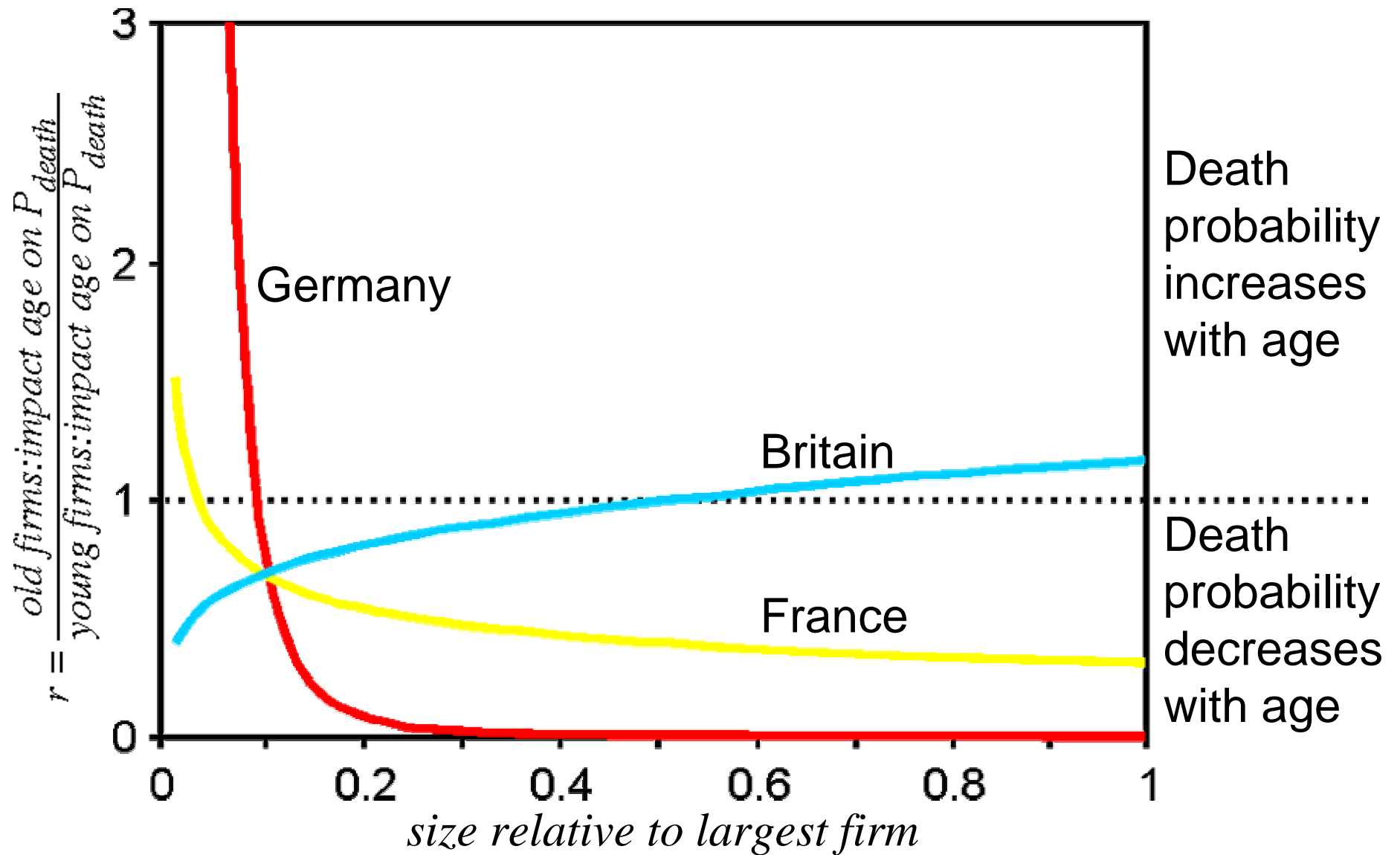
Death Probabilities

- economic recession
- Audretsch (1995): Businesses in declining industries and firms with lower growth rates. Businesses in innovation-demanding fields have lower survival rate first and a higher survival rate in later years.
- Love (1996): Death probability is influenced by births, change of unemployment and managerial skills.
- van Wissen (2000): Innovative, progressive firms
- Berglund, Brännäs (2001), Love (1996): low agglomeration effects

Death Probabilities (cont.)

Special case: Age of firm
- Mata, Portugal (1995), Audretsch, Mahmood (1995): small and young firms
- Brüderl, Schüssler (1990): death risk increases initially, and only decreases in a later stage of firm life
- Ekamper (1996): age determines firm closure in the first 10 to 15 years, but there is hardly any relationship after this age
- Hannan et al. (1998): age can have positive as negative effect

Hannan et al. (1998): Size and Age

Figure with y-axis label $r = \dfrac{\text{old firms:impact age on } P_{death}}{\text{young firms:impact age on } P_{death}}$ and x-axis label *size relative to largest firm*. Curves labeled Germany, Britain, and France. Annotations: "Death probability increases with age" (above dotted line at 1) and "Death probability decreases with age" (below dotted line at 1).

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Growth Probabilities

- Nelson and Winter (1982) state that growth depends on investments in research and development

- van Wissen (2000): Firms grow in the early stages of their life cycle, until they mature and reach a saturation level.

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State-Of-The-Art: Simulation of Firmography

Aggregated Approaches		Microsimulation Approaches	
Lowry (1964)		SIMFIRMS (van Wissen 2000)	√
Hill (1965)		Khan, Hunt (2002)	√
INIMP (Putman 1967)		UrbanSim (Waddell et al. 2003)	(√)
Forrester (1969)	(√)	SFM (De Bok et al. 2005)	√
MEPLAN (Echenique et al. 1969)	(√)	Maoh (2005)	√
IRPUD (Wegener 1998, 1982)	√	ILUMASS	√
ITLUP (Putman 1991, 1983)			
TRANUS (de la Barra 1989)	(√)		
MUSSA (Martínez 2002, 1996)			
DELTA (Simmonds 1999)	(√)		

van Wissen (2000): SimFirms

- Births: spin-offs (firm-based) and startups (labour market-based)
- Growth is based on Gibrat's law including various regressors
- Death: multi-decrement life tables
- Demand is based on concept of carrying capacity
- Consistency with the regional economic growth
- Scenarios can be run on regional eco-nomy and economic infrastructure (such as business sites, available land)

