Chapter 2
Risk Management Everywhere

Abstract The purpose of this chapter is to expand Chap. 1 with additional applications and problems. Elements of risk management are summarized and application areas considered. These include managing risks and money, industrial, and marketing risks, environmental management, as well as network risk models. This chapter is introductory and non-quantitative.

2.1 Elements of Applied Risk Management: A Summary

Risk management is multi-faceted. It is based on both theory and practice. It is conceptual and technical, blending engineering, statistics, behavioral psychology, financial economics into a comprehensive and coherent approach to make, manage and justify risk decisions, to account for their consequences and confront their residual uncertainty. It consists of a broad number of tools based on mixtures of Active-Preventive-Reactive and Passive approaches to risks management. These are:

- Ex-ante risk management tools that consist of risk intelligence and detection, data-information collection; assessing risk exposure; risk analysis and design; risk valuation and pricing; risk sharing; contractual, prevention and control measures; strategic and endogenous risks management.
- Ex-post risk management consists of risks of recovery; regret minimization; robust design, anti-fragility and contingent actions that allows us to mitigate adverse events when they occur.

Under uncertainty, when risks are not predictable, the contingent ability to recover ex-post from risk events is essential. For example, recovering from a Tsunami, recovering from an unplanned bankruptcy, recovering from false accusations etc. are based on contingent means that are set for events with no knowledge whether and when these events occur. The intent of risk management is then to alter desirably their likelihood and mitigate the magnitude of undesirable

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outcomes if they occur, share or transfer their consequences. *Risk Management uses many techniques including*:

- Risk definition and detection
- Data management and risk analysis
- Risk measurement
- Risk design and optimization
- Risk exposure assessment
- Risk sharing
- Risk valuation and Risk pricing
- Risk management: Ex-Ante, Ex-Post Robust Design and Recovery

Ex-Post risks pertain to observed risk events rather than an estimate of their prospects. Risk management principles are thus based on minimizing (ex-post) regrets, on contingent recovery plans as well as robust designs which are used to maintain system, performance within a broad act of potential conditions. For major ex-post events, FEMA in the United States plans and prepare contingencies for disastrous events, investing in the means to confront emergencies.

This chapter emphasizes a number of approaches to risk management. We consider first the valuation of risk and money with insurance and finance applications, emphasizing both their differences and similarities. The following approaches are presented: "Subjective valuation" and "Rational valuation" consisting of axiomatic approaches and risk pricing. The problems we consider cover areas of interest that cannot be covered exhaustively. For this reason, numerous problems and other applications are referred to for further study and research at the end of the chapter A number of fundamental problems are treated quantitatively in subsequent chapters.

2.2 Risk Management, Value and Money

Finance and Insurance are concerned by both risk pricing and valuation and their management—each adopting approaches that are specific to their needs and to the problems they confront. Finance for example, manage risks by hedging through a trade or a series of trades using financial products (such as options, investment portfolios appropriately assembled, securitization, etc.) while insurance manage risks through insurance contracts with various clauses to limit losses and induce insured to prevent losses. It seeks first to avoid as much as possible unpredictable claims and share risk with reinsurance firms to share and mitigate excessive claims.

For finance (and increasingly insurance) risks are priced and managed by using financial instruments (such as options, swaps, etc.). Both finance and insurance do not eliminate risk but only transfer it from one party to another at a price which we call the risk premium. When financial products are so complex that buyers are unable to calculate the risk they bear (as this was the case with structured financial products such as Mortgage Backed Securities and credit derivatives (see Chap. 9), stealth financial risks are held by the structured products holders. These products have transformed both bankers and insurers as intermediaries “re-packaging” elementary financial and insurance products into complex portfolios that they are able to sell at a profit without assuming any of their risks. Both finance and insurance are essential to the “real economy” however, without which there can be no exchange and no business (except by extremely inefficient means). Lacking finance and insurance is therefore immensely costly for an economy or any institution or enterprise confronted with risks. These risks justify the claim that some finance and insurance institutions are “Too Important To Fail” (or “Too Big To Fail”) and therefore they ought to be regulated for the risks that their failure can inflict on “society”. These firms, provide the means to sustain an industrial activity, to finance a health care system, to provide money for technological innovations and investments, to finance warranties, to insure exports (and therefore create jobs) etc. Finance and insurance and the real economy are thus complementary—one needing the other, one not functioning without the other. Similarly, managing and regulating risks in the one is essential to the other. In this sense, all economic and real activities are all locked in a complex set of relationships that defines and amplifies their dependency, and thereby their risks.

The valuation and pricing of risk is based on how and what risk we actually measure, how valuable they are to us and whether they can be exchanged, or traded (see Chaps. 8–10). Measurements of risks can however be valued financially when they are accepted as a means of exchange or trade (see also Chaps. 6 and 7).

