

Innovative activity, uncertainty and the theory of the firm

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‘[C]hange is the condition of uncertainty’ (Knight, 1921, p. 48).

‘It seems improbable that a firm would emerge without the existence of uncertainty’ (Coase, 1937, p. 40).

Abstract

The inability to predict the future impact of innovations generates surprise and inconsistency of expectations, thereby giving rise to substantive uncertainty. In this paper I concentrate the analysis on organisational coordination as a rational response to uncertainty stemming from innovative activity. Business organisations, consisting in firms or hybrid forms, are particularly suited to meet radical uncertainty because they possess reserves and establish relational agreements that increase flexibility. Thus on the one hand, business organisations are constituted by assets, such as equipment, warehouses and capabilities, that may represent useful reserves to face unpredicted contingencies. On the other, business organisations are grounded on long-term relational agreements that allow mediation among the organisation’s stakeholders, provision of incentives, simplification - through routinised procedures, division of labour and sequential aiming - and learning. Under substantive uncertainty, the entrepreneurial ability to look for and create opportunities becomes a crucial factor in determining a competitive advantage.

The paper is structured as follows. The first section is dedicated to the relationship between innovative activity and uncertainty. Sections 2 and 3 address the various ways adopted by business organisations to cope with substantive uncertainty. Finally, Section 4 focuses on the main implications for the theory of the firm of the coexistence of different degrees of uncertainty and kinds of rationality, according to the level of agents’ abilities in relation to the specific problem to be faced.

1. Innovative activity

1.1 Innovation as a source of uncertainty

Innovative activity is a source of substantial radical uncertainty since it creates the possibility of unexpected outcomes. Admittedly, technical change that leads to constant increases in production due to in-firm learning curves may easily be predicted on the basis of past experience.

However genuine innovations are characterised by a high degree of uncertainty. Post-invention applications and improvements are at first very difficult to forecast and or even imagine because

judgments about feasibility of an activity a novel kind are ‘subject to hazards.’¹ But ‘even after their technical feasibility has been established’ the inability to anticipate the future impact of innovations may still remain (Rosenberg, 1996, p. 334). Examples of innovation that have experienced an unexpected striking success or, by contrast, a serious failure abound.

Among successful innovations whose economic impact was long overlooked, even for decades, and which have led to completely unexpected utilisations, a classic case is that of the laser, for which very different uses have been developed than those initially imagined – for instance in precision measurement, navigational instruments, chemical research, surgery, the textile industry, laser jet printers and telecommunications (Rosenberg, 1996, p. 334). In the case of telecommunications, application of the laser together with fibre optics has dramatically increased the number of conversations carried simultaneously through a telephone cable (from 139 in the mid 1960s, prior to the development of lasers, to 1.5 million in the early 1990s once fibre optic cables were installed). And yet, as reported by Charles Townes, who subsequently won a Nobel Prize for his research on the laser, Bells Labs were initially ‘unwilling even to apply for a patent on the laser, on the ground that such an invention had no possible relevance to the telephone industry’ (Rosenberg, *op. cit.*, p. 336). Other famous cases of successful innovations include the steam engine and the radio. The steam engine ‘was invented in the eighteenth century specifically as a device for pumping water out of flooded mines’ and, for a long time, was regarded as a pump. Analogously, the inventor of the radio, Guglielmo Marconi, considered his invention as a device to communicate between two points, as in ship-to-ship or ship-to-shore communications (Rosenberg, *op. cit.*, pp. 337, 345, 348).²

¹ Winter (2005, p. 235). See also Harper (1996, pp. 3-21, 81-93, 295-350); Metcalfe (1995, p. 26). On the relationship between radical uncertainty and innovative activity based on the production of scientific knowledge, see Moroz (2005, pp. 305ff.).

² The first successful experiments using electromagnetic waves were carried out by Guglielmo Marconi in his house in Pontecchio near Bologna in 1894 when he was twenty years old. In his country he found no support for his invention. As a consequence, the following year he left Italy and went to Great Britain, hoping to find a better environment for the development of his

The dynamics of the commercial aircraft industry provide numerous examples of technological radical uncertainty.³ As far as unpredicted failures are concerned, one can cite the infamous case of the failure of De Havilland – the maker of the Comet aircraft – after several crashes due to an unforeseen problem of metal fatigue that culminated in a structural flaw affecting the cabin. Not only was the metal fatigue of the fuselage totally unexpected, but it was not understood for quite sometime even after the three major accidents which occurred within a single year just a few months apart.⁴ Cases in which there is uncertainty about the quality of new products are rather frequent, albeit fortunately much less dramatic, in many industries. For instance, in the encryption software industry (e.g. the anti-virus and security system industry), it is only after proven resistance against several attacks that the product can be considered effective (Giarratana, 2004, p. 792).

In general, there are at least three overlapping sources of substantive, or Knightian, uncertainty deriving from the features of innovative processes:

1) New technologies ‘come into the world with properties and characteristics whose usefulness cannot be immediately appreciated’ (Rosenberg, *op. cit.*, p. 340).

experiments. With the help of his mother’s English relatives, he was introduced to Sir William Peerce, chief engineer of the British Mail Service, who fully understood the importance of Marconi’s invention. The first radio patent was issued in London in 1896. The invention of tuning was patented by Marconi in London in 1899.

³ On this see Bonaccorsi (1996: part two).

