

2 Conceptual Foundations of Super-Flexibility: A Multi-Disciplinary Synthesis

Flexibility is often invoked as a panacea for operating in dynamic contexts. We define it as the “propensity to adapt, at times spontaneously, to fluid conditions”. In practice, it is a means of enacting swift changes and making sudden turns in order to harness new opportunities and address challenging situations. Examples include rapid acceleration (such as in entering new markets, deploying new technologies, and making acquisitions), immediate disengagement (from an unattractive market), applying brakes in an emergency (such as in a financial crisis), and deploying shock absorbers (for example in dealing with hostile takeovers).

In view of its universal intuitive appeal, flexibility has been a topic of research in several disciplines. These include economics, evolutionary biology, decision analysis and game theory, information systems, manufacturing systems, strategic management, organizational design, child development and, at its most acute form, military strategy. Several terms have been used to convey the idea, including strategic flexibility, operational flexibility, internal and external flexibility, financial flexibility, agile information systems, flexible work arrangements, flexible manufacturing systems, strategic agility, and strategic resilience. Although the terminology may be different, they all refer to the capacity to make swift adjustments in order to adapt to novel situations. This chapter examines previous research on the topic through the lenses of both, a microscope and a telescope.

As is the case in the natural world, a multitude of triggers may prompt an entity to adapt. They range from mega-events to the unique conjunction of mundane coincidences. Moreover, surprises, serendipity, luck, mistakes and accidents, both good and bad, trigger the need to adapt. Often the unique conjunction of “hard factors”, (such as market expansion, supply chain pipelines, IT, manufacturing and distribution systems), and “soft” factors (such as the chemistry among the top team and their ability to function in different cultural settings) coalesce to produce metamorphic moments.

These episodes can seldom be predicted or reproduced under similar conditions. Factors such as stakeholder perceptions, interactions among geo-distributed teams, relationships with key customers or government officials can unhinge or energize an entity. These forces coalesce to create novel “revision-triggers”.¹ Historically, in the old world, these events occurred periodically; changes could be predicted and contingency plans put in place. Today metamorphic events occur unexpectedly, rapidly and frequently. This makes it difficult to predict or to allow time to develop an appropriate response. Leadership teams try to evade danger or seize the moment by turning swiftly, reversing, accelerating, braking hard, intensifying, disengaging, and in general, deviating from an existing trajectory

¹ As stated by Brock and Carpenter 2009, p.45 “Flickering may trigger regime shifts” echoing the idea that the seeds of the change-inducing episode are difficult to discern ahead of time and may be weak.

To become viable, high tech ventures often “pivot”² through “knot-holes” or brief periods of intense “kaleidoscopic” transformation. The ensuing metamorphosis or reinvention, if successful, can unravel a varied array of adaptive niches, and expand the range of ecosystems in which it can thrive. There are, however, serious practical considerations when a firm pivots through a “knot-hole”. The “adaptive DNA” of a company is typically forged during these formative episodes. This condition is reinforced by research studies in the field of neuroscience where, *“synaptic plasticity can be modulated, sometimes dramatically, by prior synaptic activity” because “prior synaptic activation can leave an enduring trace that affects the subsequent induction of synaptic plasticity”*.³

Knowledge enterprises, from start-up ventures to global corporations, frequently need to do things differently. The frequency of unexpected or spontaneous “revision-triggers” has always been prevalent in high tech ventures. Large corporations have historically found it difficult to adapt unless they experience potentially catastrophic situations. Today, even established global corporations are trying to adapt and to reinvent themselves for a dynamic world.

2.1 Flexibility: Multi-Disciplinary Contributions

A substantial body of research on the notion of flexibility can be found across a wide range of disciplines. The earliest contributions are in the field of military strategy. Two famous French Generals, Bourcet (1888) and Guibert, pioneered the use of the “divisional structure” and faster marching speeds to improve maneuverability in battle. Decades later, Clausewitz, the grandfather of modern strategy, emphasized flexibility in three overarching areas: the significance of the moral factors, the ability to concentrate forces at a decisive point, and the value of a standing reserve (von Gueyzy et al. 2003, Hahlway 1966).

Flexibility was an implicit part of General Sherman’s (1860) strategy during the American Civil War. During his Atlanta campaign, he dispensed with supplies to lighten the load, enabling rapid movement. To achieve this, he deployed his scouts in an ambidextrous role, not only to forage for food, but also to provide an early warning system. His railway engineers rapidly repaired tracks and bridges to enable his forces to move quickly. Decades later, the British military historian, Liddell-Hart (1929, 1954) proposed an “indirect approach” to strategy that was “adaptable to circumstances” as the cornerstone of flexibility. Other military strategists consider flexibility as an essential principle of warfare (Eccles 1959, Taylor 1959). Recently, the topic has taken on a broader significance because of technological sophistication and logistical complexity of contemporary warfare.

² Rip, 2006.

³ Abraham, 1996, p. 126 & p. 129; see also de Visser, 2003, who explores the role of robustness in responding to epistatic effects in genetic adaptation.

Economists focused on flexibility during and after the Great Depression by examining the impact of oscillations in the business cycle on a firm's adaptive capability.⁴ Arrow describes it as "*a known though not thoroughly explored concept that seems to have been introduced by Hart*".⁵ Hart focused on how business entities adapt to uncertainty in the aftermath of the Great Depression and on the creation of new entrepreneurial firms: "*The entrepreneur's fundamental means of meeting uncertainty is the postponement of decisions till more information comes in—that is to say the preservation of flexibility in his business plan.*"⁶ Significantly, he proposes flexibility as a fundamental management principle for dealing with uncertainty: "*Flexibility helps an individual or a firm preserve freedom to change plans without undue sacrifice if anticipations are revised.*"⁷ Shackle's notion of unexpected events (Shackle 1953), resulting in kaleidoscopic change, is echoed in Schumpeter's notion of "creative destruction" (1926, 1934) brought about by technological innovations (Hammond 2007). Economists have also examined flexibility with regard to changing tastes and preferences (Koopmans 1953). Koopmans argued the need for flexibility is driven as much by evolving tastes as by physical options, currently available, or projected to be, sometime in the future.

Agricultural economists also viewed flexibility as a potential response by farmers in dealing with agricultural price fluctuations.⁸ Several studies have examined how farmers can respond flexibly by considering crop selection and rotation, or by switching between products, such as milk and cheese production. This agricultural focus was further extended by later research on the subject.⁹

⁴ Hart 1937a,b, Kindleberger 1937; Knight 1921; Lange 1944, Stigler 1939, Tinbergen 1932, McKinsey 1932.

⁵ Arrow 1995, p. 9.

⁶ Hart 1937a, p. 286.

⁷ Hart 1940, p 49.

⁸ Backman 1940 a & b, 1948, Mason 1938, Nicholls 1940, Timoshenko 1930, French et al. 1956, Kerchner 1966.

