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An Evolutionary Economics Approach to Ecosystem Dynamics

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Vincent Blijleven, Joey van Angeren, Slinger Jansen & Sjaak Brinkkemper. An Evolutionary Economics Approach to Ecosystem Dynamics. In Proceedings of the Seventh International Conference on Digital EcoSystems and Technologies.

Outline

- Introduction
- Core definitions of evolutionary biology and economics
- Assumptions of evolutionary biology and economics
- Innovation in ecosystems
- Diffusion and structural change
- Conclusions
- Future research

Ecosystems

- Frameworks to see the interconnected and multi-granular reality of a set of entities, to order and comprehend their complexity
  - **Business ecosystems**
    - "An economic community supported by a foundation of interacting organizations and individuals." (Moore, 1993)
  - **Software ecosystems**
    - "A set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them." (Jansen, Brinkkemper & Finkelstein, 2009)
  - **Digital ecosystems**
    - "A digital ecosystem is a newly networked architecture and collaborative environment that addresses the weakness of client-server, peer-to-peer, grid, and web services." (Boley & Chang, 2007)

Ecosystems

- Problems experienced:
  - Several key definitions have not yet been fully explored
  - Lack of an economics perspective on ecosystem evolution
- Evolutionary economics perspective to:
  - Gain insight in how to apply an economics perspective to study the self-organizing properties of ecosystems
    - Determine the **position** of a firm in an ecosystem
    - Understand how an ecosystem **develops** over time (e.g. how technological choices and chance events shape the future structure of an ecosystem)
  - Trade-offs can then be considered and balanced to positively impact **firm performance** as well as the **overall ecosystem** in which the firm operates

Core Definitions in Evolutionary Biology

- Inheritance
  - Genetic material **passed on** to offspring from parents by means of reproduction
- Variation
  - **Diversity** among a species as a result of genetic mutations
- Selection
  - **Survival or death** of individuals based on superior or inferior physical traits

Core Definitions in Evolutionary Economics

- Routines
  - Proven formal and informal procedures organizations rely on during decision making (competences)
    - Firms pass on routines to new employees through teaching and imitation
- Innovation
  - Carried out when routines are threatened by competitors.
    - Required to prevent organizations from becoming inert, inflexible, or go bankrupt
    - Leads to ecosystem diversification
- Competition
  - Organizations with superior routines/competences survive, others disappear from the ecosystem
    - Market shares, stock valuations, ...

Translated Counterparts

Evolutionary Biology	Evolutionary Economics
Inheritance	Routines
Selection	Competition
Variation (mutation)	Innovation

Assumptions of Evolutionary Economics

- Bounded rationality
  - Actors have **different** and **imperfect capabilities** to process and interpret information
  - Information is **not ubiquitously available**
    - Actors therefore display **conservative** and **risk-avoiding behavior** by relying on routines built up over time
    - Failing to review routines can lead to **path dependent behavior** (Nokia's tunnel vision – tied to existing customers and products)
- Economies of scale
  - **Entry barriers** hamper the development of an ecosystem
    - Closed standards
    - Mandatory certification
    - New ecosystem entrants are unable to grow due to preventive measures

Assumptions of Evolutionary Economics

- Historical events
  - Can lead to **inferior** and **sub optimal outcomes**
  - Firms are largely **unable to predict the impact** strategic and technical decisions will have in the **long run**
  - Historical events are often **self-reinforcing** (e.g. two-sided markets) and **irreversible**
  - Changing a platform or architecture after it turns out an alternative decision would have been superior, is **near impossible**

Innovation in Ecosystems

- Breakthrough innovations do not succeed in isolation without **complementary innovations to attract users**
  - In other words: technologies compete for users
- Technological evolution can be seen as a **chain of experiments** with new technology (variation)
  - Some technologies will successfully diffuse in an ecosystem
  - Others will fail and disappear (selection)
- This process is termed **technological substitution**
  - Incumbent technologies get replaced by new technologies
  - Shifts in market shares and stock valuations will occur
  - Triggering structural change in an ecosystem