⁴ Bonaccorsi (1996, pp. 123-6); Giuri (2003, p. 102). In 1952 the Comet successfully passed extensive test flights and obtained permission for commercial flights. Problems began one year later when a Comet crashed. Four months later, another Comet mysteriously crashed shortly after take-off. Scientists and engineers who examined a section of the fuselage and miscellaneous other parts of the crashed aircraft concluded that there appeared to be no justification for placing restrictions on the Comet aircraft. A third similar crash three months later forced the British authorities to ground Comets and perform a thorough investigation on these incomprehensible accidents. Simulations in a water tank showed that the fuselage metal suffered from fatigues cracks - starting from the corner of a window atop the aircraft where the radio aerials were housed - after being repeatedly pressurised and depressurised to represent thousands of take-offs and landings corresponding to 9,000 flying hours.

2) The impact of an innovation and its large-scale commercial uses depend on improvements that take place in ‘complementary inventions.’⁵

3) Many major inventions had their origins in the attempt to solve specific problems. ‘However, it is common that once the solution has been found, it turns out to have significant applications in totally unanticipated contexts’ (Rosenberg, *op. cit.*, p. 345).

These three features of innovative activity bring about substantive uncertainty because the possibility of unanticipated consequences prevents agents from knowing future pay-offs. Substantive uncertainty implies incomplete theoretical knowledge of the list of possible outcomes and therefore the impossibility of computing any probability distribution of future contingencies.⁶ In these circumstances, the outcome cannot be predicted as it represents a novelty for the decision makers. Since substantive uncertainty refers to a situation that may change in an unexpected manner, it is independent of personal abilities to process information.⁷ Substantive uncertainty can arise even if individuals could make full use of present knowledge thanks to complete information processing abilities.⁸

⁵ Rosenberg (*op. cit.*, pp. 342-5), for further evidence see Rosenberg (1990, p. 169).

⁶ In his theory of the firm, Knight (1921, pp. 20, 233) distinguishes between ‘measurable uncertainty’ (probabilistic risk) and ‘unmeasurable uncertainty’ (‘true uncertainty’). Coase (1937, pp. 40-1, 48-51) explicitly refers to ‘difficulty of forecasting’ but observes that Knight fails to make clear the existence of the cost of using the price mechanism and the advantages provided by the firm’s coordination in superseding the price mechanism. On this, see the comment in Slater and Spencer (2000, pp. 63-5).

⁷ For the definition of substantive uncertainty see Dosi and Egidi (1991, pp. 183-5). Substantive uncertainty corresponds to what the Post Keynesians term fundamental uncertainty linked to the intrinsic transmutability of the environment. See Davidson (1996, p. 482), Dequech (1999, pp. 415ff.); Dunn (1999, pp. 204-5, 212, 2000, pp. 346ff.).

⁸ Dunn (2001a, p. 568, 1999, pp. 204, 212). For the sake of simplicity, I do not consider here procedural uncertainty, which is caused by an insufficient level of information processing ability in relation to the degree of complexity of the situation. Procedural uncertainty may be due to inability to frame problems through selection of the relevant variables, to compute, order or assess phenomena or simply the inability to take into account possible outcomes that are nevertheless known. On the distinction between procedural and substantive uncertainty within the wider concept of radical uncertainty, see Dosi and Egidi (1991, pp. 183-5); and Morroni (2006, pp. 55-70).

Whenever the menu of choices is not fully known a priori by the decision makers but must instead be learned, creative learning may yield unexpected events and heterogeneous individual knowledge.⁹ An endogenous creation of a novelty causes incomplete theoretical knowledge in that a party may be surprised by unexpected actions of other agents. Indeterminacy of outcomes is linked to interdependence and subjective reaction. In fact, which action is optimal for one individual depends on the behaviour of the individual's opposite party, but under heterogeneous knowledge it is impossible to predict the behaviour of the opposite party, whose reactions are unavoidably based on subjective interpretation of private information. The interaction between experience of external facts and other people's actions is a continuous and never-ending process (Hayek, 1937, p. 61).

1.2 Creating new opportunities

The existence of heterogeneous abilities among individuals gives rise to the possibility that an individual or a single business organisation may discover or invent opportunities that are not yet perceived by others. Thus whoever exploits new opportunities reaps the potential benefits. In most circumstances involving radical uncertainty, individuals not only try to identify existing opportunities that are not yet perceived by others, but they also attempt to broaden the set of available alternatives and to create new opportunities. In the latter case, learning brings about the potential introduction of a genuine novelty. The discovery of new opportunities involves 'only differential access to existing information', while the creation of new opportunities implies the generation of new information and knowledge.¹⁰ Under radical uncertainty, learning consists in a

⁹ Dosi and Egidi (1991, p. 168); and Loasby (1999, p. 5).

¹⁰ Shane (2003, p. 20). The discovery process has been emphasised by NeoAustrian theorists; see, for instance, Harper's (1996, pp. 15-9, 89) critical exposition of Kirzner's (1989, pp. 20ff.; 1997, pp. 3ff.) and Casson's (1982, pp. 146-8, 201) theories of entrepreneurship. With regard to the process of creating alternatives, see also Penrose (1959, pp. 31-2, 52-6); Simon (1987, p. 292); Davidson (1991, 1994 and 1996); Freeman (1994); De Vecchi (1995); Malerba and Orsenigo (1995); Ebner (2003, pp. 130ff.); Balabkins (2003, pp. 209ff).

process of identification, discovery or creation of profit opportunities. It is an intentional process of exploring new possibilities and evolving capabilities. The firm's capabilities are the abilities to produce and sell specific goods or services that satisfy potential demand, according to the firm's specialisation and knowledge capital. They are potentialities that can be triggered in specific contexts and result from coordination and accumulation of the individual abilities possessed by the members of the business organisation.

