Growth Theory from an Evolutionary Perspective

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Neo-Schumpeterian Approaches: The Fundamental Role of Creative Destruction

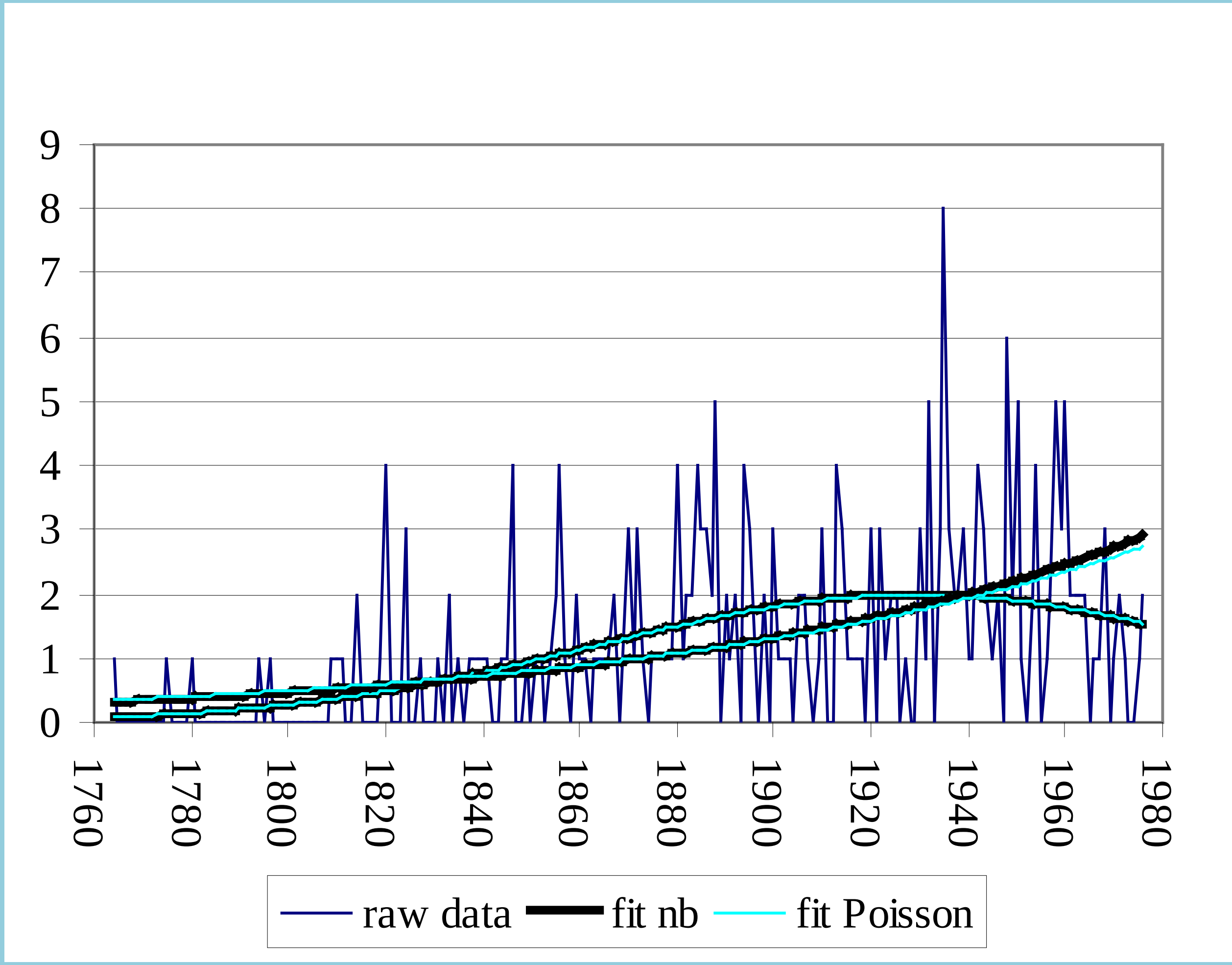
- Schumpeter (1911): Modern economic growth is not an equilibrium process but one characterized by radical innovations, discontinuities, and microeconomic heterogeneity
- This leads to sectoral turbulence, structural change, and complex patterns of long-term growth (often inadequately characterized as ‘long waves’)
- Disequilibrium manifests itself as leader-follower patterns at the sectoral, regional and international levels

