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Endogenous space in the Net era

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Endogenous space in the Net era

paper proposed for ERSA 2004, Porto

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Abstract

Libre Software communities are among the most interesting and advanced socio-economic laboratories on the Net. In terms of directions of Regional Science research, this paper addresses a simple question:

"Is the socio-economics of digital nets out of scope for Regional Science, or might the latter expand to a cybergeography of digitally enhanced territories?"

As for most simple questions, answers are neither so obvious nor easy. The authors start drafting one in a positive sense, focussing upon a file rouge running across the paper: endogenous spaces woven by socio-economic processes. The drafted answer declines on an Evolutionary Location Theory formulation, together with two computational modelling views.

Keywords: Complex networks, Computational modelling, Economics of Internet, Endogenous spaces, Evolutionary location theory, Free or Libre Software, Path dependence, Positionality.

Contents

1. Introduction	2
2. An Evolutionary Location Theory (ELT) frame	2
2.1 A system of axioms: a case for path-dependent positionality	2
2.2 Lock-ins, reforms and revolution	7
3. Libre software and the weaving of space	11
3.1 Libre software geographies	11
3.2 NK Networks	14
3.3 Artificial Neural Networks	17
3.4 Space-weaving socio-economic processes	19
3. Conclusion	20
References	21

1. Introduction

The paper addresses a simple FAQ: "Are socio-economic events on digital nets out of scope for Regional Science, or might the latter expand to a cybergeography, including digitally enhanced territories, contributing to their shared knowledge and social capital?" The drafted answer declines on a evolutionary location theory (ELT) formulation side (in Section 2) and a computational modelling one (in Section 3), suggested for understanding the working of new "distributed" organisations in the software industry, or "Libre Software".¹

The paper introduces in Section 2 Evolutionary Location Theory, aiming to contribute to an axiomatic-theoretical unification of regional science. Such a frame is centred around axioms referring to a weak dependence in endogenous time-spaces: we argue that the spatial behaviour of agents and systems is embedded in networks of structural interdependence. The social capabilities and spatial fitness of actors located in a node, weakly depends both from the previous states of the node (Paul David's path-dependence) and from its distance from the main hubs (Eric Sheppard's positionality). Putting these two weak dependences together, in some cases make them stronger, by generation of a spatial "lock-in" e.g. class exploitation, centre-periphery dominance, digital divide, loss of capabilities traps (Amartya Sen).

In Section 3 case studies are selected from the emerging software industry segment of "Libre Software" and subject to scrutiny by computational modelling views.

2. An Evolutionary Location Theory (ELT) frame

2.1 A system of axioms: a case for path-dependent positionality

In what follows we will assume a few a priori positions, integral parts of our cognitive-evolutionary research programme in economics, social sciences and regional science. Let us summarise here the essentials of this frame, in order to reduce ambiguities.

First of all some terminological and conceptual points:

Definition 1. Endogenous N-spaces and networks.

Def. 1. Geographical systems evolve in a N-dimensional time - space frame. Regional science, since from its roots in Weber, Loesch and Isard, aims to endogenise such spaces into her models. Provided we accept, as a heuristical simplification, to reduce and sacrifice commodity and cultural, natural and technological times to just 1 dimension, "time" (as neoclassical economics does), we are left then with N-1 dimensional spaces; **these dimensions are all those where communication occurs** and that cross-area communications themselves create, whenever "the message is, and builds the medium itself".

Networks or graphs are often an appropriate frame for analysing communication media and interaction spaces, although it will be useful to join other spatial or verbal frames: continuous time-space, other discrete time-spaces; propositional and narrative, historical frames.

Communications and their networks are socially generated by:

¹ We adopt, following some French scholars, the "Libre" term in order to reduce the ambiguities of "Free Software": Libre Software might be cheap but it has not generally a zero price (given for free); "copyleft" licences reduce the degrees of freedom, in order to balance duties-and-rights to use the cooperatively produced software, and preserve it from a commercial take-over; therefore a "copylefted" product is Libre in that it evolves along his life cycle within the Libre Republic of Science, but usually it is not in the public domain; its restrictions are as strong as, but have a different structure from a commercial copyright.

- Local and trans-local, organisational and cross-organisational **cultures**: e.g. regional classical cultures; regional Renaissances and trans-local Civilizations (Fernández Armesto 2001); the Mc Donald global culture; the Web hacker culture (Levy 1984, Castells 2001, Stallman 2002);
 - **Material** (part of) **arts**, crafts and technologies: from fire (Prometheus) to Internet;
 - **Spiritual** (part, components of) **arts**, religions and symbolisms; e.g. at an important crossroad of civilisations, Afro-art and its modernist re-interpretation in Paris (then in London and New York) from 1906 onwards, by Brancusi, Derain, Epstein, Matisse, Modigliani and Picasso (Bassani 2003).
- An important heuristic consequence of spaces endogeneity is the following one.

A FALSIFIABLE CONJECTURE : networks endogeneity.

If definition 1 is correct, it might follow that the entire Econo-physics literature on complex, non casual networks has to be positively recognised for pioneering this field of research and clarifying many basic issues (Barabási 2002), but it is entirely missing the point, by ignoring the most relevant phenomena and stylised facts in social and regional sciences, which are directly responsible of the rise and evolution of a network. The Popperian, falsifiable conjecture says that:

"If network spaces and topologies are endogenous (not only in our model mirror and at its scale, but also in the mirrored reality itself), it is the social process co-evolving with the network, that fabricates or dissolves nodes, links and link attractors (hubs) of this network, in such a way as to forge, shape and reshape the network topology, for the sake of network user process needs",

be them an oligopoly (that is a supply-side network user process), a final customer or a contemporary art school, from Fauvistes to Transavanguardia. The conjecture needs to be qualified: it holds entirely, partially or not significantly (and should be falsified in the latter case), according to the spaces-time scales of analysis: e.g. in the short term or narrow geographical scale some networks are approximately fixed, provided we are far from a "punctuation" (Kilgour 1998, Gould 2002) or dominant design, paradigm change. But, as we will soon specify, scale analysis is outside the scope of this paper.

For example, a Web hub like Google cannot be adequately interpreted just in terms of a network topology (à la Barabási), without a look at the network generator as well: a producer-user and users-to-users social interaction process, shaping this network evolution.

In the Google case we must analyse the market form of the underlying competitive process in the Internet services relevant segment: emergence of a quasi-monopoly or asymmetrical Schumpeterian oligopoly, in the diffusion process and dynamically emerging market for search engines; conquered market power allowing for Google to go public and making strong efforts to "milk the fat cow": diversify into other services, introduce with e-mail services a company database violating privacy, apply Shapiro-Varian (1999) rules for the commercial exploitation of a lock-in.

More generally, it is almost useless for a social scholar (after the pioneering phase) and misleading to analyse only the socially empty, underlying network: e.g. Web links (as if page links were social links), without referring to the social process of creating and modifying home pages, web sites with a view to a social communication process.

Definition 2. Cities, spatial clusters are relational super-organisms, typical of a complex civil society and appropriately representable as "complex networks".²

Def. 2. Since from the Neolithic Revolutions (Arcangeli 2004) we live in anthropic organisations more and more n-dimensionally complex, either spatially concentrated or correlated: from rural villages to a megalopolis (Turri 2000).

² We label "complex networks" a very large class of non-casual networks observable in nature, geography and societies. They show asymmetrical allocations of links across nodes i.e. various tiers of hubs (as in a central-place arrangement) and (unlikely such an ordered arrangement) "structural holes" or hypo-connected regions; sometimes, such an asymmetry is close to a log-log linear distribution.

Complex networks are often a suitable spatial frame for these self-organising spatial formations.

Their understanding cannot be framed still now and again in a "Historicist", Hegel-Marx secularised theological perspective, as if mankind was gradually, necessarily ascending step-by-step to Paradise by Historical evolution itself (nothing as such happens in Dante's *Divina Commedia* ...).