On account of the high degree of unpredictability that surrounds the outcome of basic research in many important sectors of activities, 'large firms may be more willing to undertake basic research when they have a diverse range of products and strong marketing and distribution networks that increase their confidence that they will eventually be able to put the findings of basic research to some good commercial use' (Rosenberg, 1990, p. 168). Moreover, basic research is a long-term investment which usually requires stable commitments and long-term planning that may be better provided by large firms with a strong market position. Quite often, the commercial success of an innovation is favoured by the possibility of making huge investments in R&D for product improvement.¹¹ Therefore new business initiatives, grounded on basic research, learning processes and the development of capabilities, are generally carried out by large firms. This is, in fact, the case of most new business generated during the last decades of the twentieth century, which was created and built up by existing enterprises, 'and in large part by big or at least fair-sized ones.'¹² However, despite acknowledgement of the essential function of corporate entrepreneurship, it should not be overlooked that, in some new technologies where economies of scale do not play a major role and there are low entry barriers,

¹¹ Evangelista (1999: part two) provides an empirical analysis of the impact on innovative activity of knowledge-generating activities, such as R&D and design, and new technologies embodied in fixed capital.

¹² Drucker (2003, p. xi). The generation of new business by existing enterprises have been analysed in Sathe (2003).

start-up firms have a prominent role in the development of innovations. In effect, creative and innovative activities can be favoured by the absence of rigid and hierarchical relationships, a circumstance that enhances diversity of options and tolerates variety.¹³ ‘In exploring unknown territory’ to the goal of better technologies, ‘multiple sources of decisionmaking’ formed by numerous small business organisations are essential. This explains why innovations are often associated with multiple organisations or new entry to a field.¹⁴ Various studies in innovative industries confirms the importance of small firms in opening new markets where scale economies are insignificant and large incumbents have low incentive to invest.¹⁵ As remarked by Bower and Christensen (1995, p. 51), in cases of disruptive technologies, which imply radically new approaches, ‘small ...organizations are good at placing economical bets, rolling with the punches, and agilely changing product and market strategies in response to feedback from initial forays into the market.’

In the United States, this important role of new small firms and independent entrepreneurship has been powerfully conditioned by favourable environmental conditions, in particular, the government’s anti-trust posture,¹⁶ policies that lowered entry barriers, liberal licensing practices (as in the case of semiconductor patents), tolerance of a high degree of interfirm mobility on the part of highly skilled personnel, huge federal funding for research labs, in addition to the rise of the venture capital industry as one of the major innovations in the financial sector. Last but not least, it is important to note the economic role of American universities in developing research projects which have led to useful industrial applications, and

¹³ Rosenberg (1990, p. 168); cf. Giarratana (2004, pp. 788, 799). On innovation and decreasing returns to hierarchy, see Screpanti (2001, pp. 239-41, 249-50).

¹⁴ Rosenberg (2002, p. 36, *passim*). See also Loasby (1995, p. 472, and 1999, p. 27).

¹⁵ Giarratana (2004, p. 804).

¹⁶ Rosenberg (2002, p. 8). For a description of competition laws in the United States and in the European Union, and for a general discussion on anti-trust policy, see Motta (2004: chapter 1).

in providing qualified researchers who have created high-tech firms. Quite often, new innovative firms have been created by academic entrepreneurs supported by a financial commitment from venture capital firms.¹⁷ In many hi-tech industries, this has resulted in a complex division of labour characterised by a large population of start-ups and few larger firms. ‘Large established firms tend to act as incubators of technological competencies embedded in the future entrepreneurs’ (Giarratana, 2004, p. 804). Many high-tech industries are characterised by ‘investments by large firms in promising startup firms, joint ventures and licensing and, in some cases, the acquisition by large firms of small, promising startups.’¹⁸

Giarratana (2004, pp. 788, 798-9) has highlighted that in some innovative sectors of activity, characterised by low entry barriers, the capabilities that allow firms to enter in a market and survive in the first place are completely different from those yielding firm growth. What drives firm entry is mainly the ability to combine specialised knowledge in a particularly distinctive innovative product with information about consumers’ actual or potential needs. In contrast, what drives young firms’ growth is product differentiation (by tailoring products on customer preferences), investment in co-specialised assets and technological alliances. ‘Tailoring products on customer preferences’ with product differentiation allows the exploitation of economies of scope, ‘favours the reduction of sales uncertainty and the achievement of higher market share’ (*ibid.*).

2. Coping with uncertainty within business organisations

Substantive radical uncertainty stemming from innovative activity may be mitigated both within markets and within organisations. In markets substantive uncertainty is tempered by means of special contracts, which imply screening, signalling, monitoring, incentives, or by the action of organisations that ensure information, enforcement, regulation and dispute resolution activities.

¹⁷ Rosenberg (2002, pp. 9, 36, 38-9, *passim*).

¹⁸ Rosenberg (*op. cit.*, p. 33). See also Arora and Gambardella (1994, pp. 528-9).

It is beyond the scope of this paper to consider the various ways of mitigating radical uncertainty within markets.¹⁹ Rather, this paper focuses on organisational coordination as a rational response to substantive uncertainty. Organisational coordination may take place both within individual firms as well as hybrid organisations. A firm is a social organisation and an autonomous legal entity that produces and sells goods or services by means of a set of human, physical and financial resources that are coordinated, combined and monitored under an administrative structure. Hybrid forms between the market and an organisation consist in cooperative agreements among legally autonomous firms (such as strategic alliances, franchising, collective trademarks, partnerships) which do business together ‘sharing or exchanging technologies, capital, products, and services, but without a unified ownership’. ‘Hybrid organizations exist because partners need to develop coordination, which requires interdependent investments.’²⁰

Within business organisations, uncertainty is limited and its costs reduced through the accumulation of reserves and the settling of long-term relational agreements.

2.1 Reserves

In the first place, business organisations, consisting in firms or hybrids forms, may face unpredicted contingencies by organising reserves. These are constituted by assets, such as equipment, warehouses and capabilities, that may represent reserves useful to prepare for an uncertain future.