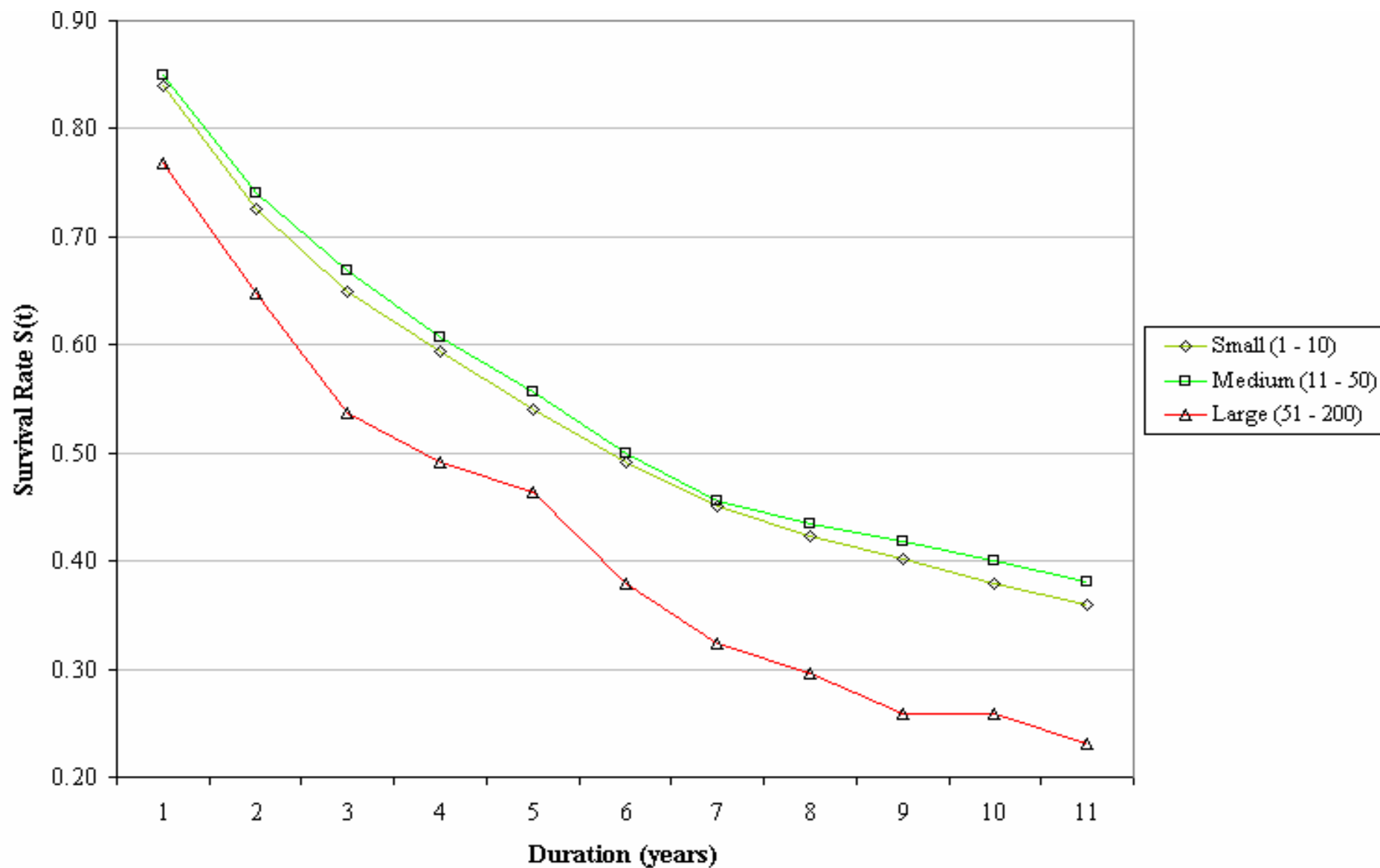**Khan et al. (2002): PECAS – A testbed to microsimulate business establishments**

- Study area is a testbed of 81 zones with a 100 raster cells each.

- Simulates birth and death of businesses, keeps track of business' age.

- Attributes of new business establishments are assigned randomly.

- Prices are adjusted in each zone every six months.

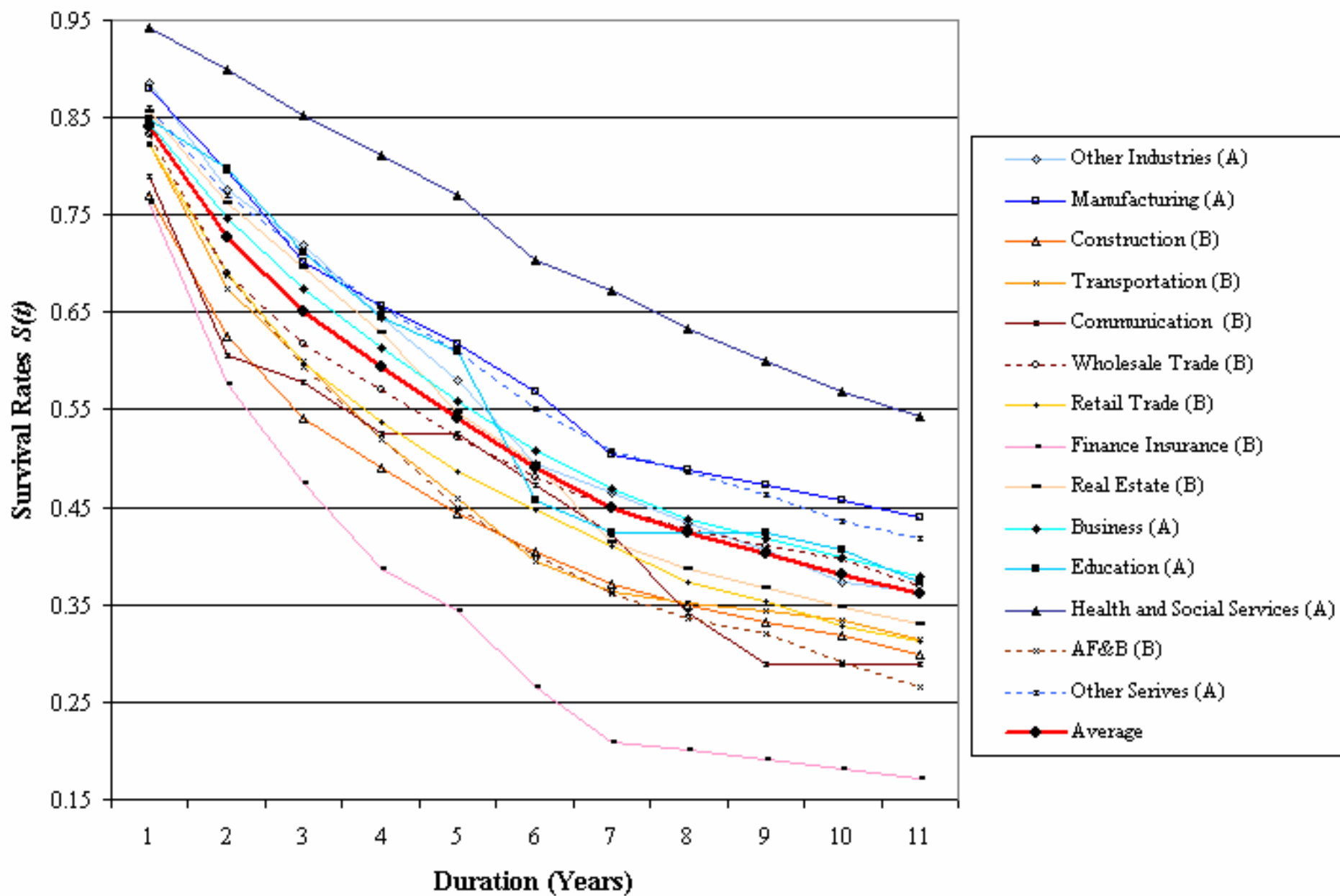# Maoh (2005): Agent-based firmographic model

- Simulates birth, death, growth and decline of firms (with 200 employees or less).
- Uses a discrete time hazard duration models to estimate death (age, size, size-squared, growth, relocation, unemployment rate, industry mix, local competition, agglomeration economies, average size of industry).
- Use appropriate regression models to explain the growth/decline process.

Establishment population
t

Failure submodule

Newly formed & in-migrating establishments
t+1

Mobility submodule

Growth submodule

Location choice submodule

Establishment population
t+1

Maoh (2005): Survival rate by business size

Maoh (2005): Survival rate by type of business

Legend:
- Other Industries (A)
- Manufacturing (A)
- Construction (B)
- Transportation (B)
- Communication (B)
- Wholesale Trade (B)
- Retail Trade (B)
- Finance Insurance (B)
- Real Estate (B)
- Business (A)
- Education (A)
- Health and Social Services (A)
- AF&B (B)
- Other Serives (A)
- Average

Waddell et al. (2003): UrbanSim

- Unit of simulation is job instead of firm.

