FOOD FOR THOUGHT AND NOT ONLY

SUSTAINABILITY TRANSITION: WASTE MANAGEMENT AND VALORISATION

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THE WORLD AT A GLANCE

Population (billions)

- **High income countries**
  - USA
  - Euro area
  - Japan

- **Upper middle income countries**
  - Brazil
  - Russia

- **Lower middle income countries**
  - China
  - India

- **Low income countries**
  - Pakistan
  - Nigeria

Size of economy (GNI in billions current USD)

- **USA**
- **Euro area**
- **Japan**

Bars not labelled represents the other countries in that group.
THE WORLD AT A GLANCE

High population growth is projected in low- and middle-income countries.

- **2013**: High income countries = 1.3B, Low/middle income countries = 5.9B, Lowest income countries = 7.2B
- **2050**: High income countries = 1.4B, Low/middle income countries = 8.2B, Lowest income countries = 9.6B
- **2100**: High income countries = 1.5B, Low/middle income countries = 9.6B, Lowest income countries = 10.9B

Source: UN-DESA, 2013
THE WORLD AT A GLANCE

Three phenomena are associated with population growth:

1. Massive rise in food demand
2. Sharp increase in CO$_2$ emissions
3. Massive rise in waste ‘production’
IT’S TIME TO MAKE A CHANGE!

There are two options:

1. De-growth (poorer and happier?)

2. Innovating in: technologies, individual behaviour, collective behaviour

Instead of a problem waste can become tomorrow's resource
IT’S TIME TO MAKE A CHANGE!
BIO-REFINERY

Biomass → Fuels → Solvent → Plastics → Bulk chemicals → Fine chemicals → Fibres → Oils

Don’t use food quality feedstocks!!
WHAT DRIVES THE CHANGE?
A THEORETICAL FRAMEWORK

Sustainability transition

- Large-scale socio-technological systems have a lot of inherent inertia
- Pushing them to change requires both:
  - a disruptive pressure of the current system from above
  - an innovation pressure from below that might form technological niches ready to take off when disruption takes place
WHAT DRIVES THE CHANGE?
A THEORETICAL FRAMEWORK

Sustainability transition

Geels, 2007
WHAT DRIVES THE CHANGE?
A THEORETICAL FRAMEWORK

Niches development drivers:

✧ Expectations

✧ Knowledge

✧ Power (networking with powerful actors)
MODELLING THE NICHE FORMATION PROCESS

✓ Social space: 3-dimentional, finite, regular wrapped grid of cells forming a torus
✓ Firms move randomly in the social space and can meet other firms
✓ Two firms interact any time they are sufficiently close
✓ In the social space there are also institutional agents whose role is to sponsor the new technology (spreaders)
MODELLING THE NICHE FORMATION PROCESS

- Initially all firms produce, using a regime technology.
- They produce under perfect competition (zero profits).
- By switching to the niche option, firms might gain extra-profits.
- The decision to switch depends on firms expectations of the new technology.
THE EXPECTATIONS MECHANISM

✧ Each firm has an expectation of the new technology
✧ It can increase any time a firm interacts with a spreader
✧ If expectation is sufficiently high the firm become a supporter of the new technology
THE EXPECTATIONS MECHANISM

✧ Supporters can establish **ties** with other supporting firms

✧ This is the first step towards the **emergence on the innovation niche**
THE EXPECTATIONS MECHANISM

✧ Supporters will **switch to the niche technology** only if they find it convenient

✧ Their expected profit has to be **higher than zero** (old technology profit)

✧ The expected profit **depend on the level of expectation**
THE EXPECTATIONS MECHANISM

Due to the initial uncertainty associated to the new technology those firms producing under the niche technology will have:

- high profits with a probability $p$
- low profits with a probability $1-p$
THE EXPECTATIONS MECHANISM

Expectations of firms producing with the new technology can either increase or decrease

- \( ex \) increases if the actual profit is higher than the expected

- \( ex \) decreases if the actual profit is smaller than the expected
THE KNOWLEDGE MECHANISM

Firms possess, at the beginning, a limited amount of knowledge on the new technology but can learn by doing producing with the new technology augments the level of knowledge.

by interacting firms within the supporters network can acquire knowledge from their partners.
THE KNOWLEDGE MECHANISM

Probability of obtaining high profits \( (p) \) increases as firms accumulate new knowledge.
THE POWER MECHANISM