Raw materials and intermediate products in inventories represent buffers that increase flexibility and make it possible to deal with any unexpected and temporary imbalance.

¹⁹ On the various ways of mitigating uncertainty within markets, see Morroni (2006, pp. 189-98).

²⁰ Ménard (2004e, pp. 348, 357); cf. Richardson (1972, p. 142); Spiller and Zelner (1997, pp. 562-3).

Moreover, multi-person business organisations can differentiate between activities, so that hazard can be shared among the various activities ‘without jeopardising the future of the business if particular methods or products are unsuccessful’ (Pratten, 1988, p. 12). This means that the cost of uncertainty in devising new markets can be reduced.

A further way in which business organisations decrease the cost of substantive uncertainty and increase flexibility is by embracing various individual abilities. The presence of different kinds of abilities provides ‘a reserve when the list of future contingencies cannot be closed.’²¹

2.2 Relational agreements

Both autonomous firms and hybrids enter into various relational agreements that represent a route to flexibility. Among various relational agreements established by these business organisations one can mention partnership contracts among professionals, cooperation contracts among workers in a cooperative, governance and licensing contracts or franchise agreements, durable-subcontracting relationships and the employment contract that is adopted within individual firm.

When complete contracts are too costly or impossible, parties settle for relational agreements that frame their relationship over time. Usually only a few obligations and expectations concerning relational agreements are explicit and written in contracts or in ethical and behavioural codes, while most are implicit. The temporal dimension, associated with expected duration, is an essential element of the relational agreement and contracts, although the expected duration of a relational contract may vary. Some relational contracts are unlimited in time, such as tenure in the employment contract; others are automatically renewed unless one or other of the parties terminates the contract by giving notice, such as supply contracts, or rent

²¹ Loasby (1998, p. 176); see also Penrose (1959, p. 94); Arrow (1973, p. 147).

contracts; still others have a temporary duration at the end of which a renewal is not guaranteed - e.g. research contracts, temporary employment contracts, etc.

As summarised in Figure 1, long-term relational agreements, within autonomous firms or hybrid forms, reduce the degree of radical uncertainty in that they enhance:

- 1) coordination and motivation,
- 2) simplification,
- 3) learning processes.

It is worth examining these three aspects individually.

INCLUDE FIGURE 1 AROUND HERE

2.2.1 Coordination and motivation

Coordination and motivation are achieved through mediation activity in conflicts of interest, indication of common aims, creation of rules, and monitoring activities, as well as the provision of incentives that boost loyalty and reduce opportunism, foster trust and generate identification (Figure 1). Continuous association is a powerful force for reducing inefficiencies that arise from moral hazard, as they create solidarity and the accumulation of experiences that develop trust and therefore create stable expectations of the members' behaviour. The desire to maintain a good reputation and to continue the relationship is another factor that enhances a climate of commitment, mutual loyalty, cooperation and trust. Trust is an essential element within organisations because organisations cannot function effectively if all their members do not develop mutual confidence.²²

Long-term relationships enable the organisation to assess performance more accurately. An appropriate structure of incentives favours motivation and the creation of shared goals and

²² Simon (1991, p. 41); Hodgson (1993, p. 90); and. (Loasby, 1999, pp. 101, 105).

responsibility; it also fosters cooperation and facilitates the transmission of information and the development of a common language, principles and rules.²³

The opportunity to check reliability over time, effective control, incentive structures and management of conflicts of interest through mediation activity can eliminate, or at least substantially mitigate, internal influence costs that spring from the attempt by one contracting party to misrepresent, manipulate and distort information (Milgrom and Roberts, 1992, pp. 167, 179, 192-6). In particular, participation in aims on the part of the members of the firm or the hybrid form are crucial in overcoming information failures.

As far as hybrids are concerned, opportunism is deterred and enforcement is achieved by extra-contractual tools and informal aspects such as reputation (based on continuity and recurrent transactions), mutual dependency, identification of shared goals among partners and social similarities.²⁴

There are a multitude of hybrid organisational forms mid-way between the market and the firm that tend to reduce uncertainty by enhancing the transmission of information, as well as offering enforcement power and organisational safeguards for specific investment. Examples abound. Rupert Murdoch's media empire is based not on owning physical assets, but on crafting 'ingenious contracts that have given influence over an effective network of media players' (Holmström and Roberts, 1998, p. 85). The Japanese system of outsourcing rests on long-term, close relationships with a limited number of independent suppliers who often belong to one and the same association, as in the case of Toyota suppliers. A small number of suppliers

²³ For excellent overviews on motivations and incentives, see Milgrom and Roberts (1992: chapters 6, 7, 11, 12 and 13); MacLeod (1995, pp. 3ff.); Prendergast (1999, pp. 7ff.); Gibbons (1998, pp. 115ff.); and Baron and Kreps (1999: chapters 5, 10-12, appendix C); Meccheri (2005, pp. 55ff.).

