



A failure trichotomy in knowledge exploration and exploitation

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ABSTRACT

In this article, we review current rationales for policy intervention in innovative activities. Focusing particularly on market and system failure rationales, we disentangle related underlying mechanisms for knowledge exploration and exploitation. We provide a novel contribution to the system failure literature by distinguishing between system-level inertia and inhibited emergence. Our conceptualization of inhibited emergence draws on literatures related to neo-institutional sociology, the social construction of technology, and on organizational cognition and learning literatures, and it presents elemental socio-cognitive mechanisms that influence and direct knowledge exploration and exploitation in innovation systems. We compare related, yet theoretically distinct concepts of market failure, system-level inertia, and inhibited emergence, and show how each addresses distinct coordinative mechanisms and field-level dynamics and related socio-cognitive processes.

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1. Introduction

The notions of ‘market’ and ‘system’ failures are at the heart of modern interventionist innovation policies. Without some kind of failure, the need for interventions would be questionable. With the multiplication of policy interventions in the domain of innovation, theoretical notions of failure have proliferated in the academic literature. In this paper, we seek to re-introduce some order to this proliferation. We review and analyze the extant literature on ‘market’ and ‘systems’ failure and propose a novel way to categorize different failure types, based on the focus, theoretical provenance, and the level of analysis within which a given failure is thought to occur. Our review suggests distinctive underlying mechanisms for market failures, system-level inertia, and inhibited emergence in innovation structures.

Our categorization identifies market failures as occurring both at the level of individual economic actors (organizational level), as well as at the level of the economic system (system level). Regardless of the level at which they occur, market failures are typically conceived of as a failure of a given actor (or system) to invest in desired activities, such as research and development. Put simply, a market failure describes a failure to invest, with different types of market failure associated with different underlying causal mechanisms. In contrast, the systems failure literature is more concerned with the failure of a given organization or a given system to produce the desired innovation outputs. Rather than problems with incen-

tives to invest, the causes for system failures are typically ascribed to deficiencies in various processes that occur within the innovation system, as well as to systemic inertia. Because innovation processes are shaped by the structural context, the innovation systems literature has attached considerable interest to structural and regulatory deficiencies that exist within innovation systems. The systems failure literature has also discussed social and cognitive processes that inhibit innovation, notably at the organizational level. On the other hand, where the exploration–exploitation dichotomy has been widely discussed and studied at the organizational level (March, 1991), the same dichotomy is insufficiently developed at the level of the innovation system (Nooteboom et al., 2006), and much less attention has been given to social and cognitive processes that inhibit emergence at the level of the innovation system. Therefore, ambiguities remain in distinguishing between mechanisms that operate at different levels, their interactions, and the ensuing consequences for knowledge exploration and exploitation.¹

¹ In this paper we draw on the exploration and exploitation dichotomy in organization theory and address internal and external constraints and enablers that organizations face in research, innovation, and technology development (Leydesdorff, 2006; Nooteboom et al., 2006). Knowledge exploration focuses on new possibilities and unexplored properties, uses, and internal and external relationships of technologies. Knowledge exploitation is about exploiting existing technological trajectories, organizational competencies, and external knowledge resources, through innovation, imitation, technology transfer, development, and production. Innovation takes different forms and is constrained in different ways in these two modes. We consider innovation as encompassing the activities that contribute to the commercialization of technological knowledge. Focus on knowledge exploration and exploitation is critical for advancing our understanding of the mechanisms that inhibit emergence in innovation systems.

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Table 1
Market and systems failures in knowledge exploration and exploitation.

Failure synthesis	Sub-category outcome	Sub-category mechanisms
<i>Market failure</i>		
Markets will under-invest in knowledge production and knowledge use due to the inherent non-proprietary nature of knowledge and related risk in knowledge and technology exploration	Underinvestment in knowledge production	Uncertainty and risk in R&D activities Failure to appropriate returns to innovation and new knowledge Public-good nature of knowledge
	The failure of the price mechanism to correctly reflect the externality benefits of technologies and innovation	Failure of the market mechanism to assign full value to externalities: (1) public good externalities (technological and infrastructural); (2) merit goods and service externalities; (3) pecuniary good externalities Undervaluation of public good benefits of technologies High transaction costs, high up-front investments, and non-excludability of public good type technologies and infrastructural technologies
<i>Systems failure</i>		
System-level inertia Institutional inertia, structural deficiencies, and lock-in to established externalities inhibit efficient (from a welfare-economic perspective) knowledge exploration and exploitation.	Deficiencies in innovation infrastructure and institutional setting	Divergent strategies among specialized functions and agents
	Structural inertia of organizations: failure of firms to learn about or take stock of emerging technological opportunities	High transaction costs for engaging in knowledge exploration and exploitation in novel technology field Established capabilities and related sunk costs in both human, organizational, and physical resources become obsolete, when technological discontinuities are competence-destroying, or when new technological knowledge arises in domains unrelated to incumbents Lack of supportive dynamic capabilities Path dependent information processing mechanisms Inability of management cognitive models to support efficient learning in the new domain
Inhibited emergence Inhibited institutional emergence due to socially and institutionally constrained sense-making, collective experimentation, learning, and discovery within innovation, production, and technology use structures	System-level inertia and lock-in: failures of innovation system and supportive structures to productively re-organize/adapt to paradigmatic technological change	Technological lock-in and path-dependencies: learning externalities, resource dependencies, sunk costs and switching costs, and information processing mechanisms Institutional effects Unproductive favoring of either exploration or exploitation of technological knowledge Asynchronous adaptation and development of innovation system constitutive elements High cost and risks associated with exploratory reconfigurations of institutions and networks
	Inhibited emergence of inter-organizational structures: established interrelation orders constrain sense-making and exploration processes, and hence, inhibit institutional emergence	Incumbents and established institutional structures dominate learning and knowledge-creation processes The institutional structure and its sunk costs and quasi-rents inhibit role renegotiation Knowledge disconnects and asynchronicity due to established role expectations in exploration and exploitation Socio-political and cognitive legitimacy constraints of new entrants results in inability to enhance structuration and change Individuals, organizations, and their respective institutional bases experience different time lags in perceiving the advantages of new ways of organizing Asynchronous sense-making by different actors contributes to failure in establishing a dual experimentation and exploitation mode in innovation systems
	Inhibited emergence of technology: Established technological structures constrain productive social construction and structuration of technology and hence inhibits technology field emergence	Constraints by existing mental models that are reinforced by prevailing institutions concerning technology use and production Distinct institutional roles and commitments by actors produce divergent translations of technology, as actors do not adequately connect their sense-making activities Perceptions of technological opportunities and limitations directed by current practice Constraints by existing value systems and institutions, may develop limited understandings of technological opportunities and respective roles of actors in the emerging social order of technology use Supportive exemplars, actors and role models for guiding innovation not present Failures in generating productive forms for collective sense-making and structural exploration

In this paper, we seek a novel contribution to the literature on market and system failures by distinguishing between system-level problems associated with inertia, on the one hand, and inhibited emergence, on the other. We define inhibited emergence as

socially and institutionally constrained sense-making, collective experimentation, learning, and discovery at the level of the innovation system. We propose that while the literature on innovation systems in particular has drawn extensively on the institutional

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