- Economic Transition Model calculates creation and loss of jobs.

- Gain and loss of jobs are assigned to zones accordingly.

Ettema: PUMA – Interaction of firm module (Concept)
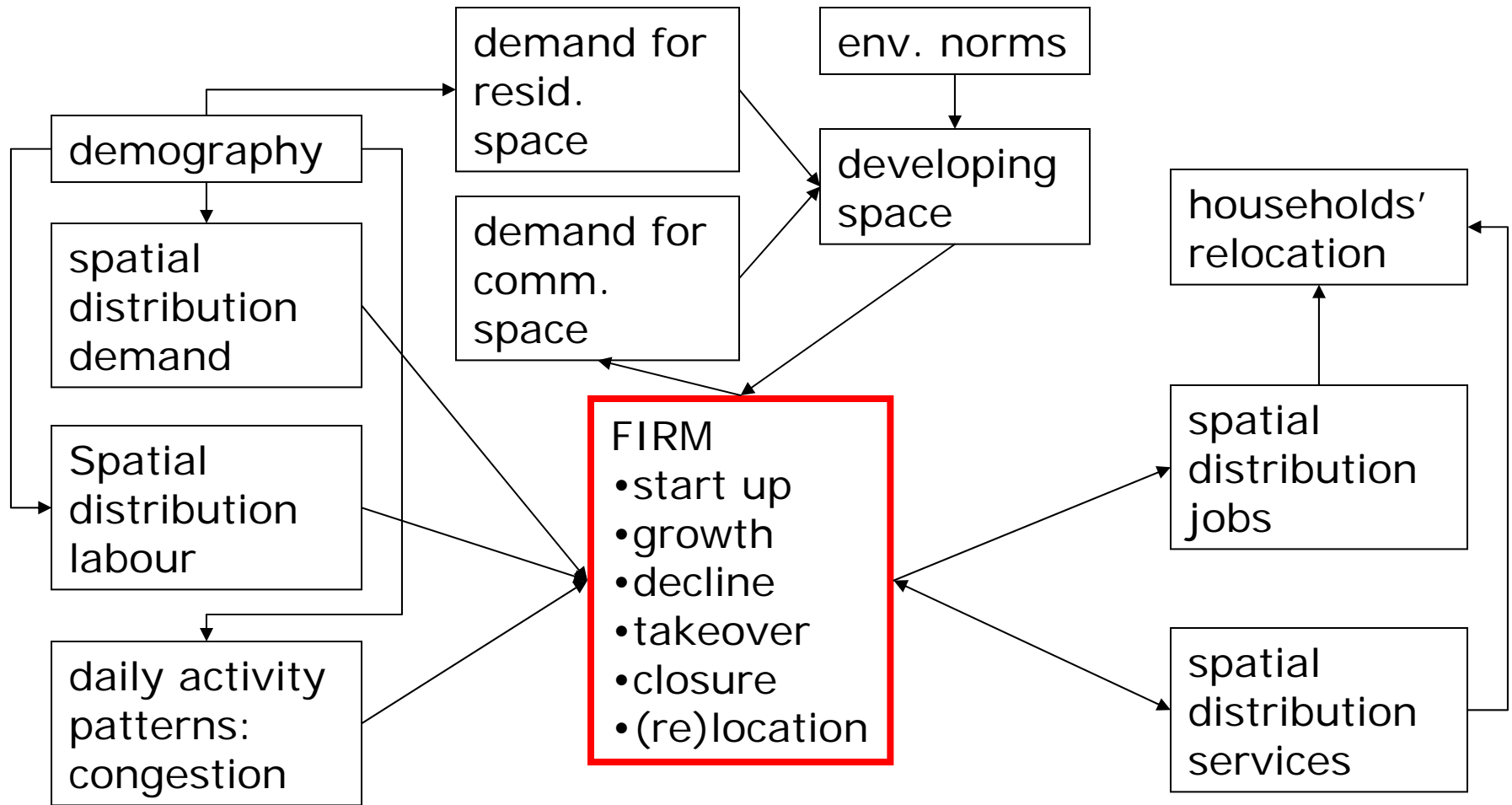
```
demand for resid. space          env. norms

demography                       developing space          households' relocation

spatial distribution demand      demand for comm. space

Spatial distribution labour      FIRM                      spatial distribution jobs
                                 •start up
                                 •growth
                                 •decline
                                 •takeover
daily activity                   •closure                  spatial distribution services
patterns:                        •(re)location
congestion
```