Insurance firms define and value and predict risk in terms of actuarial (statistical) terms and manage the value of their risks through risk aggregation and risk sharing with specific partners (rather than financial markets—although they are increasingly using financial markets). Insurance profits are then made by the spread that an insured is willing to pay (the retail price) for a contractual risk protection (or required by law to seek such a risk protection), and the cost (the warehouse price) of an aggregate portfolio of such contracts. The greater “warehouse-retail” spread price, the greater the insurance firm profit. To manage this spread, insurance firms, construct portfolios with contracts that are statistically independent (i.e. consisting of diversified risks), that are not subject to latent or rare risks and clearly delineated. As a result, insurance firms seek basically to increase their spread, maximize their returns on their capital and minimize risks.

For finance, unlike insurance, the risk spread is derived from standardized “financial and traded commodities” (such as securities, bonds, options etc. that are globally accepted as exchange instruments for returns and risks). For example, a “security” whose price provides a rate of return of 10% while an equivalent riskless bond provides a rate of return of 6%, has a rate of return of 10-6 $=$ 4% which is the price that the buyer of a security receives when it assume the security risks. As a result, in theory and in practice risk is measured and valued based on two essential model-intensive approaches consisting of the following:

1. Asymmetric (individual, firms, investor, or economic agents) preferences that are motivated to exchange. Risk, measured and valued differently by say two parties may then agree to an exchange price that is consistent with their preferences. Such a price is then specific to the parties and to their transaction.
2. The market pricing of risk, based on economic equilibrium models, summarizing the demands of buyers and sellers for "financial commodities" assumed (and therefore believed and accepted) to include and reflect implicitly the price of risk.

The first approach is based on the presumption that "persons" are not indifferent to the size of gains and losses. A risk-averse person for example, would weigh losses more than their equivalent gains! To express such subjective preferences, a number of approaches (based and often derived from expected utility arguments as we shall see in Chap. 7) pretend to represent persons' preferences. In this context, the premium a person is willing to pay to do away altogether or partly with risk indicates his risk aversion. This approach turns out not to be practical because the underlying utility of decision makers is not usually known (although it is often expressed in terms of a number of parameters that one seeks to estimate based on observed prices and trades). For this reason, models that are tested or based on economic experience are used to determine the risk premium an insured ought to be charged. These models are important as they provide a theoretical framework for assessing future risks based on implied prices. For example, insurance firms assess insured claims risks using proprietary actuarial information and formulas on the basis of which a risk premium is calculated (see Chap. 7). As indicated above a gradual shift to marketing standardized insurance products is leading the insurance business to be financial intermediaries. A marketing apparatus for aggregate portfolios consisting of life insurance and other pensions' related products are then "commoditized" and sold in financial markets as "securities". Such products are essentially insurance products dressed in a financial tunic. The importance of insurance liquidity and the ability of insurance firms to meet insured claims require that they conform to certain rules set by insurance regulators. Basel III regulation rules for example, require that they set aside a certain amount of risk free financial capital to meet potential liquidity needs (also called Capital Adequacy Ratio-CAR, Value at Risk-VaR as well as Conditional Value at Risk-CVaR, as outlined in Chap. 6). As a result, insurance firms have become complex "warehouses of risk". In some cases, elements of the insurance business has been assumed by banks while element of the banking business have been assumed by insurance firms—contributing again to an insurance/finance competitive risk convergence.

2.2.1 Insurance Actuarial Risk

An insurance contract substitutes payments now (the risk premium) for potential future losses. The size of current payments and future losses are based on the actuarial assessment and valuation for the probabilities of future losses and their size (Cramer 1930, 1955; Buhlmann 1970, 1980; Gerber 1979; Seal 1969, 1978). The risk of loss is then priced at the insured risk premium, managing assets of the insurance firms, meeting insurance regulation and building the capacity to meet losses when thy occur. In most cases, insurance firms negotiate with insured preventive measures they ought to assume in exchange for a reduced premium. When there is an information asymmetry, with one or the other parties taking advantage of such a situation, risk shifting is counter-productive, providing a gain to the one party at the expense of the other (Arrow 1963a; Akerlof 1970; Hirschleifer and Riley 1979; Holmstrom 1979; Spence 1977). To mitigate these risks, contracts are stated explicitly in terms of contractual and obligations and premium incentives (such as bonus-malus premium payments based on past claims of the insured). At times it is difficult to control what each of the parties does and therefore both inspections and controls as well as recourse to litigation provide means to control and meet the terms of the contract as agreed on and as expected (Reyniers 1992; Reyniers and Tapiero 1995a, b).

Preventive means by insured are many. For example, driving carefully, locking one's own home effectively, installing fire alarm for the plant, etc. are all forms of loss prevention. Car insurance rates tend, for example, to be linked to a person's past driving record, leading to the design of (incentive) bonus-malus insurance premiums. Certain clients (or geographical areas) might be classified as "high risk clients", required to pay higher insurance fees. Inequities in insurance rates will occur, however, because of an imperfect knowledge of the probabilities of claims and because of an imperfect distribution of information between insured and insurers (Borch 1968, 1974).