Once we abandon, as modernity did, this proto-modern linear-progressive view, we have to elaborate new, non-linear alternative axioms for relational, spatial complex systems. Let us assume that:

- any complex territorial formation (a Marshallian industrial district, a high tech Porterian cluster, a Jacobs-type of city allocating resources from declining to emerging techno-economic paradigms) lies on the verge between a maximum entropy homogeneous space (e.g. a hexagonal lattice - spatial monopolistic competition equilibrium) and a hierarchical spatial pattern around a large firm, its world locations and logistic flows (spatial oligopolistic competition games);

- once a complex space formation has emerged, in-between oligopoly games chaos and competitive equilibrium order, it will start its own life as a social super-organism: participating as a system (although not as monolithic as a hierarchical one-company one) to higher-order markets and networks, and affecting the fitness of its lower-order nodes and their networks (e.g. a firm in a district and its supply chain).

Definition 3. Variety in opportunities, and lack of opportunities or "Oppressions", in complex civil societies.

Def.3. In our frame, the citizens of a complex civil society sometimes and somewhere enjoy a wide basket of opportunities, ranging from basic needs to hyper-modern consumerism. Sometimes not. In the latter case, OPPRESSION is a deficit in agents opportunities and freedom of choice, ranging across:

- a) **poverty:** unmatched, poor satisfaction of basic needs and rights, low healthy life expectation;
- b) **alienation:** cfr. alternative analyses in the young Marx, Heidegger, Guy Debord and Pasolini;
- c) **structural holes** of low connectivity, a deprivation of accessibility in connected spaces;
- d) **subordination to power**, the latter defined with Niklas Luhmann as the fact that one agent interferes in the process "search space knowledge - search - set of available alternatives - choice - implementation" of another agent; hierarchies build multi-layer power structures;
- e) **weakening capabilities:** the lack of exercise of freedom of the a-b-c-d type, when prolonged, affects even capabilities, in an unlearning and debilitating process: your stomach shrinks, your head becomes dizzy when you are hungry for longer; many other positive feedbacks happen as well, both within and across oppression classes, namely;
- f) **hysteresis**, or dynamic lock-in of any oppression mix, combination of the above forms (unemployed, hungry, then even homeless, unshaved, etc.).

The above list can also be read with opposite sign values, as forms of freedom from oppression.³

Pursuing the approach outlined by these initial concepts, requires new theoretical developments in between regional science and the new generation of technology studies:

1. **ELT, evolutionary location theory** (Arcangeli 1992; Boschma and Frenken 2003, 2004) introduces a novel viewpoint into the classical and neoclassical location theoretical *corpus*, by analysing the generation, lifespan and selection of complex networks and territorial systems *per se*; i.e. introducing a new meso-economic level of spatial analysis, between the micro economic one (optimal or behavioural approaches to the firm) and the macro or aggregate level (regional systems development).

2. ELT in such a way contributes significantly to an axiomatic-theoretical unification of the entire regional science *corpus*, by bridging: micro-location theory; the understanding of Territorial Innovation

³ Our evolutionary frame is neutral, or at least: neither optimist like XIX Century evolutionary sociology (Comte, Spencer), nor as pessimist as Simone Weil's (1998) "bronze law" of oppression increasing with complexity. In our frame, the latter might be rephrased in this conditional form: "WEIL's CONJECTURE. **Iff** complex civil societies, in the long run, complicate their hierarchies without undertaking compensatory *welfare society* measures of cohesion, empowerment and redistribution, **then** positive feedback chains of injustice will arise and spread: d-oppression or tyranny viruses reducing societal antibody defences against a-b-c viruses and e-f lock-in".

Systems; urban and regional economics re-interpreted as different aggregation levels in the study of territorial systems economic and social fitness (growth and social welfare outcomes).

3. ELT seems to be neatly superior to NEG (New Economic Geography) in this respect: first because of its higher coherence with cross-disciplinary complex systems literature (NEG just deals verbally with complexity, but then applies incoherently static equilibrium concepts); second because of selecting wider-ranging stylised facts as targets of evolutionary models, while NEG is linked, in its application of the basic Dixit-Stiglitz model, to a narrow focus on local externalities only (Neary 2001, Arcangeli et al. 2004).

4. Although we will not deal with this subject in this specific paper, it is worth noting that geo-historical scales of analysis, and of events happening and perceived in spaces-time, are highly relevant; changing the scale modifies radically the picture, the representation of an evolving system; many analyses and propositions in this paper therefore include "hidden" scale choices that qualify them.⁴

5. This basic principle of **scale-relativity** is complicated by multi-dimensionality, since we do not expect scale effects to be auto-correlated across dimensions. Not necessarily a wider cultural scale is asynchronous with smaller scale political worlds, or corresponds to a wider time span of diffusion and impact; on the contrary, e.g. managerial or technological fads usually spread all over the global economy and disappear after a while, without leaving many traces on National State scales, but perhaps leaving inefficiency legacies in some industrial districts or sectors taking them too much at face value (CIM, BPR or TBC).⁵

Let us now move to our key system of basic axioms; in a later, more elaborate version, it will also include a differential time-space scales frame, which was outside the economy of this paper.

AXIOM 1. Weak path-dependence in networks history (Paul David).

AXIOM 1 propositions.

1.1. For path dependence we mean that transitions do not follow just random walks: their outcomes often show some degree of dependence from previous states (opposite to Markov chain models), but never show total irreversibility (that would constitute a strong dependence case). This apply both to agents and to their "colonies" or systems (David 2001).

1.2. Complex, hierarchical networks show often a log-log linear (or rank-size rule, or "scale free") concentration of relations across hubs: we expect some inertia, so that past distances from relevant hubs might somehow affect the current distances from hubs, therefore also agents empowerments might be inertial.

1.3. Non-linear, weakly path-dependent histories also exhibit an important social welfare feature: both within and across systems, there are disparities and disparity legacies across time. Those that affect capabilities and the freedom of choice need to be stressed in an Amartya Sen's perspective, because of the long lasting (although not irreversible) effects of a local history on the relational richness/poverty and endowments available to an agent's space, a local cluster, a social group (Sen 1999).

AXIOM 2. Weak network positionality dependence (Eric Sheppard).

⁴ Please note that one should take care not to extend too far the meaning of the "scale free" label, attached by Econo-physicists to a simple but quite large log-log linearity "stylised fact" and class of findings, well known to economists and regional scientists (Pareto distribution, rank size rule). For example, the notions of evolutionary time complexity and dis-continuity elaborated by Gould (2002) is a much promising candidate to account for Raup's kill curve, frequency of large to small scale catastrophes, dominant design innovations in nature and society. According to Gould, there might be three time tiers: Darwinian selection and ecosystem resilience inhabit the first tier, "punctuated equilibria" the second, great catastrophes and ecosystem revolutions the third.

Now, in Gould's approach **scale matters**, dinosaurs are dinosaurs and not just numbers: they would have perfectly survived for longer, up to second tier fitness; and time scales or "tiers of time may interact in all possible ways" (ibidem, p. 1329). Gould's (1985) original article introducing his theory of discontinuous, stepped time scales, began with an economic metaphor: the dualism in the Indian economy, between the 100-rupees notes based formal economy and the 10-rupees notes of the informal, bazaar economy: in a dual economy, almost all the exchanges just use these two notes, not the entire spectrum. So, nature might just use three breathing paces.

⁵ CIM = computer integrated manufacturing, BPR = Business process re-engineering, TBC = Time based competition. The latter might be reframed in ELT terms, where it would gain a complement: Spaces Based Competition. But the picture would not be the hasty one of hurried versions of TBC, quickly written and printed in the TBC game for becoming an early TBC guru.

AXIOM 2 propositions.

2.1. A similar pattern applies also to the other N-1 spatial dimensions. Evolutionary fitness of agents and colonies weakly (not irreversibly) depend from their network legacy and relative position in current relational networks.

2.2. Complex, hierarchical networks show often a log-log linear (or rank-size rule) concentration of relations across hubs: we expect some cross-network correlation or compactness, so that distance from the relevant hub in one dimension, will affect the distances in other dimensions, therefore also the localised agent empowerment. The compactness of network layers reproduces a "central place" type of cumulative effect even in complex networks, as in Christaller and Loesch homogeneous ones.

2.3. Therefore there are disparities and disparity legacies across spaces; moreover, by the fact that spaces are more than one, positive cross-space feedbacks might reinforce first-order effects, while negative ones might weaken the dependence from previous states and level up inequalities.