²⁴ Ménard (2004e, pp. 357-8, 362-6, *passim*); Loasby (1994, vol. II, pp. 299-301); de Jong and Nooteboom (2000, p. 12). Sako (1992) provides theoretical and empirical analysis on the link between the type of buyer-supplier relations and corporate performance. She argues that the trust and interdependence present in many Japanese firms, obtained through obligational contractual relations, can be a powerful springboard from which to achieve corporate success.

permits comparative performance evaluation, keeps the cost of monitoring low and increases the frequency of transacting. Other examples are franchising contracts; mutual dependence as in the case of a single supplier; or inside contracting, i.e. utilising the labour services of employees of subcontractors. Repeated interaction, interdependence, and organisational coordination allow information transmission to function fairly well even without unified ownership. Many hybrid organisations are characterized by ‘highly frequent transactions with highly specific investments under conditions of great uncertainty but deliberately forego the opportunity of vertical integration and often do not develop other classical safeguards against the hazards of opportunism.’²⁵ Moreover, forms of collaboration within networks of firms include practices that are generally considered highly vulnerable to opportunistic behaviour, such as broad open-ended contracts and heavy investment by suppliers in customer-specific assets, or joint product design efforts. In durable-subcontracting relationships, the interest in maintaining and renewing the joint activity leads to the creation of organisational mechanisms of reciprocity that guarantee loyalty so that concerns about ‘hold-ups’ do not prevent collaboration between individuals and organisations.²⁶ Firms can develop trust and collaboration over time by starting with small common projects scarcely vulnerable to opportunism, moving little by little to bigger subsequent projects that require specific investment. The example of the automobile industry is fairly clear: the success of Japanese firms in the US and the adoption of many Japanese practices in the US ‘makes it difficult to argue that vertical integration or detailed contracts’ are the only way to support collaboration, learning and innovation (Helper, MacDuffie and Sabel, 2000, pp. 451, 471-4).

²⁵ De Jong and Nootboom (2000, p. 12); cf. Holmström and Roberts (1998, p. 92).

²⁶ Loasby (2004, pp. 270-1); Helper, MacDuffie and Sabel (2001, p. 449); de Jong and Nootboom (2000, p. 13).

2.2.2 Simplification procedures

Long-term relationships within business organisations, i.e. within individual firms or hybrids, allow substantive uncertainty to be mitigated through simplification. Simplification consists predominantly in: i) adopting routinised operating procedures; ii) sub-dividing problems and activities through division of labour; iii) implementing adaptive behaviour by arranging goals in sequence and using performance feedback systems.

A) ROUTINES

A possible and, indeed, a very common uncertainty-decreasing strategy consists in applying organisational routines, which enhance coordination and predictability.

Organisational routines are recurrent interaction patterns learned by an organisation. They constitute the building blocks of the firm's competencies and capabilities.²⁷ Routines rest on skills that allow the members of the organisation to perform coordinated tasks in a highly relational and organisation-specific way. Under this perspective, skills are understood as 'quasi-modular components of routines' (Dosi, Nelson and Winter, 2000a, p. 4).

Organisational routines are a key repository of both tacit and explicit knowledge. As argued by Nelson and Winter (1982, p. 99), 'the routinization of activity in an organization constitutes the most important form of storage of the organization's specific operational knowledge.' Organisational routines capture collectively-held knowledge possessed by the organisation and can be inherited throughout the life of organisations as generations of members come and go (Becker, 2004, p. 660; Baum and Singh, 1994a, p. 7).

Organisational routines enhance coordination and predictability for a number of reasons. Not only do they support a high level of simultaneity and make simultaneous activities mutually consistent, but they also give stability to the practices of a team and provide each of the members

²⁷ On the role of routines in the theory of the firm see March and Simon (1958, pp. 160-1) and Cyert and March (1963, pp. 109-13). Nelson and Winter (1982, pp. 99-100, 160-1); Winter (1988, pp. 184, 189); Dosi, Nelson and Winter, (2000a, pp. 4-5); Rura-Polley and Miner (2002, pp. 275-6); Becker (2004 and 2005).

of the organisation with knowledge of the behaviour of the others on which to base his/her own decision.²⁸ Last but not least, they establish a truce among the various members of the organisation (between team members and between managers and employees) who may have potentially conflicting interests (Nelson and Winter, 1982, pp. 107ff.).

Organisational routines are characterised by stability and mutation, at the same time. Stability, in terms of 'stable sequence of interactions'; and mutation represented by incremental adaptation to experience 'in response to feedback about outcomes' (Becker, 2004, pp. 649-53 *passim*). In fact, on the one hand, organisational routines 'take place when search has been eliminated, i.e. when the individual learning process stops' (Egidi and Rizzello, 2003, p. 11); on the other, organisational routines themselves are context dependent and subject to transformations through learning processes because they evolve in an adaptive and creative manner whenever environmental conditions change. 'Routines are not inert', but typically change incrementally over time due to an internal dynamic deriving from the participants' response to the outcomes of previous iterations of a routine. This two-fold nature is only apparently contradictory. Indeed there is a link between routinisation and change because stability and simplification constitute preconditions that facilitate learning and mutation by freeing up limited cognitive resources. In other words, 'stability provides a baseline against which to assess changes.'²⁹ Arguably, technical change can be regarded as the generation of new organisational routines (Dosi and Egidi, 1991, pp. 183-5).

B) DIVISION OF LABOUR

The second aspect of simplification is division of labour. Division of labour is a simplifying tool because it reduces the individual abilities required and makes saving on learning processes possible. Organisations solve complex problems by decomposing them recursively into sub-

²⁸ See Becker (2004, p. 654); Heiner (1983, pp. 370ff.); and Hofstede (1980, pp. 155-61).

²⁹ Becker (2004, pp. 649-51, 657-9, *passim*).

problems that can be solved more easily by different functional sub-systems of the firm.³⁰ Division of labour not only favours better use of existing individual abilities, but it also promotes the creation of new abilities that influence the innovative activity.³¹

Division of labour requires intentional coordination of the individual abilities of the firm's members by the management, in order to ensure cooperation and distribution of tasks. Coordination is particularly important whenever division of labour fosters innovative activities that are disruptive of the existing organisation and tend to break the stable patterns of routines (Loasby, 2002, p. 46). In a situation of complex interdependence and rapid unanticipated changes, centralisation and the extensive reliance on fiat appear to be inadequate because they may encourage perfunctory compliance rather than consummate performance. Consummate performance is a matter of taking the initiative to advance organisational objectives in a way that goes much beyond minimal effort based on self-interested calculation.³² In such a context, there is then the need for coordination among specialised roles and active participation in decision-making processes on the part of the organisation's members.