⁹ Carley & Cryer 1964, Collins 1956, Cowden & Trelogan 1948, French et al. 1956, Kerchner 1966.

| DISCIPLINE | AREA OF FOCUS |
|---|--|
| Military strategy | Adapting operations in the “fog” of battle; Graduated response |
| Economics | New firm creation |
| Agriculture | Price fluctuations, crop rotation, technological capabilities |
| Manufacturing systems | Ordering of activities, sequencing of job shops, range and volume of product Modular manufacturing, product mix |
| Operations management | Supply chain agility, E-business |
| Strategic management | Meta-flexibility; managing the “unforeseen” |
| Decision theory | Future options, expected value of information, viable across a range of scenarios |
| Child psychology | Children and teenagers rebounding from adverse experiences |
| Information systems | Agile IT infrastructure |
| Organizational design | Structural flexibility |
| Financial engineering | Liquidity, hedging, real options, derivative & Swaps pricing |
| Systems analysis & environmental research | Repairing damaged ecosystems |

Table 1. Multi-disciplinary contributions to understanding flexibility

Interest in the topic was rekindled after the 1973 Oil Crisis, particularly with regard to corporate strategy.¹⁰ Strategic flexibility was viewed as a generic response to the “unforeseen”. A flexible firm was considered to have “*the ability to change itself in such a way that it remains viable*”.¹¹ Other researchers viewed flexibility as a means of disengaging from an arena by removing obstacles and penalties (Harrigan 1980, 1985). Several scholars have discussed the importance of organizational flexibility in rapidly changing environments.¹² The term “strategic resilience” (Hamel & Valicangas 2003) was later coined as a critical capability in addressing turbulent business conditions. Recently, strategic agility has been proposed as a critical capability for developing a “fast strategy” (Doz 2008). In aggregate, as we discuss in Chapter 5, these capabilities collectively refer to a company’s ability to rapidly “maneuver”.

¹⁰ Ansoff 1975, Eppink 1978a, 1978b, Krijnen 1979.

¹¹ Krijnen 1979, p. 64.

¹² Ackoff 1977, Perrow 1970, Thompson 1967, Tomlinson 1976.

Tactical and operational challenges have also led to the development of methods for evaluating flexibility in energy generation and distribution. These studies have focused, among other things, on the ability to switch inputs as prices change and/or supplies fluctuate.¹³ Later, studies on flexible manufacturing systems focused on the variability of product mix and output volume.¹⁴ Following the deployment of flexible manufacturing systems, a substantial body of literature has also emerged on supply chain agility in high technology industries. Attention was initially focused on calculating the value of flexibility (Kulatilaka 1988). Later research set out to integrate the various senses of flexibility. The notion of “flexagility” was proposed in operations management (Wadhwa & Rao 2003a & b).

Flexibility has also been examined in the field of engineering. The concept has been used in the design of complex systems, such as energy production, aerospace and IT.¹⁵ Recently, Saleh defined flexibility as “*the property of a system that allows it to respond to changes in its initial objectives and requirements- both in terms of capabilities and attributes- occurring after the system has been fielded.*”¹⁶ The design, development, and deployment of this capability, as these scholars have pointed out, is infinitely more complex than installing something extra at the margin to address incremental oscillations.

Formal representational progress has also been made in using flexibility as a criterion for making optimal decisions. Decision theorists have formalized the impact of evolving preferences on multi-period choices,¹⁷ have developed probabilistic measures of flexibility¹⁸ and have examined the “robustness” of decisions to withstand future changes.¹⁹ This stream of research has been extended to encompass “real-options” theory.²⁰ Research in finance has focused on the relationship between flexibility and liquidity as related to options and portfolio theory.²¹

¹³ Draaisma & Mol 1977, Friedman & Reklaitis 1975, Fuss 1977, Guerico 1981, Schroeder et al. 1981, Van der Vet 1977.

¹⁴ Adler 1988, Buzacott 1982, De Meyer et al. 1989, Gerwin 1982, Hutchinson 1973, Ira-vani et al. 2003, Mandelbaum & Brill 1989, Spur et al. 1976, Tilak 1978.

¹⁵ Fuss 1997, Chen & Lewis 1999, Hamblin 2002, Saleh et al. 2001.

¹⁶ Saleh 2008, p. 10.

¹⁷ Day 1969, Koopmans 1964, Kreps 1979.

¹⁸ Heimann & Lusk 1976, Klein & Meckling 1958, Mandelbaum 1978, 1989, Marschak & Nelson 1962, Merkhofer 1975.

¹⁹ Pye 1978, Rosenhead 1972, 1980, Rosenhead et al. 1986.

²⁰ Triantis & Hodder 1990, Trigeorgis 1996, Raynor 2001, Trigeorgis & Schwartz 2001, Ekstrom & Bjornson 2003, Gamba & Fusari 2009.

²¹ Frazer 1985, Goldman 1978, Jones & Ostroy 1976, 1984, Mason, 1986.

In recent years, agility has been put forward as an effective methodology for software development.²² With the advent of “autonomic” or self-adaptive computing, this stream of research will become more significant, especially in view of its impact on the evolution of e-business (Shi & Daniels 2003). Researchers have also examined the need for different types of user and IT system flexibility (Gebaur 2007) and its broader impact on strategy and organization (Weill 2003). How to achieve adaptive IT systems is a perennial challenge. As technology continues to evolve, research on this topic will gain additional momentum.

As described in this section, there has been an extensive body of multi-disciplinary research on the subject of flexibility. Yet research contributions have been somewhat fragmented, reflecting different priorities and situational contexts. Moreover, scholars have addressed the topic at different altitudes, and use various terms to describe the notion. These include “operational flexibility”, “strategic flexibility”, “internal flexibility”, “external flexibility”, “strategic resilience”, and “strategic agility”. The crux of the problem is that the value of flexibility is seldom precise yet rarely in doubt. The critical challenge is how to source and deploy it. In the following section, we set out to synthesize these contributions and to examine various terms that are related to flexibility.

2.2 Flexibility: Related Concepts

As we examine these contributions in some depth, we can distinguish between two discernable approaches. The first involves the study of flexibility in specific situations, typically within a disciplinary silo. The second approach is a multi-disciplinary review of the literature in order to develop a comprehensive definition, or a mathematical formulation, of flexibility. As pointed out in one such review, there are “*50 definitions of different types of flexibility in a manufacturing context*”.²³ A management scholar prefaces his contribution by suggesting flexibility is often “*used as a magic word*.”²⁴

Why does this recurrent definitional problem exist when the concept is so intuitively valued? It has been 70 years since Hart’s seminal work and the problem still exists in spite of many efforts to put forward a precise definition. In almost every substantive contribution to the field, we find a common starting point, namely to clarify the ill-defined nature of the concept. We suggest the source of this conundrum is the “polymorphous” nature of flexibility, as evidenced by the interchangeable use of several related terms (Evans 1982a). Related terms include, agil-

²² Cockburn 2001, Del Prete et al. 2003.

²³ Saleh et.al. 2008, p. 1.

²⁴ Volberda, 1998, p.2; see also Kickert 1985.

ity, adaptability, versatility, resilience, and robustness. Other concepts, such as dexterity, elasticity, liquidity, malleability, modularity, mobility, and plasticity are also at times substituted for flexibility. Table 2 defines these related concepts.

| CONCEPTS | DEFINITIONS |
|-----------------|---|
| Agility | Moving nimbly into and out of areas of interest |
| Elasticity | Stretching & shrinking with different pressures |
| (Ambi)dexterity | Developing bifunctional capability, i.e. using both hands adroitly, explore and exploit simultaneously |
| Hedging | Mitigating against the losses associated with “downside” potential at a cost |
| Liquidity | Transforming assets without switching costs |
| Malleability | Able to be bent, molded or manipulated to meet unusual conditions or unorthodox circumstances |
| Mobility | Re-deployable assets and capabilities |
| Modularity | Self-contained re-configurable building blocks |
| Plasticity | Molding to unique shapes |
| Resilience | Recoiling or bouncing back from the brink after sustaining damage, or degrading gracefully before termination |
| Robustness | Taking hits with minimal damage to functional capability |
| Versatility | Able to wear many hats or deploy various skills to function with dexterity in different settings |

Table 2. Concepts resembling flexibility

The differences between these concepts are sometimes evident, at other times unclear. For example, having the liquidity to exploit an unexpected opportunity is qualitatively different from resiliently recovering from an accident or a trauma. Similarly, buying insurance, options, buffers or slack, to protect or insulate against potentially damaging situations, is different from the agility or the dexterity needed to enter a new arena or to side-step an impending threat.