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Firmography in ILUMASS

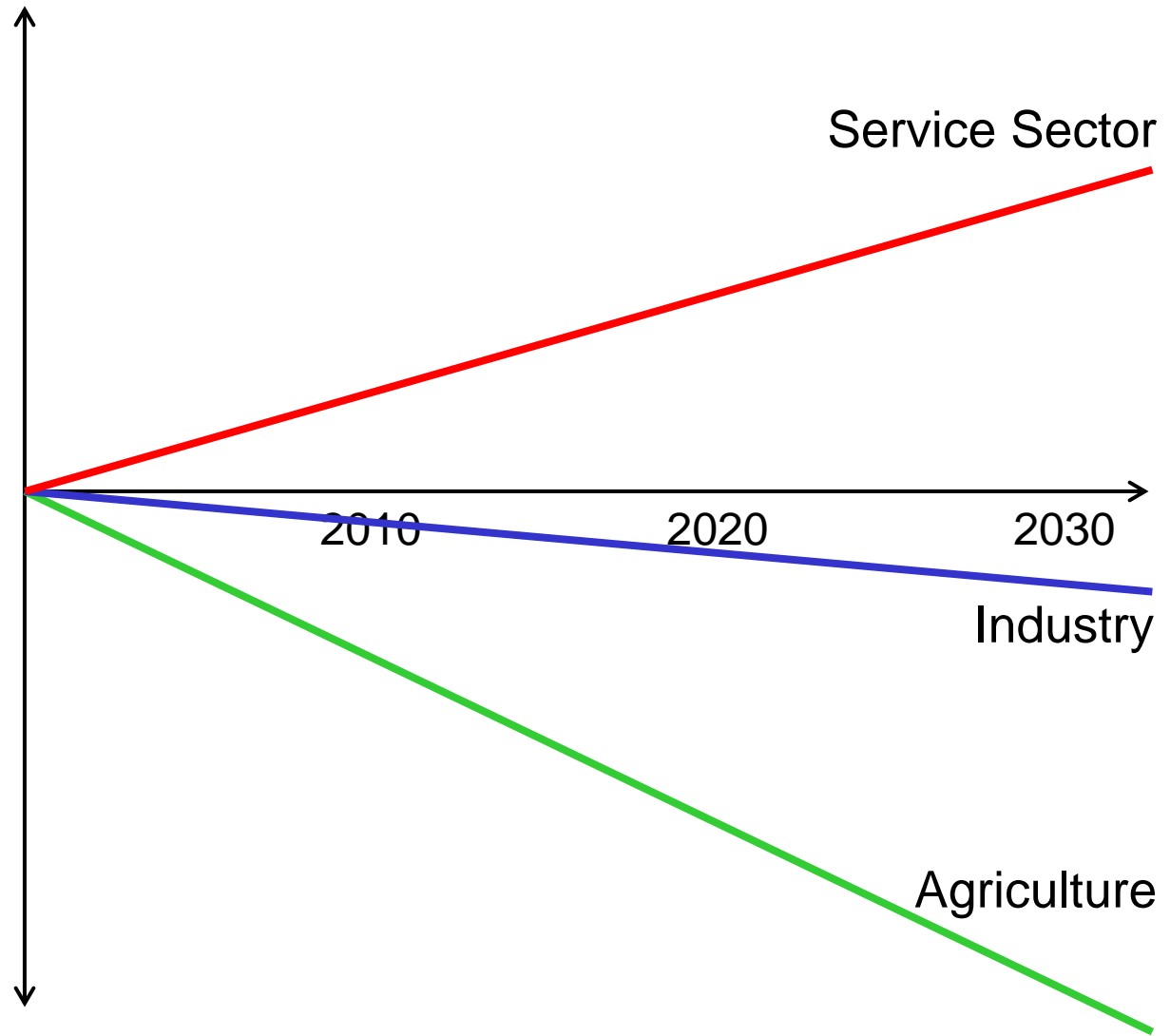Moves of businesses: Logit models or bid-choice models
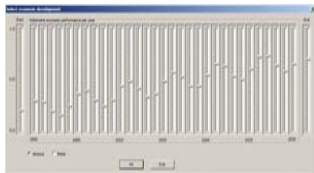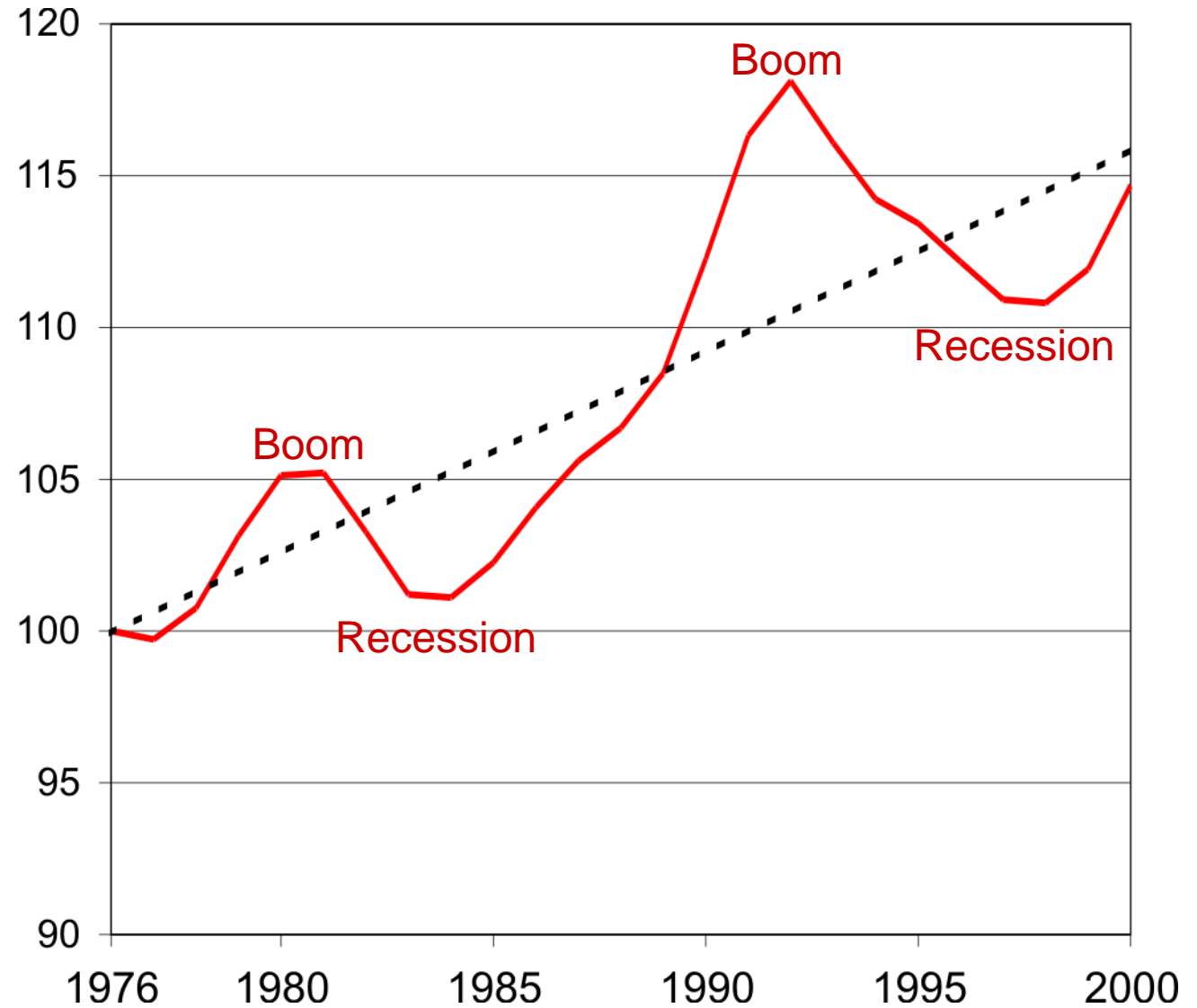Firmography: Markov models

Events include:
- new businesses are established
- employers hire or fire employees
- unsuccessful firms run out of businesses

Events are simulated in *random order*.
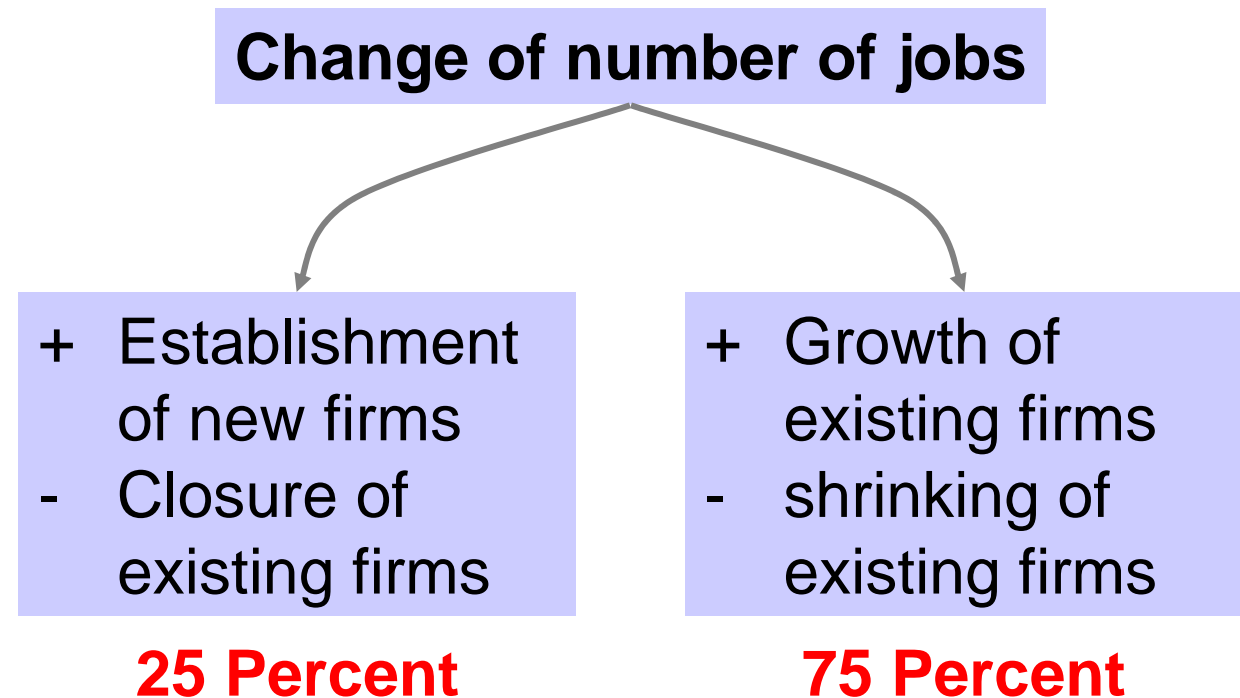
Sectoral Change: Employment