2.4. Since from the Neolithic Revolutions, cities and societies become more and more complex and diversified; again, capabilities are affected by alternative (cultural, political, etc.) geographies and by belonging to social groups with more or less accessibility to relational hubs, with welfare heterogeneity effects as before (Sheppard 2002).

AXIOM 3. Simultaneous space-time, network-history weak dependence, or "path-dependent positionality" in complex networks (David + Sheppard).

AXIOM 3 propositions.

3.1. Most spatial **complex** systems (apart from primitive or peculiar cases) are expected to belong to the intersection of the 2 axioms above, therefore exhibit combined spaces-and-times dependence. In some "primitive" cases, either just Axiom 1, or Axiom 2 only, or none will apply: let us label these as quasi-complex (when only one Axiom applies) or simple territorial formations (the latter exhibiting perfect reversibility, no-time-space dependence). Propositions 3.2 to 3.5 apply only to strictly complex cases, emerging in the self-organisation and societal evolution of a long lasting civilisation.

3.2. We expect that complex, hierarchical networks, with a limited number of hubs: on the one hand are inertial, with a memory of past distances from nodes to hubs; on the other hand are as compact as a central place arrangement: higher level hubs simultaneously dominate more than just one sector.

3.3. As a consequence of 3.2, systemic feedbacks and reinforcements are likely to arise in strictly complex spatial formations: each dimension or space weakening or reinforcing another space effects; a likely result being sometimes a local-epochal **lock-in**: in some extreme cases a lock-in of entire social groups and regional cultures (slaves and Indian pariahs, colonial economies and manual working classes).

3.4. When and where a majority $M \geq N/2$ of the N dimensions are aligned in favouring or marginalising such a group: in such cases we have "welfare success stories" or failures in the sense of Amartya Sen; the former characterising Renaissance and Golden Ages of a civilisation, the latter requiring a balancing collective and/or public action.

3.5. In sum, for those spatial networks to which both Axiom 1 and Axiom 2 apply, we can speak of spatial behaviours conditioned by "path-dependent positionality" (the intersection of Paul David's and Eric Sheppard's effects). Path-dependent positionality becomes synonymous, in our frame, with any complex social formation: a Marshallian district or a city, a civil society or a State.

2.2 Lock-ins, reforms and revolution

We address now the FAQ: "Will oppressed multitudes definitely get rid of their lock-in, by a cluster-sequence of reforms, or just by a revolution?"

Both Marxist social theory and the related Afro-Latin American "dependence theory" (e.g. Samir Amin, Celso Furtado and F. H. Cardoso, before becoming the Brazilian premier) have dealt with and pioneered the study of these lock-in, but they were both lacking a non-linear evolutionary frame:

- **Marxism** assumes entirely a Hegelian historicist, linearly evolutionary view (Rosdolsky 1971), oddly coupled with Ricardo-Sraffa economics: therefore it misses the non-linearity of History as we conceive it from our *Zeitgeist* viewpoint, in the epoch of ICT and the new sciences of complexity;

- **dependence theory**, by referring to anti-evolutionary structuralism in social sciences, assumes **strong** dependence and quasi-irreversibility, unless "revolutionary" or at least unorthodox measures of cutting trade and investments global links are taken, namely: pursuing self-sufficiency and an inward-looking economy, through import substitution and infant industry policies.

Although many similar policy conclusions might be reached even within an evolutionary frame, the latter would assume a much more flexible approach to adopting or dis-adopting such no-global policies, on a case-by-case base (as it happened in reality in Latin America, before the imposition of the free-market "ponto de vista de Washington" in the '80s and its current rejection mood): the main target being the reduction of the M/N fraction of positive feedbacks inducing a lock-in, that is acting on higher-scale phenomena (in classical terms one would say: causes, not just effects).

Both structuralist and evolutionary theories focus the "lock-in" disease, but the diagnoses and pharmaceuticals slightly differ between the two alternative paradigms. An important dividing line in their analysis is the treatment of spatial diffusion, namely its international patterns and impacts on the growth potential of a region (Dosi et al. 1988, Dosi and Soete 1988, Arcangeli et al. 1991). As sociology and economic geography have found since from the research pioneered by Hägerstrand and Pred, diffusion is an interactive process involving networks of agents, agencies and institutions (Brown 1981). The evolution of such networks plays a key role in the centralisation-marginalisation of a peripheral region. The process being a dynamic and path-dependent one, with lock-ins, and not a deterministic or static phenomenon of structural dependence: as success stories (Far East, North East Italy, Cearà in NE Brazil) and failures show (Italy's Mezzogiorno, the rest of NE Brazil, most Sub-Saharan Africa).

Another fundamental division opposes their policy implications:

- **Revolution** for Marxism, structuralism, unequal exchange models and some other versions of dependence theory (either class or anti-imperial revolutions);

- **Network-based reforms** for liberating the oppressed multitudes, according to reformist socialism (starting from Ricardian and Utopian socialisms; even the diffusion of Christianity was a network-based class struggle, against slavery: Barabási 2002) or evolutionary theory.

The latter re-interprets the diffuse uneasiness with the cathartic idea of not just a discontinuity but a bloodbath, accompanying the *Revolution Française* paradigm, by arguing that wiping out all the legacy and tradition does not help much in the real task for escaping a massive lock-in (for entire regions and social classes). The complex task of transforming network topologies and/or building new "central place systems" of network layers, for the sake of redistributing not property rights (the false illusion of communist revolutions) but accessibility to welfare drivers: capabilities, culture, key resources, land. Reformist strategies contrast revolution for the preference they accord to politics instead of war, or peaceful mobilisation instead of guerrilla, when the former is most effective and violence or warfare are avoidable without missing the lock-in liberation target (Gandhi, Mandela); but they do not imply gradualism: overcoming a resilient lock-in calls for a discontinuity (radical reforms, revolution, war).

Behind these different empirical conceptualisations and findings, there are different concepts of space. A **structuralist space** stresses:

- one-way or "predatory" links shaping an unequal exchange, structurally unbalanced space;
- such a space is the outcome of the emergence of "central" and "peripheral", mutually dependent (like in Hegel's master-slave duality) spatial formations and infrastructures (colonialist and post-colonial one-way dependence links);
- these spatial formations exhibit a **high resilience** a priori, a mirror of their social resilience: unbalanced power between centre and periphery; establishment of a merchant, often mixed race *pseudo-bourgeoisie* in the periphery. This class defends the open economy and blocks a closed economy solution that might cut the dependence links (as we argued above).

An **evolutionary space** stresses:

- both one- and two-way links, building simple or complex networks in the social communication process; complex networks usually present an unequal distribution of "potential" across nodes close to a log-log line: this unbalance emerges from the underlying social process (concentrated market forms) and is always potentially reversible (temporary Schumpeterian monopolies);
- social and spatial formations differentiate, emerge and then evolve differentially, because of their various specialisations and degrees of fitness in the competitive environment (the regional or global economy), that co-evolves with the embedded formations;
- this co-evolution and fitness parameters decide whether a formation is **more or less resilient**: e.g. markets, networks and hierarchies co-evolve and learn mutually, and this decides their evolving division of labour (Langlois 1992, Arcangeli 1996); in a very long run and ecological perspective, a superior civilisation is at odds in a harsh environment, and will normally survive for no more than a few centuries: usually until land fertility upper bounds will exhaust the accumulation process, like in a Ricardian growth model (Fernández Armesto 2001, Arcangeli 2004).

To complete the picture, a **neoclassical space**, e.g. an Isardian or Krugmanian one, usually shows:

- two-way links (e.g. intra-industry trade) in an initially homogeneous space, before agglomeration occurs;
- the optimal use of scarce resources (land, transport), optimal agglomerations sizes (maximising agglomeration benefits less congestion costs) etc. are good proxies for the fitness of an agglomeration, AS IF (Friedman) evolution was pursuing an optimal long run equilibrium;⁶
- as in Williamson's organisation theory, any formation (or agglomeration) is **not highly resilient** a priori, because sooner or later it will be challenged by a more efficient market, learning how to overcome that specific market failure (asset specificity, externality, high transaction costs) justifying the emergence of a non-market formation.