There are also important nuances embedded within these terms. For example, agility can mean being able to “dodge and weave” around competitors, or it may refer to the ability to rapidly switch direction or to accelerate into an emerging field of opportunity. Even in a defensive sense, agility is needed to avoid an approaching

disaster. Similarly, resilience has several meanings. It refers to the ability to rebound from setbacks, or the ability to regenerate or to restore damaged parts; it can also mean being able to revive a system so it continues to function although it might be slowly degrading. Robustness refers to the ability to deflect threats in hostile terrains by wearing bullet proof vests, or by being “Teflon coated”, or like shock absorbers, being capable of “riding over the bumps” or “traversing the treacherous rapids in a fast moving river”.²⁵

In evolutionary biology, resilience is defined as the time required for a system to return to equilibrium, following a disturbance, or the amount of disturbance that a system can absorb before switching to another stable regime (Brand & Jax 2007). By way of distinction, being versatile may involve multi-tasking, or like a triathlete, being competent in several different areas, reflected in the old adage of wearing many hats. These terms are clearly in some way related and have been used by scholars to give granularity to the notion of flexibility. These related concepts will be examined in the following section.

2.2.1 Adaptability

The term “adaptability” is defined as “adjusting to changing conditions”. Although it is used interchangeably with flexibility, it is qualitatively different from other related terms in that successful adaptation is the goal of being flexible. Stigler (1939) made the distinction between the two terms. He suggests that adaptability implies a singular and optimal adjustment to a transformed environment, whereas flexibility enables successive, but temporary, approximations to the optimal adaptive state. The term has been used in the field of strategic management to describe an enterprise’s ability to respond to foreseen changes; for example, when a projected scenario, such as deregulation of a major industry, becomes reality. Flexibility, on the other hand, refers to the ability to respond to the unanticipated.

Ansoff focused on flexibility as a means of coping with extreme turbulence (Ansoff 1975). His doctoral student, Eppink (1978a), studied adaptive responses of several firms to the first Oil Crisis of 1973. Later, building on Ansoff’s insights, Volberda (1996, 1997, 1998), extended the study into how firms cope with “hyper-competitive” environments. He studied how the “repertoire” of management capabilities, augmented by a firm’s organizational structure, might impact its ability to become strategically flexible. Recognizing the need for flexibility, Harrigan, (1980, 1985) examined the ability of firms to disengage from unattractive businesses. This theme was extended by Katsushiko & Hitt (2004); Hitt had previously

²⁵ Olsson et al. 2006. See also Kinzig, et al. 2006.

examined how flexibility can improve enterprise adaptation to novel conditions (Hitt et al. 1998). A recent contribution is the work of Teece (2009) who has proposed the notion of “dynamic capabilities” as a means of adapting to changing conditions.

Recently, a number of researchers have explored the notion of ecosystem resilience as a means of adapting to climate change (Chapin et al. 2006). We will return to this recurring ecological theme whereby the cross-utilization of several concepts is used to pinpoint the meaning of flexibility.

2.2.2 Agility

The term “agility” describes the extent to which an individual, a team or a firm, can move nimbly with dexterity. In nature, we often think of gazelles or cheetahs as being agile. In business settings, it refers to moving out of the way of an impending disaster, for example by rapidly adopting “poison pill” measures to thwart an acquisition, or entering a new market by buying a company before others. The term has been used in the literature to characterize a firm’s adaptive strategy (Doz 2008), organizational structure, supply chain, and IT infrastructure.

The concept has also transformed the software development process. With the advent of the “Agile Manifesto” software engineers have embraced the methodology with gusto (Cockburn 2002). The term has been applied broadly to information systems planning (Weill et al. 2002, 2006). Today, software engineers welcome changing requirements (Patten et al. 2005) and software releases are becoming monthly occurrences instead of biannual rollouts. However, several organizational problems have emerged with the wholesale adoption of this approach.²⁶ A number of researchers point to the need for ambidextrous coping strategies in implementing distributed software development projects (Lee et al. 2006). As aptly concluded “*Organizational forms and cultures conducive to innovation may embrace agile methods more easily than those built around bureaucracy and formalization*”.²⁷ (Nerur 2005)

Improving an enterprise’s agility with IT is a recurring theme.²⁸ The concept of a “scrum” has recently augmented agile methods for real-time software development. The term “robustness” is also used to denote flexibility in IT development projects.²⁹ A critical question, highlighted by a number of studies, is how much is worth paying for IT flexibility.³⁰ This continues to be a difficult question to address (Copeland & Keenan 1988).

²⁶ Turk et. al 2002, Lycett et al. 2003.

²⁷ Nerur, 2005, p. 78.

²⁸ Overby, 2006; Tallon, 2007.

²⁹ Patten 2005 & Patten et al. 2006.

³⁰ Gebauer (2006 & 2007) conducted research on IT spending decisions and the deployment of mobile technologies in terms of the ability to change the use of a system (also see Schober and Gebauer, 2008).

In addition, there is a substantial body of research on supply chain agility.³¹ Flexibility is addressed in terms of the variety of products produced, the volume and the logistics of shipping goods and the variability of sourcing components. Agility is perceived as either a combination of speed and flexibility, or as an extension of flexibility. As discussed earlier, the hybrid term “flexagility” was proposed to capture the overlapping meaning of the two concepts. In the turbulent environment following the 2008 financial crisis, this capability is critical for many companies, yet fraught with danger from what is termed the “bull-whip” effect.³²

Strategic agility (Doz 2008) has also been addressed in studying innovative corporate strategies, defined as “*not just the ability to be quick, but also to take strategic turns in a timely fashion, strategic re-direction/reinvention at high speed*”.³³ Another study defined marketplace agility as the “*ability to generate a steady stream of both large and small innovations in products, services, solutions, business models, and even internal processes that enable them to leapfrog and outmaneuver current and would be competitors and thus eke out a series of temporary competitive advantages that might, with luck, add up to sustained success over time*.”³⁴ They propose the notion of workforce scalability as the mechanism that provides “alignment and fluidity” necessary to become an agile organization.³⁵

2.2.3 Ambidexterity

This term is commonly used to denote a person’s ability to write with, or use, both hands with equal proficiency. It has been applied to bifunctional activities in organizational contexts (Duncan 1976), to denote the coexistence of dual structures, such as R&D to enable new product introductions, and quality control to ensure product consistency and supply chain alignment. The idea has also been incorporated in studies of teams developing complex software projects (Lee 2006). Switching between different modes of development is a desired capability; for example, when a “quick and dirty” response is needed, compared to a mission-critical project that needs extensive documentation and testing before being rolled out.

³¹ Buzacott 1982, 2008, Spür 1976, Slack 1987, De Groote 1994, Suarez 1996, Shewchuk 1998.

³² Lee et al. 1997, Glatzel et al. 2009.

³³ Presentation given by Doz & Kosonen on “Fostering Strategic Agility”, INSEAD, 2006, P. 1.

³⁴ Dyer & Ericksen 2006, p.3.

³⁵ In a later work, the researchers propose: “a complexity-based agile enterprise configuration to enable a firm to operate on the edge of chaos to form and reform, strategize and re-strategize on the fly.” (Dyer & Ericksen, 2008, p.3).

