Evolutionary theory: introduction and examples

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Goal

Show how evolutionary theory, and the its modelling tradition, can be used to devise policy measures, with particular focus on technological and environmental issues.

Outline

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   - Taxation policy for industrial specialization under uncertainty
   - Patents and welfare

Tenets of Evolutionary Theory

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- **Variety decreasing mechanism(s)**. Selection of successful features at the expenses of failing ones.

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Notice that selection operates at **aggregate** level, taking into account not only the set of competing firms, but also relevant external influences: government (taxation, subsidies, regulation); potential substitutes (domestic or foreign markets); global trends (technology, costs of raw materials, finance).

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In any case variety increases because of actions taken at **micro-level**, by agents supposedly endowed with the possibility to make a large potential number of changes.

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In short, evolutionary theory aims at studying **emergent properties** where micro-agents indirectly coordinate giving rise aggregate sets with specific features.

Evolutionary Economics

In conclusion, evolutionary thinking is particularly suited to represent and study phenomena with the following features:

- **Dynamic**: taking place in real-time (e.g. irreversible effects)
- **Innovative**: innovation, specially radical innovation, has an important role
- **Complex**: many different entities interact with each other, with multiple, and possibly conflicting, goals.

As such, Evolutionary Economics is perfectly suited to deal with technological innovation and environmental issues.

Evolutionary modelling

Evolutionary economists rely particularly on agent-based simulations, as other fields like sociology, psychology etc. This research tool is quite new and there is a hot debate on how to properly use simulations and how to assess their results.

In the following we briefly list the major pro's and con's of evolutionary modelling.

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  - Ev. models frequently tend more to provide a good description, but fail to produce useful results.

Examples

In the following we will present three examples of theoretical papers (i.e. not applied) generating relevant implications on policy issues.

The papers will be strongly summarized, and are meant only to provide a hint of how an evolutionary model can deal with policy issues.

Demand-based environmental incentives

Bleda, Valente, “Graded eco-labels: A demand-oriented approach to reduce pollution”, *Tech. Forecasting and Soc. Change* 2009.

Free markets are frequently held responsible for sacrificing social goals (e.g. clean environment) for individual ones (e.g. lower prices). We challenge this view with a proposal meant to exploit market mechanisms to promote green technologies.

Demand-based environmental incentives

We define products on the markets along two dimensions:

- **users' quality**: represents features of direct interest to the users (e.g. price, performance, etc.)
- **environmental quality**: represents a measure of "eco-friendliness" of the product (e.g. inverse of CO_2 required for the production, negative of the energy required, etc.).

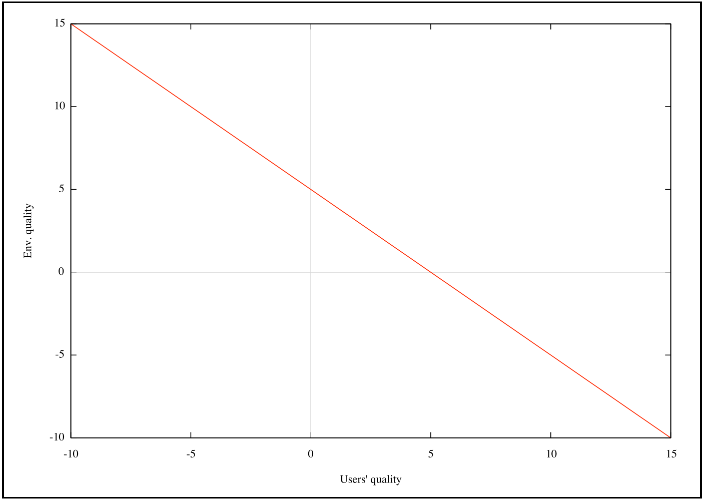
Assume that knowing such measures it is possible to compare any two products assessing whether one is better or worse than the other on each of the two dimensions (including equivalence).

Demand-based environmental incentives

Suppose the technological possibilities require to generate more pollution in exchange for “better” (e.g. cheaper) products and, conversely, less polluting technologies are also “worse” (e.g. more expensive) for users.

Firms choose which combination of the two dimensions to improve depending on the expected profits from innovation.

Feasible changes in qualities



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2. If more than one product remains, discard from this set the products scoring poorly on respect of env. quality. If one product only remains, choose it.
3. Choose randomly among the remaining products.

Demand-based environmental incentives

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1. **Baseline scenario**: consumers have no information. When using this criterion consumers choose randomly.
2. **Certification**: consumers are provided reliable information on whether the env. quality of a product is above or below a given threshold.
3. **Graded certifications**: consumers are provided with statistically reliable information on which product is scoring better on env. quality.