Traditionally, actuarial science was concerned with quantitative risk measurement and assessment. Tetens and Barrois, as early as 1786 and 1834 respectively, attempted to characterize the "risk" of life annuities and fire insurance so that they may be properly assessed and valued financially. It is due to Lundberg (1909) and a group of Scandinavian actuaries that we owe much of current actuarial theories. Actuarial statistics have initially focused on claims risks arising from bankruptcy, survival (for life insurance), accidents proneness etc. Based on economic and social considerations, "Risk Premium Principles" were suggested to "price fairly insurance contracts". Most of these approaches are based on a willingness to pay of insured, their actuarial propensity to claim and their claim history. In the last decades, risk premiums have increasingly been engineered in terms of the market price for risk.

2.2.2 Finance and Risk

Finance is motivated by three basic purposes:

- To price the multiplicity of claims, accounting for risks and deal with the adverse effects of risks and uncertainty;

- To explain and account for investor's behavior. To counteract the effects of regulation and taxes by firms and individual investors (who use a wide variety of financial instruments to bypass regulations and increase the amount of money investors can make while reducing the risk they sustain).
- To provide a rational framework for individuals and firms, financial decisions and to suit investors needs in terms of the risks they are willing to assume and pay for.

Financial risk instruments are used for risk management, allowing both an exchange of financial and real assets, a risk transfer both horizontally (for example across different products, different countries) and vertically (for example across different financial and dependent products such as options and their underlying). Markowitz (1952, 1959) suggested a risk/reward framework based on the mean and the variance of a portfolio. In this case, a portfolio's returns/variance emphasizes their substitution, with one valued in terms of the other. Risk management consists then in a risk minimization (variance) for a preferred return and vice versa, maximizing expected returns subject to a tolerable risk. Markowitz' solution provides then an efficiency curve that outlines investors' portfolio preferences. By including a risks free asset (bonds) in Markowitz' portfolio, relative risk premiums were defined and embedded in the celebrated CAPM (Capital Asset Pricing model, see Chaps. 7 and 8). Subsequent studies have suggested an inter-temporal shift and transfer of risks (see Bismut 1975; Bismut 1978 for initial and important studies in this matter as well as elements of the CCAPM pricing models, Cochrane 2000 and Chap. 8). This has allowed risk managers to better manage the *time phasing of risk and returns*.

Financial liquidity expresses the capacity to meet demands for money. It is also an appreciable source of risk when the demand for liquidity cannot be met. Following the financial crisis of 2007, liquidity was proved to be extremely important, providing immense risks to firms or persons that did not and could not access the liquidity they needed and great profits (or at least no loss) to those who possessed or could access liquidity. Further, the financial crisis has pointed out that liquidity affected significantly equity and debt market prices. The need for liquidity as a fuel of economic development and expansion has led to the stratospheric growth of credit risk and credit derivatives leading both expanding mortgage markets, insurance liquidity but at the same time to its uncontrolled and poorly regulated use leading some to call such financial products "weapons of mass destruction", presumable a dominant factor in the financial crisis and its aftermath.

Example: Managing Credit Risk To manage credit risks banks use a plethora of techniques and financial products they sell and trade in financial markets (in order to share and sell the risks they have assumed). Among the many tools they turn to for risk management are the following:

- Loan underwriting standards (i.e. procedures applied to safeguard loan reimbursements).

- Insurance of credit transactions and insurance of credit portfolios. In this case, either one or both parties, or a third party will act as guarantor to some or the risk implied in the credit transaction.
- Construct credit portfolios and their collaterals priced to be sold in financial markets (called securitization).
- Managing collaterals and hedging their values to maintain the collateral effective use as a guarantor of the loan given to a borrower.
- Diversify the credit risk across different borrowers.
- Managing the credit portfolios in light of macroeconomic developments.
- Manage the counterparty risk, both when credit transactions involve the two parties engaged in the transaction and when a third party assumes its insurance. These problems assume many forms—such as a third party (a rating firm) defining the credit quality of a portfolio, an insurance firm insuring the portfolio, etc. In such cases, issues such as, "is the rating firm providing a high rate to a bank's portfolio because they profit greatly from providing such a rating or engage in extensive other businesses with the bank? Is the insurance firm a traditional insurance firm or a financial and speculating enterprise branded as an insurance and financially safe firm?

Example: Too Big To Fail: Externality Risks and the Fallacy of Large Numbers "The lure for size" embedded in "economies of scale" and the "monopoly power" it provides have led to firms that may be TBTF. When these firms fail they have important risk consequences that are Too Big To Bear for the public at large. This is the case for industrial giants such as GM that has grown into a complex and diversified global enterprises that has accumulated a default risk too large to bear. This is also the case for banks that bear risks that are often ignored and end up also Too Big To Bear. Banks, unlike industrial enterprises, draw their legal rights from a common trust, to manage the supply and the management of money for their own and the common good. Consequences of their failure, overflow into the commons, and contribute to systemic risks, that far outstrip their direct losses. When banks are too big to fail they may use it to both assume excess risks and seek protection when their financial bets sour. Further, they may also price their services to be unrelated to their costs or their quality and exercise unduly their market power. TBTF firms create therefore risk externalities that justify their regulation and tight controls. For example, Frank Rich (The *New York Times*, Goldman Can Spare You a Dime, October 18, 2009) has called attention to the fact that "Wall Street, not Main Street, still rules Washington". Similarly, Rolfe Winkler (Reuters) pointed out that "Main Street still owns much of the risk while Wall Street gets all the profits".