In general, the concept refers to the ability to engage in apparently contradictory activities for example, by pursuing revolutionary and evolutionary change (Tushman & O'Reilly 1996). It is proposed as a means of deploying dynamic capabilities and reconfigurable assets, and adopting an organizational architecture that promotes exploitation and exploration (Birkinshaw 2004). Several studies have also used the concept to examine strategic alliances and the performance of small-to-medium sized firms (Lin 2007).³⁶

The question we must ask is how is this related to flexibility. Using both hands is an interesting metaphor to signify the accommodation of contradictory hypotheses. In this sense, we can also extend the term to denote switching between activities, using two distinctive capabilities. In defense of ambidexterity, it is often the case that contradictory factors must be accommodated in organizing a flexible enterprise (Bahrami 1992). *"ambidextrous organizations mobilize, coordinate, and integrate dispersed contradictory efforts, and allocate, reallocate, combine and recombine resources and assets across differentiated exploratory and exploitive units"*.³⁷

Research has found a strong correlation between decision-making authority and a manager's ambidexterity (Mom 2009). For example, an informal top management team, interacting with formal organization integration can produce ambidexterity (Jansen, 2009). Dealing with unexpected occurrences in a timely fashion requires several capabilities, all focused on what military strategists term the shifting center of gravity. It is precisely in such circumstances that flexibility is at a premium. Whether an ambidextrous organization is more capable of managing turbulence in dynamic settings remains an open question (Raisch et al. 2009).

2.2.4 Hedging

"Hedging" is a concept evoked by the idiom of "not putting all eggs in one basket" (Ansoff 1965). It plays an important role in financial engineering, particularly in derivatives trading (Ding et al. 2007). Hedging tools can buy insurance and are shown to be effective during "normal" market conditions. Propelled to notoriety by their role in precipitating the financial collapse of 2008, the instruments of derivative hedging or swaps trading rely on complex mathematical models to price options (Lutgens 2006). It was argued that *"almost any arbitrary pay-off function can be hedged with a piecewise linear approximation using a tailored portfolio of options"*.³⁸ However, as exemplified by the market corrections of 2008, these linear approximations function poorly when things change kaleidoscopically. A

³⁶ See also Pauwels 2005 for a view of strategic flexibility in export markets.

³⁷ Jansen et al. 2009, p.797.

³⁸ Bartram 2008, p.10.

number of researchers have attempted to address this by modeling in “jump diffusion” phenomenon when a stock price or an asset suddenly spikes or implodes (Kennedy et al. 2009).

It has been argued that we need to distinguish between “tractable” information used as a basis for options that can be acquired, and “intractable” information (surprises for example) that can not.³⁹ Over the years there has been a meteoric rise of financial engineering, based on what an eminent scholar termed “econophysics” (Shubik 2007). A clear example of the relationship between flexibility and hedging is reflected in a recent theoretical work that promotes flexible contracts with hedging to be an option for dynamic portfolio management (Caldenty et al. 2008). It should be noted, however, that “hedging” only mitigates the losses associated with the downside potential, at the expense of foregoing the full benefits of any upside potential (Merkhofer & Saade 1978). In view of the losses inflicted by pursuing these strategies, the value of hedging in providing flexibility is not always demonstrable, although this may be an over-reaction to recent events.

2.2.5 Liquidity

Economists use the concept of liquidity as a means of producing financial flexibility.⁴⁰ An asset is liquid if it can be easily converted into some alternative form of wealth with little or no conversion costs or associated penalties. Hart defines liquidity as “*the maintenance of a cash balance...in excess of turnover requirements*”.⁴¹ Liquidity considerations are an integral part of financial portfolio planning (Hong & Rady 2002) and an essential ingredient of securities design (Blais & Mariotti 2005). It has profound implications for capital generation, and can influence the configuration and deployment of securities, bonds and other financial instruments. The concept is also becoming increasingly important in the design and use of IT systems for financial trading (Mendelson & Tunca 2004).

“Slack” is an analogous concept in that it refers to unused assets and resources that can be easily converted or readily deployed. Cyert and March (1963) refer to “organizational slack” as a buffer between an organization and external discontinuities. In the context of providing a buffer, slack is another means of achieving flexibility (Bourgeois 1981).

³⁹ Mendelson & Tunca 2005.

⁴⁰ Frazer 1985, Goldman 1974, 1978, Jones & Ostroy 1976, 1984.

⁴¹ Hart 1937a, p. 290.

2.2.6 Malleability

In the same way that snakes coil around trees, “malleability” refers to the ability to bend or be easily molded. Sometimes this is irreversible and the shape solidifies, rather like putty or clay that hardens once in place. In other cases, like a gel-pack, it may be re-molded when necessary. As a concept related to flexibility, it has received the least attention. However, economists have explored the “putty-clay” hypothesis, clarifying the differences between “*ex ante*” ability to be molded, and “*ex post*” hardening that occurs once deployed.⁴² This distinction helped fuel the debate framed by Henry (1974) around the “Irreversibility Effect” and taken up later by Bernanke (1983).

In a business context, malleability allows an entity to spontaneously stretch organizational boundaries to accommodate new circumstances, for example in seeking partnerships or in forging collaborative relationships. Although the term has not been extensively used in the literature, it resembles flexibility, especially as it relates to organizational structure: “...*organization structure may be less malleable than Chandler (the famous business historian) assumed. In fact, structure can play a critical role in influencing corporate strategy*”.⁴³ The term has also been deployed in an organizational context “*where their members are malleable beings whose sense of self is influenced by their organization’s evolving social identity*”.⁴⁴

It is in this sense of a person’s ability to perform unconventional tasks that other studies have contributed to our understanding (Gist & Mitchel 1992). In the field of consumer psychology, for example, researchers have examined the notion with respect to justifying extraordinary spending decisions (Cheema & Soman 1996). Indeed, to illustrate the interchangeable nature of the terms, a relevant article is sub-titled “A Flexible Model for a Malleable Concept” (DeSteno & Salovey 1997). Malleability has also been explored in the context of decision-making uncertainty (Fong & McCabe 1999) and conflict resolution (Druckman 1993).

These contributions echo the seminal work of Koopmans (1966). He discusses the problem of selecting a meal from a menu several days in advance, when preferences are not fully known. However, progress in this area remains theoretical, except in high performance computing where: “*Malleability is the ability to dynamically change the data size and number of computational entities in an application. Malleability can be used by middleware to autonomously reconfigure an application in response to dynamic changes in resource availability in an architecture-aware manner, allowing applications to optimize the use of multiple processors and diverse memory hierarchies in heterogeneous environments*”.⁴⁵ It will be interesting to see

⁴² Fuss 1977, Albrecht & Hart 1983.

⁴³ Greiner 1973, p. 399.

⁴⁴ Spender 1996, p. 53.

⁴⁵ Desell et al. 2007 p 323.

how this plays out when IT no longer needs a “physical” presence.

2.2.7 Mobility

Historically, mobility has been viewed as a fundamental principle of military strategy.⁴⁶ Its impact is clearly exemplified in General Sherman’s Atlanta campaign and the subsequent march to the sea during the American Civil War. As he observed, “*The Atlanta campaign would simply have been impossible without the use of the railroads.*”⁴⁷ Sherman went on to praise the ingenuity of his engineers in keeping the trains running, allowing him to surprise the Confederate Army by his speed of movement.⁴⁸

The concept of mobility has also been applied in strategic management.⁴⁹ For example, inter-firm mobility of researchers and scientists has been found to lead to higher levels of innovation (as measured by patent output) due to the “cross-pollination” effect.⁵⁰ In an earlier paper, we viewed talent mobility as a critical success factor in the Silicon Valley ecosystem.⁵¹ A study of Italian pharmaceutical inventors found that there is a “*positive association between productivity and mobility*”.⁵²

Mobility that provides flexibility in this sense is different to the kind induced by the emerging explosion of mobile computing. Stimulated by the bifurcation of IT into the “cloud” and “end-points”, it will lead to a transformational change in the way organizations operate.⁵³ The collective impact of mobile computing, collaborative software, and advances in computer and communications hardware are profound. It is time to consider how to create “mobile enterprises”.

