CIES e-Working Paper N.º 196/2014

The Sociology of Creativity:

A Sociological Systems Framework to Identify and Explain Social Mechanisms of Creativity and Innovative Developments

Tom R. Burns
In collaboration with
Nora Machado

CIES e-Working Papers (ISSN 1647-0893)
Av. das Forças Armadas, Edifício ISCTE, 1649-026 LISBOA, PORTUGAL, cies@iscte.pt

Tom R. Burns (associated with Sociology at Uppsala University, Sweden and Lisbon University Institute, Portugal) has published internationally more than 15 books and 150 articles in substantive areas of governance and politics, environment and technology, administration and policymaking; also he has contributed to institutional theory, sociological game theory, theories of socio-cultural evolution and social systems. He has been a Jean Monnet Visiting Professor, European University Institute, Florence (2002), Fellow at the Swedish Collegium for Advanced Study (1992, 1998) and the Wissenschaftszentrum Berlin (1985) and a visiting scholar at a number of leading universities in Europe and the USA.

Nora I. Machado des Johansson is a researcher associated with the Center for Research and Studies in Sociology CIES, at the Lisbon University Institute (ISCTE), and to the Department of Sociology, University of Gothenburg in Sweden. Machado´s main areas of research are sociology of culture, social cognition and organization. Her studies also concern the sociology of ethics. Among her publications are articles in Public Administration: An International Quarterly, Canadian Journal of Sociology, Social Science and Medicine, Death Studies, Human Systems Management and a book Using the Bodies of the Dead: Legal, Ethical and Organizational Dimensions of Organ Transplantation. Ashgate Publishers, England 1998. She is now currently completing a book about normative and cultural changes in end-of-life processes.

Preliminary Abridged Draft (February 5, 2014); Revised (December 17, 2014)
We are grateful to Ugo Corte for his many suggestions and inputs into this manuscript. Also, earlier related collaboration with Tom Baumgartner, Marcus Carson, Jerry Ellig, Peter Hall, Ilan Kelman, and Alison Woodward has played a significant role in the development of the sociology of creativity.

Abstract

Creativity is a universal activity, essential in an evolutionary perspective, to adaptation and sustainability. This manuscript on the sociology of creativity has three purposes: (1) to develop the argument that key factors in creative activity are socially based and developed; hence, sociology can contribute significantly to understanding and explaining human creativity; (2) to present a systems approach which enables us to link in a systematic and coherent way the disparate social factors and mechanisms that are involved in creative activity and to describe and explain creativity; (3) to illustrate a sociological systems theory's (Actor-Systems-Dynamics) conceptualization of multiple interrelated institutional, cultural, and interaction factors and mechanisms and their role in creativity and innovative development with respect to diverse empirical bases.

The approach shares with key psychological theory approaches in the area consideration of key concepts such as "persons", "processes", "products", and "places "but extends these to include additional factors such as social structures and resources, social powers, selection mechanisms (acceptance or rejection), and institutionalization. Moreover, *the complex of factors identified and analyzed are specified in this article in sociological terms*. The resulting model enables one to address and answer key questions relating to creative actions and innovative developments such as "who" is involved, "why" are they driving these activities, "what" are they doing or trying to do concretely, "how", "where", and "when" in diverse instances/illustrations which illuminate human creativity. The general model enables us to distinguish between and analyze processes of creative origination/formation, on the one hand, and processes of institutional acceptance and realization, on the other hand. Innovation in these distinct phases is distinguished analytically. It formulates a phase structure model in which the phases of origination and innovation generally and the phases of acceptance and institutionalization are identified and analyzed. Finally, the work introduces and applies key concepts such as rules and rule regimes -- norms, roles, institutions, and cultural formations -- in general, social structure. Moreover, it identifies socially based creativity production functions and particular cognitive and action mechanisms as features of rule regimes that generate innovations.

Applications and illustrations in the article are diverse ranging from, for instance: (i) "the lone coyote" who exercises creativity based on absorbing a field of knowledge, concepts, challenges, problems, solution strategies, creativity production functions or programs (and who is likely to be in contact with libraries, relevant journals and may be directly or indirectly in contact with a network of others); (ii) groups in their particular fields operating greenhouse driving problem-solving and creative activities – both self-organizing groups as well as groups established by external powers (whether a private company, a government, or a non-government organization or movement); (iii) or entire societies undergoing transformations and radical development as in the industrial and later revolutions.

The article introduces and applies a model stressing the socio-cultural and political embeddedness of agents, either as individuals or groups, in their creative activities and innovative productions. The agents are socialized agents, carriers of socio-cultural knowledge, including some of the knowledge essential to engage in creative processes in a particular domain or field. In their creativity, agents manipulate symbols, rules, technologies, and materials that are socially derived and developed. Their motivation for doing what they do derives in part from their social roles and positions, in part in response to the incentives and opportunities – many socially constructed – shaping their interaction situations and domains. Their capabilities including their social powers derive from the culturally and institutional frameworks in which they are embedded. In carrying out their actions, agents mobilize resources through the institutions and networks of which they are a part. As social agents, they are carriers of constructed values and motives and culturally established ideas, strategies, and practices (e.g., "a cultural tool kit.") Their creative actions are *social actions,* given meanings in cultural and institutional terms in the domains or fields in which they engage in their activities. Power considerations are part and parcel of the analyses, for instance the role of the state as well as private interests and social movements in facilitating and/or constraining innovations and creative developments in society.

In the perspective presented here, generally speaking, creativity can be consistently and systematically considered to a great extent as social, cultural, institutional and material rather than largely psychological or biological.

Key words: Creativity, innovative development, system theories, sociology, psychology, field, agency, rule regime, creative production function, context of creativity, context of receptivity

I. **BACKGROUND**

This work has three purposes: (1) to argue that key factors in creative activity are socially based and developed; this implies that sociology can contribute to understanding and explaining human creativity; (2) to apply sociological systems theory's (in particular, Actor-Systems-Dynamics, ASD) in conceptualizing multiple interrelated institutional, cultural, and interaction factors and mechanisms in describing and explaining creativity;[1] (3) to enable linking through the application of the systems approach in a systematic and coherent way the disparate social factors and mechanisms that are involved in creative activity and to describe and explain different forms and mechanisms of creativity and innovative development.

We introduce a model taking into account the social embeddedness of agents, either as individuals or groups, in their creative and innovative productions (Granovetter, 1985). The agents are socialized agents, carriers of socio-cultural knowledge, including some of the knowledge potentially useful in concrete innovative/transformative processes. In their creative activities, they manipulate symbols, rules, technologies, and materials that are socially derived and developed. Their motivation for doing what they do derives in part from their social roles and positions; in part in response to situational incentives and opportunities, many of which are socially constructed, shaping their interaction situations and domains. Their capabilities including their social powers derive from the culturally and institutional frameworks in which they are embedded. In carrying out their actions, agents mobilize resources through the institutions and networks of which they are a part. As social agents, they are carriers of multiple values and motives and culturally established ideas, strategies, and practices (e.g., a "cultural tool kit" (Swidler, 1986)). Their actions are *social actions*, given meanings in cultural and institutional terms in the domains or fields in which they engage in creative activities.

[1] Elements of the sociological systems theory -- agency-structure-dialectics (ASD) -- were first formulated by the sociologist Walter Buckley (1998, 1967), drawing on general systems concepts and applications in the natural sciences, engineering, and mathematics (other approaches were developed by Talcott Parsons (1951) and Niklas Luhmann (1995) (see Burns, 2006a on systems theories in sociology). He and a number of those following him in diverse contexts and in some cases collaborating with him (Margaret Archer, Tom Baumgartner, T. R. Burns, Philippe DeVille, David Meeker, Felix Geyer and Johannes van der Zouwen) as well as later collaborators (Svein Andersen, Marcus Carson, Helena Flam, Peter Hall, Nora Machado, Atle Midttun, Christian Stohr, among others) contributed to developing a sociological systems theoretical variant incorporating in the theory general system concepts such as system, interconnectedness, feedback, reciprocal causality, equilibrium, morphostasis, morphogenesis, transformation, multi-agent systems, etc. which were given meaningful social science definitions and interpretations. In addition, the theory incorporated core sociological concepts such as: (i) Actors, agency; (ii) Normative, institutional and cultural forms (social structure as rule regime); (iii) Human interaction and other social mechanisms (processes); (iv) Socio-cultural and institutional dynamics (adaptation, restructuring, evolution, transformation); (v) Environmental and material conditions on which human populations and social systems depend. Each of these rubrics refers to areas of theoretical and methodological development in ASD.

Besides the scientific aim to construct a general theory of human agents, social systems, and their interactive dynamics, we aimed to develop a framework which not only recognized and took into account for explanatory purposes the environment and material conditions but provided conceptual/theoretical and methodological tools to relate to, and collaborate with, natural scientists, engineers, and mathematicians

Applications have included cognitive models (judgment theory, paradigms, social cognitive dissonance), interaction models (sociological game theory, agential power theory, negotiation theory, conceptualization of interaction patterns and dynamics, group dynamics and equilibria, phase process models), institutional and cultural models (social rule system theory), structural power models, social change and development models (formation and phase theories in economics, administration, and politics; evolutionary models) (see Burns, 2006b for an overview).

The article applies a *sociological systems framework* to describe and analyze creative activity and innovative developments: investigating the who, why, what, how, and where of particular instances/illustrations – which are diverse and illuminating of human creativity.[2] The approach shares with key psychological theory approaches in the area consideration of key concepts such as "persons", "processes", "products", and "places " (see Table 2) but extends these to include additional factors such as social structures and resources, social powers, selection mechanisms (e.g., acceptance or rejection), and institutionalization. Moreover, *the complex of factors identified and analyzed are specified in this article in sociological terms*. The resulting model(s) enables one to address and answer key questions relating to creative actions and innovative developments such as "who" is involved, "why" are they driving these activities, "what" are they doing concretely, "how", "where", and "when". The models enable us to distinguish between and analyze processes of creative origination/formation, on the one hand, and processes of institutional acceptance and realization, on the other hand. Innovation in these distinct phases is distinguished analytically. A phase structure model is formulated in which the phases of origination and innovation generally and the phases of acceptance and institutionalization are identified and analyzed. In addition, the work introduces and applies key concepts such as rules and rule regimes -- norms, roles, institutions, and cultural formations -- in general, social structure. [3] Moreover, it identifies socially based creativity production functions and particular cognitive and action mechanisms as features of rule regimes that generate innovations. Finally, power considerations are part and parcel of the analyses, for instance the role of the state as well as private interests and social movements in facilitating and/or constraining innovations and creative developments in society.

Applications and illustrations in the article are diverse ranging from, for instance: (i) "the lone coyote" who exercises creativity based on absorbing in a field of knowledge or practice, concepts, challenges, problems, solution strategies, creativity production functions or programs (he or she is likely to be in contact with libraries, relevant journals and may be directly or indirectly in contact with a network of others); (ii) groups in their particular fields operating greenhouse driving problem-solving and creative activities – included here are self-organizing groups as well as groups established by external powers (whether a private company, a government, or a non-government organization or movement); (iii) entire societies undergoing transformations and radical development, for instance, the early industrial revolution and the currently ongoing "sustainability revolution" (discussed later).

---

2 Burns (2006) provides an overview of sociological systems theories, in particular, Parsons (1951) and Wallerstein (2004) as well as Luhmann (1995), but to our knowledge, neither in their theorizing nor in empirical studies did they focus particularly on human creativity, although Parsons recognized the importance of innovation, in, for instance, formulating his "adaptation function" (A) in his AGIL scheme.

[3] Most human social activity – in all of its extraordinary variety – is organized and regulated by socially produced and reproduced rules and systems of rules (Burns et al, 1985; Burns and Flam, 1987; Burns and Hall, 2012; Giddens, 1984; Goffman, 1974; Harré, 1979; Lotman, 1975; Posner, 1989, among others).[3] Social rule systems play a key role on all levels of human interaction. Such rules are not transcendental abstractions. They are embodied in groups and collectivities of people – in their language, customs and codes of conduct, norms, and laws and in the social institutions of the modern world, including family, community, market, business enterprises and government agencies. The making, interpretation, and implementation of social rules are universal in human societies, as are their reformulation and transformation. Human agents (individuals, groups, organizations, communities, and other collectivities) produce, carry, and reform these systems of social rules, but this frequently takes place in ways they neither intend nor expect. As Harré and Secord (1972:12) pointed out, "It is the self-monitoring following of rules and plans that we believe to be the social scientific analogue of the working of generative causal mechanisms in the processes which produce the non-random patterns studied by natural scientists."

In the models introduced and applied here the social embeddedness of agents, either as individuals or groups, in their creative activities and innovative productions is stressed. The agents are socialized agents, carriers of socio-cultural knowledge, including some of the knowledge essential to engage in creative processes in a particular domain or field. In their creativity, agents manipulate symbols, rules, technologies, and materials that are socially derived and developed. Their motivation for doing what they do derives in part from their social roles and positions, in part in response to the incentives and opportunities – many socially constructed -- which make up their interaction situations and domains. Their capabilities including their social powers derive from the culturally and institutional frameworks in which they are embedded. In carrying out their actions, agents mobilize resources through the institutions and networks of which they are a part. As social agents, they are carriers of constructed values and motives and culturally established ideas, strategies, and practices (e.g., a cultural tool kit. Their creative actions are *social actions,* given meanings in cultural and institutional terms in the domains or fields where they engage in their activities.