No space concept is in abstract superior to another: each one plays an axiomatic role in alternative regional science paradigms. The conceptual barriers across paradigms preclude an eclectic approach that might be sometimes more productive for the interpretation of spatial dynamics.

Our system of hypotheses might and would currently be labelled as "deterministic", although not in such strict terms as with "strong" dependence theory. This is partially true, but:

- the determinant is not given: it is a continuous accumulation of experiences, learning and relational flows;
- the cause-effect linearity of classical determinism is definitely suppressed: it does not hold in endogenous, complex and rugged spaces;
- the assumed dependences are weak in the sense that reversibility is always possible, and most likely when window opportunities open up (liberated slaves regions; Trade Unions and the Welfare State; de-colonisation and apartheid breakdown; changes of techno-economic régime).

⁶ Allan Pred (1969) was actually arguing on such "AS IF" lines on spatial fitness: "as if" von Thunen, Weber and Loesch statically optimal arrangements were even dynamic attractors, within some sufficiently large basin, at least during "normal" spatial trajectories, far from exogenous shocks and punctuations; in his later works he abandoned this didactically useful neoclassical hypothesis.

Let us take an outstanding case of long-term reversibility. It was not written on any "destiny book" that China, in one of its golden epochs, would - after a sharp political struggle at Court between its large imperialistic coalition (merchants, the military and the smugglers) against the mandarins, won by the latter - close up its borders in a "splendid isolated state" in the mid XV Century, and give rise to its decline compared to the new North Atlantic civilisation.

By carefully applying to the global economy its basic, simple location theory, Alfred Weber was able to forecast, almost one century ago, a scenario of China coming back to a world leader position. But, the more the global economy approaches Weber's basic scenario, the more our knowledge requirements (necessary as a basis for industrial policy, international trade, R&D and investment decisions and strategies) imply more detailed breakdowns of this scenario: is China just catching up or even forging ahead? And in which one single dimensions, scales and time spans ? (Ernst 2004).

Lesson: with non-linearity and complexity (Gould 2002, Bertuglia and Vaio 2003, Puu 2003), not everything can be forecasted, but scenarios based on good theory might focus the real drivers, or eventually guess the right outcomes even without identifying such drivers, with some good luck.

In sum, the social capabilities and spatial fitness of actors located in a node, weakly depends both from the previous states of an actor or node (Paul David's path-dependence), and from its average distance from the main hubs (Eric Sheppard's positionality).

Putting these two weak dependences together might, alternatively:

1. (CASES OF MISMATCH, ASYMMETRICAL - ASYNCHRONOUS COMPENSATION, negative feedback) either make them **even weaker and more reversible**, when a rich history compensates for a poor geographical positionality (e.g. modern China, before Mao Zedong Imperial dictatorship and his deathful "Big Jump" in the late 1950s), or viceversa (e.g. modern Zarist-and-communist Russia, after the modernisation early attempted by Alexander III and pursued by Stalin's deathful industrialisation in the 1930s). This category of cases levels out the extremes, reduces the degree of societal complexity and self-organisation, sometimes leading them to chaos, but seems to play also as an **easy-reversibility attractor of "successful" revolutions**. This was in fact - with a contradictory mix of backwardness and capitalism - a testbed and favourable environment for both the French paradigm and the communist revolutions during WW I and II. ⁷

2. (CASES OF ECHO, RESONANCE, positive feedback) Or, when Proposition 3.4 applies, weak one-dimensional dependences will **reinforce mutually themselves, become stronger** and stronger. This category includes a "welfare-positive" (Golden Age) or "welfare-negative spatial lock-in" (in the latter sub-category: slavery and class exploitation; colonialism and centre-periphery post-colonial relations; cultural and digital divide; continuous slide of capabilities, with cumulative losses of freedom and opportunities in "under-classes").

The second category includes the opposite and extreme outcomes of (comparatively, for their epoch and civilisation) complex civil societies: either Golden and Imperial Age global leadership, or acute marginalisation, or the two together (US metropolitan areas and their ghettos). **This is why complex civil societies are not necessarily neither automatically cohesive.**

Complex network marginalisation, e.g. in mature, pre-decline US and Roman Empires, calls for (ghetto, slaves) revolts or reforms, but much less for a revolution, a more frequent phenomenon at Empire peripheries and/or lower levels of complexity of the civil society: post-colonial Africa, China at his worst deprivation in millennia of high civilisation, half-modern Russia and semi-colonial Cuba (a geographical paradox with its late communism, closeness to Florida and inclusion of Guantanamo: today's non-place where, like in Auschwitz, humanity and law are suspended).

⁷ Unluckily the same kind of explosive mix of declining, hopeless and poor history, together with geographical centrality might actually be leading us close to a WW III: it is concentrated today and for the next couple of decades (according to fossile combustible scenarios) in the Middle East, where Islamic fundamentalism is playing a similar role as Marxism in the past: "opium for the people", the seductive illusion of escaping capitalism by simple shortcuts.

Let us introduce here some basic notions on our case study area, Libre Software. GPL or the "copyleft" software license (a very clever and elaborate inversion of traditional copyright licenses) released by FSF (the Free Software Foundation), marked the start-up of this new mode of software **cooperative production** - i.e. division of labour in sections and tasks allocated to a community -, and **"libre" distribution** of this product and its derivatives, even outside this initial community.

GPL was perhaps the major innovation by Richard Stallman, alongside with his activity as a programmer and leader of the first hacker generation; many other "free" or "open source" licensing agreements followed (also including dual, or coupled licensing targeting alternative user groups), some of them less stringent than GPL and much more business-oriented. But, in the live debate that followed, Stallman (2002) has always objected to the latter type of far-from-GPL compromises between cooperative and commercial drivers, that the milestones of a cooperative mode of production and distribution must be carefully preserved, even when going towards the market and its needs; otherwise commercial software might just exploit Libre Software as a « free » input, increasing its extra-profits and not paying any duty to the Scientific or Hacker Community.

In fact he might be right in his analysis, besides being legitimately defending the rationale of his original and complex innovation; at least this is suggested by this research finding in the literature on Libre Software: **a delicate ecology characterises both the Programmers "Republic of Science" in itself, and particularly at its interface with the software and services industries; this peculiar ecology must be taken into proper account in scenarios and strategies.**

If one wants to release Libre Software (not a proprietary one), produced in a cooperative (not a hetero-directed, hierarchical) way, she will have to follow a narrow path in terms of the licensing allocation of duties, property, use and other rights, because:

- on the one hand a cooperative project quality is affected by "trust" attractors, and clever programmers will hardly be willing to cooperate voluntarily to anything ambiguous;
- on the other hand, she has to cope with a variety of market and non-market links, connecting the project to its current and perspective client base.

Once such a narrow path, and "right balance" is found between the (not always convergent) requirements of a high, qualified cooperation and a wide diffusion potential, a project idea can be engineered; with all the necessary ingredients: the institutional, licensing, organisational, quality-preserving and social arrangements, the solution-focusing and technical features, the project will definitely take off. But the right balance has to be maintained even afterwards, in terms of an evolving social contract with former and new actors, taking into account new events and different market conditions, during the project implementation phase.

Then cooperation and adoption swarms, with positive feedbacks, will often characterise a Libre Software project life, so much opposed to the lack of swarms and the organisational routines of a commercially produced and diffused product. Around a core team, different groups of developers will agglomerate around a Libre Software challenging and interesting project: highly socially motivated co-designers, more central or peripheral co-developers, derivative product developers and finally products (and related packages or services) distributors, likely to be more economically motivated.

We expect, as some evidence confirms, social and economic motivations to be intertwined, but likely to have social motivations and technical intrinsic aspects much stronger near the "centre" of a project community, while economic and utilitarian aspects will emerge more at its periphery, namely on its diffusion side.

In fact, at the same time as the supply side enlarges, adoption waves will extend the project interactions to larger and larger, more peripheral circles: the mass of new (not necessarily cooperative) users of a stabilised version of the final product; after the early stages, not only programmers-users but even non-technical end users will finally enter the interactive scene, if the project is successful and has a large diffusion potential, like in some paradigmatic success stories (Apache and Linux).