Service Sector

2010 2020 2030

Industry

Agriculture

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Economic Waves: Employment Change

Change of Number of Jobs

The sectoral change and the economic prosperity determine the number of jobs.
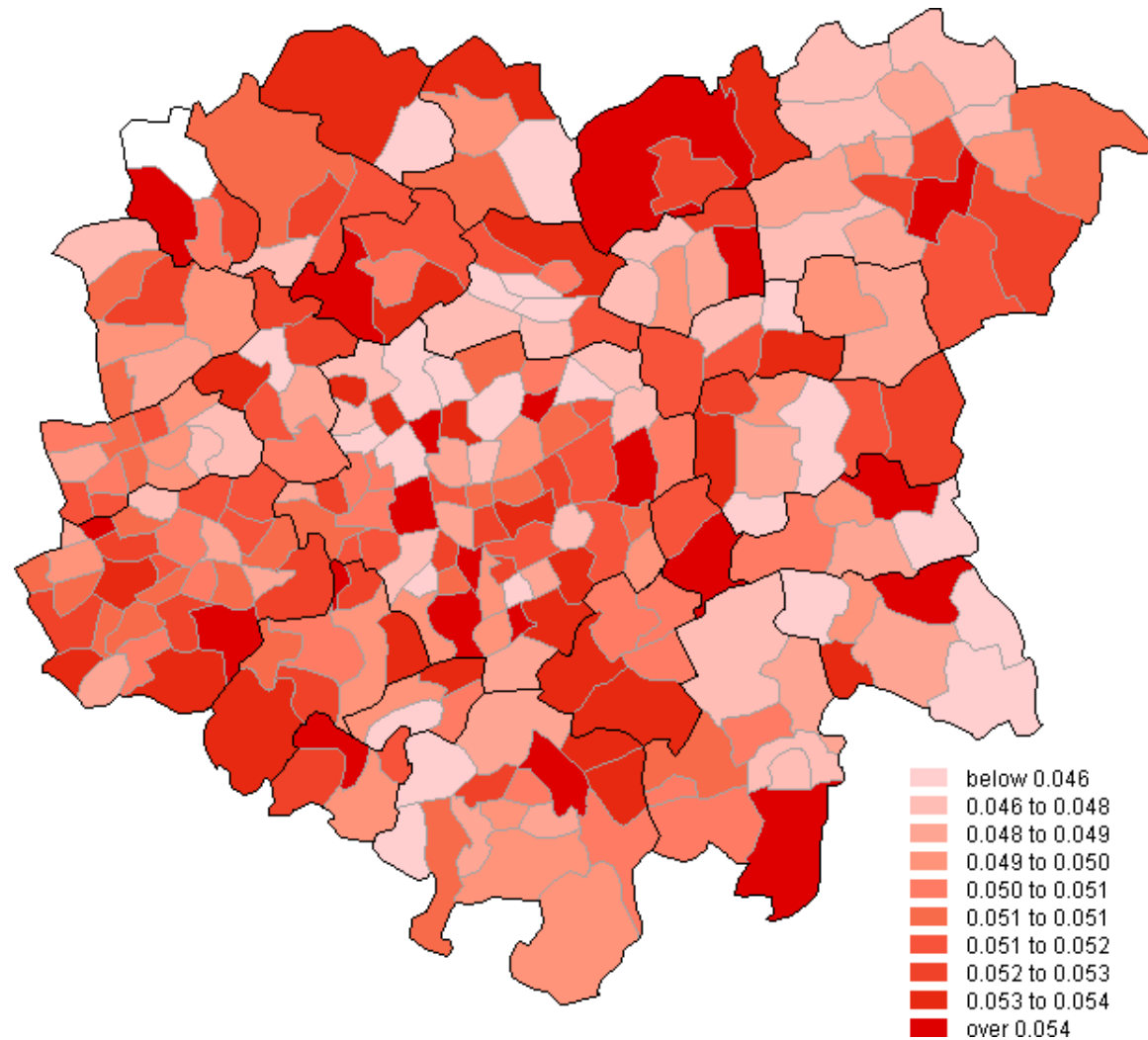
Change of number of jobs

+ Establishment of new firms - Closure of existing firms	+ Growth of existing firms - shrinking of existing firms
25 Percent	**75 Percent**

Estimating Number of Birth and Declines

The change of number of jobs per business type is estimated based on
- sectoral change,
- economic prosperity, and
- number of highly-qualified people.

The three elements are aggregated by Cobb-Douglas-Function.

$$\Delta e_k = s_k{}^{\alpha_k} \cdot p_k{}^{\beta_k} \cdot q_k{}^{\gamma_k}$$

Share of Highly-Educated People

ILUMASS

Legend:
- below 0.046
- 0.046 to 0.048
- 0.048 to 0.049
- 0.049 to 0.050
- 0.050 to 0.051
- 0.051 to 0.051
- 0.051 to 0.052
- 0.052 to 0.053
- 0.053 to 0.054
- over 0.054

Estimating Number of Birth and Declines

Estimation for business type x: + 2 %

Reg. data of new establishments   10 %
Reg. data of closing businesses   6 %
Resulting Change   + 4 %

Estimation: new establishments   9 %
Estimation: closing businesses   7 %
Resulting Change   + 2 %

New Business Establishments

New establishments have to find a location even if the site characteristics are not favourable for the business.