✧ Power is defined as firms’ endowment of strategic resources

✧ Individual power is randomly assigned at initialisation and increases any time a firm makes extra profits

✧ The total sum of individual power represents the overall network power

✧ As individual and network power increase → production costs under niche option reduce
SIMULATING NICHE EMERGENCE
THE SIMULATION SET-UP

✓ Consider a population of N=100 firms
✓ Located on a grid sized 32x32
✓ Timeframe investigated is 2600 time-steps corresponding to a 50 years time span
SIMULATING NICHE EMERGENCE
THE SIMULATION SET-UP

✧ Reference model → No policy action

✧ Two policy tools → Spreadsers & Subsidies
SIMULATING NICHE EMERGENCE
THE SIMULATION RESULTS

☑ Results presented are based on single batches of 100 runs

☑ For a robustness check we ran each batch twice comparing average values of all the relevant indices and found that results were highly comparable
SIMULATING NICHE EMERGENCE
THE REFERENCE MODEL – RESULTS

Niche technology – supporters and users

Niche technology – established links
SIMULATING NICHE EMERGENCE

THE REFERENCE MODEL – RESULTS

✧ There is a large number of firms supporting the new technology, but almost nobody switching technology – WHY?

✧ Intuitively → there is a general positive feeling about the niche option BUT this is not sufficient to induce firms to abandon the regime option and switch technology
SIMULATING NICHE EMERGENCE
THE REFERENCE MODEL – RESULTS

✧ A firm switch technology if its expected profits exceeds normal profits

✧ This crucially depends on the level of expectations of firms upon the niche technology

✧ As it seems, an agent with an expectation level just above the threshold (0.75), in spite of being a supporter, will be unlikely to switch technology
The system is locked into a *mild-support trap* i.e. a situation in which there is a large support for the new technology, yet unable to promote the emergence of a technological niche.

To verify this we calculate the expectation level of supporting firms reached during the simulation and found that it never exceeds 0.79 being on average 0.78.
Understanding the trap

✧ Firms’ expectations increase if actual profit is greater (or equal) than the expected profit and decrease otherwise.

✧ However, if firms do not switch technology they will never get the opportunity to experience positive profits and therefore increase their expectations.
On the contrary a sufficiently large number of *early adopters* might revert this equilibrium:

- early adopters will lower the niche production costs employing their resources for experimentation
- This, in its turn, will induce more producers to switch technology

- This can be triggered by a policy intervention
SIMULATING NICHE EMERGENCE
TWO POLICY ACTIONS

An information campaign conducted increasing the number of spreaders
• 4 cases → 3; 5; 7 and 9 spreaders

The introduction of subsidies
• 4 cases → 3% 5%; 7% and 9% of revenues
SIMULATING NICHE EMERGENCE

SUBSIDIES – RESULTS

Niche technology – supporters and users
(3% subsidy)

Niche technology – supporters and users
(5% subsidy)

Niche technology – supporters and users
(7% subsidy)

Niche technology – supporters and users
(9% subsidy)

Niche technology – established links
(3% subsidy)

Niche technology – established links
(5% subsidy)

Niche technology – established links
(7% subsidy)

Niche technology – established links
(9% subsidy)
SIMULATING NICHE EMERGENCE

SUBSIDIES – RESULTS

Striking result

- The number of supporters drops as subsidies rise from 3 to 5 percent
- Also the number of links drops significantly as subsidies increase

Counterintuitive → as the innovation niche takes-off, the supporters’ network collapses (both in terms of size and density) WHY?
SIMULATING NICHE EMERGENCE
SUBSIDIES – RESULTS

The mechanism at work:

• As subsidies increases, a growing number of firms are encouraged to switch technology
• Initial high level of uncertainty → some firms experience positive profits (and, consequently, increasing their expectations), and some other firms experiencing negative profits (and, therefore, reducing their expectations)
• This turbulent situation results in a significant reduction of the number of supporters and, correspondingly, to an increase of the strength of the support (average level of expectations rises as subsidies increase from 3% to 5%)
SIMULATING NICHE EMERGENCE
INFORMATION CAMPAIGN– RESULTS

Niche technology – supporters and users
(3 spreaders)

Niche technology – supporters and users
(5 spreaders)

Niche technology – supporters and users
(7 spreaders)

Niche technology – supporters and users
(9 spreaders)

Niche technology – established links
(3 spreaders)

Niche technology – established links
(5 spreaders)

Niche technology – established links
(7 spreaders)