C) SEQUENTIAL AIMING

The third aspect of organisational simplification is sequential aiming. Sequential aiming consists in sequential attention to goals that allows adaptive decision-making on the basis of performance feedback. It can in effect be regarded as a simplifying behaviour that identifies aims and adjusts

³⁰ Egidi (1992, pp. 8-12, 2002, p. 110); Egidi and Rizzello (2003, p. 8); Loasby (1998, p. 178); and Ricottilli (2001, p. 4). See also Levinthal and March (1993, pp. 95ff.); Ramazzotti (2004, pp. 38ff.).

³¹ On the relationship between division of labour and innovation, see Rosenberg (1965, pp. 131-9); and Loasby (1999, pp. 131-2, 2003, p. 15).

³² Simon (1991, p. 32); Freeland (1996, p. 513, 2001, pp. 25, 312).

intermediate goals to reality on the basis of information springing from the organisation itself and from the environment.³³

Sequential aiming within business organisations simplifies individual decision-making because it helps their members to discern and pursue specific aims. It can be seen as a two-phase process:

1) Picking out aims and dividing them into intermediate goals or targets, thereby setting aspiration levels; breaking problems down into parts; establishing a particular operational and cognitive division of labour; looking for suitable information and choosing the appropriate means.

2) Determining a particular sequence of time horizons (or planning horizons) on the basis of an aspiration level and intermediate goals that have been identified; implementing performance feedback systems.

In the first phase, the identification of goals and targets is characterised by the coexistence of two attitudes:

a) *passive adjustment* based on assessment of past results or on the past performance of similar business organisations;

b) *active reaction* by identifying new aims that trigger a process of change.

The truly distinctive feature of adaptive behaviour within the firm is the tension between adjustment and innovation.³⁴ Innovative activity may constitute an attempt to overcome the existing trade-offs among conflicting aims. If abilities are heterogeneous, the propensity and ability to innovate varies amongst individuals even in the same environmental conditions.

³³ On sequential decision making, see Lewin et al. (1944, pp. 333ff.); Simon (1955, pp. 244, 248-53, 1959, p. 297, and 1972, p. 415); Cyert and March (1963, pp. 34ff., 118ff.); March and Olsen (1975, p. 335); Kahneman and Tversky (1979, p. 32); Herriott, Levinthal and March (1985, p. 219); March (1988a, pp. 3, 11, 1997, p. 12); and Greve (2003).

³⁴ On the coexistence of adaptive and innovative attitudes, see: Bianchi (1990, pp. 164-5); Sabel and Zeitlin (1997, pp. 5-6); Hodgson (1998, p. 179); Runde (1998, p. 14 fn. 19).

The second phase of the sequential aiming process is the determination of a particular sequence of time horizons within which the process of increasing benefits and reducing costs takes place. This second phase consists mainly in the implementation of performance feedback applied to each subsequent period of time (Greve, 2003, pp. 39ff.). Sequential aiming, through performance feedback, reduces the negative effects of substantive uncertainty because it facilitates:

- ❖ learning processes;
- ❖ flexibility in terms of adjustment, over time, of individual decisions to changing conditions;
- ❖ reduction of the effects of evaluation and forecasting errors.

If environmental conditions are extremely volatile and uncertain, business organisations tend to arrange aims and targets in a sequence, determining the time horizon of each aim and goal and thus deciding when an action should cease. Goals change because preferences may, and usually do, change on the basis of personal experience and according to the evolution of environmental conditions. The present is linked to the future by the ability to plan and form mental images of possible future events on the basis of a creative re-elaboration of past experience (Ingvar, 1985, pp. 127-9). Planning, imagining and anticipating a 'world of the possible' is a specific human characteristic, linked to the organisation's ability to innovate and create new opportunities.

2.2.3 Organisational learning

The development of capabilities through creative learning within business organisations is a way to cope with substantive uncertainty. Creative organisational learning consists in an intentional process of expanding capabilities and exploring new possibilities that involves a change in production techniques, i.e. in the method of production and/or in the quality of goods produced, but it may also be accompanied by a change in market conditions. The higher the rate of innovation in the markets in which firms operate, the more important learning becomes in order

to create, maintain and renew the competitive advantage. Organisational learning is driven by ‘the search for a better performance in a continuously changing environment.’³⁵ In a changing environment, business organisations have an interest in advancing knowledge because they are aware that the ability to learn is the most enduring source of competitive advantage.³⁶ They enhance internal learning, even in the case of non-tradable information and knowledge, because they overcome the lack of interest in transmitting the relevant information between individuals through the identification of common goals; moreover, they are able to offset the impossibility of transmitting tacit knowledge by the internal creation of non-explicit knowledge based on experience. Though tacit knowledge cannot be transmitted either within the market or within organisations, it can be *created* within organisations through an interaction among their members in a ‘generative relationship’ that develops their knowledge, skills and performance (Hodgson and Knudsen, 2003, pp. 9-11). Business organisations favour the creation of tacit knowledge by giving access to activities that enable individuals to acquire the necessary experience through learning by doing and learning by using. Learning by doing and by using lead to an increase in productivity as the total number of units produced increases over time.³⁷

The tacit dimension of knowledge is present, more or less, in all production processes and in particular in innovative activities. Nonaka and Takeuchi (1995, pp. ix, 9-10) have pointed out that creative learning processes within organisations lie in social interaction between tacit knowledge, which is rooted in experience, and explicit knowledge, which can be expressed in words and numbers. Organisational learning consists in a continuous and dynamic interaction

³⁵ Dosi and Marengo (1994, p. 221); Dosi, Marengo, Fagiolo (2005, p. 322); Dosi, Faillo and Marengo (2003, p. 13).