2.2.8 Modularity

Modularity is a pragmatic way of achieving flexibility in nature, as exemplified by colonial invertebrates such as barnacles, mussels and whelks (Hughes 2005).

⁴⁶ Liddell-Hart 1954, Fuller 1946, Shank et al. 1991.

⁴⁷ Sherman 1875 p. 399.

⁴⁸ Liddell-Hart 1929.

⁴⁹ Mascarenhas 1989.

⁵⁰ Breschi & Lissoni 2006.

⁵¹ Bahrami & Evans 1995.

⁵² Lenzi 2006, p. 30.

⁵³ Developing mobile systems for diverse uses and field conditions presents a special range of design and testing considerations (Oulasvirta & Nyyssönen, 2009). Mobility continues to be a critical challenge; this was highlighted by a study that indicated the problem with existing systems is that “they all work in one direction only and do not sufficiently recognize uncertainty” Shank et al. 1991, p. vi.

Just like cells in a beehive, modularity has been proposed as a means of achieving flexibility especially in product design and organizational “scaling” (Clark 1997, Sanchez 1997). Researchers argue that by “*splitting options and decentralizing decisions, control is fragmented, (thereby enhancing) evolution*”.⁵⁴ The concept has been applied to manufacturing operations (Baldwin & Clark 1997) and has become a mantra in product design (Baldwin et al. 2000). The pioneering work of Baldwin has been extended to software (Rusnak et al. 2007), and to the evolution of regional clusters (Baldwin & Woodward 2007). Recently, the notion of modularity has been applied to capital budgeting decisions (Gamba & Fusari 2009).

Sanchez (1997, 1999) developed a prescriptive approach to modular product design that was later applied to marketing and organization design. This work was further extended to test how modular architectures impact innovation and/or imitation (Galunic & Eisenhardt 2001). Another group of researchers found that modular organizational designs facilitated innovation, whereas non-modular structures provided a stronger imitation deterrent (Ethiraj et al. 2008). The interesting question posed by this stream of research is the impact of product modularity on organizational design. An empirical study concluded that while “*modular products lead to more reconfigurable organizations ... product modularity contributes less or not at all to another part of organizational modularity, firms shifting activity out of hierarchy*”.⁵⁵

Modularity is defined as a means of “*encapsulating interdependencies within decomposable self-contained units, called modules, and minimizing reciprocal interdependencies between modules*”.⁵⁶ In some senses it is viewed as a decomposition design heuristic to enable upscaling and downscaling of capacity with minimum interconnection penalties. Recent studies have examined the impact of modularity on product and organizational design with mixed conclusions. In essence, while it is easier to scale up and down, modularity may not enhance the ability to shift gears and make sudden turns.

The viability of this approach, when facing stochastic events, has recently been questioned: “*In highly volatile environments, modular search strategies are shown to have a high probability of becoming trapped into low fitness zones of the landscape, since they only change locally, they take too long to get out. Integral search strategies, on the contrary, perform search on a broader spectrum and can therefore jump out of low fitness zones of the landscape in which, sooner or later, everybody will fall in a highly volatile environment.*”⁵⁷ Looking at the topic from a different vantage point, another study found “modular organizations do not necessarily

⁵⁴ Baldwin 2001, slide # 10.

⁵⁵ Hoetke 2006, p. 513.

⁵⁶ Ethiraj et al. 2008, p. 939.

⁵⁷ Brusconi, et.al. 2007 p. 130.

encourage the construction of managers' mental models with a capability to generate more strategic options and, thus, do not increase strategic flexibility."⁵⁸ In conclusion, although it is clear that modularity does enhance flexibility, its effectiveness clearly depends on the situational context.

2.2.9 Plasticity

The notion of plasticity has been proposed as an adaptive mechanism in evolutionary biology, in computational optimization, and in strategic management.⁵⁹ In evolutionary biology, the notion of "organic evolution" was introduced in the nineteenth century (Baldwin 1896). The basic idea is that ecosystems are inherently dynamic and "*no single phenotype is consistently optimal. Natural selection, therefore, will favor organisms that are capable of altering their development to track environmental changes*".⁶⁰

The notion of "phenotype plasticity" denotes an organism's real-time adaptation to environmental disturbances (Ancel & Fontana 2000). In evolutionary biology, it is viewed as a means of facilitating spontaneous, context-specific, adaptive adjustments. These may be either defensive in nature (Agrawal & Fishbein 2008) or they may enhance predatory activity (Hill et al. 2003). Mechanisms that facilitate organic adjustments are often hidden until brought into play (Wycliffe & Bear 1996). This is a crucial point to note. As mentioned earlier, when entrepreneurial firms pivot towards a new direction, they often go through "knot-holes", using "hidden" talents. Novelty, by definition, can not be foreseen, although prior adaptive activity can put in place mechanisms that may be tuned to the new situation (Mockett & Hulme 2008). This prior activity is referred to as "meta-plasticity" and conceptually parallels strategic flexibility (Evans 1982; De Leeuw & Volberda 1996), meta-flexibility (Epplink 1978) and "größere flexibilität" (Meffert 1986).

In a seminal work, it was concluded; "*The more variation in a plastic repertoire, the less time a sequence (of RNA) spends in its best structure. In this way plasticity is costly and, is ultimately reduced by natural selection in constant environments*".⁶¹ This view echoes Stigler's insight that a flexible response is, in essence, a successive approximation to the "optimal" adaptive action (Stigler 1939). In business this could imply that in a disturbed equilibrium, plasticity is a mechanism that enables firms to make adjustments to adapt to ephemeral environmental changes.

⁵⁸ Adamides et al. 2007, p. 10.

⁵⁹ Dewitt 1998, 2004, Paenke et al. 2007, Ancel 2000, Jedlika 2002, Daoudal 2003, Bayne 2004, Piersma 2003, Langerhans 2002, Heckhausen 2001, Wickliffe 1996, Giovanni & Rivkin 2007.

⁶⁰ DeWitt 1998, p. 466, see also Daoudal & Debanne 2003.

⁶¹ Ancel & Fontana 2000. p. 278.

Mechanisms by which organisms create “phenotype” plasticity parallel, in some degree, research undertaken in evolutionary computation. Costs of phenotype plasticity are only warranted if the environment transforms in ways that bring embedded plasticity into play. If the environment shifts into a benign state, or a novel state, then there are limits to inherent plasticity (DeWitt 2003). In this regard, it has been shown in artificial evolutionary systems (Paenke 2007) that phenotype plasticity with non-inheritable adaptive capabilities (Baldwinian inheritance) tend to perform better in changing environments, compared to those that have them passed on from prior generations (Lamarckian inheritance, Piersma & Drent 2003).

Agrawal (2001) itemized adaptive responses by organisms in situations where there are species interactions. He distinguished between responses to competition, mutualism, predation risk, parasitism and food quality.⁶² Responses varied from strategies such as defensive structures in aquatic invertebrates, to hiding, reduced feeding activity, transformation into a parasite of the predator, habitat induced camouflage,⁶³ increased immune functions and several more.⁶⁴ The point here is that in the natural world there are response repertoires to variations in the ecosystem. It is difficult to generalize because responses are unique to specific situations and contexts.