Niche technology – established links
(9 spreaders)
The system performs well overall

✧ As the number of spreaders increases, it increases the size of the innovation niche, the speed at which the niche emerges, and the size of the supporters’ network

✧ In this case we do not observe the sharp reduction in supporters and links observed in the case of subsidies due to the presence of a conspicuous number of spreaders

✧ We observe, on average, a weaker level of support among supporting agents if we compare this policy tool with subsidy
SIMULATING NICHE EMERGENCE

CONCLUSIONS

✧ All in all spreaders are more efficient than subsidies
  ✧ the size of the niche is consistently larger and its emergence is significantly faster

✧ Moreover, a policy action based on spreaders is able to keep high the number of supporters, a fact which allows the development of a dense network through which knowledge is effectively exchanged, resources are rapidly shared and, eventually, costs of production are reduced
SIMULATING NICHE EMERGENCE

CONCLUSIONS

Occurrence observed through this model allow us to conclude that favourable elements for the emergence of an innovation niche are:

1. The constant promotion of a supportive environment, since experimentation can be a harsh process (at least in the earliest phases) that burns out expectations in the new technology and, consequently, network resources

2. The promotion of a strong support which should go behind a general endorsement of the new technology and that should be sufficiently strong to overcome adverse conditions that might occur in the earliest experimentation phases
THE CASE STUDY:
BIPLASTIC NICHE AND WASTE VALORIZATION

In this study we look at the Italian bioplastic sector, assessing its potential to develop into a mature technological niche.

Specifically, we concentrate our attention on bioplastic shopping bags, based on urban bio-waste valorisation (as opposed to bioplastic produced through dedicated crops).
THE CASE STUDY

Snowball sampling technique allowed us to construct a social network of 64 actors

✧ 48 firms (producers of bioplastic shopping bags)

✧ 8 suppliers of raw material (chemical industry, both national and international)

✧ 8 institutions (e.g. regional and local authorities, universities, NGOs, etc.)
THE ITALIAN BIOPLASTIC PRODUCTION: Network architectural properties

Key: Diamonds represent Producers; Up triangles represent Suppliers; Squares represent Institutions
THE ITALIAN BIOPLASTIC PRODUCTION: Network architectural properties

Key: Diamonds represent Producers; Up triangles represent Suppliers; Squares represent Institutions
FINDINGS
NETWORK ARCHITECTURE

✔ Overall both communication and knowledge networks are well **connected and rather dense**

✔ The networks contain only two **peripheral** cut-points

✔ Any activity involving the exchange of information is **not significantly dependent** upon any particular member

✔ The social-network is **flexible and unstratified**
THE ITALIAN BIOPLASTIC PRODUCTION - ATTRIBUTES’ NETWORKS

Key: Diamonds represent Producers; Up triangles represent Suppliers; Squares represent institutions. Attributes levels: Green is High level; Blue is Medium level; Yellow is Low level; Red is Very low level.

Communication network (attribute: expectations)
THE ITALIAN BIOPLASTIC PRODUCTION - ATTRIBUTES’ NETWORKS

Key: Diamonds represent Producers; Up triangles represent Suppliers; Squares represent institutions. Attributes levels: Green is High level; Blue is Medium level; Yellow is Low level; Red is Very low level.

Communication network (attribute: knowledge)
FINDINGS
EXPECTATIONS AND KNOWLEDGE

✓ Actors are knowledgeable but there is an inefficient use of resources available in the network with a group of knowledgeable actors occupying peripheral positions in the network or being completely disconnected from the central component.

✓ On the other hand, there are sceptical agents (i.e. characterised by low expectations) which have a central position in the networks.
CONCLUSIONS

✓ The architectural structure of the network in question offers great opportunities for the development of the technological niche

✓ Actors are overall knowledgeable and can contribute to the learning mechanism, by letting knowledge flow in a flexible and unstratified network

✓ The weakest feature of the system relates to expectations, which are generally low for those agents occupying central positions in the network

✓ The low level of expectations probably stems from the high level of uncertainty associated with the technology under investigation, a fact which had emerged already in previous studies
POLICY IMPLICATIONS

Actions to be undertaken to foster the development of the bio-plastic strategic niche

✧ Act on expectations
  ✓ Information campaigns
  ✓ Market assessment to reduce uncertainty

✧ Act on knowledge
  ✓ Experimentations (mainly scaling up)
  ✓ Enhance knowledge flows through bonding and bridging activities (give a central position to knowledgeable actors!)