³⁶ Levinthal (1995, p. 22); cf. Chandler (1992, p. 84, 2003: chapter 1, p. 5).

³⁷ Productivity increases deriving from the learning effect may decline as a result of ‘organisational forgetting’ due to the fact that a firm’s stock of production experience depreciates over time, mainly because of employee turnover. On ‘organisational forgetting’ see Benkard (2000, pp. 1036, 1051).

between tacit and explicit knowledge. The conversion of tacit into explicit knowledge makes communication possible and allows non-transmittable and untradable knowledge to be turned into transmittable and tradable knowledge. This process involves different knowledge creating entities, such as individuals, teams, firms and organisations of firms, and takes place at different levels because front-line employees, middle managers and top managers all play a part (Nonaka and Takeuchi, 1995, pp. 15, 56-7). Within business organisations, learning processes imply effective communication and active participation. Participation by the members of the firm means that they are considered as effective agents in the process of knowledge growth and not as mere inputs that passively adjust to external parameters.

Organisational learning is based on localised knowledge, which is affected by the cognitive frames and actual capabilities of firms,³⁸ and is generated by an intensive outside-inside interaction as well as the ability to utilise outside knowledge (absorptive capacity). The interaction among suppliers, customers and members of the firm involves redundancy in information and knowledge sharing, resulting in a situation whereby overlapping information and knowledge is shared among members of an organisation and with individuals outside of the organisation. Redundancy of knowledge encourages communication, and thus effectively facilitates learning (Nonaka and Takeuchi, 1995, pp. 11-4, 80-1). Multi-technology firms need to have knowledge in excess of that which is required for their internal production, as they must address the task of coordinating networks of suppliers of equipment, components; specialized knowledge is also an indispensable requirement. 'By knowing more, multi-technology firms can cope with 'imbalances caused by uneven rates of development in the technologies on which they rely and with unpredictable product-level interdependencies' (Brusoni, Prencipe and Pavitt, 2001, pp. 597-8, 608).

³⁸ Antonelli (2003, pp. 1ff., 2004, pp. 40ff., 247ff.) who offers an in-depth analysis of the characteristic of localised technological change. See also Dosi and Malerba (1996a, p. 4).

When radical uncertainty is due to a highly innovative environment and volatility of markets, there is an increasing need for complementary external capabilities that can be satisfied by collaboration among firms.³⁹

3. Implications for the theory of the firm

The final issue I wish to address concerns the implications of the possible presence of substantive uncertainty for the theory of the firm.

3.1 Multiple rationalities, different degrees of uncertainty and optimisation

The foregoing analysis has shown that considering substantive uncertainty is crucial in understanding organisational functioning. Reserves, constituted by several types of assets, and various relational agreements are responses to a hard-to-predict world.

Modern neoclassical theories of the firm limit the analysis to certainty or weak forms of uncertainty characterised by fully pre-specified and closed systems that allow complete abilities, with free or costly information (the latter due to informational asymmetries). In these theories probabilistic risk and uncertainty end up being considered as synonymous, whilst true uncertainty is neglected.⁴⁰ This allows easy mathematical formalisation and precise predictions based on familiar optimisation techniques. For instance, the property rights approach and many transaction cost models assume asymmetric information with farsightedness, i.e. that individuals are able to know the payoffs associated with the all possible outcomes of their actions even if the contracting parties possess different information. This naturally excludes the possibility of

³⁹ Ménard (2004e, p. 357-8). On applied analyses see also Gulati (1995); Arrighetti, Bachmann and Deakin (1997); Nooteboom, Noorderhaven and Berger (1997); de Jong and Nooteboom (2000); Colombo and Delmastro (2001); Nooteboom (2003, pp. 14-5).

⁴⁰ As Robert Lucas (1981, p. 224) claims, 'in case of uncertainty, economic reasoning will be of no value.' For a discussion on this point see: Machina (1987, pp. 121ff.); Dosi and Egidi (1991, pp. 173-4); Davidson (1991, p. 129); Rosenberg (1996, p. 340).

substantive uncertainty. However, positions in this regard are not unanimous. The importance of substantive uncertainty in the economic processes is increasingly acknowledged by some authoritative mainstream economists. For instance, Hart - who in his theory of incomplete contracts assumes perfectly rational agents with asymmetric information – recognises that ‘in reality, a great deal of contractual incompleteness is undoubtedly linked to the inability of parties ... to think very carefully about the utility consequences of their actions. It would therefore be highly desirable to relax the assumption that parties are unboundedly rational’ (Hart,1995, pp. 81). A similar and even stronger position is expressed by Radner who rightly holds that ‘significant features of the organisation of firms ... can only be explained by a satisfactory theory of truly bounded rationality’ (Radner, 1996, p. 1372).⁴¹ The possibility of substantive uncertainty is explicitly assumed within the Post Keynesian, the competence, the evolutionary and the cognitive perspectives, while different degrees and kinds of uncertainty are presumed in most transaction cost studies.

Recognition of the analytical importance of substantive uncertainty by no means implies discarding explanations which are based on the assumption of perfectly rational agents and use of optimisation techniques under certainty or probabilistic risk. Perfectly rational behaviour can be postulated and optimisation techniques can be applied in all circumstances in which: (i) the problems at hand are well specified, (ii) the decision makers’ abilities are sufficient to cope with them; and (iii) decision makers perceive that it is worth bearing the cost of a consistent and calculated choice.