Defining Innovation in Ecosystems

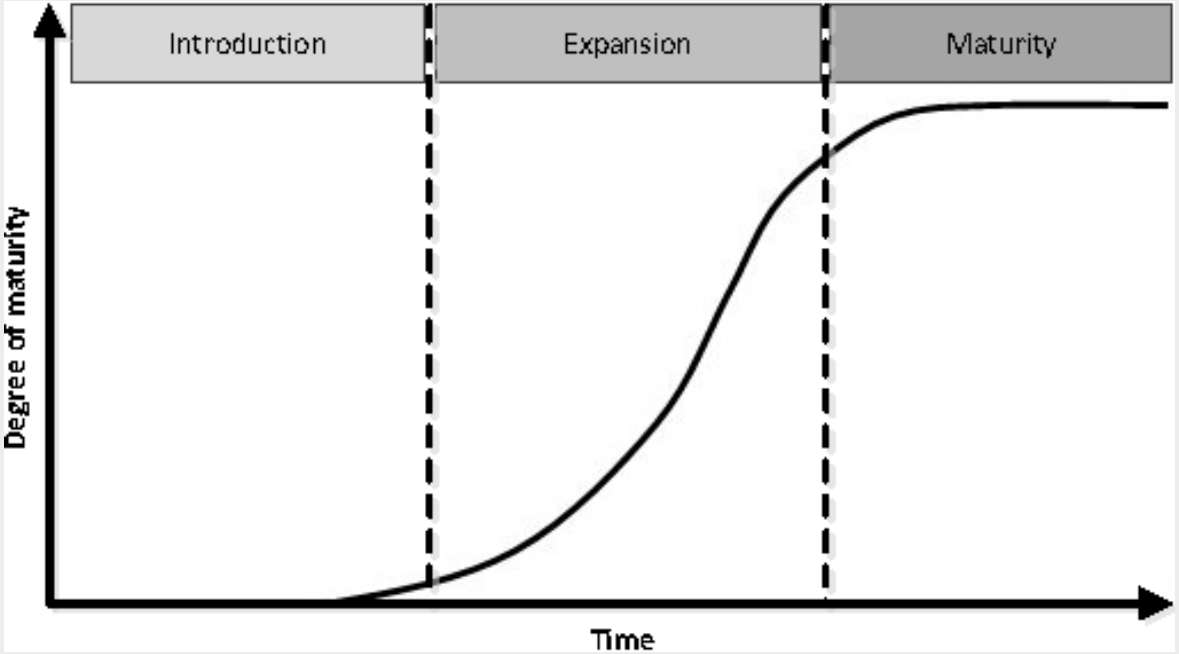
- Innovation is the primary source of variation
  - Firms with effective and flexible routines will **outperform** their peers with ineffective and inflexible routines
- Distinction between two types of innovation
  - **Product innovation**: successful development and introduction of a new hardware or software product, technology or service
    - Samsung Galaxy lineup, Windows OS, technological standards
  - **Process innovation**: successful application of a new and more efficient production process
    - Agile, Lean
- Firms compete on **product quality** through product innovations, and compete on **minimizing costs** through process innovations

Defining Innovation in Ecosystems

- Second distinction between types of innovation
  - **Radical innovation**: establishment of a new dominant design that is embodied in a new software product, technology or service
    - Comes with a **new set of core design concepts and principles** (i.e. a dominant design) upon which **complementary** products, technologies or services can be built
    - New delivery models (SaaS / cloud), introduction of Apple's iPhone in 2007
  - **Incremental innovation**: refinement and extension of an established dominant design in a software product, technology or service
    - Niche creators that refine, diversify and extend a dominant platform
    - Can lead to a technological trajectory and technological paradigm
  - **Dominant design**: de facto technology standard in an ecosystem

Diffusion and Structural Change

- Radical innovations diffuse among users through **adoption**
- Diffusion processes tend to follow a **similar pattern** (S-curve), also called the adoption curve
- Three phases can be distinguished:
  - Introduction
  - Expansion
  - Maturity