Neo-Schumpeterian Approaches: Modelling

- While a rational expectations, intertemporal optimization approach to creative destruction is possible (cf. Aghion and Howitt 1991), this seems to throw out the radical uncertainty of the process with the bathwater, and necessitates other extreme simplifying assumptions
- Alternatively, agent-based computation models following upon Nelson and Winter (1977) have been developed
- Some stochastic process models amenable to analytic treatment have also been studied (Iwai 1984, 2000, Henkin and Polterovich 1986, Ebeling and Jimenez Montano 1984)
- Analytical results based on evolutionary ecology can also be derived for stochastically perturbed dynamical systems (Silverberg 1984, Silverberg and Lehnert 1996)

Neo-Schumpeterian Approaches: Recent Interfaces between Data and Modelling

(Silverberg and Verspagen 2003, CJE)

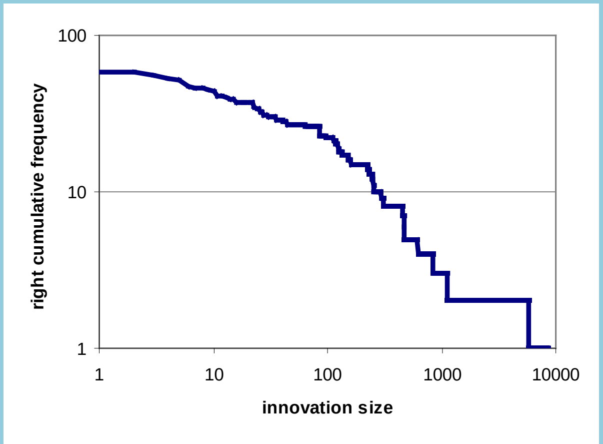


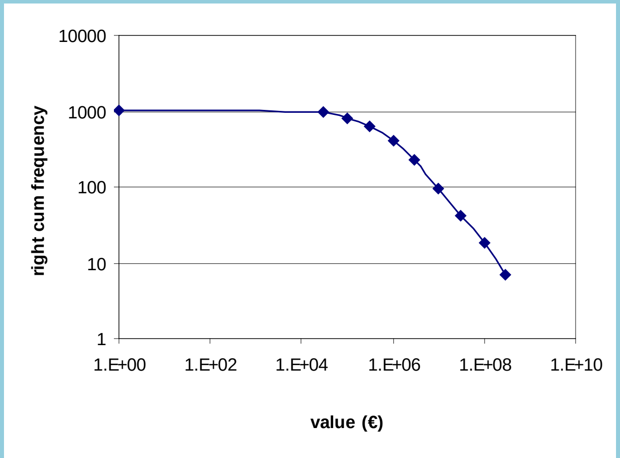
Implications of Poisson Regression Analysis on Time Series of Radical Innovation

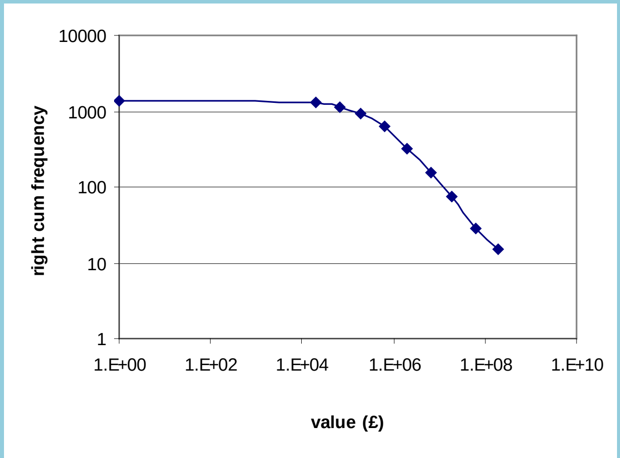
- Overdispersion (negative binomial model) is always highly significant, indicating clustering
- The Poisson arrival rate is increasing at slightly less than 1% pa and best modelled by a second-degree polynomial
- There is no strong evidence for periodicity