In sum,

(1) In our perspective, creativity can be consistently and systematically considered to a great extent as social, cultural, institutional and material phenomena rather than largely psychological and/or biological.

(2) The most obvious sociological instances of creativity are found in innovative groups and communities. But even "individual" innovators are located in culturally and socially established field which provides symbolics, concepts and models, established rules and norms, technologies and material resources as well as creativity strategies and production functions. Such a socio-cultural and material context is obviously not simply psychological, although individuals engage in psychological processes using socially provided elements (Sawyer, 2012:8-9).

(3) The sociological systems model outlined here helps to conceptualize and analyze creative activity in a perspective different from those system approaches found in psychology and management studies, in part by systematically stressing and explicating the social dimensions of human creativity, including the socially based facilitators and constrainers of creativity, especially social structural and agential dimensions.

(4) The approach can be used also for policy purposes (Carson et al, 2007); for instance, in supporting and guiding research and development and facilitating transitions to new societal arrangements, for instance, to accomplish sustainability (see section V; Burns, 2013, 2012; Burns and Carson, 2014).

This characterization of socialized agents performing social actions applies to all of the phases of any innovation/creation process (as specified in our phase model introduced later). The theory specifies key contextual factors, agents, activities/phases, and technologies in creative/innovative processes; it draws on one variant of sociological system theory (Burns, 2006a, 2006b, 2008; Burns et al, 1985; Burns and Flam, 1987) and its extension to socio-cultural evolutionary theory (Burns & Dietz, 1990; 2001; Burns, 2005).[4] It focuses on issues such as the following:

- the socio-cultural, interactional, and material contexts of creativity; that is, its embeddedness and context dependence (Baumgartner et al, 1986; Burns et al, 1985; Granovetter, 1985);
- institutional and social structural arrangements that facilitate or constrain creative activities

[4] In regard to the application of an evolutionary systems perspective in the case of creativity, see Arthur (2009:167ff) and Czikzentmihalyz (1999).

- the particular social powers, resources, and tools participants utilize in creative action, which are socially regulated (e.g., through institutional arrangements including political authority, property rights systems, and markets);
- socially grounded and embedded innovation processes may result in the creation/production of new entities or the transformation or recombination of existing ones;
- the immediate social context of reception: either acceptance or support of an innovation and creative activity, or the rejection and resistance to it. We are referring here to the immediate agents and mechanisms verifying, supporting, and legitimizing the realization or the rejection of creations;
- social retention and institutionalization transmit over time and space a creation or innovation as socially or political acceptable, in part legitimate – or block such retention and institutionalization.

Creative activities reflect diverse social arrangements and processes in which they take place. These processes entail social definitions and constructions -- in a particular social field or arena: whether in defining problems, possibilities for solutions, opportunities for innovation or mobilizing symbols, methods, resources in the creative as well as the development phases of innovation.

The sociological approach outlined here helps us to address and answer such questions as:

(1) Who are the agents likely to initiate innovation and creative developments – in particular, what are their social positions, if any? What drives an agent or group of agents to initiate creative action?
(2) The approach identifies agents and mechanisms that not only initiate and facilitate but alternatively, constrain or block creative processes and the institutionalization of an innovation. Also considered is the reversal of "successful" innovations or their severe restriction in applications. Multiple, diverse creative strategies and production functions are identified.
(3) What is innovation or creative action: ideas, artifacts, products, institutions, cultural formations, socio-technical systems, and "system" complexes generally.
(4) Through what mechanisms – how – and with what "ingredients" is creativity or innovative action accomplished? Our approach identifies the creative strategies and production functions mobilized and applied by an innovative agent(s).
(5) What conditions/contexts are conducive to agents initiating creative action and facilitating creativity activity and the production of novelty and innovative development? And what are major constraining and blocking factors and mechanisms relating to an innovative initiative or creative development?

In sum, the sociological systems approach identifies multiple contextual factors (material, social, normative, economic and political) which play a role in driving, facilitating, and realizing creative initiatives, on the one hand; or, constraining or blocking creative processes and developments, on the other hand. It stresses multiple drivers: curiosity, fun, need, challenge of solving a problem, the drive for finding better or more optimal solutions, the pursuit of fame and fortune, and much more. It also identifies the actors and mechanisms that play a significant role in the acceptance, incorporation, and institutionalization of innovations and creative developments in social contexts as well as key determinants of non-acceptance and blockage of

acceptance and institutionalization. Throughout, there is a consideration of power and resource control, interest configurations, and oppositional processes.

The approach distinguishes a number of different social organizational contexts of creativity, which opens the way to apply group (Corte, 2013; Farrell, 2001) and social organizational theories (Chen, 2012; Woodward et al, 2004) as well as social network theories (Collins, 2000; Plagett and Powell, 2012) to the description and analysis of creative activity in different contexts.

The approach also distinguishes primary creative processes (initial origination or formation of a novelty or creative development) from secondary creativity (for instance, innovations associated with applications and institutionalization) as well as cascading developments.

II. CREATIVITY AND CREATIVE OPERATIONS

Most scientific work on creativity has been in the fields of psychology and management (Amabile, 1996) Csikszentmihah (1990), Puccio et al, 2010, Sawyer, 2006, 2012, Simonton, 2004, Weisberg, 2006), among others). Sociology cannot be said to have had an explicit focus on "creativity," rather, innovation has been the preferred rubric. Nonetheless, there is a body of relevant literature in sociology (Baumgartner and Burns (1984), Burns (2005), Carson et al (2009), Chen (2012), Corte (2013), Collins (2000), Farrell (2001), Florida (2002), Hollingworth et al (2011), Joas (1996), Padgett and Powell (2012), Parker and Hackett (2012), Parker and Corte, 2014, Thorton (1999), Woodward et al (1994), among others, addressing sociological aspects of creativity, innovation and entrepreneurship.[5] The particular innovation/creation models, which we present here, derive from a *sociological systems framework* (see especially Baumgartner et al, 1986; Burns et al, 1985; Burns and Hall, 2013; Carson et al, 2009). They combines the idea of directed problem-solving and adaptation, innovation and evolution in complex selective environments (Burns and Dietz, 1992, 2001). The models describes and explains innovation and adaptation, transition, and transformation through the factors of human agency and social and material structures.

1. What is creativity, creative action?

Creative human action is universal (see, for example, Table 1).[6] It relates to innovation, invention, discovery, design, creation, formation, origination – there is a complex of such terms and concepts. It is observable in the actions of individuals, networks, groups, organizations, entire communities, but, as we stress, it is above all social in character – hence, the importance of a sociological treatment of it, as we outline in this article (see Joas, 1996).

Creativity entails a *process* of originating, transforming, or adapting ideas, artefacts, systems, a sector or domain, states of the world, or any other entity which is constructed as differing or deviating from what already exists in the context of creativity, for instance, a particular field or interaction situation. As Boden specifies (Boden, 2004: 1; Batey and Furham,

[5] Much earlier sociological work is still relevant, for instant those of Colum Gilfillan (1935) and W.F. Ogburn (1922).

6 Creativity can be seen in most everyday activity, not just in the arts, sciences, and technological development (see Table 1): The cognitive processes of normal people as they solve problems that require creativity, innovation – old solutions do not work or new problems arise without apparent solutions with established problem-solving tools -- conditions which evoke creative processes.

2006:426), "ideas" encompass concepts, poems, musical compositions, scientific theories, cooking recipes, choreographs, jokes, etc; "artefacts" include paintings, sculptures, steam engines, vacuum cleaners, pottery, cosmetics, platform shoes, jewelry (see Table 1 below).

Our conception emphasizes process as well as product: creativity involves one or more creativity production functions; the created entity is the product or output. Also significant are the agent(s) involved in the process, their particular capabilities and access to resources (materials and technologies) used in originating, shaping, producing innovations and creative developments.

Note that our conception implies that an "innovation" need not be the first instance – it may have been already created in another time and place. But to be defined as a novelty, it needs to deviate from or be original in relation to existing entities in the context in which it is produced – it is "new in the context."

Our conception does not – in contrast to most approaches – require that the innovation be useful-adaptive, valuable, appropriate or accepted for inclusion in a field or domain. These processes of judgment and acceptance entail other mechanisms and development, as formulated in out models in later sections.

The innovations or created entities are *systems-in-themselves*. Any such a system entails a concept -- typically with a name -- in the agent's or agents' cognitive framework. Typically, it has a defined purpose or purposes (although it may fail to function according to purpose). It also has a structure with one or more components or subsystems that serve its practical functioning or overall purpose. Associated with any such systems is a complex of rules concerning practical matters of use (how to use and possibly how to maintain);[7] other rules concern access (who has rights to access and use, and when and where).

Our conceptions and models as well as illustrations are elaborated in the following sections.

2. The Extraordinary Creations of Human Agents

There is an extraordinary diversity of human creations and innovations, distinguished by their originality, their usefulness in many instances, and their aesthetics:

Through their interactions and initiatives, actors produce to varying degrees innovations encompassing not only new technologies and socio-technical systems, new products, but social or user practices as well as cultural discourses, narratives, and symbols. For instance, an innovator tries or tests alternative(s) out of curiosity or play with others; or, the innovator(s) solve(s) hitherto unsolved problems, or develops solutions to problems others have solved differently, or develops novel products -- the entity created or produced is referred to as an innovation or creative development.

In principle, the variety/diversity of creations is unlimited and continually expanding, as human agents develop new concepts, new powers, new technologies and techniques. One basis for continual innovation and creativity is the ceaseless identification of new types of causal and control technologies and new socio-technical systems, adding to the lists above. *Many new powers are constructed by controlling or harnessing causal mechanisms or operations (discovered or constructed)* (Burns and Hall, 2013). Examples of new "types of power" include: (i) "Genetic engineering" based on exploitation of natural mechanisms. Utilizing the knowledge

[7] Innovative systems may be designed and constructed either as a complex or symbol (a narrative, painting, or a mathematical formulate), a conceptual system such as atomic theory or game theory, or a socio-technical or system or production function which exploits one or more basic causal process(es).

of the life sciences (genetics), there is increasing power to manipulate, change, reconstruct life processes of plants, animals, and humans. (ii) Using knowledge of psychology and the other social sciences, humans have developed new powers to influence thinking including forms of advertising, propaganda, brainwashing and utilization of the "Stockholm Syndrome". (iii) The WWW and other social network technologies enable individuals and groups to reach large populations. Thus, there are new forms of mass persuasion, mobilizing people and resources in order to influence politics and policies. NGOs are very active in all of this as are the social network media.

Table 1: Diverse Areas of Creativity

Creativity in Weaponry and Killing	■ Swords, bow and arrow, spears, AK47, cannon, armored vehicles, etc. ■ Human history of developing military formations (the Greek Phalanx, Roman Legion, organized cavalry, panzer division, etc.) ■ Murderous use of chemicals, biological weapons, ■ Development and use of nuclear weapons ■ Nazi systematic mass killings; extermination of Indians in the New World; genocide in most parts of the world either to eliminate groups and/or terrorize populations ■ Delivery systems for WMD ■ Drones
Creativity in Political Forms and Strategies	■ State formations (3000BC-2014+ ■ Regulatory and governance arrangements (see later) ■ Democratic political parties ■ Totalitarian political parties (Communist Party, the Nazi Party) ■ New systems of monitoring and policing (for instance, NSA using for monitoring and eavesdropping established IT devices as well as newly created communication technologies relating to the social media ■ Non-government organizations ■ International government organizations
Creativity in Technology and socio-technical systems	■ Genetic engineering techniques and GMO products (see later) ■ Nano conceptions, techniques, and materials (see later) ■ Invention of the automobile, telephone,airplane, PC, internet, etc. ■ Energy technologies: windmills, solar, geothermal, hydro-power, nuclear (see later) ■ Creating a new process, production process such as Bessemer for producing steel ■ Organ transplantation ■ Biological processes: genetic manipulation, cloning ■ Built environments: dams, reservoirs, aqueducts, bridges in many shapes and forms, roads, buildings

	of great diversity ■ Creation of symbols: traffic symbols, engineering symbols and representations, mathematical concepts and their symbols such as "zero", "infinity" (corresponding to fundamental concepts) ■ Algorithms, technical protocols
Creativity in Science	■ In physics in the development of concepts such as "atoms", electrons, "quarks", "black holes," "dark matter," as well as universal constants such as the speed of light in a vacuum, the gravitational constant, Planck's constant, the masses of the electron, proton, and the neutron, Avogadro's constant, Boltzman's constarnt etc; and theories such as quantum theory, relativity theory, theories of solid-state physics, new instruments of observation and measurement ■ Germ theory of disease,[8] vaccines, antibiotics ■ In the social sciences, the concept of public opinion, the creation of instruments to measure public opinion ("surveys"); demographic models, simulation models; concepts such as policy paradigm, meta-power, rule system theory, game theory, sociological game theory; in the biological sciences, "ecology", photosynthesis, genes, DNA, evolution, natural selection ■ The "unconscious", psychiatric diseases such as schizophrenia, "paranoia,""bipolar," ■ New statements of problems and new solutions in mathematics and science: differential and integral calculus, group theory, geometry, fuzzy and rough sets (and their applications in conceptualization and in machine design), fractals and fractal designs, …
Rule systems:	■ Languages, etiquette, rituals ■ Games and their rule systems ■ Creation of legal systems, the concept and system of rights, institutional arrangements, ■ Commercial Law ■ Law of the Seas
Creativity in Thinking, Believing	■ Gods and mythologies ■ Creation and formation of discourses about "soul," "spirits," "supernatural beings," "immortality"

[8] The development of the germ theory of disease entailed *a long creative evolution*. The invention of the microscope (1600s) played an early key role, opening up an entirely new invisible realm and leading to the idea of "animalcules". This idea was developed by well-known scientists such as Robert Boyle (1627-1691) and Robert Hooke (1635-1703) and later refined by Louis Pasteur and others in the 1800s. These developments led to our contemporary view of pathogens as agents of disease. The creative evolutionary process resulted in the gradual improvement and growing sophistication of germ models, driven by curiosity and challenge, the accumulation of data, and the invention of ever-new instruments and medical techniques of observation and treatment (Firestein, 2014).