Banks are not the only economic institutions that are TBTF (Too Big To Fail) and can produce risk externalities. In the energy sector, a study by the National Academy of Sciences has pointed out to extremely large hidden costs that are not accounted for by the energy industry, but assumed by the public at large. Fujiwara (2004), using an exhaustive list of Japanese bankruptcy data in 1997, has pointed out that firms fail regardless of their size. Further, since the growth of firms has been fed by debt, the risk borne by large firms seems to have increased significantly, threatening both creditors and borrowers alike. In fact, the growth of size through a growth of indebtedness combined with ''TBTF'' risk attitudes has contributed to moral hazard risks, with firms assuming non-sustainable growth strategies with stealth and important risk externalities.

When size is based on networked firms (such as large global networked financial institutions, "supply chains", health care networks, electrical power grids), their dependence increases and failure can be contagious (see also Mandelbrot and Hudson 2006, Serafın Martınez-Jaramillo et al. 2010; Allen and Gale 2000). Saito et al. (2007), while examining inter-firm networks noted for example that larger firms tend to have more inter-firms relationships than smaller ones and are therefore more dependent. In particular, Saito points out that Toyota purchases intermediate products and raw materials from a large number of firms; maintaining close relationships with numerous commercial and investment banks; with a concurrent organization based on a large number of affiliated firms. Such networks have augmented both Toyota's dependence and its supply chains risks. Thus, when one supplier controls a critical element needed for the proper function of the whole firm, lacking this element can lead to the whole supply chain to be immobilized. Renault, in France, experienced such a state of affairs when a small plant in Normandie with no more than a hundred employees could strike out the whole Renault complex. By the same token, a small number of traders at AIG could bring its "Too Big To Fail" firm to bankruptcy. Simulation experiments on a network of cooperating banks was conducted by Aleksiejuk and Holyst (2001) to assess the propensity of a systemic breakdown using percolation theory and its contagious effects. Their simulation have shown that sudden withdrawals from a bank can have dramatic effects on the bank stability and may force it into bankruptcy in a short time if it does not receive assistance from other banks. More importantly however, the bankruptcy of a simple bank can start a contagious failure of banks that can lead to a systemic financial failure.

TBTF Risks raise an essential question: Can economies of scale savings compensate their risks. Such an issue has been implicitly recognized by Obama's administration proposal in Congressional committees calling for banks to hold more capital with which to absorb losses. The bigger the bank, the higher the capital requirement should be (*New York Times*, July, 27, 2009, Editorial). However such regulation does not protect the ''commons'' from the risk externalities that banks create and the common sustains. Further, augmenting inexorably the capital banks must hold will necessarily reduce the ability of banks to lend and therefore their profitability.

2.3 Industry Processes and Risk Management

The transformation of industry following the first industrial revolution, has redefined risks to be embedded in parts "uniformity", in "product assurance", in a consistent and a repetitive process. These have led to risks to be measured and managed by the “control of variations”. Non-performance or a deviation from specifications as well as departing from a process specs’ identified as essential risks. These resulted in an industrial approach to risk management which is adopted as a standard in many other professions. It is based on:

- Control and process design for systems with no default, no errors, no defects and consistency
- The propensity to maintain the manufacturing process in control, i.e. operating to meet its conformance to pre-sets standards through statistical sampling and controls and assure its supplies and delivery
- Zero errors and faults tolerance through prevention, robustness and comprehensive managerial approaches to risk management.
- Manage Variations in all ways feasible and economical. Meet expectations or operate to meet agreed on standards of supply or manufacture.
- Maintain a process propensity to be repetitive with variations within defined bounds.

Risks of default, of breakdowns, of non-conformance, supply risks, quality risks etc. were thus defined and industrial risk management based on maintenance, reliable designs, statistical controls, inventories etc. For example, Shewart (1931) introduced principles of statistical (risk) controls to control parts and products uniformity. The standard deviation (a statistical variation) was associated to risk and used to construct control charts that are used since.

Statistical approaches were applied to all sorts of problems (in agriculture, in insurance, in health care, etc.). Classical tools coined under the names SPC (Statistical Process Control), SQC (Statistical Quality Control) as well as Experimental Design and Robust Control (se Chap. 11). In the 1980s, the number of parties involved in a process (whether industrial, service, health care, development, management, etc.) became so large, interdependent and complex that their management became overwhelming. For this reason more systematic and comprehensive approaches were needed. These led to defining a series of acceptable and easy to understand and apply tools for the many parties involved in a process (Fig. 2.1).