3. Libre software and the weaving of space

3.1 Libre software geographies

Since from the start, regional science has meant to make economic, geographical and other abstract spaces endogenous within economic theory (see Def. 1 above). In this paper we argue that the same effort is important today for the new relational spaces that are forging the complex networks of distant collaboration, with their new topologies where **cultural and organisational distances matter more than the geographical one** and its traditional proxy by transport costs (Arcangeli 2004).

An important field of application of our system of concepts-definitions and axioms-hypotheses is Libre Software itself: on the one hand it represents a massive emergence of endogenous cooperation networks into the software industry and the Internet economy; on the other hand the wide diffusion and success of its software products, although still suffering from weaknesses in their business models, are likely to affect the final user with a different impact from a commercial software package: at least above a minimum threshold of computer literacy, "open source" products allow the user to enrich her capabilities and degrees of freedom; finally, exchange relations are embedded in an ethical and friendship frame of market and non-market exchanges of use values, this case study constituting an important one fitting the ideas of the founder of economics as a social science, Adam Smith. Padrin et al. 2004 argue that a pure economic model (Lerner and Tirole, 2002) without these social dimensions, would not forecast the observed levels of cooperation, but would predict a "cooperation failure" that has not yet happened.

Let us start our analysis by taking a look at the map [fig. 1] available on the www pages of the Debian Project, a large libre software project dedicated to produce the homonymous Linux distribution, showing the geographical localization of the developers involved. We can see that developers collaborate at the whole planet scale. We have no pattern of regional agglomeration, even if there are strong and clear-cut differentiation between Europe, North-America, Japan and some other regions on the one hand, and the rest of the world with very low density on the other end. If we compare this map with a map of Internet infrastructure such as one reporting the density of routers [fig. 2], we see that the maps overlap quite well.

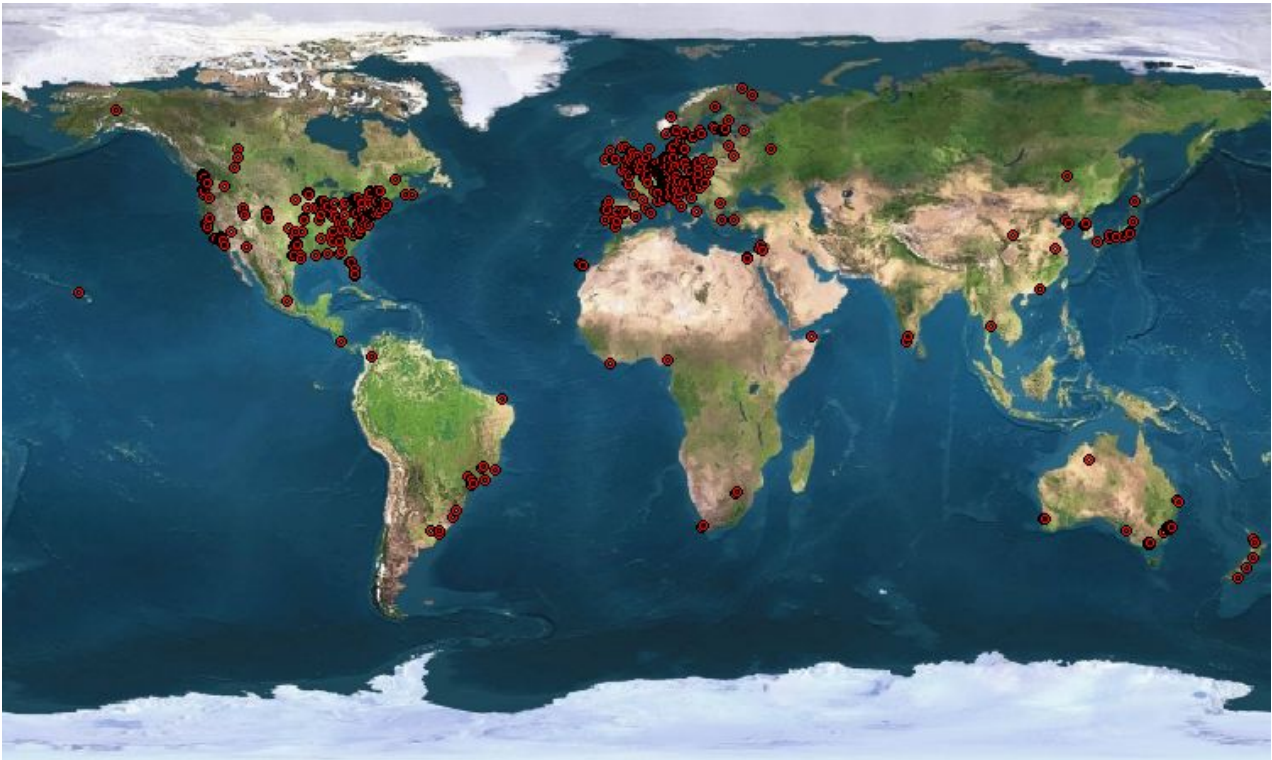


Fig 1. Debian developers map. Source: Debian Project www.debian.org

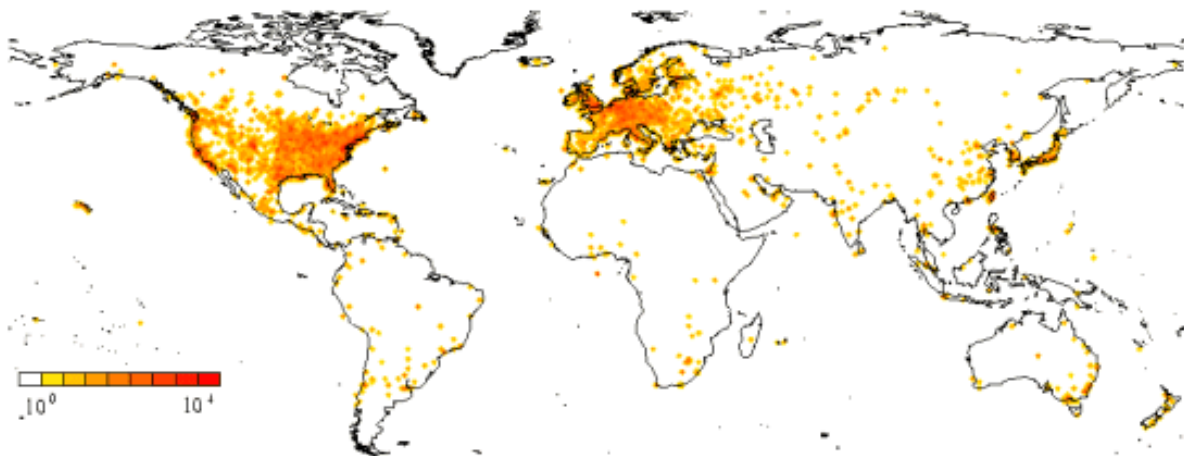


Fig 2. Internet routers density map. Source: 'An atlas of cyberspaces' www.cybergeography.org/atlas

But what happens if we zoom to a continental region scale, to an developers high-density area such as Europe? There are agglomeration patterns, strong regional differentiation or distributed patterns? Let us take a look at the map of developers involved in some libre software projects related to Linux on handhelds [fig. 3].



Fig. 3. Developers map for some Linux on handhelds projects.

This map is quite general in its main characters among libre software projects. We can recognise clear distributed patterns signalling that collaboration took place largely and effectively in digital enhanced environments on Internet, not conditioned by physical geographical issues. Therefore digital enhanced spaces are already socio-economic relevant nowadays, even if collaboration media evolution is only in early stages.

This all suggests a threshold in socio-economic and technological network infrastructures beyond which collaboration projects assume distributed and geographically spread forms and the socio-economic processes move and expands into a digital-enhanced geography (usual environments extended via the net media).

To investigate these issues we started a two-sided project: on an empirical side and on a theoretical computational modeling side.

In this paper we discuss and introduce on the theoretical and modeling side the issues involved and the research tools needed to bring to maturation a concept of space, from an exogenous container where processes occur to an endogenous and dynamic product of the processes themselves and an interaction space. By the way, it's interesting to acknowledge that, *mutatis mutandis*, research trends in this direction show themselves in theoretical physics itself [Rovelli 1999].

In this section we chose to introduce smoothly some issues involved first, by illustrating two suitable models and the related emerging pictures, and then sum up and conclude drafting some concepts and a modeling framework to allow research to go further in grasping deeper insights of our surrounding net society in its unfolding.