	■ New religious and philosophical as well as ethical systems, e.g. "New Age" ■ Innovative ways of thinking about and solving problems, for instance social problems, community programs, prison reform ■ New techniques of persuasion and influencing the minds of others
Organizational and administrative forms	■ Formal associations, partnerships, limited liability enterprise ■ Factory systems, task forces, investigative bodies; networks, communication systems. ■ Corporate arrangements ■ Franchise arrangements
Sports and game creativity:	■ Creation of a sport or type of sport, e.g. spectator sports (tennis, football, cricket/baseball, basketball). ■ Parlour games including card games, chess, checkers, go, etc. ■ Also, many new types of games such as computer and internet games. ■ Creative performances or strategies in particular sports (ice dancing) and games (chess) ■ Surfboarding (Pre-Columbian Polynesian; modern surfboarding, 20th Century), Skateboarding (1950s, California), snowboarding (1960s), BMXing (mid 1970s (see later discussion))
Creativity in Aesthetics and imagination	■ Creativity in the visual arts, for instance a diversity of perspectives: French impressionists (Farrow), German Expressionism, Cubism, Surrealism, Dadaism, Abstractionism, etc.[9] ■ Creativity in music (Boorstin): Gregorian chant – "harmony of the universe" – polyphony, leading arguably to Bach, Mozart, Beethoven, Chopin, etc. and many others ■ New techniques in dance, theatre, filmmaking ■ Invention of the novel, "detective story", "travelogue", "romance," "science fiction"; mixing genres (for instance, Bolano "In Antwerp" merged novel and detective narratives). ■ Creation of literary characters: Don Quixote, Brothers Karamazov, Frankenstein, Dracula, Sherlock Holmes, Batman & Robin, Superman, James Bond, etc.[10]

[9] Parker and Corte (2014:10), drawing on Becker (1982) and Farrell (2008), point out that creative art groups develop new artistic practices, develop/acquire and use new materials and technologies, concepts and forms that deviate from established artistic practices and expressions and lead to new artistic movements. The impressionists come to mind, which Farrell investigated, but also Bauhaus, Andy Warhol, and more recently Jeff Koons (prior to Warhol and Koons, Marcel Duchamp reimagined mass-produced products as art objects including a bicycle wheel, a urinal, a bottle-holder). Koons like Warhol has been spectacularly successful but also continues to generate strong opposition from the public as well as many art critics (he and his studio with 128 employees is innovative in many different ways, not least in marketing.

[10] The creation of monsters is *not* a Hollywood invention. Ancient Egypt, the Greeks, the Aztecs, many traditional and prehistorical societies – and, of course, our contemporary societies, above all in films and other forms of visual

	■ Creation of gardens and parks: Hanging Gardens of Babylong, Omsted's Central Park of New York, national park concept/institution
Creativity in lifestyle, role behavior, dress	■ Creation of non-mainstream lifestyles: Bohemian, hippie (rejecting mainstream culture through choice of dress, hairstyle, music, attitudes toward work and authority), yippie (socially and environmental conscious lifestyle opposed to much of the mainstream but distinguished from the less hygienic and ambitious hippies), etc. ■ "Burning Man Project". It is a week-long annual social experiment taking place in Black Rock Desert in Northern Nevada; it concerns sexual experimentation, psychedelic drugs, concepts of community, art, radical self-expression, radical self-reliance with as many as 70,000 participating (it's been going 28 years). ■ "Furry sub-culture" where participants dress up to become live versions of diverse stuffed animals at their gatherings and maintain their fuzzy identity over very extended time frames.[11] ■ Change in gender identities – clothes, shoes, hair, behavioral codes, use of cosmetics, and more. ■ In contemporary times there is continual innovation in hairstyles, clothes, shoes, tattooing, piercing, etc.
Creativity in the home and home life	■ Home (inside and outside architecture, decorations, plant selection and gardens) ■ Furniture ■ Kitchen design, kitchenware ■ Food and dietary patterns ■ Bedroom, beds, mirrows, etc. ■ Sexual practices (also developed of course outside the home) ■ House cleaning and sanitation ■ House drainage

Innovation has two main themes according to Arthur (2009:164): One is this constant finding or putting together of new solutions out of existing toolboxes of pieces and practices. The other is industries (sectors, domains, fields) constantly combining their practices and processes with functionalities drawn from newly arriving toolboxes, and new domains. This second theme, like the first, is about the *creation of new processes and arrangements* (our italics), new means to purposes….a new domain of significance (think of the digital one) is encountered by all industries in an economy. As this happens, the domain combines some of its offerings with

arts – have done this. "Monsters" are imaginarily constructed from the parts of real animals including humans, that is, they are hybrids, for example, the unicorn, sphinxes, flying bulls, centaurs, satyr (for the Greeks a man with a horse's ears and tail, but in Roman representations a man with a goat's ears, tail, legs, and horns), man's head with a penis in place of the nose, a horse with a single onyx-like horn on its forehead, gigantic legs, and a lion's tail as well, lions with serpent necks, gazelles with fish fins (Wengrow, 2014; Riggs, 2014). With genetic engineering (see later), some of these hybrids can in all likelihood be physically created.

[11] We are grateful to Erik Hannerz for bringing our attention to this phenomenon.

arrangements native to many industries. The result is new processes and arrangements, new ways of doing things, not just in one area of application but all across the economy." Such diversity of creativity – conceptually and empirically --- is illustrated in the following sections.

When it comes to major societal innovations, there is typically *a cascade of developments*: for instance, diverse creative-destructive processes resulting from the invention of the automobile or the transistor or assembly-line production robots. Arthur (2009:179) points out, "…the transistor entered the collective around 1950 (step 1); replaced the vacuum tube in most applications (step 2); set up needs for the fabrication of silicon devices (step 3); caused the vacuum-tube industry to wither (step 4); became a key component of many electronic devices (step 5); and caused prices and incentives for electronic equipment to change (step 6)….listing events this way makes them look too neatly sequential. In practice, they do not follow each other in a tidy way. Often they operate in parallel…And of course any of these events takes time to play out. A technology takes time to diffuse through the economy, and the economy in turn may take several years to adjust itself to the novel technology."

As an example of a very large-scale cascade, consider the formation of the "factory system". It entailed a complex of interrelated innovations and transformations. Typically in such transformations there was no simple predetermined sequence unfolding but an economic, political, and technical logic to the initiatives and developments (Andersen and Burns, 1992; Baumgartner and Burns, 1984). Arthur (2009: p196-198) points out, "When workable textile machinery began to arrive around the 1760s in Britain, it offered a substitute for the cottage-based methods of the time, where wool and cotton were spun and woven at home by hand in the putting-out system. But the new machinery at first was only partly successful; it required a larger scale of organization than did cottage hand work. And so it presented an opportunity for – and became a component in – a higher-level organizational arrangement, the textile factor or mill. The factory itself as a means of organization – a technology – in turn required a means to complement its machinery: it called for factory labor…A new set of societal means of organization had appeared – a new set of arrangements – and with these the structure of the Victorian industrial economy began to emerge…" "In this way the original arrival of textile machinery not only replaced cottage hand manufacturing, it set up an opportunity for a higher-level set of arrangements – the factory system – in which the machinery became merely a component. The new factory system in turn set up a chain of needs – for labor and housing – whose solutions created further needs, and all this in time became *the Victorian industrial system. The process took a hundred years or more to reach anything like completion*…" (italics ours)

Factories entailed the creation of not just new organizational arrangements (a type of socio-technical system) but brought forth *a new kind of person* or populations of new agents. A working class was shaped and reshaped in the context of industrialization. Arthur (2009: 196-198) writes, "…Factory discipline, says historian David Landes, 'required and eventually created a new breed of worker…No longer could the spinner turn her wheel and the weaver throw his shuttle at home, free of supervision, both in their own good time. Now the work head to be done in a factory, at a pace set by tireless, inanimate equipment, as part of a large team that had to begin, pause, and stop in unison – all under the close eye of overseers, enforcing assiduity by moral, pecuniary, occasionally even physical means of compulsion. The factory was a new kind of prison; the clock a new kind of jailer.' The new technology caused more than economic change, it caused psychological change."

A new industry based on new technologies and other innovations typically call forth other new industries; it requires that new organizational arrangements be set up; it causes new technical and social problems and hence creates new opportunity niches; and all these themselves may call forth further compositional changes (Arthur, 2009:195). The sociological systems approach can effectively orient us to, and provide us with, a language and methodological tools of description and analysis for the cascades of innovations and transformational processes associated with the industrial revolution – and now the ongoing sustainability revolution (see later discussion).

The preceding Table emphasizes, as pointed out earlier, the range and variation of creativity, in *all areas of human activity*. There is an unfortunate tendency to overemphasize the locus of creativity in the arts as well as in technology and science. However, in our perspective, creativity is the hallmark of human adaptation and survival.

III. SELECTED SYSTEMS APPROACHES TO CREATIVITY

Systems approaches to creativity are several (see Table 1). They stress that creativity and innovation results from *multiple interrelated factors in dynamic interplay*. In psychology, there are arguably two leading system approaches: Csikszentmihalyi (1990, 1999) and Puccio et al (2010) (also see Sawyer (2003, 2012), and the Handbook of Creativity (1988) which contains articles presenting their systems approaches). Both of these approaches see creativity as a systemic process that results in a novel idea or product that is *recognized and accepted by others.* Puccio et al (2010) combine persons, processes, and leadership in an "environment" or field to produce creative changes (e.g. social change, change in personal, innovation in technologies including built environments, etc). Csikszentmihalyi's approach (1990) focuses on the interaction behavior between individuals, cultural domains and institutional fields, resulting in creative initiatives and developments. From the cultural domain, rules and practices are transmitted to, and incorporated in, individuals. The creative products of persons – contributing to *variation* in an evolutionary sense – are selected for eventual inclusion in the cultural domain through institutional fields involving agents of judgment including experts (this approach shares several commonalities with the sociological systems approached presented below).

The sociological systems perspective identifies a few key social components of creative activities. Socially contextualized creative activities call for specification of context(s), the embedded creative agents, the inputs in relation to them (necessary materials, knowledge, knowledgeable agents, etc.) and agents' translation of the inputs into the innovation activities and their outputs -- potential creations, transformations, and recombinations (see Figures 1 and 2). Drawing on earlier work on the sociology of creativity and innovation (see section II), we focus attention on the social nature of creative agents (whether individuals or groups), the social character of their actions and interactions (including mobilizing and exercising power, cooperating, competing, and conflicting), the institutional-cultural conditions (social structures) that facilitate or constrain or possibly block creative action, and the conditions that make for receptivity and acceptance of creative action or its products, on the one hand, or its rejection or suppression in the larger societal context, on the other hand. We highlight then the social systemic features of creative action and its possible products. Key features of our sociological systems framework (ASD) are presented in Figure 1 and Table 3.

While there are parallels in the sociological and psychological system approaches, there are major differences: (1) Social actors, individuals as well as collectives, in the sociological systems framework are not only embedded in social systems but also construct, adapt, and

transform such systems including those of which they are a part. They are the *major endogenous factors in the construction and evolution of systems and in the production of creative acts and innovation.* Such agency is largely social, and its actions and interactions are sociological in character although individual cognitive and evaluative/judgment processes – socially grounded -- play a significant role in social contexts. [12] (2) ASD theory incorporates in a natural and coherent manner – in contrast to psychological approaches – the conceptualization of institutions and cultural formations. In general, in sociology there are elaborated structural theories, and applications of these to the analysis of, institutions and culture and, in general, social structures. The ASD approach conceptualizes as foundational in sociological structural analysis social rules and rule regimes. While the latter are systemic in character, they are carried and applied/interpreted in many cases individually. (3) The ASD approach does not assume that creativity -- or creative actions and their products – are predicated on social usefulness or even immediate applications – as do the psychological system theories. Application, receptivity, and judgment of usefulness relate to *later phases in innovation developments* (see the phase model of creativity and innovation, Figure 3). This is because social acceptance, judgments of usefulness, and institutionalization of innovation are typically *key social processes* in themselves – distinct from the phases of creation and innovation. The processes making up the "receptivity context" call for specification and analysis in order to understand the response to creativity *in its social (and economic and political) context*. (4) Like other systems approaches, ASD theory recognizes multiple interrelated processes and causal mechanisms, but it particularly attends to and elaborates the causal mechanisms of social actors and social structures (institutional arrangements, cultural formations) (Burns and Hall, 2013).[13] Social structural factors and mechanisms in the "context of invention" enable or block to a greater or lesser extent initiating actions and the resources and powers available to social agents; they also govern and regulate the "context of acceptance/selection and institutionalization" (rejection or suppression of innovation).