For example, TQM (Total Quality Management) seem to standardize the use of simple statistical tools to allow both their acceptance and simplify the technical exchanges required in quality and risk management. These tools express the need to systematize and quantify: Sources of risks; Measure and accumulate data; Find relationships; Summarize variations; Seek risk causes; Seek what are the important contributing factors to risks. The Table below Fig. 2.1 summarizes both the techniques used and their intent. These approaches are both common and easy to understand and can be used to communicate among and across the parties that are involved in an industrial process. Other approaches and tools were also suggested. They are essentially based on the following: Risk definition (what is most important and what to measure that will help prevent risks and responds to your needs); Measure what is essential and revealing to track, to test, to predict and to

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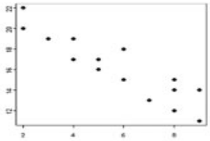
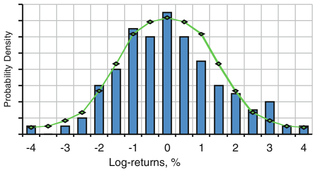
<tr><td></td><td>Scatter Plots to demonstrate elemental relationships or a lack of such relationships</td></tr>
<tr><td>
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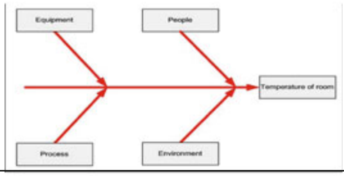
<tr><td>
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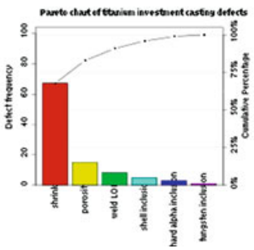
<tr><td>
</td><td>Pareto charts to provide an ordering of what is more important and what is less so.</td></tr>
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Fig. 2.1 Tools for quality and risk management

control and finally, improve performance and risk, value and price performance and its risk.

As industry processes became more networked and integrated, risk dependence grew as well, becoming far less manageable. Further, growth in productivity reduced market prices and the need of industries, having mastered the economics of production, dominant needs became needs to market, sale and profits.

A Summary: Industrial Process and Risk Management

Figures 2.2 and 2.3 above summarize some elements defining a process of risk management. We note in particular, “Risk Definition”, “Risk Data Assembly”,

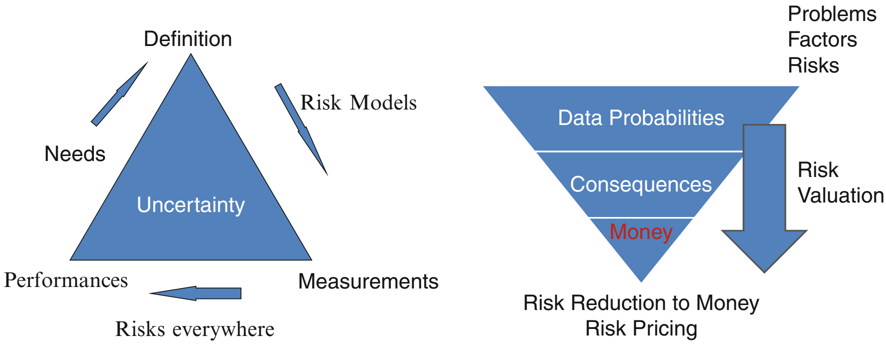

Fig. 2.2 Industrial management and risk everywhere: definition, measurement, performance

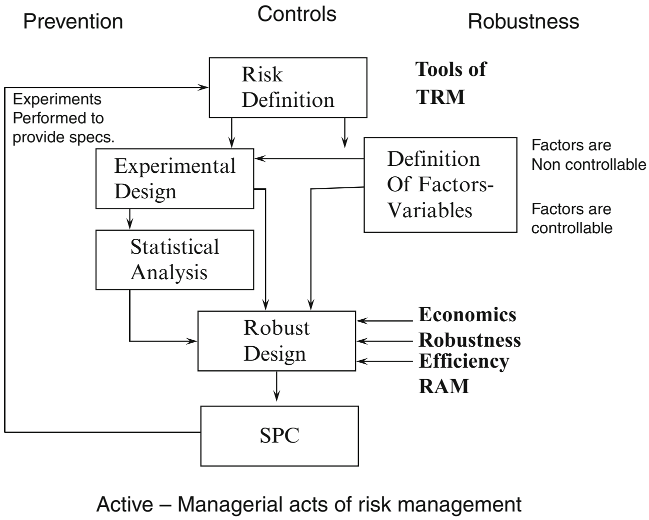

Fig. 2.3 Statistical tools and the management of risk

"Statistical and Experimental Design" and Statistical Control. Examples to these tools to manage risks in other fields, more similar than different, abound. For example, auditing traders, control of shipping lanes and ships entering a port, controlling a portfolio's performance over time, controlling experimental results in a medical lab, are such cases. Over time, firms have grown from industrial to service, to retail, to supply and networked and stealth firms loosely controlled and A-national—belonging to no one in their pursuit of profits and global positioning. Risk management has in this process become far more complex, far more elusive to regulation and controls.