Innovation Size Distributions (Pareto Plots) Based on Monetary Value

(Silverberg and Verspagen 2007, JE)







Harvard patent license fees (left), NL patent valuation survey (middle), UK patent valuation survey (right)

Implications of Extreme-Value Analysis for Innovation Size Distributions

- Radical innovations can be distinguished from incremental ones by letting the data determine the cutoff of the Pareto tail
- Radical innovations represent 20-50% of all patented innovations using monetary values, but less than 10% in citation terms
- The tail of the monetary innovation distribution is pathological, i.e., has no finite moments (blockbusters)

A Complex Systems Model of Innovation based on Percolation Theory (Silverberg and Verspagen 2005 JEDC, 2007 JEIC)

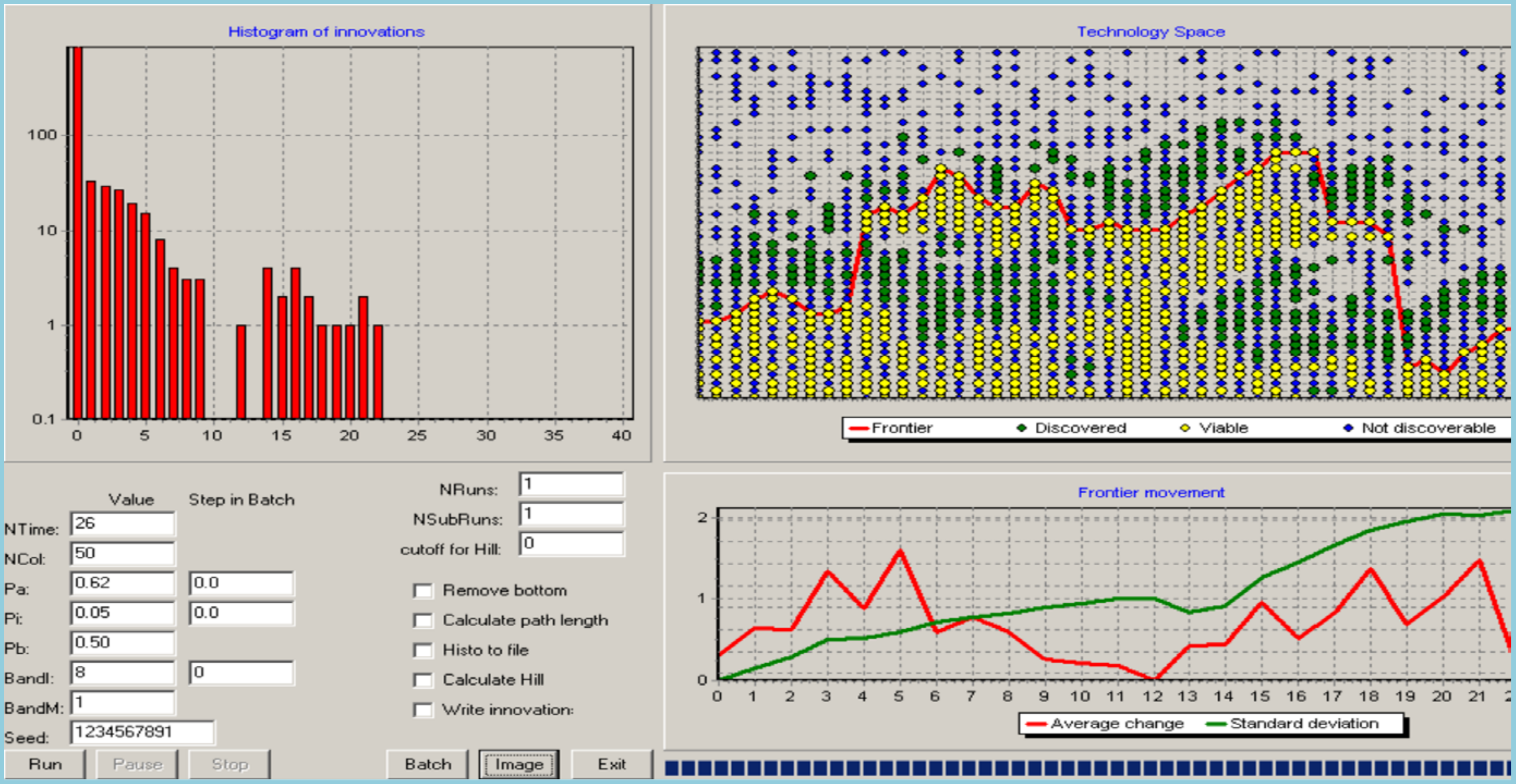
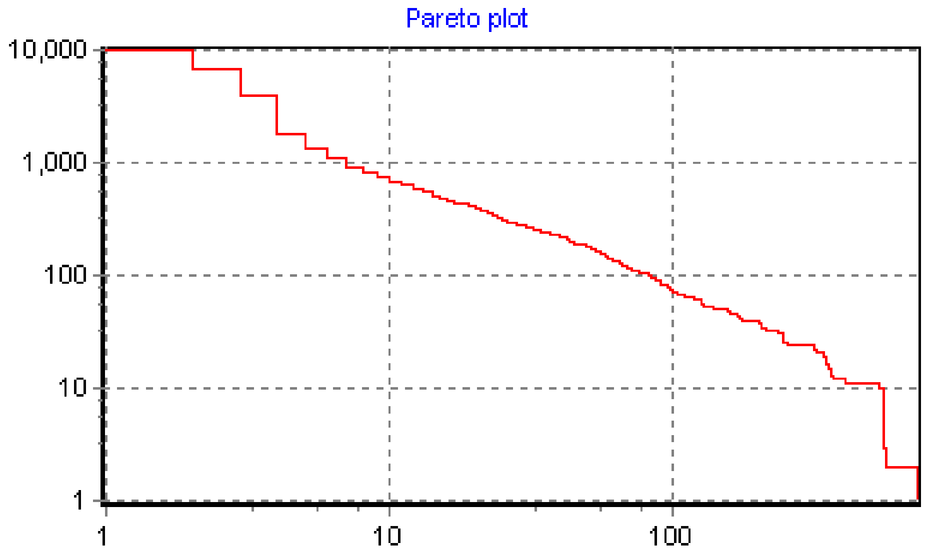
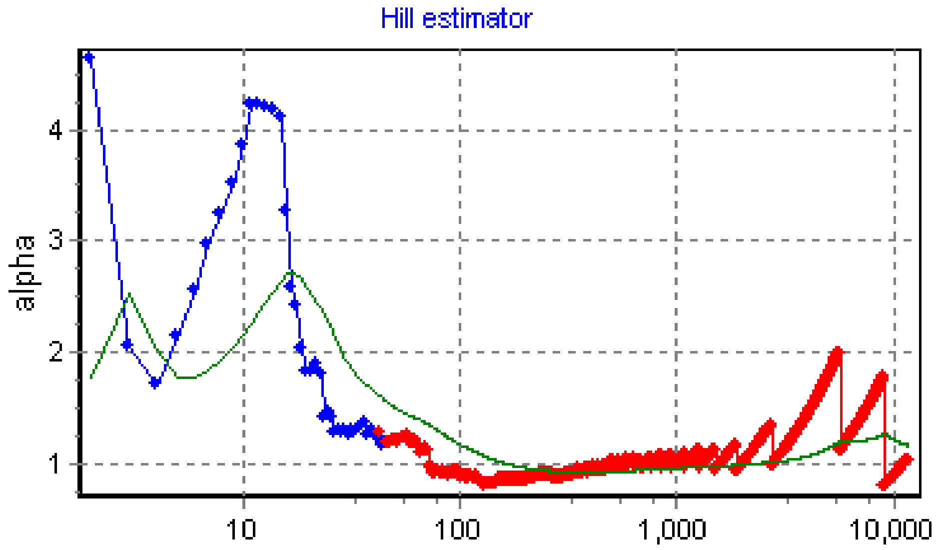


Figure 7. Screen shot of computer simulation at time 24. Snapshot of lattice on upper right, time series of average rate of innovation and standard deviation of BPF on lower right. A histogram of the number of innovations of various sizes can be discerned on the upper left.