The three systems approaches – two psychological and one sociological-- are summarized below in a comparative table specifying multiple key variables.[14] The third column lists the "four Ps", multiple factors that several psychologists working in the field of creativity research have identified as universal aspects in their investigations and analyses of creativity and which comprise a form of system of variable constructed by induction (Batey, 2006; Rhodes, 1961; Gautam, 2012; Sawyer 2003, 2012).

---

[12] Some actors are better than others at drawing upon and exploiting the opportunities for creativity and innovation in their situations – which derives in part from their history and involvement with others, their knowledge of and ability to draw on the cultural elements available to them in their social action situations. They often have learned to see things in new ways, making connections; being alerted to chance and to the opportunities presented by contradictions and complexities, recognizing familiar patterns in the unfamiliar so that new patterns may be formed by transforming old ones, being alert to the contingencies which may arise from such transformataions.

Traits of creative individuals: an ability to think metaphorically or analogically as well as logically, independence of judgment (sometimes manifesting itself as unconventionality, rebellious tendencies, readiness to take risks, revolutionary thinking and acting; a rejection of an inadequate simplicity (or premature closure) in favor of a search for a more complex and satisfying new order or synthesis. Possible naivete or innocence of vision may be combined with stringent requirements conditioned by judgment and experience. Ability to negotiate verification by judges is a final stage in a creative development. preceded by familiarity with the problem, and selling or buying a new vision.

[13] Buckley (1967:125) focuses our attention on such systems of interlinked components that can only be defined in terms of interrelations each (and all) of them in an ongoing development process that generates emergent phenomena (in part innovative).

[14] See Lubart (1999) for criticism of system approaches to creativity.

TABLE 2: Key Systems Concepts/Dimensions relating to Creativity and Innovation: A Comparative Perspective

CONCEPTS	Psychological Systems Theory (Puccio et al. 2010; see also Woodman et al. 1993)	Socio-cultural Systems Theory (Csikszentmihalyi 1988, 1999; McIntyre, 2012)	General Four Ps Frame-work (multiple factors)	Sociological Systems Theory (ASD)
Context/en-vironment	Environment Psychological and Physical Settings	Place/Environment fields with experts and members of one or more disciplines, domains	Place/ Pressures	Context/Environment: (a) immediate situation or field of interaction; (b) more encompassing material and social structural environment with agents
Actors/persons	Person/ Personality: Skills, Background, Experience, Personality, Knowledge, Motivation	Individuals or persons as innovators as well as multiple actors including experts and judges acting as gatekeepers	People, Persons	Multiple socialized actors or agents (individual or collective) in designated roles who are knowledgeable about the prevailing social rule regime (see 3 below) and knowledgeable in a given domain (of rule regime(s)) or field (of action and interaction) (as well as possibly in adjacent or related fields), and are responsive to role demands and situational incentives
Cultural, Institutional Factors	Leadership	Symbols, rules and other socio-cultural factors, collaborative relations, domain knowledge, structure of the field or domain		Social Structure: cultural-institutional arrangements (economy, polity, culture): conceptualized as Rule regimes with (a) roles and role relationships including multiple actors in diverse roles including leadership roles; (b) norms, group or organizational incentive structures & pressuring mechanisms (c) shared body of symbol systems and knowledge or beliefs in a given domain or field (as well as possibly in adjacent fields)
Social power Factors		Persuasion		Powers mobilized and utilized in creative activities
Resources				Materials and technologies utilized in creative activities in a

				given field
Process /mechanism	Process: Stages of thinking working alone or in collaboration with others.	Collaboration, creative processes	Process	Process: (a) social interaction, collaboration, structuring, powering and governancing; (b) invention, construction, transformation, recombination, production of variation, innovation
Output	Product/outcome : solutions to problems, ideas, inventions	Creativity judgments, products, new patterns relative to existing ones	Products, Creative performance	Output: Concepts, designs or proposals, blueprints at variance with established or institutionalized designs, novelties, innovations, creative developments (a new entity, concept, a "product", "law", "regulation," new institution, new system or socio-technical system, paradigm)
Selection: Acceptance or rejection	Creative Change Social change, personal change, innovation	Selection and transmission mechanisms:[15] an idea, product, process is adopted or sanctioned by others, typically key agents in a field or domain		Social judgment and acceptance possibly resulting in institutionalization (sanctioning, legitimization) – OR NOT. That is, on the basis of social selection mechanisms, established authorities or powerful agents accept or reject an innovation or creative development ("gatekeeping") in the field of innovation or in the larger political, legal, and economic contexts.

The sociological systems model of creativity is elaborated in the following sections, stressing the *social character of each of the factors of creative action and also the qualitatively differentiated phases of the creative process, whether a single individual is involved or one or more groups and organizations.* The theory emphasizes key sociological features from the initial recognition or identification of a problem or idea or want – which is often the point of departure of creative attempts -- to its realization in "creative or innovative initiatives."

[15] Csikszentmihalyi (1999: 315-316) rightfully connects a dynamic systems perspective to evolutionary concepts: the production of variation, selection and transmission (see also Burns and Dietz, 1992, 2001). He (1999: 315-316) stresses the importance of this phase in the establishment and institutionalization of innovation: to be creative a variation has to be adapted to (acceptable to) its social environment and it has to be capable of being passed on through time. This conception of creativity is repeated in Sawyer (2012:214) and is assumed by Amabile (1982:1010).

IV. SOCIOLOGICAL SYSTEMS MODELS OF CREATIVITY

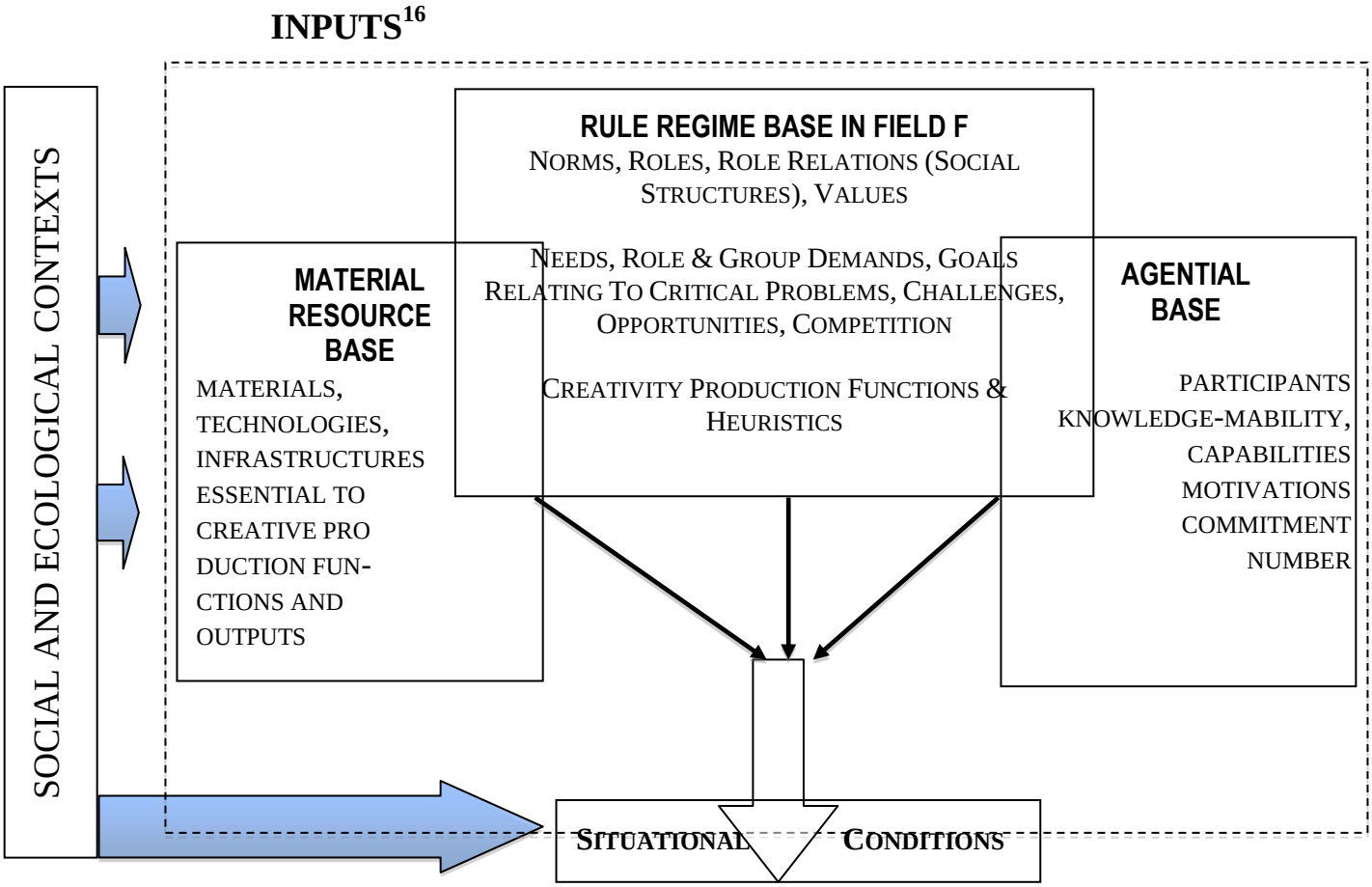
1. Context-Dependent Creative Social Action: ASD Input-Output Model

As suggested earlier, Sociology has a long history of theorizing and conducting empirical studies on innovation and creative action and transformation -- to which the authors of this article as well as many others have contributed in investigations carried out in diverse social, socio-political, and technical contexts (see Baumgartner and Burns (1984), Burns (2005), Carson et al (2009), Corte (2013), Collins (2000), Farrell (2001), Hollingsworth et al (2011), Joas (1996), Padgett and Powell (2012), Parker and Hackett (2012), Parker and Corte, 2014; Woodward et al, 1994, among others) and section II. Our sociological systems approach, in particular, contrasts in a number of ways to psychological systems approaches to creativity (as outlined in Section III) emphasizing:

- Social agents are collectives as well as individuals, both capable of certain forms of creativity in particular fields
- Social structure -- institutions and cultural formations – based on rule regimes are prominent features of the context of creative action and its outputs in a given field of activity or performance.
- Social action and interaction – the nuts and bolts of creativity – are shaped and regulated by the embedding rule regimes
- Particular production functions -- which under some conditions produce novelty with certain likelihoods -- are available in the rule regimes (established cultural formations and institutional arrangements) applying to one or more fields.
- "Gatekeeper" agents are involved in social structures and mechanisms of judgment which play a role in the acceptance or rejection of – ultimately, the institutionalization or exclusion of -- innovations (Czikzentmihalyz, 1990; 1999; Park and Corte, 2014).
- The social context of selection and institutionalization of novelty in more encompassing social systems typically also entails a type of secondary or tertiary innovation in applications and adaptations.

The model below (Figure 1) specifies contextual factors as well as the key input-output factors: in particular, knowledgeable, capable agent(s) of creative action; appropriate technologies and materials; creativity production functions; and indicates creative outputs occurring with varying degrees of likelihood, depending on input factors and production processes discussed below. The *field F* consists of an action and interaction context consists with particular actors and their relations, rule regimes, established socially shared concepts and models, technologies and materials, and production functions (Fligstein and McAdam, 2013; Park and Corte, 2014).

Figure 1. Systems Theory Input-Output Model of Creative Action



OUTPUTS [17]

INTERACTION,
PRODUCTIONS,
OUTCOMES

[16] The rule regime governs to a greater or lesser extent – depending in part on external agents and conditions -- agent(s) identity and participation in field F, norms, roles, and role relations and provides rules as the basis of values, beliefs, passions and production functions. The shared knowledge of the rule regime defines relevant concepts, designs, potentialities in the Field F (as well as possibly other fields) and the commitments and goals some of which drive creative activity. The rules of the regime govern to a greater or lesser extent – depending in part on external agents and conditions – the material resource base; materials, technologies, space/places, and time.

[17] As discussed later, the outputs, in particular innovations and creative developments, are subject to judgment and acceptance/rejection and eventually possible institutionalization.

The complex of key interrelated factors presented in the ASD input-output model are – in a nutshell:

TABLE 3: KEY COMPONENTS OF ASD INPUT-OUTPUT MODEL
Contexts: Social and ecological contexts including interaction situation(s) in F.
Relevant Rule Regime(s) applying in a given field F (or fields)
Agents with appropriate knowledge, capabilities, and motivation in field F or related fields
Appropriate Relations and interaction patterns among agents (roles and social structure) defined and regulated by rule regime(s) in field F
Appropriate resources (materials and technologies) for agents' creative strategies and production functions in field F
Production functions or strategies in field F (as part of the deconstruction of the "creative process")
Outputs: successes and/or failures; likelihoods
Acceptance judgment in as well as outside F

Several psychological theorists (Boden, 1994; Batey and Furham, 2006; Csikszentmihalyi 1988; 1999; Gautam, 2012; Rhodes, 1961; Sawyer, 2003, 2012, among others) have earlier identified some of these same components (see Table 2), for instance, the creative "process," creative "individuals" or agents with their "knowledge and capabilities," their "relationships" (especially leadership), the "characteristics of the situation/context" influencing actors' motivations and orientations as well as "resource" access and level of availability, "outputs" or products, and the social acceptability of their innovations,. Our contribution has been to sociologize these and to view them as a general system of interrelated parts in a given context, as elaborated in the following sections.