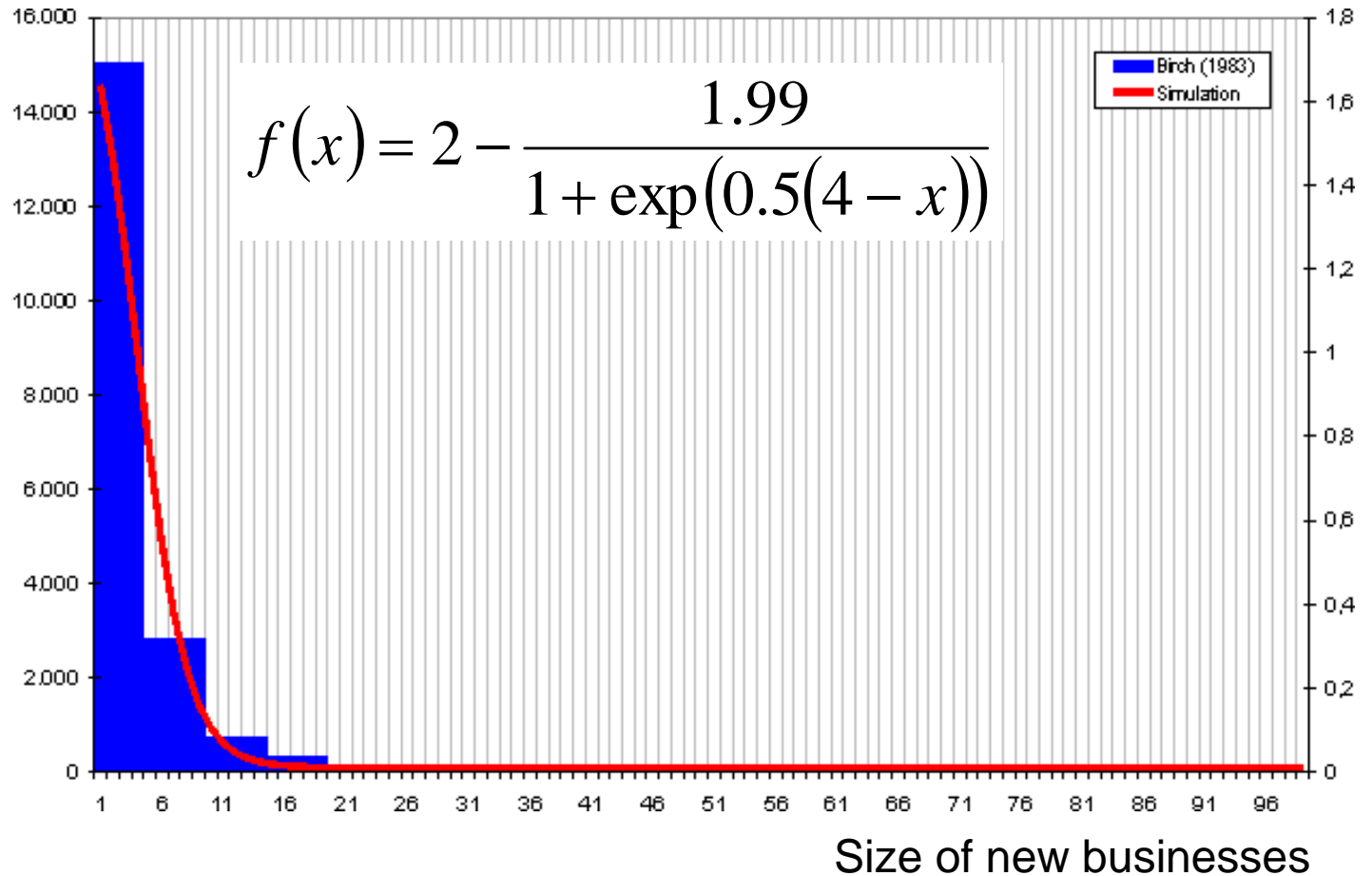A few smaller businesses are located at the entrepreneur's home.

New businesses tend to have rather few employees.

Size of new Businesses (Birth)
Histogram

Size of new businesses

Size of new Businesses (Birth)
Histogram and simulation graph

$$f(x) = 2 - \frac{1.99}{1 + \exp(0.5(4 - x))}$$
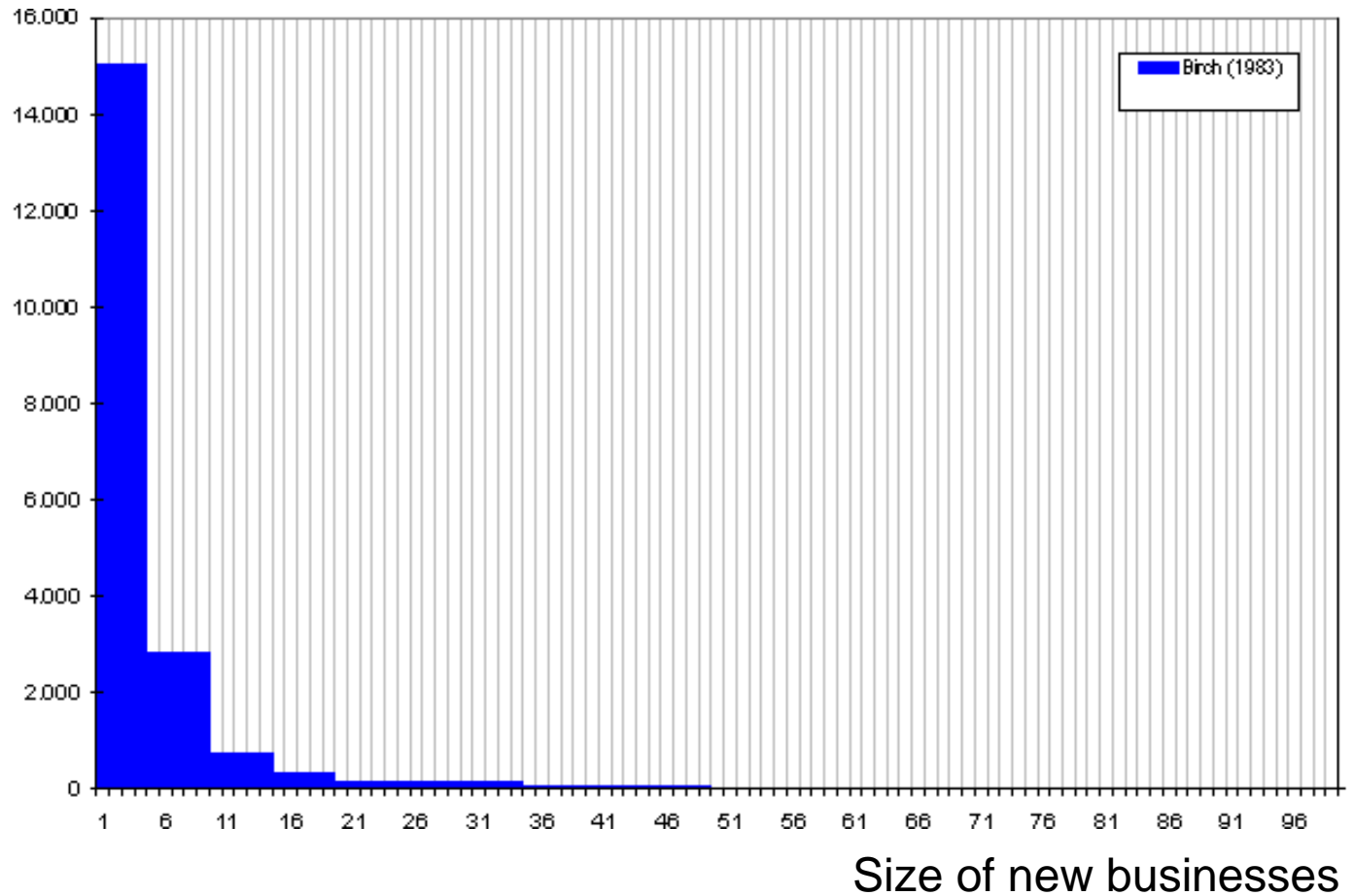
Size of new businesses