Innovation size distribution, moving firms, <q>=0.5, σ=1, m=3, π=1





Product Space Network (C. A. Hidalgo, B. Klinger, A.-L. Barabási, R. Hausmann, Science 2007)

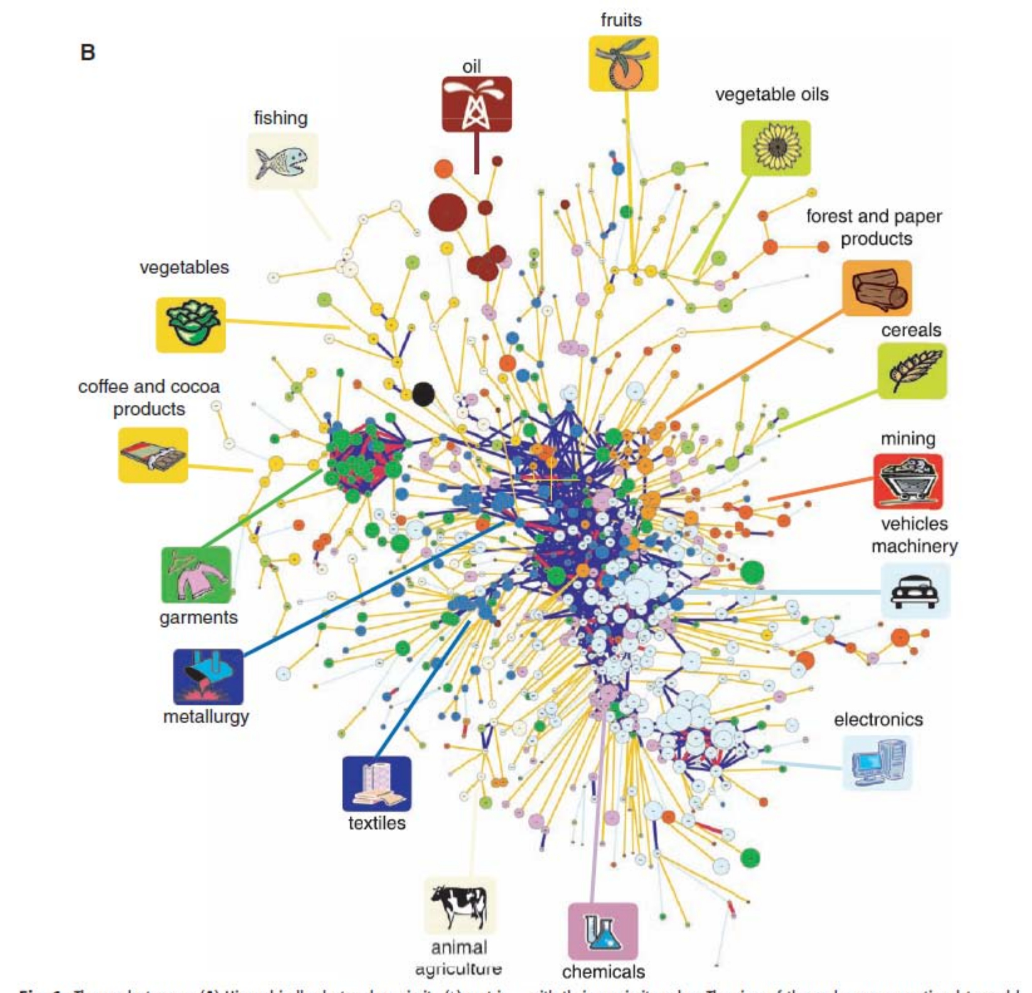
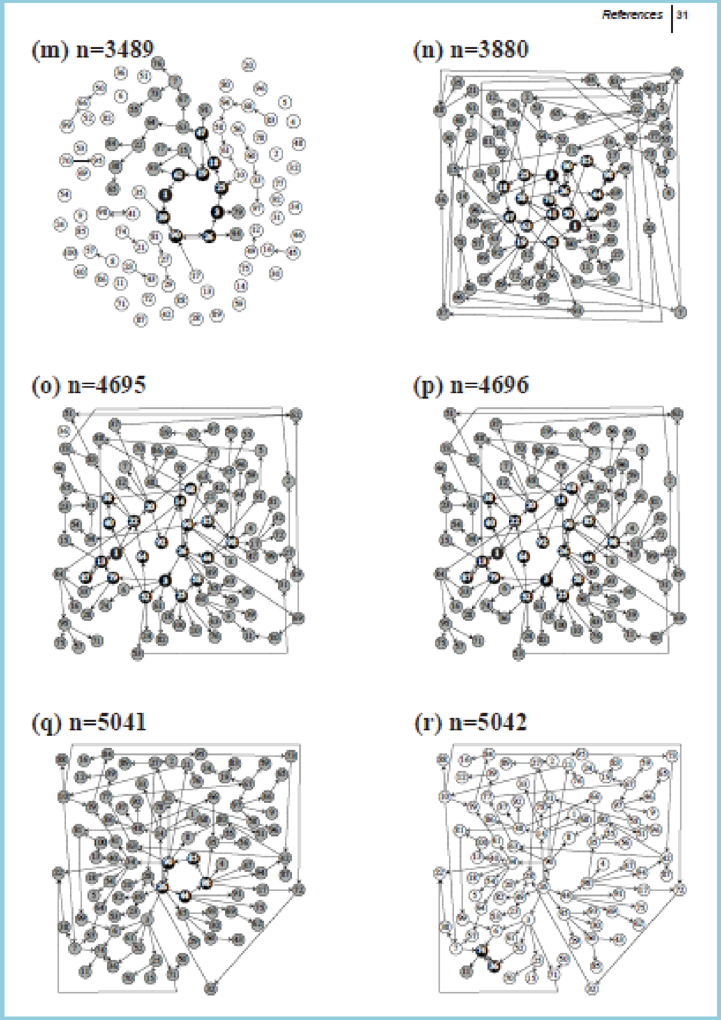