2. Creativity and Innovation Production Functions (Burns et al, 2014)

A production function is a rule complex. It is characterized by such rules as: (1) the rules directing and regulating the performance of a process related to a purpose, value, or goal; (2) participatory rules specifying the appropriate actor (or actors) to engage in the process (in the case of multiple actors, their role relationships and tasks in the production are typically specified); (3) rules concerning the appropriate resources (materials, technologies) deployed in the activity; (4) there are usually even rules specifying the particular time and place for the production activities (Burns and Flam, 1987).

Production functions, as rule complexes, vary in their degree of specification, organization, and coherence. For instance,

(1) Some are highly organized and routinized complexes combining specified tasks, resources, and actors to perform certain activities and to accomplish certain outputs.[18] In the case of a group, members and their roles are specified by the regime, for instance, a rule complex defining leadership roles and task-actor-resource relations.
(2) Production functions may be relatively open and flexible but nonetheless serving as a frame for conceptualizing, organizing and regulating key group activities and collective judgment and decision-making processes. Thus,
   - Incomplete complexes/algorithms opens the way for participants to fill in some of the unspecified dimensions (often by taking into account contextual conditions, contingencies, "rules of thumb)."
   - Actors in specific roles with specified objectives or purposes may be left to work out how to perform or realize specified objectives (that is a high level of discretion).

Highly specified and organized production functions can be activated and performed routinely in an appropriate context. More incomplete, underspecified production functions (such as those consisting of heuristics and "rules of thumb") have to be applied and worked out by the agent (in the case of a group, multiple agents) in practice, which typically entails judgment and learning processes, even trial and error. In the case of a well-developed production function – when it fails because of contextual conditions, agential mistakes or ignorance, or technological or material limitations – another level of problem-situation and uncertainty confronts the actor (or group), and increases the likelihood of reform attempts – for instance, possibly replacing some of the people, or the technology, or even the production function. Such situations arise also in action settings which cannot be defined or an appropriate response determined within the perspective of the relevant regime(s).

In sum, repertoires of production functions range from well-organized systems through relatively open and flexible rule complexes to heuristic principles for social action to only vague ideas of purpose and means. Nonetheless, the latter may serve as a point of departure for conceptualizing, organizing and regulating key group activities and functions (production processes, collective judgment and decision-making).

The following section discusses a selection of production functions associated with creativity.

3. The Modalities and Diversity Of Creative Production Functions.

Creative production functions are highly diversified in part because they are context sensitive, in part because they differ in different fields and with respect to different objects of innovation. In diverse fields there are differing institutionalized problem-solving modalities. In the course of trying to solve problems as suggested in Figure 2 an agent or agents initiates innovative activities with different ambition levels, means or "toolkits" (Swidler), strategies, and resources.

The general ASD models presented in Figures 1 and 2 stress the identification of key operations (symbolic, both symbolic and real), procedures, algorithms, heuristics, strategies – all

[18] **Organized-routinized complexes** for key collective and production processes are found in earlier work: models of administrative arrangements are found in Burns et al, 1985; Burns and Flam (1987), Burns and Hall (2012); models of negotiation procedures are found in Burns et al (1985), Carson et al, 2009, Roszkowska and Burns (2010); collective deliberation and decision-making/conflict resolution are considered in Burns and Roszkowska (2008).

consisting of rule complexes – utilized in creative actions. The core idea is that of a problem-solving model whereby new solutions are generated, or established older solutions are adapted or transformed.

There are at least five basic modalities of creative production:[19] origination/formation, transformation, combinatorics, adaptation, and dialectics. The latter encompass less directed, more fluent creativity strategies and production modalities to generate innovative ideas, artifacts, and whatever: these include brainstorming, experimentation, dialectical exchange, alternative conceptualizing of existing entities, etc. Typically, however, there are composite forms.[20] A principle idea is that creativity entails a spectrum of *socially established and available operations for constructing one or more entities or rearranging them or transforming them*. It typically involves operating on a set of already existing objects, rules, representations, paradigms, or notations as well as institutionalized methods, strategies, and designs (see below, also Csikszentmihah (1999:315) who points out that "Original thought does not exist in a vacuum. It must operate on a set of already existing objects…" or uses them as a point of departure). [21]

Below we provide selected illustrations of the different types of creative and innovative production processes:

I. **Origination/Formation** (imagining). Origination (Arthur, 2009) entails a process of starting out with a completely new or different idea or phenomena. In some cases, formation entails initiatives practically "from scratch." One has a problem, but no models or designs for solving it – even adaptive possibilities may not be ready-at-hand in such conditions. A motivated innovator (or innovators) tries trial and error, experimental and "play" strategies (see below), e.g., the strategies of working with alternative models or procedures of fusion or differentiation).
For instance,

- Creating a new entity, process or structure (with natural, technical and/or social factors and mechanisms). In general, creating a new process or structure is often realized through "capturing" and controlling or manipulating natural, technical, social phenomena for particular human purposes or goals.

[19] Arthur (2009: 163) refers to several mechanisms of innovation with parallels to those formulated here.
(a) Innnovation may consist in novel solutions being accomplished in standard engineering – the thousands of small advancements and fixes that cumulate to move practice forward (greater effectiveness, reliability, less cost, more esthetics, etc.), as in novel solutions in engineering, medicine, social work, and law.
(b) Invention of radically novel technologies, systems, concepts, category systems. Such innovations include novel technologies; some of these are developed by changing their internal parts or adding to them in the process of structured deepening.

[20]There may be combinations of the multiple processes, for instance the conceptualization of DNA involved formation as well as combinatorics.

[21] The U.S. Patent Office (and multiple levels of U.S. courts) have wrestled with concepts of "discovery", "invention", "novelty",. "innovation", "creation". An established, general principle holds that patents are granted to "whoever invents or discovers any new and useful… compositions" (Kevles, 2013:83). Laws of nature, manifestations of nature, and natural phenomena are to be excluded, even if great human ingenuity and inventiveness are involved in their discovery. The USPO (and the courts) insist on a "human inventive step". If scientists gave, for instance, bacteria new qualities, this qualified as an "inventive step", "the product of significant human creativity" and a patent could be issued. Discovery of a DNA segment is not patent eligible, even if it has been isolated by human action – because "it is a product of nature;" however, if it is manipulated so as to create a new DNA – then it is eligible precisely because it is new and produced by human action (Kevles, 2013:83).

- Constructing new elements or complexes of elements or relations among elements. These may be rules, symbols, concepts, material objects and processes.
- Development of new categories/category systems
- Renaming an element or complex of elements so that it is treated or used in a very different way than previously

Origination is putting into a particular time and space an element or complex of elements that did not exist previously, whether a symbol (for instance, the 0, 1, and ∞ symbols), concept (atom, nucleus, architecture of the subatomic world, institution, game, cognitive dissonance), entirely new technology (nuclear power, nano technologies), built environment, social structure, institution, new forms of power and authority). For instance, "bureaucracy" (in one or another form) entailed the social organization of participants in such a way as to control their behavior and the entire apparatus could be used for control and productive purposes; the "Bessemer process" entailed the development of a new method for making purified steel by blasting compressed air through molten iron to burn out excess carbon and impurities; or, the concept of a jet engine as opposed to a propeller driven engine for airplanes, or the concept of a limited liability company as opposed to a partnership with complete owner responsibility.

In the "discovery" of penicillin, Fleming's basic role superficially viewed seemed simple enough. But this discovery necessitated a very definite knowledge framework and set of existing technologies. As Arthur (2009:169) points out, "It required biochemical processes to isolate the active substance within the mold, other processes to purify it, and still other ones to produce and deliver it. Penicillin had its parentage in these means and methods. The discovery would not have been possible in a society that did not possess such elements. Existing means make penicillin possible. All technologies emerge out of existing technologies in the sense that these in re-formation and re-combination directly made them possible"(Arthur, 2009:169). (see Table 1 for many additional examples).

Opportunities for creativity emerge in the context of needs or problems to be solved (Arthur, 2009: 175). For instance, the potential demand/need/potential receptivity for entertainment that in early societies was fulfilled by public spectacles and storytelling came to "require" (or called for) in a more modern, urbanized world a panoply of sports, dramas, movies, musical performances. What appear to be simple needs multiply into subgenre – for instance, modern people develop interest in many kinds of music, or dramas, and/or sports, etc. An activity like skiing originated in Norway and Sweden as early as 5000 B.C. using a relatively thin plank of wood (and a pole) for *practical transport purposes*, but evolved during the 1800s into recreational, exercise, and competitive forms. Skiing sports themselves diversified into a number of new forms and technologies: downhill, cross-country, freestyle skiing, snowboarding, and heliskiing (use of helicopter to take skiers up to unreachable peaks), among others. All point up the powerful, diversified creativity of humans – in this case in the field of winter sports.

II. Transformation

Transformation entails restructuring, remaking an element or complex of elements so that it differs qualitatively and quantitatively from what there was before the transformative action; others are conceptual revolutions such as the Copernican revolution of the movement of planets, the industrial revolution, and political revolutions. Transformative operations include adding to, subtracting, and replacing parts and wholes.

Transformation entails taking an entity and making it into something else (not all transformations result in novelty; some maintain identity, common mechanisms). In genuine innovative transformations, one replaces one or more components and/or relationships with a substantially different component or linkage.

Earlier we referred to transformation operations, for instance, those not only to change the values of parameters but to change the parameters themselves.

In the industrial revolution (see later discussion), the development of automobile transport entailed myriad innovations and transformations. Arthur (2009:175-176) stresses the cascade of restructurings and transformations associated with the emergence of auto transport: "The automobile in 1900 created a set of ancillary needs – opportunity niches – for assembly-line manufacture, for paved roads and properly refined gasoline, for repair facilities, and gas stations. And gasoline in turn set up further needs for refineries, for the importation of crude oil, and for the exploration of oil deposits. Every innovation (for instance in the case of technology) by its very existence sets up an opportunity for fulfilling its purpose more cheaply or efficiently; and so for every technology there exists always an *open opportunity* (indeed, many possible opportunities). And for another, every technology requires supporting technologies: to manufacture it, organize for its production and distribution, maintain it and enhance its performance. And these in turn require their own sub-supporting technologies.

Reflecting generally, we find many instances of transformation derived from following particular procedures:[22]

- Conduct operations transforming an artifact, concept, belief system, rule and symbol system
- Copy an entity and then adapt it, modifying some or many of its properties and mode of functioning, particularly in relation to a new context.
- Differentiating(demarcation/separation) a set of elements (making a distinction not made before, for instance, in the subatomic particles of atoms, or distinguishing stars from planets, or separating psychology from philosophy)
- Integrating or synthesizing elements of diverse sorts.
- Changing the quality or structure of a complex of elements by adding or removing, or replacing some or all of the elements with different elements, or by changing, removing, or replacing relationships

III. Combinatorics

Combinatorics is a type of transformation, combining and re-combining -- components and linkages of a complex are rearranged. The resultant complex differ significantly (dissimilar in qualitative and/or quantitative terms) from the original. For instance, combine A and B that had never been combined before; or, replace B with C (this illustrates fundamental operations of "adding", "subtracting", "replacing", "transforming" (Burns and Gomolinska, 2000)).

If AB were identified as such, then their differentiation into separate entities in A and B, is a creative action. Typically, there will be additional challenges to address in maintaining each of them separately. Or, fusion where A and B are separate entities, and the initiator brings them

[22] In the field of film, Charlie Chaplin, Buster Keaton and others adapted and eventually transformed their techniques and skills in the transition from silent movies to talking movies). Roles were also transformed and developed, for instance Charlie Chaplin's original clown role was transformed into the very different clown creations of Chaplin's daughter, Popov.

together into a single unit AB (which will involve solving interlocking or integration problems): for example, hybrids, fused biochemicals, or fusion of organizations.
The fusion and differentiation cases of combinatorics are special types of "formation", namely the formation of AB from separate entities A and B and the formation of A as distinct from B in the case A and B are initially bound together.

New elements (concepts, designs, technologies, socio-technical systems, social systems) may be constructed from elements that already exist, that is, these are available as possible building blocks – elements for the construction of still further elements and systems.[23] For example: radio transmitters and receivers, in conjunction with other elements, made possible an entirely new complex invention, the socio-technical system of radio broadcasting (Arthur, 2009:167-168)

In general, given the elements in a field, domain, or setting, agents act creatively, innovatively in diverse ways through forming, changing, rearranging, transforming elements in the given field, domain, or situation. *Many "innovations," for instance a concept, symbol, artifact, or socio-technical system, can entail simply inserting it in or importing it to a new context, or using it in a new way or for a new purpose. This type of invention differs from genuine origination or novel creation.*
In sum,

- Combinatorics including integration of components in new ways (for instance, in the case of radio-broadcasting systems -- hundreds if not thousands of components were put together, establishing a new socio-technical system (Arthur, 2009).
- In general, combinatorics can combine existing elements in new ways to create a new artifact, material, concept, belief system, rule and symbol system, or material structures
- It encompasses new ways of interweaving and interlocking different threads of knowledge, ideas in science and culture, combining musical themes and voices (Bach's polyphonic music based on combining different "musical voices"), verses, styles, story threads

In the human formation of new complex structures – combinatorial formation and evolution is prominent and common.