3.2 An NK Networks view

The NK networks are among the most interesting models used to study evolutive processes. They have been introduced by Stuart Kauffman [Kauffman 1993] and used by some researchers like Luigi Marengo, Koen Frenken and Marco Valente in their insightful 1999 [Frenken et al. 1999].

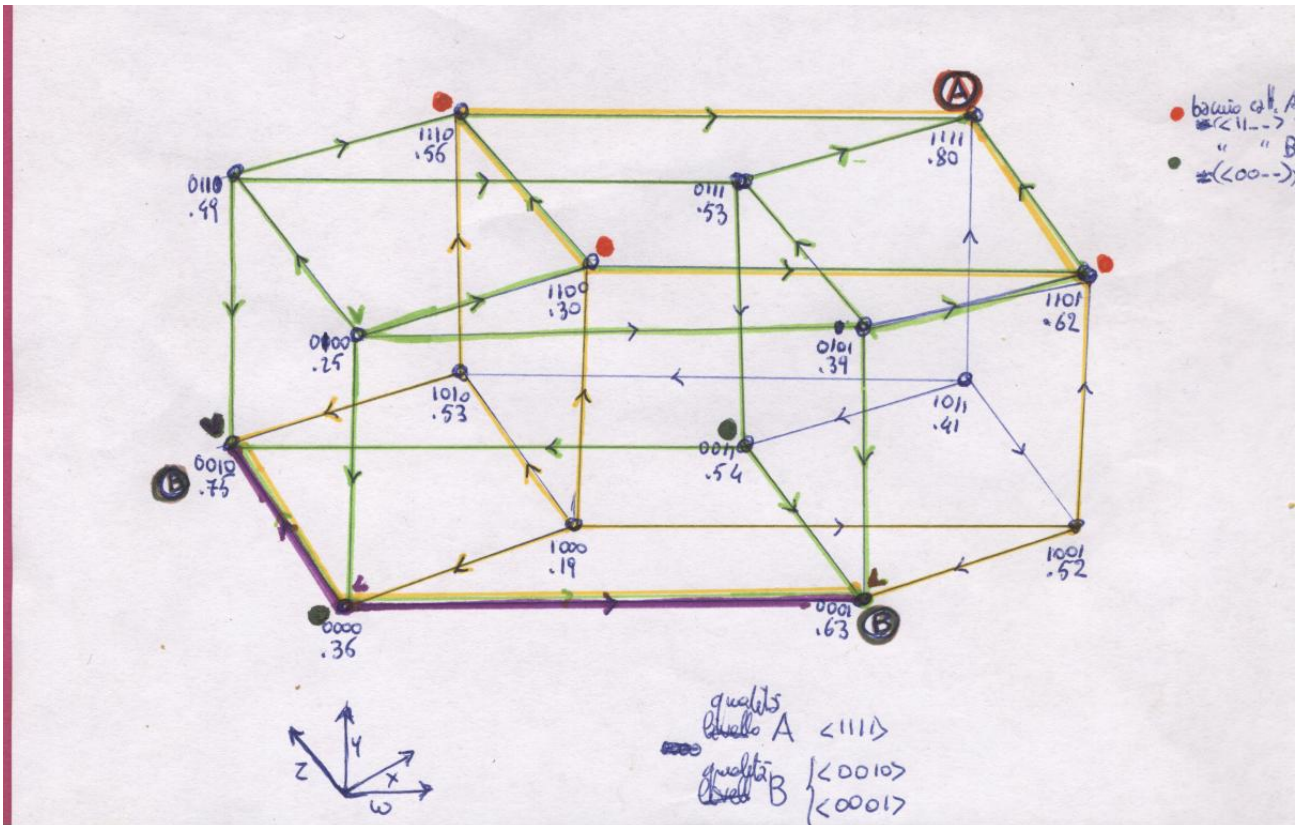
Problems to evolve a solution for are modeled as NK networks, where the name recalls the two parameters N and K that control the complexity degree. Complexity stems from the interdependence among the subparts a problem is composed of. As an example of a reference problem, we can think of a mechanical design one, where the dimensions of some components of a dynamic structure have to be tuned. A satisfactory solution must be searched among all the possible different configurations of the components dimensions.

More abstractly and generally, in NK networks we search among solutions codified as binary strings of N bits, trying to gain better and better 'fitness' values, reaching hopefully a satisfactory one, if not optimal. The interdependence among elements (bits) are embedded in the way the fitness measure is constructed for a generic random NK network. This collects, by summing, all the contributions associated with every element (bit), which in turn. But the contribution to the fitness associated with an element does not depend only by that single element: other linked K elements concur. So a more or less complex interdependence structure is behind the fitness measure of a network. Varying K from 0 to N-1, complexity becomes higher and higher.

In this landscape we can test different evolutionary processes that go from string to string, step after step, modifying the current string in a more or less myopic way. The source of inspiration for Kauffman was the evolution of genes by natural selection processes.

Coming now to our themes, we start discussing a suitable picture, based on NK networks. The starting point, although in another interpretative context, was the cited work of Marengo, Frenken and Valente, that points out how the evolutionary success depends critically upon the spectrum of allowed single steps, stressing in particular the severe failings implied by too little and local steps compared to the interdependence degree K.

Let us think of a hypothetical segment of the software or information services industry, populated by four firms spread in different geographical locations on the planet. These four units are active in different know-how areas. The user value produced by the industry segment comes out from an overall valuable combination of software and services offered. The segment knows a technological evolution trajectory searching ever better solutions to offer to users.



In fig. 4 we can see a generic randomly extracted NK network with $N=4$ and $K=2$. Solutions, on the vertexes of the hypercube, are labeled with 4 bit strings. A measure of user value can be read near them. The hypercube four dimensions (x , y , z and w) are associated one to one to the four know-how areas of the different firms.

As we can see, the optimal solution is the string $\langle 1111 \rangle$ (for our visual ease we choose the labeling to set all 1s in the optimum, without changing the structure of the network), followed by $\langle 0010 \rangle$ and $\langle 0001 \rangle$. Let us suppose that only $\langle 1111 \rangle$, is a fully satisfactory (A quality) solution for users, while the other two are second (B) quality ones, useful but affected by irritant failings.

Till now we have seen only an ordered set of solutions. Now it's time the evolutionary process enters the stage. A step by step incremental process, in the line of the cited paper. Let us first suppose steps to reduce to one-dimensional improvements contributed by one firm at a time. In figure we can see the graph made by the directed links corresponding to all possible steps. A particular evolutive history will be then composed by a sequence of these links, from a starting solutions to a final one proposed to users. All histories end in one of three end point solutions, casually just the three seen above. One is obviously the optimal solution $\langle 1111 \rangle$ (A for short). The other two are not optimal, nevertheless it does not exist a viable path to escape, because all the steps bring to lower value solutions. They are attractors like A. Let us name B the set of the two. The hypercube plane $\langle 11 _ _ \rangle$ is a capture basin for A, because all the histories arriving in this plane, inevitably end in A. The plane $\langle 00 _ _ \rangle$ is the equivalent for B. In the remaining vertexes there are more than one possible step open, randomly chosen with equal probability by the evolutionary process.

Let us see what happens starting from $\langle 0000 \rangle$. In order to reach A we need contributions by all the firms. But we can easily note that no such history exists. The only two possible histories, violet colored in figure, end in B, with only one firm involved, z or w . The resulting industry segment will be populated by one firm only, not allowing for whichever contribution by the other ones.

Now let us change starting points, considering the four solutions from which we could, in principle, reach A by contributions only in three dimensions. We can imagine these starting solutions accessible by using already

available know-how, as a byproduct of other parts of the industry.

For <0010> and <0001>, just started just arrived. In fact we are in B. No new specialized industry segment.

But if we start from <0100> and <0001> the things change, and allow a diversified set of histories. We can see them in figure colored in green (from <0100>) and yellow (from <1000>). In both cases they end up in A or B with equal probability. There's a clear path-dependency. The collaboration geography articulates.