2.4 Marketing and Risk Management

A fast changing environment, increasingly uncertain, combined with an aggressive and global competition has changed the market place. Firms have recognized these changes, their opportunities and risks and have sought to adapt to a fast changing environment. Traditional marketing strategies to manage risks are to "diversify", to "grow", "control markets horizontally" (seeking monopoly market powers) and, "aggressive brands advertising". Consumers too, confronted with more choices may be increasingly disloyal and therefore unpredictable characterized at best by dubious probabilities. As a result, marketing functions, often viewed as a "buffer" between the operating firm and its markets is increasingly challenged by markets, consumers and post sales and complementary services.

Risk and uncertainty have always beset marketing. The beginning of marketing research (and risk) activities appeared in the late 1920s and early 1930s. The first well known text Marketing Research and Analysis by Lyndon O. Brown, did not appear until 1937. Subsequently, (in the late 1940s) a number texts introduced descriptive statistical methods, such as tabular and graphic presentations. Although the lion's share of marketing handling of uncertainty has been followed by data handling and statistical methods, numerous attempts have been made at formulating probability models, risk optimization models (stochastic brand switching and advertising, truth in advertising etc.), sales forecasting, new products prospects, repeat purchase models and their like (see Tapiero 1975a, b, 1977a, 1978b, 1979, 1982, 1982a, b, 2000a, 2005e). The concern for data collection and validation, statistical surveys of consumers, brand management and control, manage the marketing mix to mitigate marketing risks, are some of the issues that confront marketing managers. The concerns of marketing risk management consist then in altering in a desirable manner, the future market states (opportunities), the probabilities of these states and their means to profit. We consider below a sample of specific marketing risks. Experience and an extensive set of retail and consumers studies and their consumption are equally relevant to financial retail firms, banks and clients oriented businesses.

2.4.1 Reputation Risks

A cruise ship, belonging to a large corporate entity in the shipping business, departs from safe sea lanes, ventures dangerously close to shore put its passengers at risk and sink the ship with some passengers drowning and others traumatized. Of course, aside from the loss of property, the potential legal litigation that the Corporate entity, the ship owner, will face, compensation to the 4,000 passengers of the ship etc. will most likely contribute to an immense financial consequence (whether the firm is insured or not). No less important however is the reputation risk—resulting from a number of factors that affect the perceived future safety of the firm performance and thereby its attractiveness. It affects further the current financial performance of such firms with investors and traders factoring future financial consequences into current prices. In this particular case, it may imply a falling stock price, a contagious sales of securities, future consumer behaviors, disappointment-regrets risks, future reservations to be cancelled, a lower demand for the firms services and on. Reputation risks is therefore important and can strike any firm or person, due to word-of-mouth and social media contagion, due to down-rating of a firm, due to incompetence and errors of one or more employee, or firms strategic decisions (such Bank of Americas requesting unreasonable payments for using an ATM machine), due to strategic actions by counter parties or due to external and revealing events (pointing out to an incongruence between a firm's stated reputation), to a firm lies revealed, etc. Reputation risks are also gaining an increased attention. A survey by the Federation of European Risk Management Association (FERMA) with the Institute of Risk Management (RIM) found that reputation risk from social media was cited a "material risk" by nearly 50% of European companies—making it one of the greatest cyber threats that organizations face. Further, reputation risks are not rare. A 2010 study of the world's 1,000 largest companies found that 80% of those firms have a major "reputational event" every five years that causes them to lose a fifth of their value (*Wall Street Journal*, January 17, 2012, p. B5). For these reasons, particular attention is given by corporate firms to engineering their reputation and mitigating its risks by advertising and "false" advertising as the example below highlights.

2.4.2 Advertising Claims and Branding Risks

Advertising claims and consumers' experiences define claims reliabilities, namely the probability that an advertised claim is confirmed or not by the experienced purchaser. Reliable claims are important as they contribute to branding of products and to their re-purchase while unreliable claims can lead to a loss of clients and in some extreme cases (as it is the case in drug advertising claims) to extremely large litigation costs. Since true products characteristics are necessarily random (due to the production process, use and misuse of the product) advertising claims truthfulness is inherently random as well. There is therefore always a probability that an advertising claim is not met. Advertising claims that underestimate product characteristics might be reliable", namely be mostly true, but then they might not entice first time purchasers, while overly optimistic advertising claims might entice first time purchasers but be perceived as unreliable by repeat purchasers who might switch to other competing products. In this sense, the decision to advertise or to claim returns or advantages one does not always have, is necessarily concurrent to the decision to "what to advertise". Such decisions are compounded by the fact that in prevalent marketing philosophies, a consumer is also a consumer of services (such as warranties, product servicing, an investor, an insurance client etc.) and a firm profits not only from the revenues generated at the time of sale but also in derived revenues maintained as long as the customer remains a client of the firm.