There are clear parallels to enterprises facing turbulent environments. Rumelt introduced the concept of organizational plasticity in exploring business strategy.⁶⁵ *“There are a number of erroneous assumptions that most economically-oriented strategy researchers continue to borrow from economics. At this moment those that are clearest are plasticity, rationality of collective action, and homogeneity of beliefs. I believe that the most important of these is plasticity—the assumption that firms readily respond to exogenous shocks and changes in competitive conditions. The centerpiece of microeconomics is the deduction of autonomous responsiveness (mediated by self-interest) to changes in prices, technology, taxes, etc. Yet the truth is that firms change only with difficulty. Changing strategy and the structural forms and administrative procedures that undergird strategy is difficult, costly, risky, and time consuming. I shall call this lack of plasticity inertia.”* This term “plasticity inertia” points to the friction and the resistance an enterprise encounters when trying to deviate from its trajectory, in what strategy scholars have recently termed “stylized deviations”.⁶⁶

Smead & Zollman (2009) explore the process of adaptation by plasticity by using evolutionary game theory. Their conclusion makes an important distinction

⁶² Bayne 2004, Roll & Shibata 1991, Unger et al. 2006.

⁶³ Montgomerie et al 2001.

⁶⁴ *ibid.*

⁶⁵ Rumelt 1995a, p. 102, see also Rumelt 1995b.

⁶⁶ Gavetti & Rivkin 2007.

between *developmental* plasticity and *behavioral* plasticity. Developmental plasticity is a function of contextual and experiential adaptive behavior as an entity matures. Behavioral plasticity focuses on the competitive and other interactive forms of adaptation. This distinction may explain why startup firms exhibit adaptive potential as they grow and develop, compared to large, established enterprises whose adaptive behavior is typically predicated on some form of crisis. It also mirrors the conclusion of neuroscientists in exploring the impact of contextual and experiential influences on plasticity. They distinguish between associative memory plasticity and the functional organization of cortical processes (Li et al. 2006).

The notion of plasticity is rich, yet its relationship to flexibility has not been explored extensively. In studying flexibility in business, researchers have concentrated on the “genotype”, instead of realizing that it is at the “phenotype”, or at the level of the enterprise, that flexibility has tangible value. This may help explain why generic measures or approaches to flexibility may be of limited value.

2.2.10 Resilience

Just like a starfish that can regenerate a lost limb, the term “resilience” refers to the capacity to withstand or bounce back from shocks without permanent damage or rupture, and the tendency to rebound or recoil, showing buoyancy or recuperative power. In a nuanced sense, the term also refers to a system’s ability to degrade gracefully, providing minimal functionality long enough for the task at hand to be completed. The notion is extensively discussed in ecosystem management, child psychology and strategic management. Entrepreneurs exhibit this trait, frequently bouncing back from the setbacks inherent in creating a business.

Systems analysts have used the term to denote a natural ecosystem’s ability to restore itself after a catastrophic event, such as a hurricane, or a radical change.⁶⁷ For example, the construction of a hydroelectric dam changes the surrounding habitat by diverting the flow of water. Resilience in this setting refers to the ability of the natural species living in the habitat to recover to their former population levels. As succinctly put, resilience in complex systems is characterized by abrupt transitions between alternative persistent states (Chisholm 2007, 2009).

As a response to environmental degradation and the threat of “global warming”, resilience has become a mantra. It is proposed as a measure of an ecosystem’s ability to regenerate itself⁶⁸ and to recover from a traumatic shock, such as a dam rupturing or the unintended consequences of disposing hazardous wastes.⁶⁹ This stream

⁶⁷ Holling 1973, Fiering 1982, Grümme & Breitenacker 1981, Hashimoto et al. 1982.

⁶⁸ Holling 1973. Grümme 1976.

⁶⁹ Collingridge 1983, Fiering 1982, Hashimoto et al. 1982a, 1982b, Keeney 1983.

of work has been extended to consider the sustainability of natural ecosystems, such as Florida's Everglades (Carpenter & Walker 2001) and socio-technical ecosystems (Gunderson 1999).

The concept of resilience has received significant attention at the Beijer Institute for Ecological Economics⁷⁰ and the Santa Fe Institute (Jen 2004). Mäler encapsulated the rationale when he argued "*the probability for the system to flip from the currently preferred state to an alternative one- an undesirable state- would be smaller (ceteris paribus) for a higher resilient system*".⁷¹ This work has been extended by economists studying resilience as a form of insurance⁷² and to crisis management in public sector organizations. They focus on responses to earthquakes and other natural disasters, when operating in a state of "permanent whitewater" while "shooting the rapids" (Olsson et al. 2006).

Educational psychologists use the term resilience to refer to individuals who become stronger as a result of overcoming major problems in their lives.⁷³ Developmental psychologists have studied how children recover from trauma during childhood and adolescence.⁷⁴ Other studies have examined how the children of parents with alcohol or drug problems rebound from dysfunctional home lives (Werner 1986).

Although the concept has many interpretations (Olsson et al. 2003) the need to put it into practice is evident (Luthar et al. 2000). While it has been viewed as an important element in recovery from childhood trauma, it needs to be analyzed at a higher level of specificity in terms of single life events versus cumulative risk (Vanderbilt-Adriance 2008).

In a business context, the term "strategic resilience" has been used to describe a firm's ability to withstand or to bounce back from a damaged state and to recover from shocks and setbacks.⁷⁵ Knowledge enterprises inevitably experience setbacks and have to deal with the challenge of recovery. Some setbacks result in damage. Whatever the cause of the damage, an enterprise must bounce back by rapidly regenerating itself. Clearly, many entities place a premium on resilience after the financial crisis of 2008.

There are clear parallels with start-ups in Silicon Valley, where entrepreneurs often become successful only after they overcome major obstacles (Bahrami & Evans 1995). These setbacks often induce transitional or metamorphic episodes, referred to as "knot-holes". Knot-holes may be precipitated by the rapid demise of a

⁷⁰ Mäler, 2007, 2009; Carpenter et al. 2009.

⁷¹ Mäler et al, 2007, p.4.

⁷² Baumgärten, et al. 2009, Quaas, et al. 2008.

⁷³ Rutter 1985, 1987, Carver 1998, Masten et al. 1990.

⁷⁴ Werner 1986, 1993; Masten 1999.

⁷⁵ Hamel & Valikangas 2003, Valikangas 2007.

blockbuster product, the sudden departure of the founders, or intense exposure to external scrutiny after an IPO.

In Silicon Valley, successful teams often endure several knot-holes and, in so doing, develop the capacity to manage novel situations spontaneously. They develop a thick skin and the resilience needed to bounce back. The process can help crystallize an enterprise's "purpose" and clarify its core priorities and critical trade-offs. It is during these challenging times that flexibility is at a premium. Paradoxically, these situations are also least likely to be forecasted ahead of time, as is the case in environmental ecology (Brock & Carpenter 2009). This process can result in a firm "shedding its old skin" as if emerging from a chrysalis.⁷⁶

2.2.11 Robustness

Just as the crocodile's digestive system is robust and can accommodate a wide variety of foods, or camels store water in their humps to withstand arid desert conditions, the term "robust" is defined as "not slender or delicate or weak". As such, it is often used interchangeably with flexibility, especially when functioning in extreme conditions. The literature on robustness spans operational research (Rosenhead 1972), computational optimization (Paenke 2006), evolutionary biology (Hagen 2005) and ecosystem management (Kitano 2004).

The concept was introduced in operations research as a decision criterion in addressing complex, uncertain situations. The focus was on a system's ability to endure shocks and perturbations not considered during initial assessments.⁷⁷ In this context, the term refers to a system's ability to gain the highest proportion of good, or the lowest proportion of undesirable consequences, within a given "action space".

An enterprise's robustness is proposed as a measure of how much it can withstand shocks if it "hits" obstacles in high-risk, dynamic arenas. It is analogous to having a "force-field" around the enterprise, an "airbag" to absorb a blow, a "Teflon" coating to insulate and protect, or shock absorbers placed in areas of maximum impact. It is argued that robust systems can neutralize, deflect and dissipate the impact of turbulence. Simply put, robustness refers to the ability to remain unscathed.