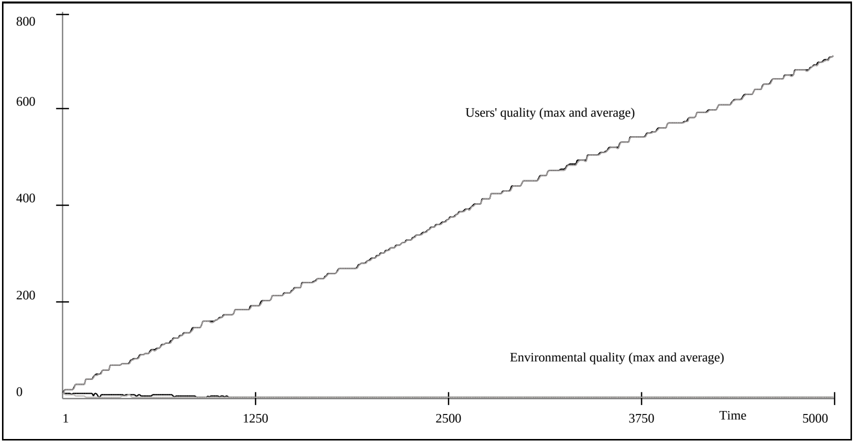
Demand-based environmental incentives

In the baseline scenario research on improving env. quality is neglected because it does not provide any competitive advantage.

A firm investing in developing (partially) green technologies would suffer because of poorer users' quality (recognized by customers) and no reward for its green credentials (not recognized).

As a result, firms pursuing clean technologies are selected out of the market, at the expenses of highly polluting ones.

Baseline scenario

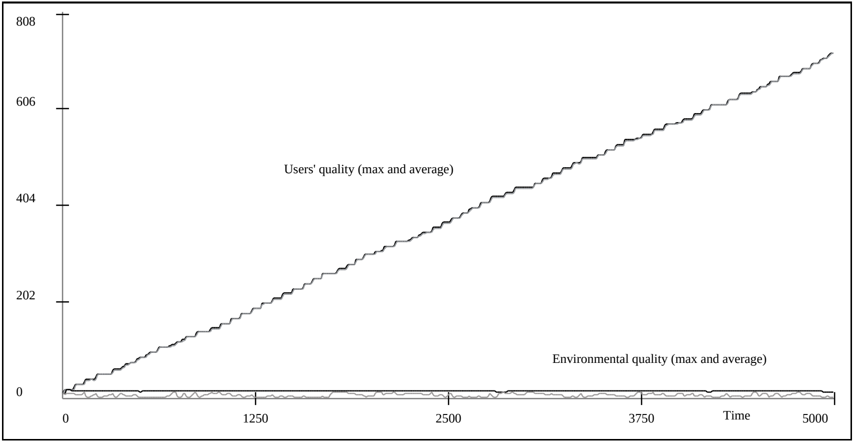


Demand-based environmental incentives

A similar result is obtained by using certifications that guarantee a minimum level of env. quality for certified products.

Producers pursuing this strategy would possibly satisfy a niche of “green” consumers, but would never be able to develop further technologies balancing environmental impact and overall quality of the product. This is because no consumer can appreciate differences in the green dimension, besides certification, and no reward can be expected from further environmental innovations.

Certification



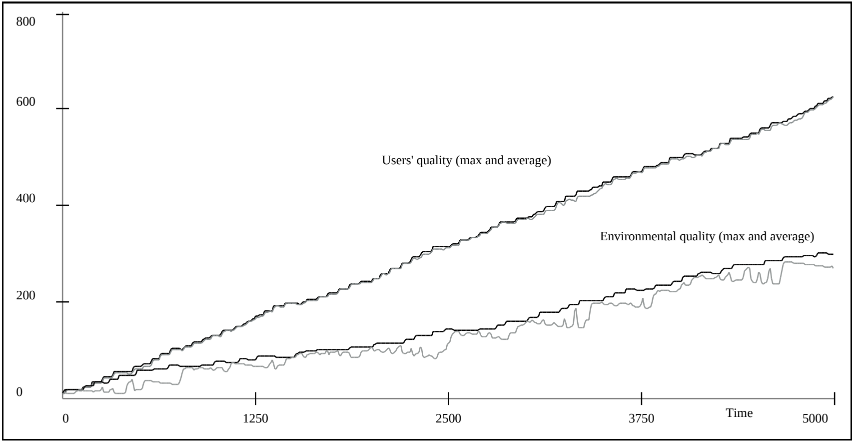
Demand-based environmental incentives

Radically different results are obtained by providing consumers with the capacity to assess which product, among two, is the least polluting.

In this case firms have the economic imperative to not neglect the environmental dimension, since this aspect becomes the tie-breaker when innovation brings competitors with similar levels of users' quality.

Being able to sustain competition on secondary aspects is crucially relevant to defend market positions when differences in the primary characteristics are minimal.