Closure of Businesses

Every simulation period some firms run out of business, depending on the sectoral change and economic prosperity.
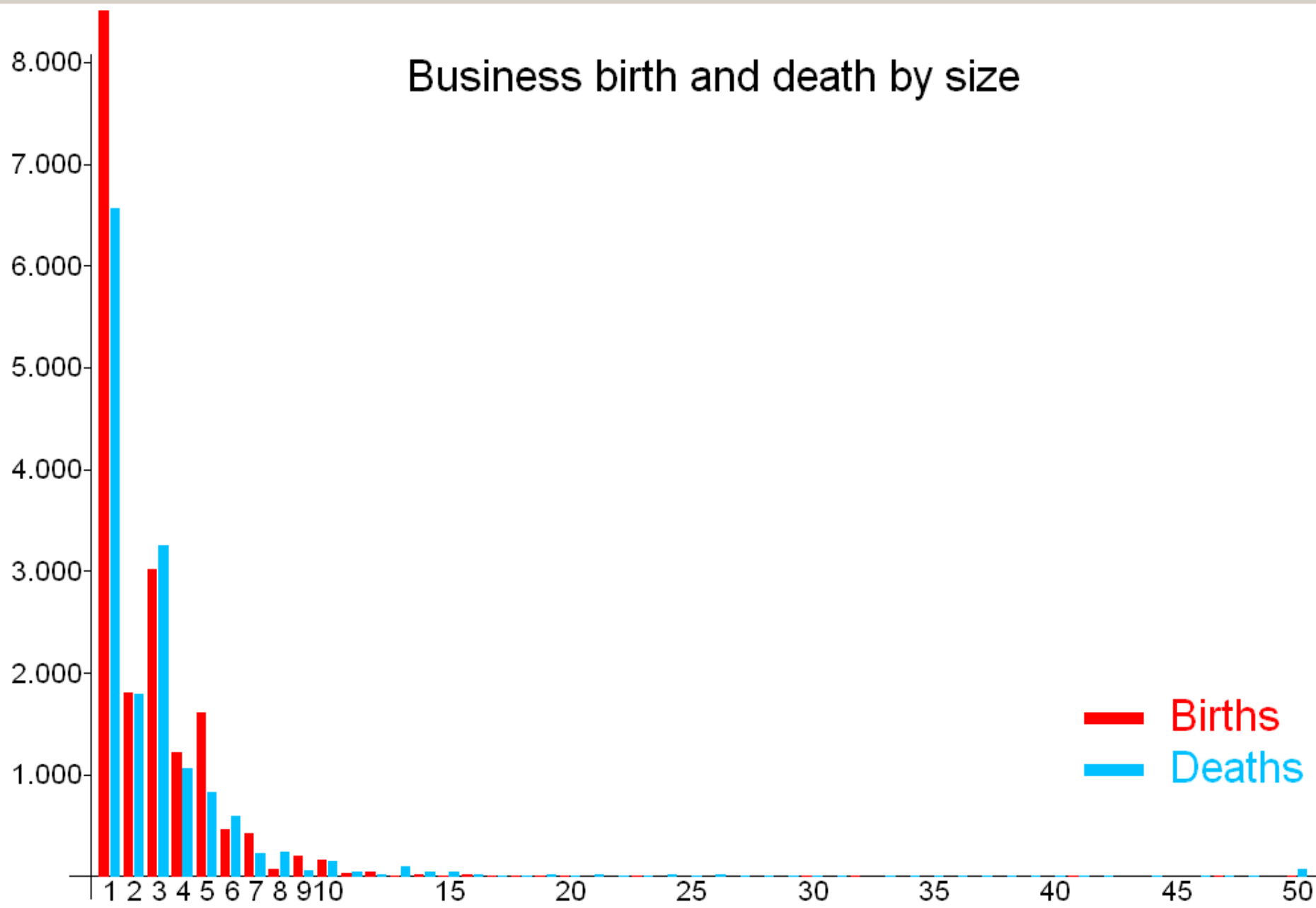
Mostly, small businesses are closed. Larger businesses try to absorb the economic recession by reducing the number of employees.

Size of closing Businesses (Death)
Histogram and simulation graph

$$f(x) = 2 - \frac{1.99}{1 + \exp(0.5(4 - x))}$$

Legend: Birch (1983) — Simulation

Size of closing businesses
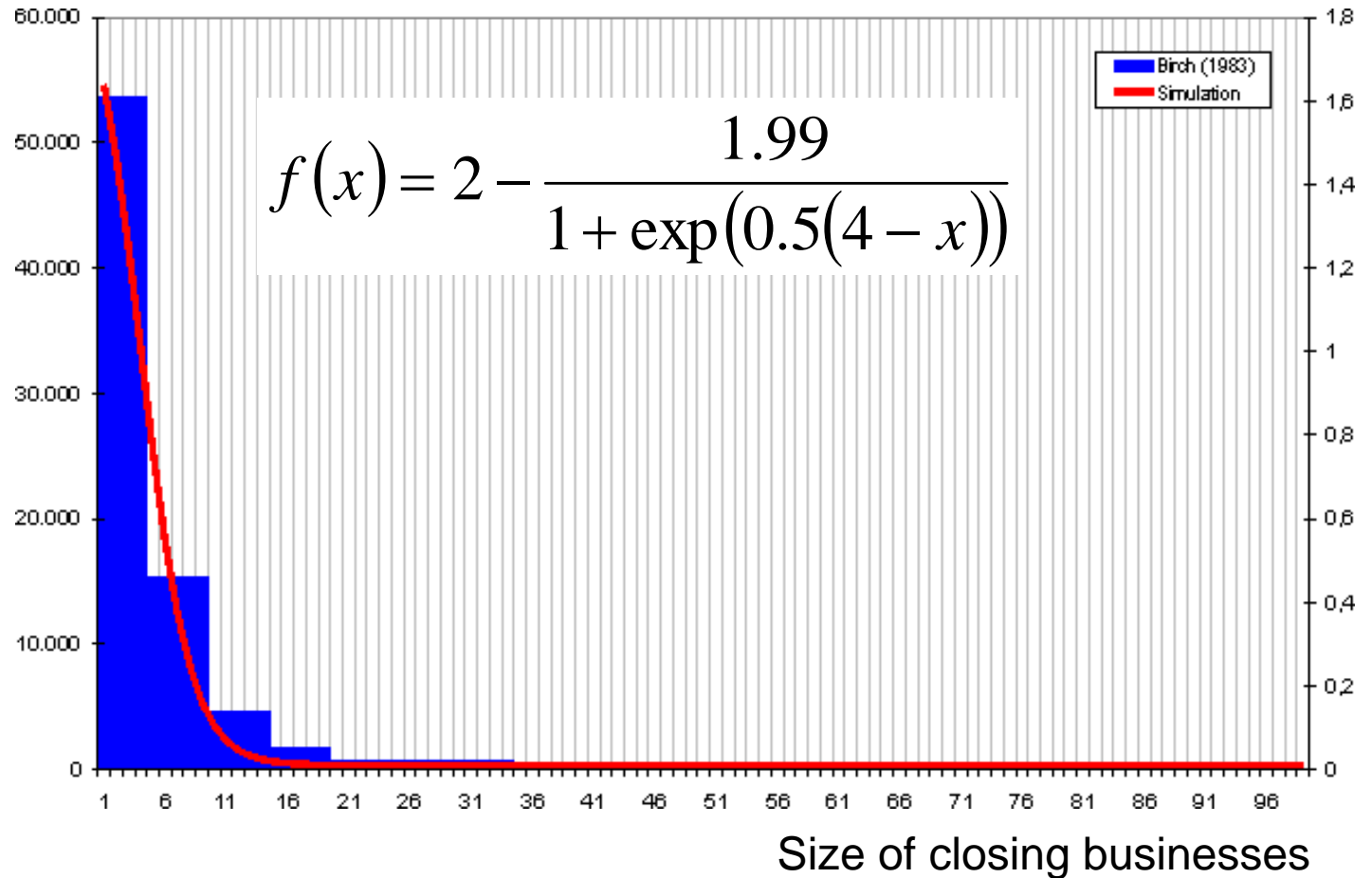
Change of Number of Employees