IV. Adaptation/Modification

Adaptation of an concept, technology, symbol, or entity X would entail, for instance, applying it under similar circumstance but doing so differently than in the past – making adjustments in it so that application is feasible, for instance changing the values of its parameters. Even in starting a formation from what appears to be scratch, an innovator may have confronted similar problems in the past and may be able to adapt the earlier innovation for her present purposes, for instance, in developing a vaccine, (as now in the multiple efforts to create a vaccine against Ebora). Procedures have been developed in earlier vaccine development such as using live but weakened pathogens, using dead pathogens, or pathogens genetically manipulated.

But simply applying X in a new context typically requires making some adjustments so that X "fits" properly the new context (see illustrations in a later section).[24]

[23] Arthur, 2009:167-169) refers to "self-creation" and autopoiesis.
[24] Some researchers would not refer to this action as creative, or possibly only as weak creativity, small c-creativity.

(1) The horse-drawn wagon or carriage was adapted to use with an electric or gasoline driven motor and a steering device, among other technological adaptations in the construction of the automobile on the basis of the wagon.
(2) The establishment of Xerox's PARK PC unit entailed adapting a taskforce model of social organization to the IT setting with the purpose to develop a PC, engaging a creative task force, among other things, introducing explicit norms about group sharing of data and intensive collaboration with an aim to creating a PC (in which they eventually succeeded (see later).
(3) The formation of the Palm Oil Roundtable in 2004 entailed applying/adapting an established an international non-government organization (INGO) prototype in a new field with its particular agents, technologies, products, institutional arrangements and cultural formations, for the purpose of regulating tropical forest exploitation and palm tree oil development (see later).
(4) Imitation and adaptation or transformation on the basis of a new or different purpose or idea. Beethoven copied the work of others and adapted it according to his own ideas and passions. For instance, when he decided to compose a quartet for the first time, he copied an entire Haydn quarter in order to learn and use as a form as a point of departure for his own work; in his final piano sonata, he made use of passages from Haydn and Mozart.[25]
(5) GlaxoSmithKline recently used an established algorithm to develop a vaccine to combat Ebola. Putting it simply, the algorithm entailed taking a common cold virus engineered to carry two Ebola genes that would stimulate a person's immune system to produce antibodies against Ebola. The vaccine has been shown to work on animals and is now (Autumn, 2014) being tested on humans.
(6) For dealing with a current regulatory problem, one adapts an old law – or imports a law from abroad and adapts it to the different cultural, institutional, and political context.

V. Dialectical Strategies and Production Functions for Creativity

"Dialectics" concerns interplay between different perspectives or paradigms, problem-definitions, solution-complexes which elicits combinatorial, transformational, and other creative reflections and operations so as to generate innovations and foster creativity generally. This is suggested by the simple "Helegian/Marxian" formula, thesis-antithesis-synthesis. Dialectics is illustrated in processes such as: (1) arranging exchanges as in debates and scholarly defenses; (2) initiating exploration combined with reflection and hypothesis generation; (3) initiating "trial and error" strategies as well as more systematic experimentation; (4) recruiting diversity, "mixing" participants with different perspectives; (5) brainstorming; (6) heuristics, among others. There are strategies and modalities of activity to help generate ideas, alternative conceptions of existing entities, proposals for creative initiatives.

Experimentation modalities

"Trial and error" and other forms of experimentation – effectively complemented by a norm of being alert to emergent discoveries and possibilities – are common procedural tools to gain insight, to make discoveries, and gain understanding for purposes of generating ideas, innovation and creativity.

Play modalities

[25] Shakespeare and others at the time copied from one another without much ado.

Play and stimulation of the imagination, visionary experiences combined with a norm of alertness as well as ultimately strategies for directed or systematic problem-solving.[26]

Heuristics (Polyi, 1945; Tversky and Kahneman, 1982). These are search or discovery techniques ranging from utilizing "rules of thumb" to trial and error strategies. Some instances of heuristics are relatively sophisticated, for example: (1) start with one or more concrete cases in order to articulate a more general case or model; (2) or, start with a general conception and search for one or more areas of possible application in order to correct, elaborate or adapt the general conception; (3) solve a simpler version of the problem at hand, then elaborate or adapt the solution when connecting back to the original challenge; (4) solve a related problem and determine potential parallels of the problem-solution complex to the original challenge; (3) transform the problem into something else different, which proves solvable and then transform back to the original state, making use of insight gained into solution(s) obtained.

Diversity recruitment for groups and networks

Recruit or establish contact/communication with persons with new or different perspectives or with special knowledge (consultants, experts from other fields or other traditions) in order to gain access to potential ideas, new frames, methods, strategies, possibly innovative solutions.

Normative climate-setting

Among the norms fostering innovation and creative development, the following are often established:

- norms – and even special roles – encouraging or honoring creative works and results.
- norms of alertness to attend to chance happenings, serendipity, accidental discoveries, unintended developments, mistakes, and accidents in one's own explorations and experiments as well as those among competitors or others working in the field or related fields.

Discussion

In sum, actors have multiple creative strategies and production functions. They draw upon these in the face of creative challenges, whether driven by curiosity, need, or social pressure. They may combine, for instance, different functions such as "play and experimentation" and "engage potential experts" (and even creative competitors).

Analytically, we may distinguish innovative initiatives that are radical, moderate, or minimalist (of course, the potential innovator or power-brokers may decide not to change anything, which is a default case).

- Reframe/redefine the concept and/or purpose of an entity. For example, "a toilet was made into an art object" (Dadaism). Tanks were combined into a new kind of military unit, the "Panzer division" rather than being deployed simply as an "iron horse" accompanying troops (Kemeny, 1983).
- Adapt existing systems structurally so that they can be used for purposes other than what they were designed for or originally envisioned.
- Or, apply them in an altogether different context than.
- Paradigm shift (revolutionary) from an old paradigm (complex of dimensions) to a new one (Carson et al, 2009; also, see later discussion). A new paradigm is originated on the basis of an entirely new concept or principle, new methods, and production processes; examples are

[26] Much creativity has its source in the visionary experiences and dream world – this is above reason and logic. In order to express such insights and inner experiences, an innovative language is invented with new images, concepts, and meanings.

the Ford factory system as well as many other socio-technical innovations in the industrial revolution, quantum theory, theory of biological evolution, the theories of genes and DNA, radically new technology developments such as nuclear energy, nano technologies, GMOs (several of these to be discussed later).

Section VI examines some of the societal and material requisites in revolutionary creative developments as opposed to minor adaptive developments.

4. The ASD Phase Model of Creativity Production and Acceptance/Institutionalization

An innovation or creative production process typically consists of a series of activities differentiated into phases (Figure 2 highlights the qualitatively different activities). The ASD model of creative production processes identifies the multiple phases (seven) in creative action and innovation as well as reception/acceptance, legitimation, and institutionalization.[27] Thus, two major contexts of social action and interaction are distinguished in the phase model: *(A) the context of creation (Phases I, II, and III)* and *(B) the context of social acceptance (or rejection), legitimation and institutionalization (Phases IV, V, VI, and VII)*.[28]Note that Figures 1 and 2 specify agency (actions of an innovator or inventor (individual or collective), social structures, interaction/communications and process developments relating to producing novelty as well as relating to "acceptance" (or rejection) and possible institutionalization of novelty/innovation.

Note that the creative production process is *not linear*—but loops backwards and forwards.[29] For instance, negotiation or blockage in Phases IV, V, VI, or VII may lead participant(s) to return to earlier phases, restarting the process in Phase I, II, or III. Also, creative processes may be aborted, for instance in a particular phase, because key agents exit or essential resources cease being readily available or are not obtainable, or the process and/or its products are suppressed because of external dictates. Even key participants in an innovative development may decide, for instance in Phase IV, to terminate an innovation initiative because they morally reject the creation or fear the reaction of powerful agents in their environment (or, on the basis of further analyses, they anticipate the unsustainability of the creation (see discussion about the personal computer case later)).

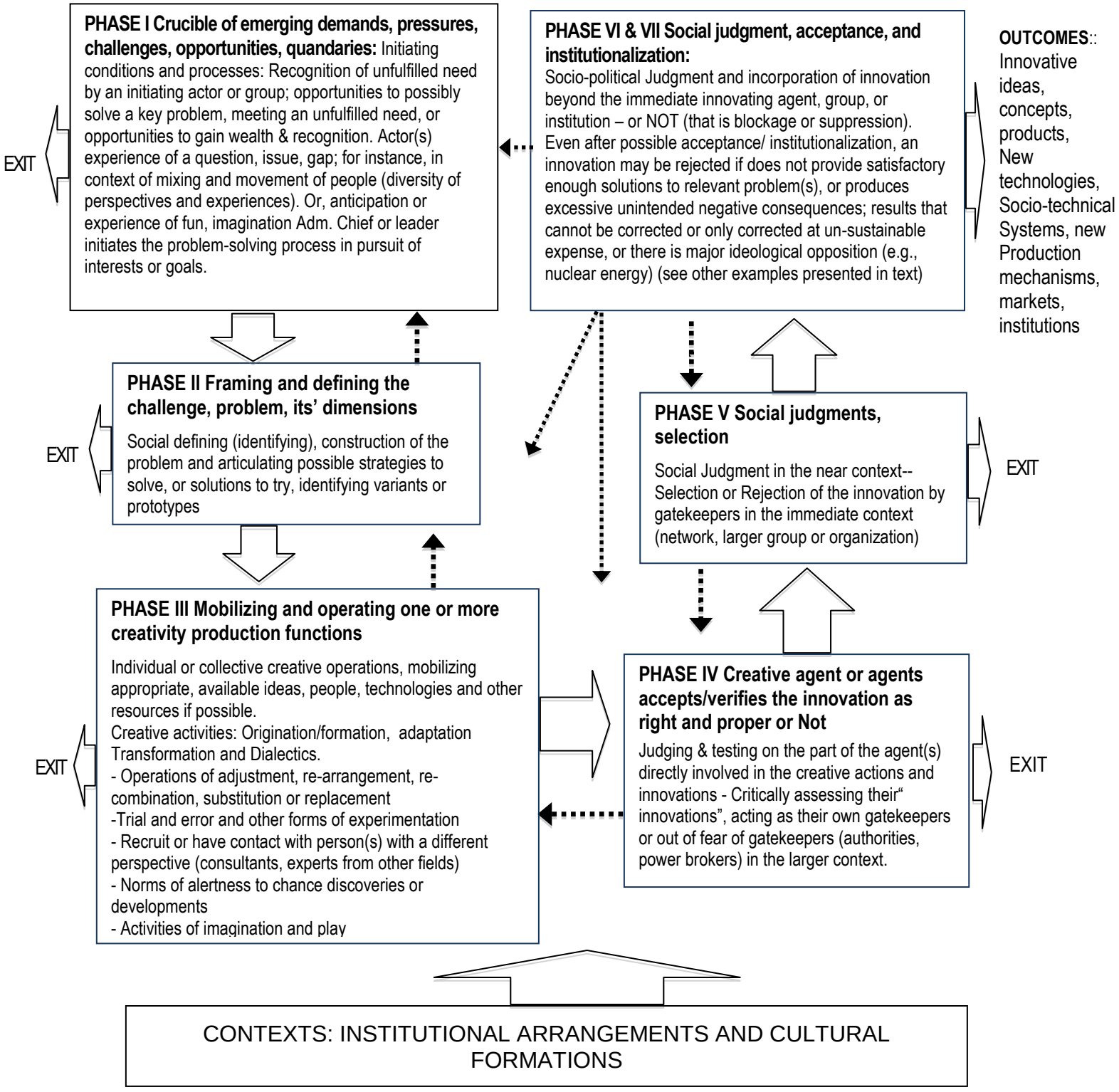
---

[27] Farrell (2001) developed a phase model for his collaborating creative groups, but the model concerned group development but not the process of creativity. But one might link the two phase processes, to show how stages of group development influence the creation and distribution of cultural products (as suggested by Fine, 2003:658). Other phase model approaches are found in the literature on creativity

[28] Further phases are distinguishable concerning adaptation of an innovation, development, and further assessment. G. Walras (1926) envisioned a process consisting of 5 stages (Wikipedia, "Creativity"; Simonton, 1999): (i) preparation (preparatory work on a problem that focuses the individual's mind on the prolem and explores the problem's dimensions; (ii) incubation (where the problem is internalized into the unconscious mind and nothing appears externally to be happening; (iii) intimation (the creative person gets a "feeling" that a solution is on its way), (iv) illumination or insight (where the creative idea bursts forth from its processing into conscious awareness; (v) verification (where the idea is consciously verified, elaborated, and then applied). Ogburn (1922) identified four stages in the case of technical innovation and development: invention, accumulation, diffusion, and adjustment. Adjustment, as a form of adaptation, concerning bringing non-technical aspects of a culture in line with the invention; limitation of the process of adjustment led to "cultural lag", a concept which was closely associated with Ogburn.