Introduction Phase

- Dominant designs of incumbent firms **mature** and have been perfected through incremental innovations
- **Windows of opportunity** therefore open to new and agile firms with flexible routines
- Radical innovations will have to **prove** themselves among competing innovations introduced by rivals
  - Early adopters and venture capitalists are crucial to generate e.g. an **initial user base** and to fuel **marketing** and **manufacturing processes**

Introduction Phase

- Deciding factors (self-organizing effects) at play
  - **(1) Increasing returns**
    - An increasing number of customers serves as bait for niche creators
    - An increasing number of niche creators extending and refining the innovation attracts more users, while concurrently solidifying the position of the radical innovator (*increasing returns to adoption*)
  - **(2) Technological lock-ins**
    - Users will become dependent on the innovation and are then unable to use the innovations provided by competitors without facing switching costs
  - **(3) Switching costs**
    - Users are forced to duplicate their investments
    - Examples are nontransferable app store purchases between Apple's iOS, Google's Android and BlackBerry OS.

Introduction Phase

- Deciding factors (self-organizing effects) at play
  - **(4) Critical mass**
    - An increasing and sufficient **user base** coupled with the **refinement** and **extension** of a design leads to the establishment of the new dominant design in an ecosystem
    - Turning point and decisive moment in the diffusion process
    - Only one or a couple of variants make their way into the expansion phase.
    - Remaining firms either get evicted from the ecosystem, or lag behind successful competitors

Expansion Phase

- Self-organizing economic mechanisms remain in effect
- Firms will increasingly compete through **process innovations**
  - Dominant design has become de facto technology standard
  - Process innovations allow firms to attain **production efficiency** and **cost reduction**
- Firms also compete through **product innovations**
  - Introduction of **newer versions** of their products, services or technologies, to achieve:
    - Differentiation
    - Quality improvements
    - Niche exploitation

Expansion Phase

- Consequences of the new dominant design becomes clear
- Despite refinement and extension by niche creators, may the dominant design turn out to be **sub optimal** compared to earlier designs proposed (by rivaling firms)
  - Bounded rationality
  - Historical (chance) events
  - Economies of scale
  - Path-dependence
  - Irreversibility

Maturity Phase

- As the dominant design matures, the rate of process and product innovations will slowly come to a halt
  - **Technical potential** to further improve a dominant design decreases
  - **Market demand** saturates – innovation diffusion process stops
- A small number of firms with perfected routines survive the selection process and emerge as ecosystem dominators
  - Leading to an **oligopolistic ecosystem structure**
- Windows of opportunity will open again
  - Initiates **self-renewal**
  - Repetition of diffusion process conform adoption curve (s-curve)
  - Incumbent firms will be challenged and new entrants vie for dominance – again altering ecosystem structure

Conclusions

- Introduction of **basic concepts** from evolutionary biology and economics to analyze and comprehend the **structural development** of an ecosystem
  - Variation (innovation) causing diversity in an ecosystem
  - Inheritance (routines)
  - Natural selection (competition) based on routines
- Discussion of **self-organizing properties** in ecosystems
  - Bounded rationality, historical events, economies of scale, path dependence, irreversibility, lock-ins, switching costs, ...
- Different **types of innovation**
  - Product versus process innovations
  - Radical versus incremental innovations

Conclusions

- Illustration of applicability of concepts presented by means of an exemplary **diffusion process** (s-curve)
  - **Introduction phase**
    - Innovators battle for their design to become dominant
  - **Expansion phase**
    - One or a few dominant designs are subject to increased adoption and incremental improvements, and succeed at the cost of others
  - **Maturity phase**
    - Innovation slowly comes to a halt as innovations are perfected
    - Windows of opportunity open for firms to introducing new radical innovations, triggering ecosystem self-renewal

Future Research

- (Longitudinal) qualitative research
  - Validate the **applicability** of evolutionary biology and evolutionary economics concepts presented during each phase in the diffusion process
  - Study **differences** between self-organizing effects in digital ecosystems versus traditional (e.g. manufacturing) ecosystems
- (Longitudinal) quantitative research
  - In-depth studies on the different phases of an innovation diffusion process (s-curve) through e.g. data mining to find **domain-specific success patterns**

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