⁷⁶ Sybase, Inc. is a good example, evolving as a database company in the 1990's to become a key player in mobile software.

⁷⁷ Rosenhead et al. 1972, Rosenhead 1980.

Researchers at the Santa Fe Institute have explored the principles of resilience and robustness in several application domains (Jen 2004). They set up an entire research area devoted to robustness in biological and social systems. Their research focuses on socio-technical systems, biological ecosystems, organizing the Internet, computation, integrated circuit design, molecular neurology and genetics. In genetics, phenotype robustness is defined as *“the reduced sensitivity of a phenotype with respect to perturbations in the parameters that affect its expression”*.⁷⁸ In this context, a crucial distinction is made between environmental robustness (buffering against non-inheritable responses to perturbations) in contrast to genetic robustness, viewed as recurrent mutations.

While this phenomenon, encapsulated in the term “perturbations”, has received attention at the Santa Fe Institute (Helbing et al. 2009), it is also the focus of research at Stockholm’s Beijer Institute of Ecological Economics (Brock & Carpenter 2009). Brock & Carpenter introduce the concepts of “squealing” and “flickering” as nuanced indicators of weak signals of an impending system flip into an alternate state that can be mitigated by robustness. They propose these measures in order to pinpoint which parts of a system need to be robust to prevent a system flip into a catastrophic state. It is a measure of the flexibility inherent in a system to muffle or magnify these signals, thereby providing an early warning system. As they argue *“Flickering may trigger regime shifts...Conditions that increase muffling will decrease the chance of regime shifts caused by shocks. Conversely, conditions that increase magnification will increase the chance of regime shifts caused by shocks.”*⁷⁹ These innovative concepts have significant implications for developing a dynamic strategy. We will return to this topic in Chapter 5.

The broad swathe of application areas underscores the ubiquity of the concept of robustness. In this body of research, there is frequently an overlap between the terms, robustness and resilience. Although conceptual clarity has been proposed several times (Read 2005), the interchangeable use of the terms obscures a potentially crucial distinction between the two. Resilience refers to the capacity for revival and renewal and the ability to “bounce back”, whereas robustness is about the capacity to withstand change by “bouncing off” or repelling undesirable revision-triggers.

⁷⁸ de Visser et.al. 2003 p. 1960.

⁷⁹ Brock & Carpenter 2009 p. 25.

2.2.12 Versatility

The term “versatility” is defined as turning readily from one subject or occupation to another or having the capacity to deal with many subjects, at times simultaneously. The term was first introduced by Bonder in military operations research to conceptualize how various systems can be deployed in different theaters of operations, or utilized to do a variety of different things within a given theater of operations.⁸⁰ He argued that versatility is achieved by installing the capability to respond to a wide range of scenarios ahead of time, or by rapidly modifying an approach, once a change has occurred (Bonder 1976).

Tangentially, anthropologists accredit a versatile diet as a driving force for the success of our earliest Homo ancestors. They had “*biological and cultural adaptations for a more flexible, versatile subsistence strategy. This strategy would have put the earliest members of our genus at an advantage given the climatic fluctuation and the mosaic of microhabitats in Africa.*”⁸¹ Other anthropologists attribute human mobility as a source of versatility (Devine 1985). The natural world offers other examples of versatility. A chameleon is the most erudite example. Other animals have evolved their behavior to adapt to changing conditions. For example, as a result of global warming, snow melts earlier in parts of the Arctic. This poses a problem for the ptarmigan as the male birds maintain their white plumage (camouflage in the snow) in order to attract breeding partners. It has been observed that male birds, after mating, dirty up their plumage by rolling in the mud to prevent predators from seeing them too readily.⁸²

In a business context, versatility is about being able to seamlessly switch between different priorities, for example, from prototyping to production, or from R&D to sales. It is also an essential characteristic of effective entrepreneurial teams, where the need to shift gears and to improvise is at a premium.⁸³ In addition, it is useful when assessing a knowledge worker’s capacity to multi-task, to wear different hats, and to deal with multiple priorities and reporting relationships in complex matrix organizations (Bahrami 1992).

2.3 Integrating Different Senses of Flexibility: A Unifying Framework

The preceding conceptual analysis of related terms illuminates the “family resemblances” between the different senses of flexibility. It also highlights the complex

⁸⁰ Bonder, 1976, 1979.

⁸¹ Unger et al. 2006, p. 210.

⁸² Montgomerie et al, 2001.

⁸³ Brown & Eisenhardt 1998.

and multi-dimensional nature of the concept. As depicted in Figure 5, in some senses, such as plasticity, malleability or elasticity, the term denotes a degree of pliability, in that the object must yield to some form of pressure. In other senses, such as liquidity, it means that things can be easily modified; for example, assets that can be converted to another form without incurring any switching cost.⁸⁴ Other terms, such as agility and versatility, denote an object's capacity to redefine itself as conditions change, or in a proactive sense, to bring about a new state of affairs.

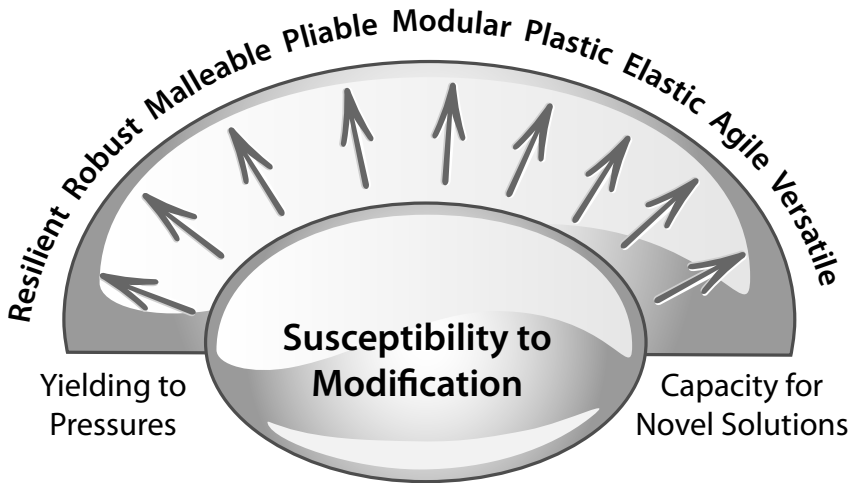


Figure 5. The “polymorphous” nature of flexibility

Our review of the literature leads us to conclude that flexibility is a *polymorphous* concept. The underlying definitional problem that has plagued the topic is one of consistency and transferability, in that those attributes that provide flexibility in one context need not be the same as, or appropriate for, other situations. This, we suggest, is the underlying reason for the conceptual schizophrenia prevalent in the literature. To be truly flexible, all the attributes have to be considered and deployed appropriately in context. An enterprise may have to be agile in entering a new market, versatile in introducing new products, resilient in dealing with setbacks, and robust in protecting intellectual property or brand reputation. Often, multiple capabilities may have to be deployed in parallel.

Several researchers have alluded to a general overarching sense of flexibility, termed “meta” flexibility, “strategic flexibility”⁸⁵ or “größer flexibilität”.⁸⁶

⁸⁴ The idea is inherent in computing and the notion of “hot-swapping”, when peripheral devices are connected and disconnected during a computer’s operation.

⁸⁵ Ansoff 1965, Eppink 1978, Volberda 1998.

⁸⁶ Meffert 1985.