2.4.3 IPO, Reputation and Risks

Investopedia's definition of an IPO ('Initial Public Offering—IPO') is "The first sale of stock by a private company to the public" (http://www.investopedia.com/terms/i/ipo.asp#ixzz1kysbF3L5). Typically, IPOs are issued by smaller, younger companies seeking capital to expand as well as "cash in" on their prior achievements and an expectation of future returns. However, IPOs are also used by large privately owned companies seeking to be publicly traded. This is an inverse process where firms are privatized for both profit and to avoid the regulation required by publicly traded companies. IPO are however gambles for the firm, its employee and its investors. For employees, the IPO is both an opportunity and a risk. On the one hand it "liquefies" their holdings, or the options they received instead of, or as a complement to their salary. On the other it is also a risk to their shares' potentially diluted and arising from the legal transformation of the firm that can change appreciably the corporate structure, the work environment and employees' pension holdings.

IPO's are performed in a number of ways, summarized by directly turning to the public (as it was the case with Google's IPO) and IPO's through financial intermediaries. In this latter case, the IPO issuer obtains the assistance of one or several underwriting firms, providing professional advice, access to capital investment and become more credible to prospective market investors. For example, advising on the type of security to issue, whether common or preferred or some financial products denoted in local or foreign currency, their voting powers and other characteristics. Advisors then seek to define a market sensitive price based on their markets analysis with a favorable chance for the IPO to succeed and where to issue the IPO (for example, in Wall Street, in London, in Shanghai, Hong Kong and other countries). The IPO is therefore part of an elaborate process resulting in a "public offering" summarized by the initiated firm "seeking to go to market" or "induced to go to market". The end process is a public offering.

IPOs are not without risk however: Future Expectations and Partial Information providing the IPO issuer an informational advantage. It can also punish the IPO issuer if ex-post, it turns out to have been misleading (whether intended or not). For example, Groupon, "the daily deals" internet firm founded in 2007–2008 that went public in 2012 had an astonishing growth rate going public in 2011 with a market valuation of 20 Billion Dollars. However, once public, Groupon was open to scrutiny and ever since has met a harsh criticism essentially due to its accounting (used to project publicly its financial performance and based on "certain assumptions and forecasts" that the company used). This resulted in the company reporting losses, and a reputation that led the market to reduce its price dramatically (on March 30, 2012, the stock price went down by 6%). For these reasons, the firm, its shareholders and employees and prospective buyers may on the one hand be at risk and on the other be enriched.

For firms, potential risk exposures arise due to regulatory risks (including stock Exchange requirements to comply to a set of rules, increased responsibilities of directors and officers of the firm, etc.); An enhanced corporate governance responsibility including an increased exposure to potential personal liability; An Increased regulatory scrutiny; New regulation in relation to the publication of financials (for example, late publication of financials would lead to regulators imposing fines and/or penalties); In addition, alleged errors, omissions, misstatements in the listing offer document etc. may lead to potential lawsuits inherent in the offering document itself. Shareholders rely on statements made in the document and an alleged misstatement, or breach of the offering, could lead substantial defense costs and the potential settlement cost. Finally, insider trading can result in substantial fines and a legal cost once the IPO has been issued (whether successfully or not).

For shareholders, there are additional risks. Some may result from the dwindling of their hold on the firm, while other result from an increased number of shareholders augmenting the probabilities of potential future lawsuits. Further, a growth in stock market volatility following the IPO, may contribute to a decline in the shareholders' stock prices as well as potential claims occurring to changed and additional geographical locations where the firm was not listed. Finally, while a positive growth in earnings is rarely challenged by shareholders, a disappointing performance of the firm after an IPO and required to divulge internal procedure, accounts and projections, can lead to additional and troubling legal claims and reputation risks.

Client (stock purchasers) risks abound. The firm may provide partial or incomplete information and thereby increases stock purchasers' counter-party risk. The IPO may be a ploy by its management and a number of angel investors seeking a quick turnaround profit rather than a capital expansion for future prospects. Finally, external bubble markets condition or a unique reputation fed by intensive and purposeful advertising to brand the firm as an extraordinary opportunity may also be a source of risk for prospective clients. For the firm, counter party risk may incur potential indemnities to underwriters in the event of being sued as a result of misstatements: The offering document usually allows for indemnities to be provided to the underwriters and/or sponsors of an IPO. If the listing company is sued for misstatement in its prospectus, not only will the directors and officers be potentially liable, but further indemnities may have to be provided to counterparties.

Additional elements that point out to an IPO success are based on stock market valuations and aggregate market and international conditions (such as liquidity, relative returns on stock investments, regulation and the cost of capital etc.). In a global world, IPO will also follow markets where opportunities are largest. Recent statistics have pointed out that over the last 5 years the number of IPO's in the US has been declining dramatically while IPO's in Europe and Asia have been increasing appreciably. These elements point out to both global trends in the competition of financial markets for IPOs. Macroeconomic factors such as market liquidity can also lead to IPOs bubbles or “hot IPO markets” (Chemmanur and He 2011; Ritter 1991; Beatty and Ritter 1986). Market liquidity combined with investors and managers’ real options, both contributing to the potential to cash in at advantageous market condition, can usher an “IPOs contagion” of successful IPOs increasing the market hunger for IPO’s investments. These elements point out to both opportunities and to IPO risk factors, plagued by uncertainty (and thus gambles).