[29] This relates to what Gregory Derry (and Jochen Fromm (2004:28) see as the workings of science: [Science is] "starting with ideas and concepts you know, observing the world, trying different things, creating a coherent context, seeing patterns, formulating hypotheses and predictions, finding the limits where your understanding fails, making new discoveriew when the unexpected happens, and formulating a new and broader context within which to understand what you see."

Figure 2. Phase model of the generation and acceptance of innovations and creative developments



4.1 Differentiation in the Phases

Phases differ in terms of key participating agents, their appropriate rule regimes, their resource bases, and contextual conditions.

(i) In the phase cycle, phases I, II, and III are characteristic of **"the socio-cultural context of the production of novelty"** while phase IV, V, VI & VII refer to the **"socio-cultural context of acceptance/selection and institutionalization.**"[30] Social roles, resources, and strategies as well as, of course, interaction patterns differ in these different contexts. In particular, the agents involved – and the roles they play – shift to a greater or lesser extent in the phases of the cycle. In each phase there will be variation in the knowledge and skills mobilized, and the capabilities and leadership called for. In line with this variation, involvement/motivational factors are likely to differ, e.g. a shift occurs from drivers such as curiosity or group sociality to considerations of economic gain or recognition, or consideration of social and environmental impacts and reactions. Such shifts make for different sources of conflict – and their possible resolutions. For instance, conflicts shift from substantive cognitive or technical conflicts to conflicts over how much to stress economics or how gains and recognition among those involved in the innovations should be distributed.

(ii) In phases I, II, and III, actors involved in groups may explicitly or tacitly agree or disagree about the nature of the problem or challenge and the appropriate way to think about and deal with it in innovation initiatives; disagreement may arise also about what can be considered a particular "solution" – or whether or not a particular solution can be actually be accomplished. Phases IV, V, VI&VII are likely to be characterized by conflicts between the actor(s) involved in creative initiatives, on the one hand, and outside judges and "gatekeepers" assessing and reacting to an innovation, on the other hand.

Phase I is a sub-context in which actors experience challenges, curiosity, expressive needs, social, political, economic and technical pressures, etc. (motives for initiating an innovation process and developing it is often mixed).

In the innovation process, an agent or agents try to frame and define the challenge or problem and its dimensions in Phase II. In the course of determining what is the challenge or problem, how it should be conceptualized, the agent or agents mobilize resources (including possibly qualified people and problem-solvers) and operates/conducts one or more creativity production function leading to an output – which with some likelihood will be an innovation "solving" the initial challenge, problem, or need.

[30] The model here distinguishes analytically between discovery or invention and its acceptance/rejection in a socio-cultural context. The psychology theorists define an innovation as both original and useful as well as sustainable within a given field (Csikszentmihalyi, 1988, 1990; Sawyer, 2007; Parker and Corte, 2014). We consider an innovation as a product of the processes of generating novelty. The acceptance as well as institutionalization of novelty entail social processes, analytically distinct from the creation/innovation processes, hence, our specification of the *context of acceptance, legitimation, and institutionalization*. Parker and Corte (2014:10) appear to have bought into the common psychological perspective and consider an entity as creative when it is novel *and* "creates change within or substantial transformations a given field or social order." However, this conflates two creative mechanisms: the initial novelty generation and the creative impact of the novelty in a field or in society. In our model, the two mechanisms are distinguished and kept distinct – but we recognize that they may be cases, where the two mechanisms are more or less closely linked or integrated.

Many attempts at innovation fail because actors cannot mobilize critical resources, for instance, they lack ownership rights, authority or access to forms of "venture capital"; or, they lack technologies or socio-technical infrastructures like laboratories or particle accelerators; or, they lack sufficient knowledge (or access to expertise with such knowledge; it might not be available in the setting, for instance, in a developing country without substantial modern educational infrastructure); or, in the case of a multi-agent process, the actors lack organizational capability essential for mobilizing and coordinating/controlling the resources and people (the task-resource-agency nexus) and conducting creativity production functions.

In multi-agent production processes, the quality of communication and collaboration is a critical factor (Farrell, 2001; Corte, 2013). As pointed out later in the case of the PARC (at Xerox) group which created the PC, norms of sharing data and knowledge were established; openness in exchanges in their meetings was made standard practice, that is, one of several operative norms for the group. This made the group highly effective as a creative instrument but did not solve the challenge of acceptance and institutionalization by the overall organization (as in the case of Xerox, as discussed later).

(iii) The rule regime base (social relational and institutional arrangements) may vary in the different phases – indicated by differentiated norms, roles, and leadership. For instance, ownership or property rights patterns are likely to shift. Ownership initially may be *de facto*. The group "owns" the innovation by virtue of immediate control or their isolation from external agents. "We can perform it, build it, execute it, others cannot, we therefore own it." Later ownership is institutionalized through patenting or copyrighting in the course of Phases IV, V, VI, & VII (in which, of course, the innovators might not have full control unless they are powerful companies or government agencies).

(iv) Technologies and materials mobilized in the different phases typically vary. These differences are often qualitative but there may be quantitative differences, for instance, a shift from a need for a few limited resources and participants to massive mobilization, as production activities are moved from "a small garage" in which a prototype or a few variants are produced to substantial buildings where mass production is launched. Or a small group, through publications and educational programs, diffuses a new theory or model such as the DNA model into a vast network of assessors and developers.

(v) Note that access to or control over agents, technologies, materials, and the innovations themselves are mediated by the particular rule regimes (specifically, authority and ownership relations) which apply in one or more phases.

(vi) Essential materials and technologies may be available to varying degrees to the agent or agents involved. A powerful agent has, or is likely to have, greater access than marginal or resource poor agents. Even highly creative persons or groups may not be in a position to try or to realize their creations. The process of innovation cannot be initiated or completed. For instance, in the case of Leonardo de Vinci's many designs and inventions, there was a lack not only of sufficient knowledge but suitable resources and technologies for their realization. The realization of many of them had to wait several hundred years.

(vii) The interactions and production processes – and the leadership and division of labor -- in the different phases usually differ substantially, particularly when multiple agents are involved (but in any case they may in any case overlap to varying degrees).

(viii) In complex innovation developments, or in instances of cascading developments, the phase cycle is repeated numerous times, as strings and complexes of innovations are produced (see later discussion of genetic engineering (GMOs) and nano-materials).

The phase model distinguishes the socio-cultural and institutional conditioning of creative actions ("the context of creativity, invention or discovery") from the acceptance/receptivity processes ("the context of acceptance and institutionalization"). The model orients us to looking for shifts in agents or their roles including leadership, in the interaction and production patterns, in the resources mobilized and deployed, and in the relations and interactions with agents outside of or not directly involved in the creative process *per se*. Also, a distinction is made between immediate or near reactions of acceptance or rejection (in Phases IV and V) from those reactions in the more encompassing context (typically economic and/or political) that enable or block acceptance and institutionalization (Phases VI and VII).

V. CONCLUSIONS

(1) Creativity and innovation are universal human activities, essential to adaptation and sustainability in an evolutionary perspective (Burns and Dietz, 1992, 2001).

(2) Our theoretical and empirical work has viewed the generation of novelty as a function of social structures (interaction fields, networks, groups, organizations), resource bases (appropriate materials and technologies), knowledgeable and capable agents (individuals and collectives), and interaction processes (powering, exchanging, competing, and conflicting).

(3) Creativity – in its production and acceptance -- is socially embedded. Social structural factors – for instance, institutions, cultural formations, networks and groups of agents – operate in and through the phases of creativity, on the one hand, possibly facilitating creative action and innovation, or, on the other hand, constraining or blocking it.

(4) Creativity and innovation studies, therefore, should systematically take into account the sociability and powers of agents, the institutional arrangements and cultural formations which make up, for instance, the context of invention and creativity as well as the context of acceptance and institutionalization, the two major contexts differentiated in our systems approach.

Failure of a particular innovative initiative is not only a question of absent or scarce resources ("the need for more resources") or the limited knowledge, capabilities, and social relations of the agents involved ("the need for more creative people" and the "need for more creative social interaction") but depends also on oppositional and political controls generated within institutional, cultural, network, and power contexts.

(5) Agential factors (combined with structural/power factors) may constrain or block innovative initiatives or developments – because key actors are in a position to decide over the mobilization and allocation/deployment of resources, because they are culturally/normatively narrow, unimaginative, because they have vested interests in existing entities and are opposed to change. In a word, there may be a major gap between those who have power, on the one hand, and those who have creative ideas and innovative project proposals, on the other hand. One of the motivations of agents utilizing and seeking power is to be able to develop and try to launch their creative projects -- or, on the other hand, to be able to block creative initiatives and developments of others.

(6) The work presented here points up that contexts, agents, rule regimes, and resource conditions of particular fields, which are policy prioritized, need to be investigated to identify and map out sources of potential facilitation as well as constraints. The latter may possibly be altered in order to improve creative developments, for instance, for the sake of renewable energy, resource conservation, and protection of the environment. On the other hand, such creativity may be policy constrained in fields where new developments *should be* discouraged, e.g., development of new weapons of mass destruction, risky new chemicals and biomedical

innovations, risky experimentation with new kinds of biological materials or human cloning (as well as many other hazards).
(7) In our systems framework, creativity is consistently and systematically viewed as a function of social, cultural, and institutional factors rather than exclusively or even largely psychological or biological factors (although the later should of course be taken into account).

Several of the central questions concerning innovation and creative development addressed in this article have been:

(1) What are the characteristics of innovations and creative developments These may concern ideas, artifacts, products, socio-technical systems, institutions, cultural formations, other "system" complexes, societal developments, etc.
(2) What drives an agent or group of agents to initiate creative activity? Typically, there are multiple factors or mixed motives, certainly when groups, organizations, and societies are involved. This work has identified multiple factors (material, soci-cultural and normative, institutional and organizational, economic and political) that play a role in driving and facilitating and realizing, on the one hand, and constraining and blocking, on the other hand, creative initiatives and developments.
(3) In what socio-cultural and organization contexts are major creative initiatives taken and innovative developments take place? Or not? We identified diverse social organizational contexts for creative action, and emphasized the particularly rich contexts in which many creators and innovators operate, drawing on their contexts to experience, define or discover problems, challenges and quandaries and to find or develop solutions. We should again (see above) emphasize those factors that constrain or block creativity – or creative realization: a lack of qualified agent or agents, lack of sufficient or high enough quality resources (materials and technologies), risk adversity, participants' generalized fear of punishment or suppression, social controls and sanctions against deviance including the deviance inherent in innovations and creative actions in any given social context or domain.[31] The resource scarcity may be the result of an absolute unavailability of the necessary resources or the result of powerful agents withholding them or using them for other purposes.
(4) Through what mechanisms – how – and with what "ingredients" is innovation or creative development accomplished? The article identified several of the strategies and production functions mobilized and applied by an innovating agent or agents: adaptation, formation, transformation, combinatorics, and dialectics.

(5) It also identified several of the key factors explaining innovation and creative development – factors that facilitate and amplify, on the one hand, or block and hinder, on the other hand, creative mechanisms.

In sum, key features of our sociological systems framework have been presented: (1) the socio-cultural and material contexts and settings of creativity, that is, the social and material embededness of creative activity; (2) the social character and roles of innovative agents and their actions entailing creativity and the production of new elements or combinations of elements; (3)

[31] The particular innovations may or may not "work", may or may not be acceptable to authorities (professional experts, juries) or enterprise and political leaders (Stalin's influential opinions on modern genetics and relativity theory).

social structures (institutional arrangements and cultural formations) conceptualized as rule regimes in which agents are embedded but which they reproduce and restructure, often as part of their creative activity; (4) the particular powers,[32] resources, and tools which are accessed and mobilized in socio-cultural and institutional contexts and utilized in creative action and development; (5) the interaction bases of creative action (including communication, powering, cooperation, competition, and conflict); (6) the possible production of novel entities, concepts, technologies, products, designs and proposals, or the transformation or recombination of existing ones; (7) the context of reception, acceptance or rejection of creative acts, in particular the agents and mechanisms in verifying, supporting, legitimizing the realization of creations, on the one hand, or their rejection or suppression, on the other hand; retention and institutionalization processes define and establish the creation/innovation as valuable or useful – at least in the short-run. Over the long-run, as with many technological innovations, creative initiatives and developments may run out in the sand; among other things, because they prove destructive of much in the social and/or ecological environment that is essential to sustainability, or they may prove directly self-destructive.

Times of great social instability and uncertainty are often those where there is a special need or challenge to develop innovations and new systems, even revolutionary ones. This paradox — the gap between the challenge and the readiness of key actors with resources to face the challenge in creative, new ways — is characteristic of modern conditions. The paradox is explained by the genuine uncertainty in the situation, and the unwillingness of many powerful actors to take risks – above all, in losing their power and status -- at the same time that risk-taking is absolutely essential to innovation and new developments. We wait suspended between the old, which has lost the assuredness and wide-spread support enjoyed earlier, and the new, which is still unknown and, therefore, cannot command widespread support, in particular financial support. A certain immobilization pervades our institutions. The question is: Can human societies — and their governments and entrepreneurial groups eager to try to meet the challenge — find effective ways and means to stimulate innovation and risk-taking.