Let us consider the first case. Every history of A kind (ending in A) implies exactly three steps, in all the possible ordered sequences of x, y and w. But not with the same probability to occur. Sequences with earlier x contributions are more probable. An x step is in fact always decisive for A against B, because brings the histories on the capture basin of A. For the rest, z and w steps occur with the same probability in both their relative sequence orders (z earlier than w or vice versa). This could maybe signal a certain grade of parallelizability and weaker dependence between the two firms contributions and activities, interesting mainly from the point of view of software maintenance and services erogation.

More varied the set of histories of B kind, that are not all 2 steps long. In fact there are also histories 4 steps long, with two steps of these (not consecutive) acted by the same firm. These longer histories are less probable by the way, 8% against 42% of the 2 steps ones.

There is here a variety of industry segment arrangements. Here y contributions play for B a role similar to what we have seen above for A by x, because they bring to the capture basin of B. We can see in fact that histories can flow along the plane <01__>, always equally uncertain to end in A or B, till the first step in x or y dimension that happens choose the final outcome.

The other, yellow colored case is not too different. X and y are still the discriminant moves. This confirms that the associated firms have a crucial but incompatible role in the industry segment. In both cases the geography of potential collaboration arrangements shows two distinct areas, discriminated by the presence of x or y firm, with strong consequences in terms of user value offered (A or B). Unlike the green path, in the yellow colored one there is no history longer than 2 steps, and consequently the three firms arrangements lack in the industry segment.

But what happens if we change slightly the evolutionary process allowing for more collaborative contributions? We will see that the collaboration geography is a matter of the NK network as well of the evolutionary process on it.

Till now the contributions were strictly local to single firms, drawing from and developing only inside the boundaries of their know-how areas. And then these contributions located themselves quite straightforwardly in strictly sequential dependence chains, inducing probably a standard supply chain industry arrangement, with low communication flows among the firms.

But let us now suppose firms able to collaborate more effectively and co-produce technological contributions, for example two firms together at a time, taking advantage better of the synergic potentials of their know-hows, still differentiated but not water-tight compartmentalized. This suggests more advanced organizational forms and collaboration media, available at the collective level of the industry segment.

So let us introduce in the model 2-dimesional contributions. We can note immediately that although there's still a B attractor with its lock-in nature, its capture basins collapse to only the two points. Starting from <0000> now a rich set of histories branch around and the most of them reach A. The situation is also more favourable for the starting points <0100> and <1000>. Still no evolution from the other two, because they are B or local optima.

Moreover, the wide variety of histories signals an improved evolutionary fluidity and induces a collaboration geography able to integrate in a synergic way the diffrentiated contributions of the diverse firms. Probably we can expect also that there's an enhanced flexibility to readapt and reconfigure the collaborative arrangements.

The B attractor halves itself if we introduce 3-dimensional contributions and vanishes with 4-dimensional ones. The system gain ever more in ability to integrate and debvelop to the best the differentiated and interacting know-hows of the diverse firms.

3.3 An Artificial Neural Networks view

If now we want to proceed and deepen our understanding of the interplay between interaction media and distributed organizational forms, we can use a model introduced recently by one of the authors [Padrin 2001], conceived as a first step in an evolutionary path of models useful in addressing these themes. We change our modelling framework from the one seen above, and we enter the field of artificial neural networks (ANR), specifically one of the most advanced subarea dealing with dynamic 'recurrent' nets (not the common input-output maps, but dynamic feedback systems). With an articulated and original model studied and adapted to represent in a simple, focused, clear and general enough manner, a group of interacting agents who self-organise themselves, supported by a spectrum of technological media. Linking up again with the thread in the subsection before, we can think of the firms that evolve at the same time their differentiated knowledge and a distributed organization apt to integrate them in order to saw and customize software and services to implement solutions for their diverse customers.

We recall here only a summary overview of the model and present some of the evidence collected experimenting with the model.

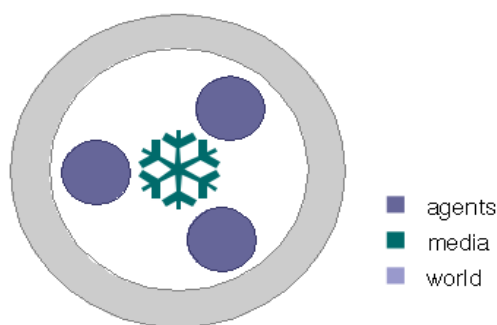


Fig. 5. Model overview

The model is populated by agents interacting with the world, and among them via media. Agent are 'bounded-rational' in the sense of Herbert Simon. They are endowed with a given structural power to support cognitive processes, and with this they have to interpret, act and communicate. With this same power, they differentiate and develop diverse skills, competences and knowledge.

In the model processes operate at two distinct levels: operations and organizational evolution. At a first operating level the agents in the organization perform the activities the organization is set up for such as interpreting the wishes and needs of the specific customer, designing a solution and implementing it in terms of software and services. At a second upper level, the organisational evolution characterises the organisation and, if successful, yields some ability to operate and collaborate at the first level. At the operating level, the model is built to emphasize the modes and properties of cooperation in the cognitive work and action in the world. With a special attention to the distribution of contributions and their integration via media supported interaction.

Nothing prevents an agent to go as a single. But when the knowledge needed becomes more complex and diversified confronted with the bounded cognitive power of the single agent, a pressure is generated towards forms of organized cooperation. So agents organize themselves, differentiate and distribute the cognitive work. At the same time, the need arises to communicate among the differentiated agents in order to integrate effectively their contributions. As a result the organizational-communicational competences develop. In order to do that all, the agents co-evolve in their support a complex of interaction and communication media sewn

according to their needs, building upon a raw digital (and non) infrastructure with a given structural power and richness (in the graphs named as media spectrum). In this view, digital technologies enrich the spectrum of interaction modes available to the agents.

In the figure [fig. 6] we can note how the modes and characteristics of process of organisational evolution (second level) are critical for the success in extracting the potentials offered by the agents and the technologies.

We can observe, by looking at the graphs (Fig.6) of a gross proxy related to the quality of the solutions, how the evolutionary performances change drastically, varying a parameter of the same evolutionary process. Only in the second case of the three we see a full success. In the other ones the process is not fluid and elastic enough and get entrapped at some point into solutions that are only locally optimal. We have seen an analogous situation before ("B" basins in the context of NK networks). Evolution is not at all a magic word, contrary to a certain diffused overuse as a generic buzzword. Different processes show very different performances.

Now in fig. 7 we can take a look at a slice view of some experimental statistical elaborations. In the figure the average success, in a suitable test of the evolved organisations is shown at varying number of agents (each of individual cognitive power 2) and media spectrum. As a little note, here and further the evolutionary process is always the same, the second (the best) of the three seen above

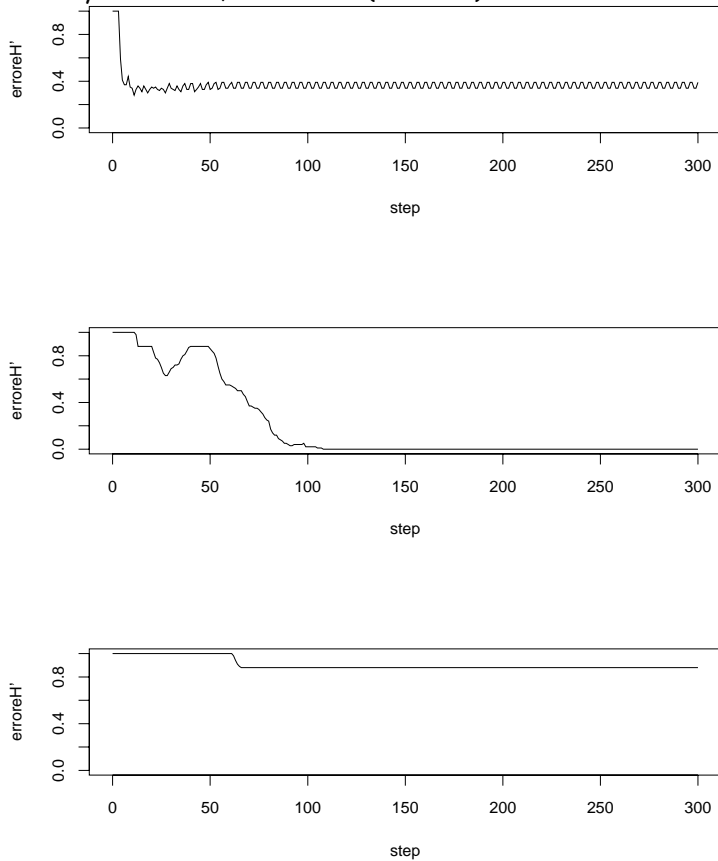


Fig. 6. Evolutive performances (error H') for three values of the process parameter η .