Graded eco-labels



Demand-based environmental incentives

These results, besides being produced with heavily pessimistic assumptions, hold also for approximate definitions of “env. quality” measures, with large equivalence spaces, and even mistakes.

Crucially, they do not rely on experts to assess the technologically feasible green level, or on enforcement. On the opposite, they provide the incentives for the market to fully exploit the technological possibilities.

Growth and taxation policy

Di Maio, Valente, *Uncertainty, Optimal Specialization and Growth*, LEM Working Paper Series, 2006/5, Pisa (submitted to JEBO).

The paper focus on the use of *comparative advantages*. This idea is used to state that a country should fully specialised in the sector that provides the highest relative productivity.

Many critics claim that some diversification is good, but fail to produce a general and simple model to support their claim. Our paper assumes uncertainty, that is a country cannot really know for sure which sector will be “lucky” before making irreversible investments, though the probability distributions are known.

Growth and taxation policy

The model may summarized as follows:

$$\begin{aligned} P(r_x = r_H) = P(r_y = r_L) = \pi \\ P(r_x = r_L) = P(r_y = r_H) = 1 - \pi \end{aligned} \tag{1}$$

where $r_H > r_L$ are the rate of returns and π is the probability that sector x is lucky. For each share of capital λ invested in x there will be an expected growth rate. The highest growth is generated by the optimal diversification λ^*.

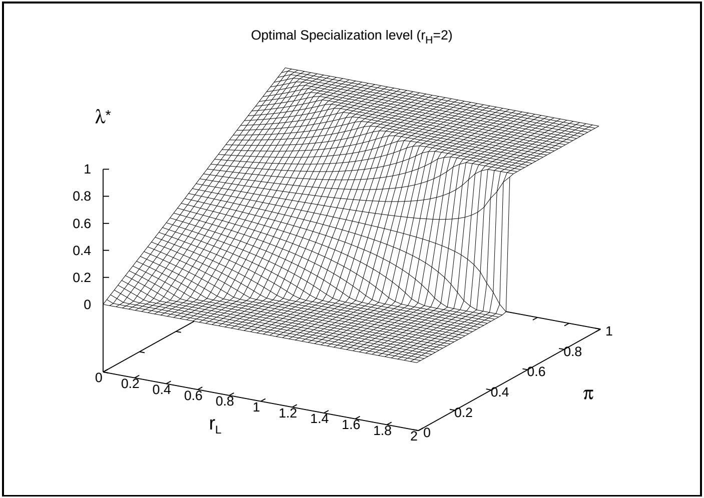
Growth and taxation policy

A first result, derived from mathematical biology, shows that the traditional interpretation of CA holds only if the goal is to maximize year-to-year income.

But GDP growth differs from GDP levels, since the income level of one year determines the available resources to invest in the following period.

In this case a country is not interested growing at high speed, if this implies rare, but dramatic, drops in absolute levels. Rather, a country should prefer a lower average speed but get an "insurance" that no sudden drop in absolute levels will ever occur. Formally, the problems changes from maximizing an arithmetic average to maximize a geometric one.

Optimal diversification



Extension 1

The baseline model assumes that the same event affects all agents.
Suppose instead that relevant events have correlation c^2 among agents. This will modify the average rate of return for a given distribution.

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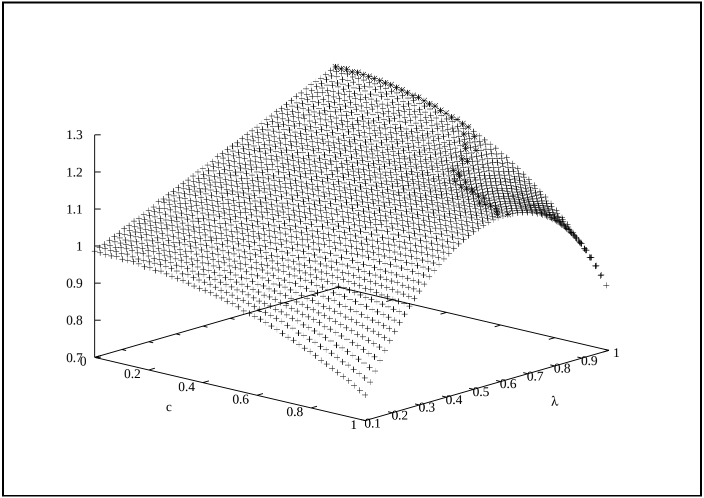
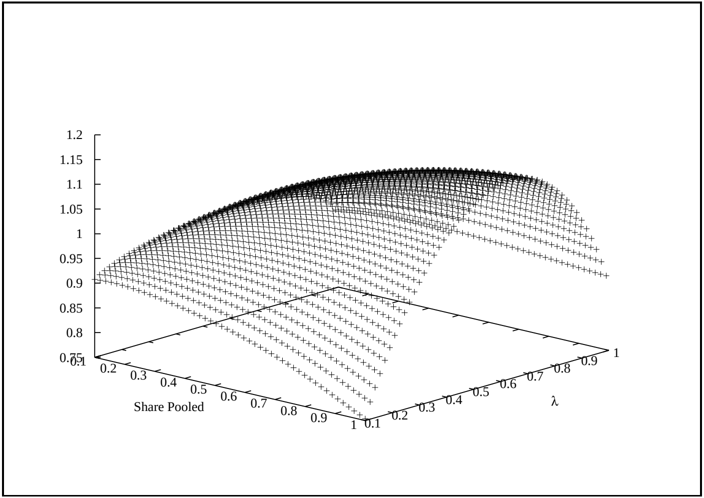