This “higher order” notion is not only difficult to articulate, but is especially challenging to implement. To build on our conceptual analysis, it is clear that there is an underlying commonality encapsulated in the notion. We synthesize terms with a family resemblance under the umbrella concept of “super-flexibility”. Our goal is to provide a conceptual framework that integrate the different senses of flexibility, from agility, versatility, and adaptability, to resilience, robustness and malleability. As depicted in Figure 6, the “arc of super-flexibility” provides a visual construct that incorporates its various nuances along a dialectical spectrum; the ability to transform on the one hand, and the capacity to withstand on the other. The conceptual dualism is encapsulated in the maxim; the best form of defense is offense. Table 3 highlights the inherent dualism embedded in the different senses of flexibility.

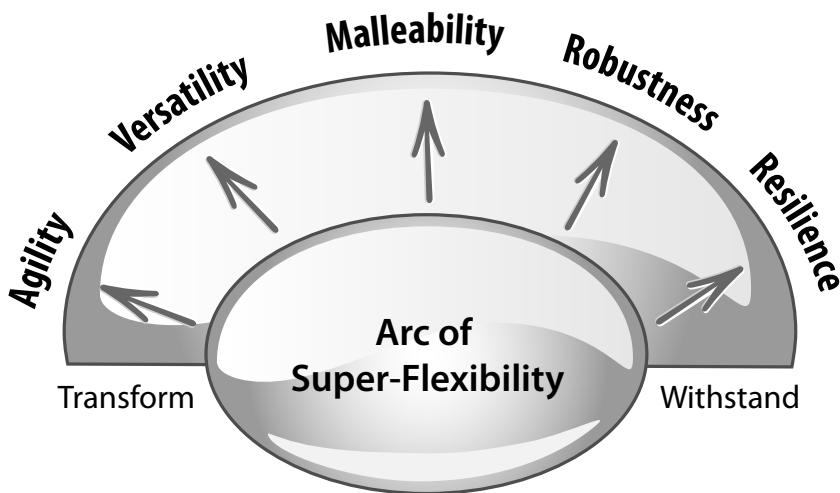


Figure 6. The arc of super-flexibility

In summary, we define the term “super-flexibility” as the ability to dynamical-ly adjust to fluid conditions, at present and in the future. At times this may entail transformation and reinvention. At other times, it may mean staying the course, and hunkering down to withstand unsettled conditions. In certain cases, it may imply the capacity to do both, often simultaneously. In addition, sometimes adjustments may be temporary and ephemeral.

| FLEXIBILITY | WITHSTAND | TRANSFORM |
|---|---|--|
| AGILITY (Gazelle, Cheetah) | Rapidly switching to a defensive posture (Wellington's squares), rapid turns or reverse, jumping out of the way of an impending disaster. | Swiftly modify existing structure for an ephemeral situation, ephemeral IT user needs, scaling across geographies, re-deploying in a new domain. |
| ADAPTABILITY (Tadpole to Frog Caterpillar to Butterfly) | Anticipated response to expected triggers, scenarios or planned contingencies. | Capitalizing on the exigencies of a novel situation, responding to new user needs. |
| (AMBI)DEXTERITY (Orangutang, Amphibians and Marsupials) | Bi-modal direction shift, "explore and exploit". | Simultaneously scaling up or down, dual use technologies, switch between high and low gears. |
| ELASTICITY (Stork, Flying Fox) | Shrinking back while maintaining composure. | Stretching without breaking. |
| HEDGING (Squirrel) | Mitigating downside risk. | Skimming upside potential. |
| LIQUIDITY (Jellyfish) | Moving resources from offense to defense without friction. | Recombining without time or resource friction/penalties, smooth s in product mix/volume. |
| MALLEABILITY (Octopus) | Easily bent into non-regular shape with the potential to return to its previous state | Bends into new shape, able to be modified for a new situation. |
| MODULARITY (Bees, Ants, Coral reef) | Downsize without impacting other components | Recombining organization units, product subsystems, IT systems |
| PLASTICITY (DNA, genetic code) | Phenotype adaptation to environmental conditions, eg an increase in predators. | Phenotype adaptation to environmental conditions eg temperature/ nutrient abundance. |
| PLIABILITY (Snake) | Molding into shape. | Bend back and forth. |
| RESILIENCE (Starfish) | Staying power, bouncing back, recoiling from stress to resume previous posture, degrading gracefully. | Returning to good health after trauma, overcoming disadvantage to succeed. |

| FLEXIBILITY | WITHSTAND | TRANSFORM |
|--|---|---|
| ROBUSTNESS (Crocodile, Hippo, Whale) | Ruggedized for hostile environments, bouncing off threats, withstanding pressure. | Teflon coated, air bag safety devices, heat shields feature preservation. |
| VERSATILITY (Chameleon, Hummingbird) | Horses for courses, fit for different ecosystems, differentiated responses. | Wearing different hats/ multitasking, regroup like a flock of birds. |

Table 3. Super-Flexibility and its different nuances

Super-flexibility is the ability to draw on a portfolio of concepts to devise approaches and capabilities in order to adapt to dynamic realities. The goal may be to either withstand and/or to transform as conditions morph. These have to be uniquely configured according to the needs of the situation, the capabilities of those executing the change, and the intent of the endeavor. There is no “silver bullet” or generic formula that can solve the “problem” of flexibility. Actions that may be appropriate one day in a particular set of circumstances may be totally inappropriate in almost identical circumstances on another day. One size does not fit all. Knowledge workers have to select and to deploy the type of flexibility that may be most appropriate in a given context. The different senses of flexibility point to different tools that can be deployed for different purposes. This is why the subtitle of the book is “*A Toolkit for Dynamic Adaptation*”.

2.4 Conclusion

This chapter described multi-disciplinary contributions to explore and explain the notion of flexibility. We explored several related concepts with a “family” resemblance. We proposed the umbrella term “super-flexibility” to integrate its various meanings and nuances.

In the multi-disciplinary literature on flexibility, there seems to be an underlying assumption that flexibility is a tangible capability, an attribute of a system, or even a quality of a decision or a strategy. This may be the case but is not the whole story. Being flexible is not just about having the right combination of *capabilities* or assets but also about *lubricating* dysfunctional pressures that build up when adapting to new realities. Its effective deployment, we suggest, depends on the ability to act spontaneously, to be configured for simplicity⁸⁷ and to provide lubrication and minimize friction.

⁸⁷ Also see Davis et al. 2009.

Real-time adaptation is difficult. It takes ingenuity to face a novel situation and true leadership to improvise on the spot. This is why simplicity is critical for real-time adaptation. After extensive research on machine tool scheduling⁸⁸ it was concluded that simple machines were easier to modify for novel outputs than those optimized for dealing with predicted contingencies. The latter require complex modifications and were ineffective when they had to adjust to unexpected changes in demand or product mix. Our experience in Silicon Valley bears this out. Simpler things are easier to change, especially when complex “real-time” modifications are needed.

In the following chapters, we transpose the conceptual to the practical application of super-flexibility. Since, we argue, most business situations are unique, we do not intend to propose “best practices” or generic approaches. Instead, we present five “conceptual coat-hangers” as diagnostic frameworks. These should be considered as a menu of options and as food for thought. Entrepreneurs, executives, and knowledge workers should view these as diagnostic tools, core principles, and shared frameworks. They can be used when devising strategies, developing execution roadmaps, reorganizing structures, aligning teams, or recycling assets. The frameworks are derived from our field research and practical experience in Silicon Valley since 1982. Taken collectively, we hope they provide an alternative optic that enable our readers to reflect on their experiences and to devise novel approaches as they address the challenge of perpetual adaptation in an age of transformation, innovation, and discontinuity.

⁸⁸ Iravani et al. 2003.

Super-Flexibility for Knowledge Enterprises

A Toolkit for Dynamic Adaptation

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