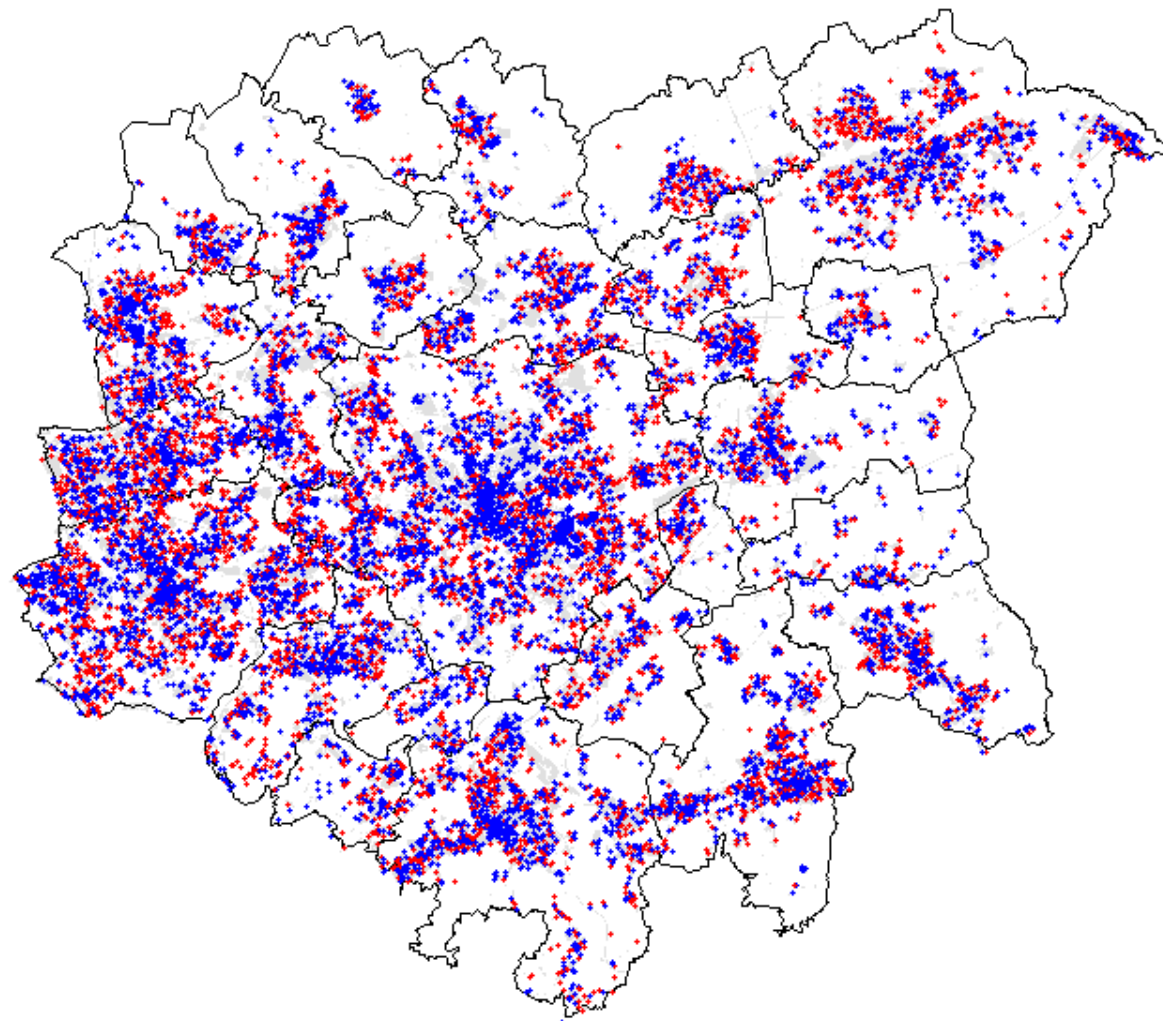Businesses may grow or shrink by hiring or firing employees.

Probabilities for growing and shrinking are estimated based on sectoral change and economic prosperity.

Estimating Change of Business Size

Depending on the overall economic trend employers hire or fire employees.

File   Edit   View   State   Window   Help
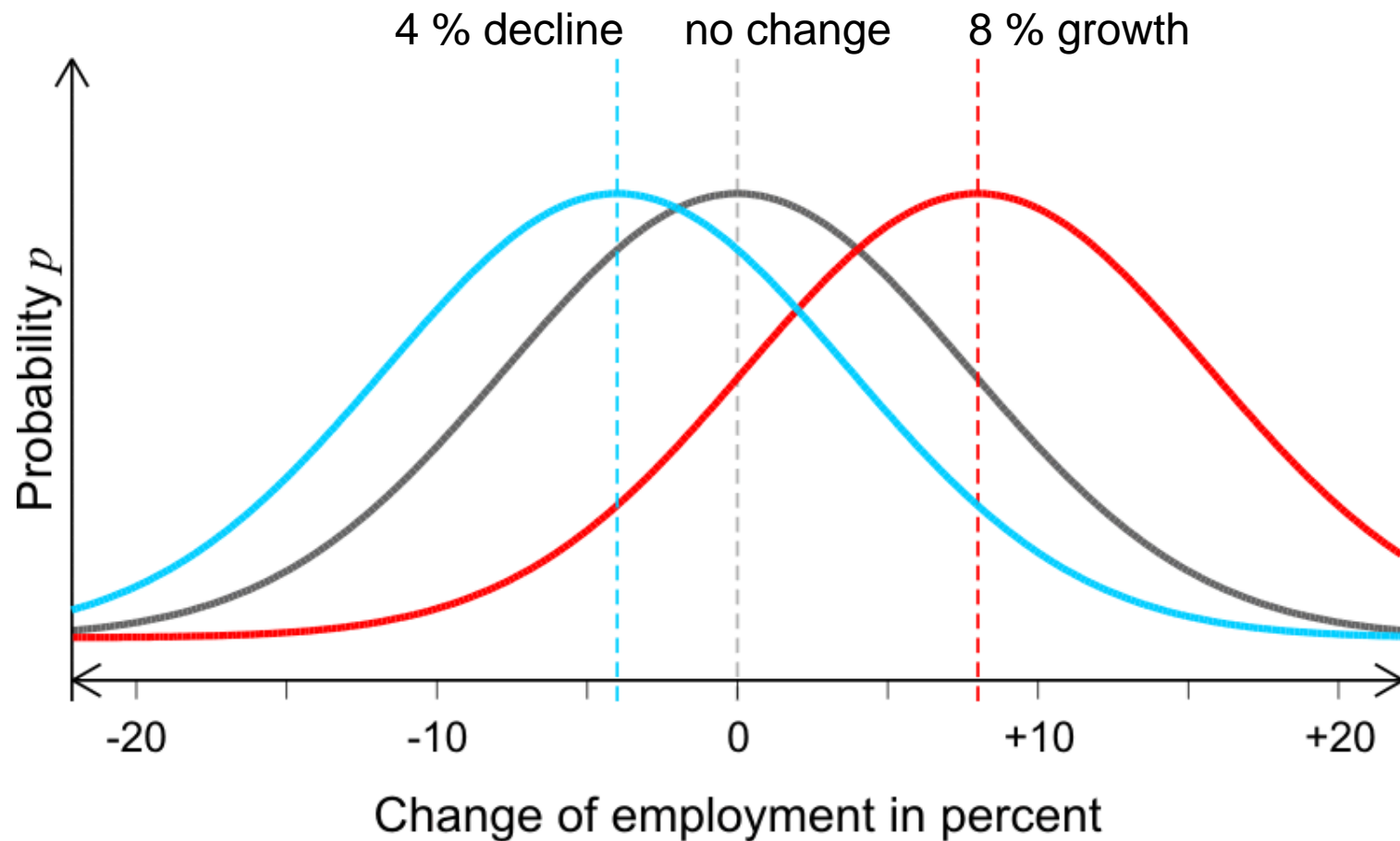
Birth and Death of Establishments

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Conclusions

In theory, integrated urban models ought to include persons, households, developers and businesses as actors.

Most current models reduce businesses to simulation of employment or keep employment static.

With an increasing effort spent on activity modelling it is just consequent to model the destinations with more dedication.

Most changes to businesses and thereby employment are induced by firmography.

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