Extension 2

The baseline model assumes that all agents take their returns and given them back to the state, than at the next round of investment redistributes all the capital in equal shares, independently from the previous returns.
Suppose instead that share of returns pooled to redistributed is smaller than 100%. This affects the average performance of the country.

Extension 2


1.2
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1
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1
λ

Growth and taxation policy

The policy dilemma stems from a development of this result. We consider that the decisions on single units of capital are controlled by independent decision makers.

Each of them will have the incentive to “bet” on the most promising sector, and nobody would act as “insurer”.

The country naturally turns into sub-optimal full specialization.

Growth and taxation policy

The solution proposed is a taxation system meant to align collective (i.e country level) and individual interests. We show that a budget-neutral taxation system can be computed such that the taxes paid by “winners” are re-distributed to the “losers”.

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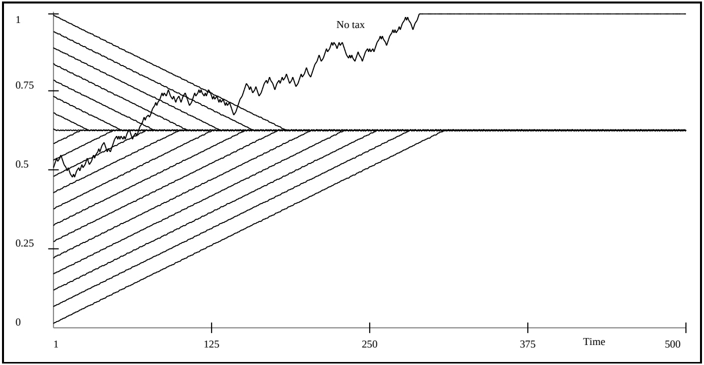
The taxes level is such that if the individuals distribute their investments according the optimal level of specialization, their net income (after taxes and subsidies) is identical for all. Better still, in case of imbalances, the income of the investors in the scarce sector is higher than that of the over-invested one, pushing towards the correct balance.

Optimal taxation and redistribution



Patent protection, innovation and welfare

Dosi, Marengo, Pasquali and Valente, *Knowledge, competition and appropriability. Is strong IPR protection always needed for more and better innovations?*, rejected by JEBO.

Patents provide an incentive to generate innovations (increasing welfare), but give monopoly power to raise prices (decreasing welfare). Can an appropriate balance be identified on the basis of the nature of the technological space?

Patent protection, innovation and welfare

We build a model where firms use profits to invest in R&D, generating innovations. Prices are set in order to maximise profits.

We draw on the literature on complexity in order to distinguish between “complex” technological spaces and “simple” ones.

Patent protection, innovation and welfare

A **complex** space is one in which the system is made of several interacting components, so that any change to one component affects the performance of any other.

A **simple** space is one in which components can be modified without affecting the performance of others.

Simple tech. spaces

We show that in simple spaces patent protection is necessary, otherwise firms compete on prices only and cannot cumulate sufficient funds to finance innovations. Welfare enjoys low prices but suffers from lack of innovation.

With patents alternate firms exploit market power to cumulate funds, but are constantly under thread of imitation in the medium term by innovators of other components. Since the space is simple, it is always possible to merge different innovations on separate components.

Complex tech. spaces

Conversely, in complex spaces innovation is forced to follow a narrow pattern, since the imitation of only one component cannot guarantee an improved system.

With patents a single firm can hold on a crucial component preventing the emergence of equivalent system for a long time. They have ample room to exploit monopoly power, and competitors are forced to compete on prices only, reducing their scope for research.

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2. Its models are particularly suited to deal with innovation and complex interactions, core aspects of environmental policy debates.
3. Ev. models can be used to explain how certain phenomena have been produced, and to test the feasibility of different policy instruments.
4. Ev. models can be designed to be calibrated and adjusted in real-time, in order to incorporate unexpected events and guiding possibly necessary adjustments.