REFERENCES

Alexander, J.C. 1995. *Neofunctionalism*. London:Sage

Amabile, T. 1996. *Creativity in Context: Update to the Social Psychology of Creativity*. Boulder, Colorado: Westview Press

Amabile, T. 1982 *The Social Psychology of Creativity*. New York: Springer-Verlag, 1983.

Andersen, S. and T. R. Burns, 1992 *Societal Decision-making: Democratic Challenges to State Technocracy*. Aldershot, Hampshire: Dartmouth Publications.

Archer, M.S. 1995. *Realist Social Theory: The Morphogenetic Approach*. Cambridge: Cambridge University Press.

Arieti, S. 1976 *Creativity: The Magic Synthesis.* New York: Basic Books.

Arthur, W.B. 2009 *The Nature of Technology*. New York: Free Press.

Arthur, W.B. 2005 *The Logic of Invention*. SFI Working Paper (2005-12-045). Santa Fe, New Mexico: Santa Fe Institute.

[32] The Burns and Hall Meta-power paradigm book proposes that the operation of three qualitatively different powers – agential, social structural, and material/ecological – is part and parcel of the creativity of evolutionary processes. That is, agential construction and social structural construction and selection combine with the creative-destructive character of natural powers and their selectivity. In other words, the material and ecological world is creative through its drivers and impacts (but without intentionality).

Barron, F. and D M Harrington, "Creativity" the Social Science Encyclopedia, A. Kuper and J. Kuper (eds.), London & New York: Routledge, pp 167-168.

Barron, F, and D M Harrington. 1981. "Creativity, Intelligence, and Personality." *Annual Review of Psychology* 32(1):439–476.

Batey, M. and A. Furham 2006 "Creativity, Intelligence, and Personality: A Critical Review of the Scattered Literature. *Genetic, Social, and General Psychology Monographs.* Vol. 132 (4): 355-429

Becker, H.S. 1982 *Art Worlds.* Berkerly: University of California Press.

Bennis, Warren G., and Patricia Ward Biederman. 1997. *Organizing Genius: The Secrets of Creative Collaboration*. Basic Books.

Boden, M.A. (ed.) 1994 *Dimensions of Creativity.* Cambridge, Mass.: MIT Press.

Boorstin, Daniel Joseph. 1985. *The Discoverers*. Vintage Books.

Buckley, W. 1998. *Society – A Complex Adaptive System: Essays in Social Theory.* Amsterdam: Gordon and Breach.

Buckley, Walter. 1967. *Sociology and modern systems theory*. Oxford, England: Prentice-Hall.

Burns, T. 2006a "System Theories" In: *The Encyclopedia of Sociology*, Blackwell Publishing, Malden, Mass.

Burns, T. R. 2006b "The Sociology of Complex Systems: An Overview of Actor-Systems-Dynamics" *World Futures: The Journal of General Evolution***,** Vol. 62: 411-460

Burns, T. R. 2007 "Dynamic Systems Theory" In: Clifton D. Bryant and D.L.Peck (eds),*The Handbook of 21st Century Sociology*, Sage Publications Thousand Oaks, California.

Burns, T. 2005 "Social Sciences and Technological Change" Brussels: EU Commission, Social Science and Humanities Advisory Group, Background Paper (BP6) (2005.08.16)

Burns, T. R., T. Baumgartner, and P. DeVille 1985. *Man, Decisions, and Society*. London: Gordon and Breach.

Burns, Tom R. and Tom Baumgartner. 1984. Transitions to Alternative Energy Systems: Entrepeneurs, Strategies, and Social Change. Colorado: Westview Press.

Burns, T. R., U. Corte, N. Machado 2014 "Toward a Universal Theory of the Human Group: Sociological Systems Framework Applied to the Comparative Analysis of Groups and Organizations." ULI/CIES Report No. 182/2014. Lisbon: University of Lisbon Institute/CIES.

Burns, Tom R., and Tom Dietz. 2001. "Revolution: An Evolutionary Perspective." *International Sociology* 16(4):531–555.

Burns, Tom R. and Tom Dietz. 1992. "Cultural Evolution: Social Rule Systems, Selection, and Human Agency." *International Sociology*, Vol. 7: 259-283.

Burns, T. R. and H. Flam. 1987. *The Shaping of Social Organization: Social Rule System Theory with Applications.* London: Sage.

Burns, Tom R. and Peter Hall (eds). 2012. The Meta-Power Paradigm Impacts and Transformations of Agents, Institutions, and Social Systems Capitalism, State, and Democracy in a Global Context. Peter-Lang publishing.

Burns, T. R. and E. Roszkowska 2008 "The Social Theory of Choice: From Simon and Kahneman-Tversky to GGT Modelling Of Socially Contextualized Decision Situations." *Optimum- Studia Ekonomiczne*, No. 3 (39).

Carson, M., T. R. Burns and Dolores Gomez Calvo. 2009 *Public Policy Paradgims: Theory and Practice of Paradigm Shifts in the European Union.* Peter Lang, Frankfurt/New York/Oxford, 2009

Chen, Katherine K. 2012. "Organizing Creativity: Enabling Creative Output, Process, and Organizing Practices." *Sociology Compass* 6(8):624–643.
Corte, Ugo. 2013. "A Refinement of Collaborative Circles Theory: Resource Mobilization and Innovation in an Emerging Sport." *Social Psychology Quarterly* 76(1): 25-51.
Csikszentmihalyi, M. 1990 "Society, culture, and person: Creativity." In: R.J. Sternberg (ed.). Cambridge: Cambridge University Press
Csikszentmihalyi, Mihalyi. 1999. "Implications of a Systems Perspective for the Study of Creativity." Pp. 313–38 in *Handbook of Creativity*, edited by R. J. Sternberg. Cambridge, England: Cambridge University Press.
Csikszentmihalyi, Mihalyi. 1998. Creativity and Genius: A systems perspective. In Andrew Steptoe (Ed.) *Genius and the Mind*. Oxford: Oxford University Press, pp.39-66.
Csikszentmihalyi, M. 1990. The domain of creativity. In M.A. Runco & R.S. Albert (Eds.), *Theories of creativity* (pp. 1990-212). Newbury Park, CA: Sage.
Csikszentmihalyi, Mihaly. 1996. *Creativity: Flow and the Psychology of Discovery and Invention*. New York: Harper Perennial.
Csikszentmihalyi, Mihalyi 1988. Society, culture, and person. A system view of creativity. In R.J. Sternberg The nature of creativity. (pp.325-339). New York: Cambridge University Press.
Collins, R. 2000. *The Sociology of Philosophies: A Global Theory of Intellectual Change*. Harvard University Press.
Farrell, M. P. 2001. *Collaborative Circles: Friendship Dynamics and Creative Work*. University of Chicago Press.
Firestein, S. 2014 "What scientists really do." New York Review of Books, 2014, October 23.
Florida, R. L. 2002. *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life*. Basic Books.
Florida, R. L. 2012. *The Rise of the Creative Class: Revisited*. Basic Books.
Gautam, S. 2012 "The Four P's of Creativity."
Geels, F. W. 2004 "From sectoral systems of innovation to socio-technical systems insights about dynamics and change from sociology and institutional theory." *Research Policy,* Vol. 33, pp. 897-920.
Geels, F.W. and Schot, J.W., 2010, 'The dynamics of transitions: A socio-technical perspective' in: Grin, J., Rotmans, J., Schot, J. in collaboration with Geels, F.W. and Loorbach, D., 2010, *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. London:Routledge, pp. 9-87
Gilfillan, S. Colum. 1935. *The Sociology of Invention*. Follett Publishing Co. Chicago.
Gilfillan, S. Colum. 1970. *The sociology of invention: an essay in the social causes, ways, and effects of technic invention, especially as demonstrated historicly [sic] in the author's Inventing the ship*. M.I.T. Press.
Gorny, E. (ed.) 2007 *Dictionary of Creativity: Terms, Concepts, Theories & Findings in Creativity Research.* Netslova, Russia. http://creativity.netslova.ru/Meme.html.
Hollingsworth, R. et al (2011) *Major discoveries, creativity and dynamics of science*, edition echoraum, Vienna
James, Henry. 1909. *Italian Hours*. Houghton Mifflin.
Joas, Hans. 1996. *The Creativity of Action*. University of Chicago Press.
Kaufmann, J. and R. J. Sternberg (Eds.), 2010 *The Cambridge Handbook of Creativ*ity (pp. 145-173). New York: Cambridge University Press.
Kevles, D 2013 "The Genes You Can't Patent", NYRB, September 26, 2013.
Lonnroth, M., P. Steen and T.B. Johansson 1977 Energy in Transition. Stockholm: Secretariat

for Future Studies (Published in 1980 by University of California Press).
Lonnroth, M., T.B. Johansson and P. Steen 1980 Solar versus Nuclear . New York: Pergamon
Lonnroth, M. 1978a "The Oil Peak and Beyond." Stockholm: Beijer Institute and Secretariat for Future Studies.
---------- 1978b "Energy Futures for Sweden." Stockholm: Secretariat for Future Studies.
Lubart, T.I. 1999 "Componential Models". In: M.A. Runco and S. Pritzer (eds.) *Encyclopedia of Creativity.* New York: Academic Press.
Luhmann, Niklas. 1995. *Social Systems.* Translated by John Bednarz, with Dirk Baecker. Stanford, Calif.: Stanford University Press.
MacKinnon, D.W. 1970 "Creativity: A Multi-faceted Phenomenon." In: J. Roslanksy (Ed.), *Creativity.* Amsterdam: North-Holland Publishing
Mooney, R.L. and T. A. Razik (Eds) 1967 *Explorations in Creativity*. New York: Harper and Row.
Mohr, P.J. and Barry N. Taylor 1998 "Fundamental Physical Constants" http://web.mit.edu/birge/Public/formulas/phys-const.pdf
Ogburn, W.F. 1922 *Social Change.* New York: Dell.
Parker, J. N. and U. Corte 2014 "Collaborative Creativity: Toward a Comprehensive Theory of Creativity from Groups to Fields." Ms.
Parker, J. N., and Hackett, Edward E. J. 2012. "Hot Spots and Hot Moments in Scientific Collaborations and Social Movements." *American Sociological Review* 77(1):21.
Parsons, Talcott. 1951. *The Social System*. Glencoe, IL: Free Press.
Parsons, Talcott. 1966. *Societies: Evolutionary and Comparative Perspectives*. Englewood Cliffs, NJ: Prentice-Hall.
Padgett, J. F. and Powell, W.W. 2012 *The Emergence of Organizations and Markets*. Princeton University Press: Princeton, NJ.
Puccio, G. J., & Cabra, J. F. (2010). "Organizational creativity: A systems perspective." In J. Kaufmann & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativ*ity (pp. 145-173). New York: Cambridge University Press.
Rifkin, J. 2011 *The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World*. New York: Palgrave.
Riggs, C. 2014 "Bull with wings." Review of D. Wengrow's *The Origins of Monsters*. TLS, September 12, 2014, p. 25.
Rhodes, M. 1961 "An Analysis of Creativity." *The Phi Delta Kappan*. Vol. 42, No. 7 (Apr., 1961): pp. 305-310
Roszkowska, E. and T. R. Burns 2010 "Fuzzy Bargaining Games: Conditions of Agreement, Satisfaction, and Equilibrium." Group Decision and Negotiation Volume 19(5), 421-440
Runco, M.A. and S. Pritzer (eds.) *Encyclopedia of Creativity.* New York: Academic Press.
Sawyer, R. K.. 2008. *Group Genius: The Creative Power of Collaboration*. Basic Books.
Sawyer, R. K. 2003. *Group Creativity: Music, Theater, Collaboration*. Psychology Press.
Sawyer, R. K. 2012. *Explaining Creativity: The Science of Human Innovation*. Oxford University Press.
Sciulli, D. 1992. *Theory of Societal Constitutionalism: Foundations of a Non-Marxist Critical Theory*. New York: Cambridge University Press.
Simonton, Dean Keith. 2004. *Creativity in Science: Chance, Logic, Genius, and Zeitgeist*. Cambridge University Press.
Simonton, Dean Keith Simonton. 1999 *Origins of Genius : Darwinian Perspectives on Creativity: Darwinian Perspectives on Creativity*. Oxford University Press.

Sterling, R. J. 1998 *Handbook of Creativity*. Cambridge: Cambridge University Press
Swidler, Ann. 1986 "Culture in Action: Symbols and Strategies." *American Sociological Review* 51(2):273.
Wallerstein, I. 2004. *World-Systems Analysis: An Introduction*. Durham, N.C.: Duke University Press.
Weisberg, Robert W. 2006. *Creativity: Understanding Innovation in Problem Solving, Science, Invention, and the Arts*. John Wiley & Sons.
Wengrow, D. 2014 *The Origins of Monsters.* Princeton: Princeton University Press.
Woodward, A..E., J. Ellig, and T. R. Burns 1994 *Municipal Entrepreneurship and Energy Policy: A Five Nation Study of Politics, Innovation, and Social Change*. New York: Gordon and Breach.
Woodman,R.W., J.E. Sawyer and R.W. Griffin 1993 "Toward a Theory of Organizational Creativity." *The Academy of Management Review*, Vol. 18, No. 2 (Apr., 1993), pp. 293-321