Arguably, in many contingencies when the problem at the hand is well specified and when individuals possess the relevant information and knowledge as well as sufficient information processing ability, the hypothesis that they are able to foresee all possible pay-offs is plausible and useful for analysis of the interaction among the various aspects of organisational

⁴¹ See also Augier, Kreiner and March (2000, pp. 559ff.).

coordination and functioning. However, in some circumstances - which are significant for decision-making within business organisation - individuals are unable to predict all possible pay-offs due to the conditions of substantive uncertainty. Within a comprehensive theory of the firm both the perspective which assumes farsightedness and that encompassing substantive uncertainty must be considered according to the particular problem under consideration. These different perspectives can coexist because they address diverse decision strategies in dissimilar contexts.

I do not argue against the assumption of perfectly rational behaviour and optimisation techniques if they are applied in the specific circumstances where individuals have the relevant information and knowledge and sufficient computing ability to estimate all possible pay-offs. I criticise applications of assumptions 'outrunning applicability', i.e. applications in utterly implausible contexts. I contend that in a comprehensive theory of the firm, both farsightedness and substantive uncertainty must be considered according to the context. The very same firm adopts different decision procedures according to the degree of uncertainty associated with the various situations to be faced. As a consequence, the behaviour and the kind of rationality will be different in relation to the degree of uncertainty involved in the problem at hand. In this sense, actors can be seen to have 'multiple rationalities' (Grandori, 1995, pp. 10-1, 84-5). Therefore models based on different degrees of uncertainty and kinds of rationality may be considered complementary if the different domains of application are clearly identified.

A key point is that discarding a priori the possibility of substantive uncertainty deprives the theory of the firm of a crucial element that is linked to the essence itself of business organisations, since business organisations can be seen as a response to a hard-to-predict world.⁴² The unknowable nature of future events and cognitive limits help to explain why individuals join and develop business organisations. If this is so, taking into consideration the possibility of

⁴² On this see Galbraith (1967, pp. 25ff., 354); and Spender (1989, pp. 42-5, 186); cf. Dunn (2001b, pp. 12ff., 2001c, pp. 164-7).

substantive uncertainty within the theory of the firm is in accordance with the very object of the analysis.

3.2 From constraints to opportunities

There is a crucial difference between an analysis of the firm which excludes substantive uncertainty and an analysis which considers *also* the possibility of substantive uncertainty. When all alternatives are known, the decision-making process involves considering the cost of alternative courses of action under specific constraints. In this case, binding constraints appear to constitute the relevant analytical element in determining the optimal choice. In contrast, under substantive uncertainty, alternatives are not given and individuals endeavour to acquire new information. In this second case, constraints still play an important role, but the ability to look for and create opportunities then becomes the relevant analytical element.

Considering the possibility of unpredicted contingencies permits a more satisfactory account of the entrepreneurial role. In facing uncertainty, the judgment of the entrepreneur-manager is essential to discover or create opportunities.⁴³ As highlighted by Knight (1921, p. 311), under radical uncertainty, entrepreneurial decision-making is based on the ‘faculty of judgment’ which is tacit because it is the fruit of on-the-job experiences that consist in learning processes over time based on personal interaction, learning by doing, learning by using. For these reasons entrepreneurial knowledge is firm specific and therefore largely non-tradable.⁴⁴

In the presence of uncertainty, the growth process of a business organisation can be regarded as the result of the entrepreneurial ability to exploit the joint advantages provided by the interplay between capability, transaction and scale-scope aspects. First, developing

⁴³ For references to, and a discussion of, how imagination and intuitive processes explain entrepreneurial actions, see De Vecchi (1995, pp. 145-6); Harper (1996, pp. 88-92); Sabel and Zeitlin (1997, p. 11); Witt (1998, pp. 67ff., and 1999, pp. 390ff.); Loasby (1999, pp. 7, 31, 36ff.). On the human ability to construct new representations of problems, see Egidì and Rizzello (2003, p. 13).

⁴⁴ Cohendet, Llerena and Marengo (2000, pp. 107, 109). On entrepreneurship see also Hagedoorn (1996, p. 891); Shane (2003); and Kalantardis (2004).

capabilities means finding, interpreting and using knowledge in order to create, maintain and renew a competitive advantage. Secondly, transaction costs affect the extension of organisational coordination within firms (vertical integration) or among firms (hybrid forms), and can be eliminated by the internalisation of external processes. Thirdly, in designing the operational scale of each process the firm has to balance the productive capacities of different complementary inputs and intermediate stages in order to take advantage of economies of scale and economies of scope.

In Morroni (2006, pp. 177-88) I showed that the presence of radical uncertainty strongly amplifies both the significance of capability, transaction and scale considerations as well as the interaction among these aspects, which emerges from the specific characteristics of information, knowledge and production elements, in particular: i) transactional, organisational and productive knowledge that is dispersed, heterogeneous, tacit and costly; ii) indivisibility and complementarity of some production elements; iii) the existence of set-up processes in using information and knowledge; iv) the low cost of replication of some information and knowledge.

The entrepreneurial ability to exploit the opportunities provided by organisational coordination of the foregoing three aspects and to limit the negative effects of informational hazards and other counteracting forces are fundamental elements in understanding differences in the revealed performance of firms and their opportunity for growth. However, the firm's performance does not depend solely on managerial abilities, but also on the interplay between the various basic conditions and decision-making mechanisms.

Moving towards consideration of the economic impact of the search for new opportunities opens up the possibility of widening the field of economic analysis to include the economic effects of creative learning and study of the processes by which firms acquire or lose their competitive strength. With the upsurge of the knowledge-based economy, learning inevitably becomes a central issue because intelligence-related assets and the ability to learn are playing a more and more prominent role in determining production and transaction costs and consequently

in shaping the competitiveness of enterprises and the growth of economic systems. The emergence of a knowledge-based economy provides increasing scope for firms and organisations of firms that favour learning within markets.

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Figure 1 Uncertainty-decreasing strategies within business organisations