Fig. 1. The product space. (**A**) Hierarchically clustered proximity (φ) matrix representing the 775 SITC-4 product classes exported in the 1998–2000 period. (**B**) Network representation of the product space. Links are color coded with their proximity value. The sizes of the nodes are proportional to world trade, and their colors are chosen according to the classification introduced by Leamer.

Putting the Pieces Together: Extremal Evolutionary Dynamics on an Endogenous Industrial Network

(based on Jain and Krishna 2006)



Punctuated Equilibrium in EED (J&K 2006)

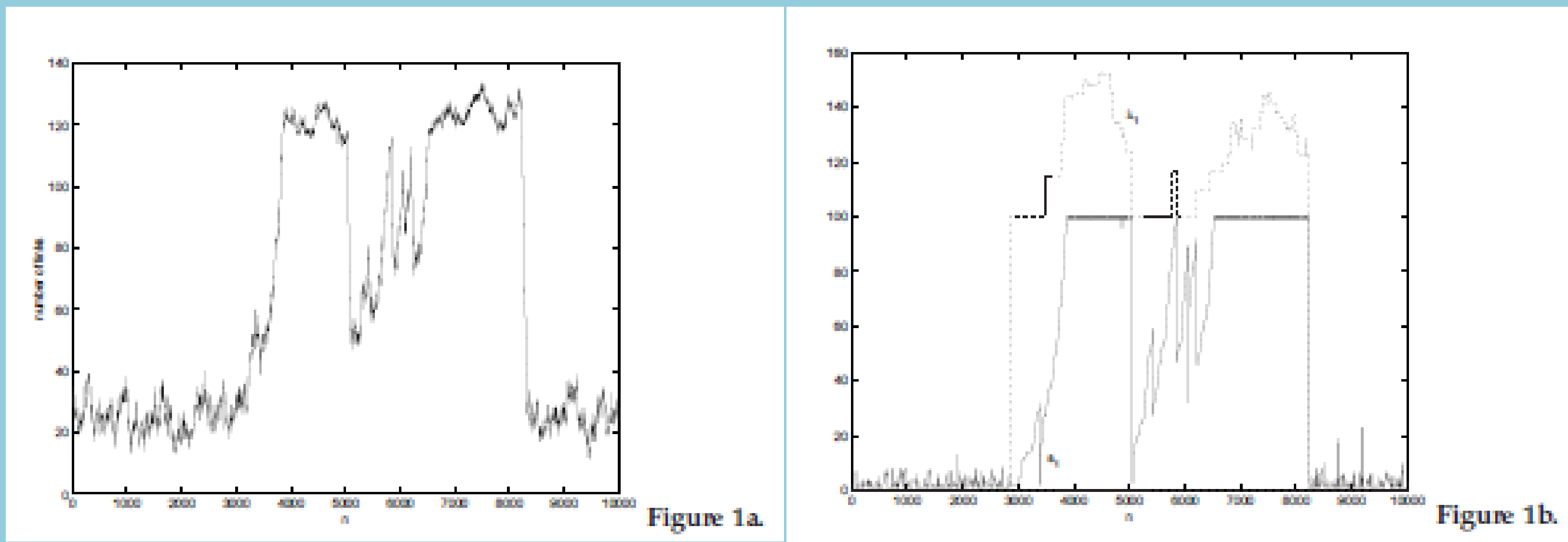


Figure 1. A run with parameter values *s* = 100 and *p* = 0.0025. The *x*-axis shows time, *n* (= number of graph updates). Fig. 1a shows the number of links in the graph as a function of time. In Fig. 1b, the continuous line shows *s*1, the number of populated species in the attractor (= the number of non-zero components of *Xi*) as a function of time. The dotted line shows *l*1, the largest eigenvalue of *C* as a function of time. (The *l*1 values shown are 100 times the actual *l*1 value.)

The Problem with Growth Accounting, or Why Does Everyone Have their Own Main Driver of Growth?

- Growth accounting à la Solow/Swan is based on the existence of a smooth, differentiable aggregate production function, homogenous of degree one, so that, from Euler's theorem, the rate of growth of output can be decomposed into the weighted sum of the rates of growth of the inputs (with the weights summing to one and representing the "contribution" of each input).
- What's wrong with this?
  - all inputs are perfect substitutes for each other – there are no complementarities or synergies
  - if the economy actually consists of a heterogeneous population of production units, the aggregation conditions necessary to derive an aggregate production function almost certainly do not apply (Felipe and Fisher 2003). This is what evolutionary economics posits.

The Problem with Growth Accounting (cont'd)

  - all the other neoclassical assumptions probably don't hold either: representative agent shortcut, perfect competitive markets, marginal cost pricing - but this is almost an afterthought
- In practice, empirical economists are just regressing some growth rates against other growth rates with the additional constraint that the weighted sum must add up. If there is no genuine cross-variation in factor proportions (i.e., multicollinearity in input growth rates due to complementarities), then the decompositions are not robust or meaningful. Depending on which variables are introduced and which functions are estimated on which data, radically different results can be obtained.
  - Phelps Brown (1957): "The conclusion must be that the fitting of the Cobb-Douglas function to time series has not yielded, and cannot yield, the statistical realization of a production function. It can describe the relations between the historical rates of growth of labor, capital, and the product, but the coefficients that do this do not measure marginal productivity.

So how do we find a balance between complementarity and substitutability?

- Because of dynamic threshold effects, some inputs may play triggering roles in economic development, determining whether a country catches up or falls behind (e.g. Verspagen 1991)
- Synergies may exist between different factors, leading to strongly nonlinear responses. Capture with NK landscape type models, or percolation on network?
- Some degree of short and long-term substitution undoubtedly coexists with complementarities. Is there a unifying framework for representing the tradeoffs?

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