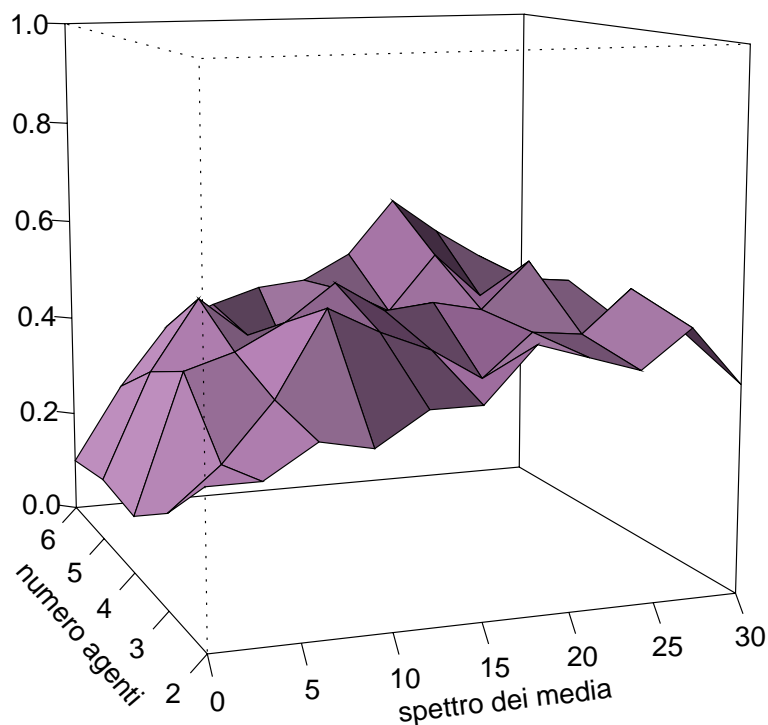


Fig. 7. Average performances of the organisations (test 2, agents cognitive power 4)

We can note how the impact of the technological dimension is determinant with gain up to 600%. The success does not carry on rising with the two dimensions considered, but there is a saturation level, when we reach the limits of the evolutionary process adopted in dealing with the complex task of evolving ever richer organizations in terms of number of agents and media spectrum. With better evolutionary processes we can easily forecast that saturation comes later and the richness of organisations rise, as the performances in all the graph. The kind of process here used is pretty unsophisticated, not assuming the agents have too advanced co-evolutionary abilities of the organizational-communicational or technological kind.

Let us investigate which organisational forms are produced, looking at how the cognitive work gets distributed among the agents and subgroups of these, paying attention to the network of contributions created by the interplay of differentiation and integration. We are now interested to identify distributed, 'centralized' or 'chaotic' behavioral patterns as shown by the various organizations evolved. In the first kind of them the work gets distributed among communicating agent; in the second there's a concentration around few agents or one, which can or not constitute in turn a distributed subgroup; in the third, the activities are diffused but in an uncoordinated manner so to interference and undermine the operating ability. Some initial analysis with quite unsophisticated methods tends to suggests a clear picture. In general for the most the organizations show some combination of distributed and chaotic characters, with agents cooperating with partial effectiveness. If we look at the performances, then we note clearly that effectively distributed behaviors get ever more widely diffused as we go upwards in the performance scale. Some part of the organizations shows centralized characters, when in presence of low values of the media spectrum the overall performances are determined only by few agents or only one.

3.4 Space-weaving socio-economic processes

Let us sum up then the issues we have introduced by the two above pictures.

3-d euclidean physical space is obviously of no use in them. Analysis develop around the interplay of

human and socio-economic processes and technological interaction media in an evolutionary dynamic setting. Organizational forms are central and control the patterns and degree of differentiation and integration in collaboration enterprises. The effectiveness and fluidity of the evolutionary processes are also deeply conditioned by them. But processes do not live in unstructured collaboration environments, on the contrary different forms of collaboration 'geographies' emerge and change in time.

And from the latter consideration it comes a question: in digitally extended environments has the concept of space to be abandoned or can be restated on a deeper and more fundamental ground, so to support space/'geographical'-like analysis?

We can start by observing that what we are mostly interested to, when using space concepts even in physical space, is not the 3d euclidean structure, but the interconnection structure of the local neighborhood environments. Social interactions in physical space are, by social gravity laws, mostly local to a neighborhood environment, and we interact mainly with agents and things inside it. We can move and change it. Nevertheless by passing through (slowly or through fast avenues, pipelines) a sequence of intermediate neighborhoods. And distance between two neighborhoods is related to how long will it take to move from one to another.

We can define space around the central concept of interaction by the notion of interaction neighborhoods/contexts. This goes as well for physical, as social as digitally enhanced social spaces.

Let us pick up a physical space related economic example: we have to move some goods from a context where they have been worked out to a different one where a customer is willing to use them. We'll not consider the minimal path from all the available ones in the 3d euclidean space, because trucks have to go along roads and we are interested to a graph of connections. The relevant distance measure is related to the actual process and costs of transportation including congestion costs. So it is the transportation activity that defines distance and the relevant connection geography. Besides, goods histories record the causal dependence link between activities in the two contexts, the goods acting also as carriers of (one-way) interaction at distance. We might define also time around the concept of interaction, by the notion of a causal relationship across events, when such a causal link is perceived.

So we can think of space-time in terms of a network of interactions [see for example the notion of causal networks in Wolfram 2002] that is woven endogenously by a complex of intertwined distributed and concurrent processes, some of which human and some of which digital, besides other ones.

Computational modelling seems among the most promising and powerful tools we have available now to research these issues. Among the core theoretical frameworks now conceivable, it seems to us interesting to investigate the potential of **graph-rewriting systems**. They sum up a graphical network form and a full computational power. Besides their suitability to express distributed processes, some advanced threads of theoretical research in computer science show ever increasing interest in them [refer to Padrin 2004 for a detailed discussion of the proposed framework, from a computational modelling technology point of view].

Moreover, from another perspective, they can also be seen as among the most natural evolutions of the framework of cellular automata, so much diffused in geographical studies. The latter are in fact severely hampered in terms of supporting many research endeavors, by their exogenously fixed regular space structure and by the global clock that controls the strictly synchronous and simultaneous updating of all the parts of the automata in a single step.

3. Conclusion

The paper has introduced first of all a frame for an Evolutionary Location Theory, aiming to contribute to an axiomatic-theoretical unification of Regional Science, and then advances in the computational modelling of collaborative spaces.

The former frame is centred around a few propositions on path and space dependence. As communication-cooperation networks become complex with societal evolution, the social capability and spatial fitness of an actor located in a node, becomes weakly dependent: both from some previous node

states (Paul David's path-dependence) and from its distance from relevant hubs (Eric Sheppard's positionality). Finally, also from the coupled effects of space-time weak dependence. In fact, by putting the two dependences together we have "*path-dependent positionality*" which:

- in some cases make them even weaker;
- in other cases ever stronger: by positive feedbacks and generation of a spatial "lock-in", either a successful one or a social oppression lock-in (see Def. 3 in Section 2).

In Section 2 we had conjectured that, *if spaces and network topologies were endogenous, they would co-evolve with the user social communication processes*. Section 3 has accumulated some materials in support of this conjecture, whenever the collaboration (Libre Software) geography generated by a model, was both function of the network itself, and of the user socio-economic process. The provisional conclusion, and legacy to further research, varies according to the scale of the analysis (geographical scales, hyperspace observation point heights and time tiers): on one extreme even a large scale network of networks is endogenous to an appropriate, long run social process; at the other end, a small scale net is a given frame for a local application, a short term use or ground-level observation of a cyberspace: provided we are in normal trajectories, i.e. far away from punctuations or dominant design mutation phases (otherwise even the small scale becomes turbulent).

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