Pricing an IPO (i.e. a valuation of the IPO initiative when it is going to market) is therefore a challenging and a risk problem with information asymmetries with future events unknown and strategic risks (i.e. game like among an IPO’s parties, see Chap. 12). IPO pricing therefore more of an art than a financial problem which is resolved technically. For example, empirical studies report that investment banks and commercial banks that are involved as financial advisors with lucrative fees to IPOs have no particular advantage one over the other when pricing IPOs. Nevertheless, rules were made not to allow banks private research with an interest in an IPO to be published before the IPO. This is currently overturned.

Example: IPO underpricing The risks of over pricing an IPO and face litigation costs, reputation risks and a downfall in a firm market price leads (for risk averse firms) IPOs to be underpriced. There are a number of theories that explain such observations. A number of research papers have indicated that IPO are underpriced as a form of insurance also coined the insurance effect and to lower expected litigation costs (the deterrence effect). Evidence for both these aspects is embedded in three factors that define the initial IPO price:

- Signaling. A lower underpriced IPO signals a quality that allows firms to raise more capital in the future (Welch 1989).
- Information asymmetries. On the one hand it provides an initial and larger demand for the IPO issue (and therefore increases its returns and price) and a reputation risk on the other, if the IPO firm does not meet its projected expectations or turns out to have misled investors.
- Litigation risks whose probability and magnitude are a function of the disparities in actual and reported information.

Under-pricing may also be a compensation for uncertainty that particular and uninformed investors bear compared to informed (insiders) investors. Thus, ex-ante uncertainty is an important determinant of an IPO price that may justify underpricing. To mitigate this uncertainty, some IPO firms turn to financial institutions with a high reputation to manage their IPO (for example, Facebook turning to Goldman Sachs and to leading banks, international IPOs of Chinese firms are also turning to local banks to help the launching of their stock in foreign local markets, etc.).

Example: IPO and Facebook The Facebook IPO has, as the public media explained (May–June, 2012), been disastrous resulting both from the mismanagement of information and claims regarding Facebook potential earning capacity (on what bases these estimates were created?) and on error in trading in Nasdaq that have resulted in both a lack of trust by individual investors as well as discriminatory actions taken by leading banks to favor themselves and their clients. In the weeks that followed the IPO, Facebook lost close to 16% of its valuation. In addition, the prospect of court cases lingering over Facebook and its associated institutions is contributing to risks that will be latent for some time. This has been reflected by an extraordinary decline in its market valuation after its first two weeks.

2.5 Externalities and Risks Management

Environmental pollution that spill over into the public domain with no consequences to its perpetrator are risk externalities. Their consequences can be health, financial, international, political that can linger over long periods of time. Managing these risks involves a broad set of questions and potential means that are prevalent in economic, environmental, social and health sectors. These include for example: regulation; preventive efforts to be implemented by both firms and the public; contingent recovery and emergency preparedness; legal pursuits that perpetrators will have to face; who pays for it and in what proportion; are the responsible parties penalized; etc.

Say that a Chemical firm employing 1,000 persons has an environmental accident due to some malfunction resulting in a public damage. If such a firm is to be punished harshly and its employees joining the lines of the unemployed will their costs be sustained by the public domain? Similarly, rare earth—those materials needed for many and important parts in technology intensive products are known to produce extensive environmental damage. This has led to the production of such rare earth only in a country willing to assume this damage for the returns it brings. However, when there is only one country producing rare earths and it exercises its monopoly power over all other countries, are the political risks and financial costs of not producing rare earths appropriately assessed at their right value? Similarly, car drivers enjoy their car while at the same time they do not assume the environmental consequences of the car's pollution which could have been avoided had they selected to walk or use an environmental efficient public transportation. For these reasons, environmental risks are prevalent in everything we do. On the one hand, they are harmful, on the other they derive from what we need, we want and do. A similar argument can be applied to banks' risk externalities.

Concepts of risks applicable to sustainable development are both interdisciplinary and omnipresent in many disciplines. Each discipline contributes its particular wants and characteristics. For example:

- How to assess the risks of an industrial policy (pollution, costs and efficiency, etc.)
- What are environmental risks and what are their multiple consequences (financial, reputation, regulation, etc.)
- How can we recover from environmental disasters
- What are production risks derivatives and what are their costs and their environmental impact.

- How are environmental risks subcontracted and transferred (for example disposing of nuclear and others wastes in willing and poorer countries)
- What are the strategic (gaming) factors in environmental regulation and what are their consequences—economic and otherwise
- What are potential pollution abatement technologies and how can they be values and priced.

2.6 Networks and Risks

Networks abound and have multiplied in all kinds and all sizes. They also compound risk and uncertainties resulting in greater interdependence and a far greater complexity to contend with. Network risks are prevalent in industrial networks; in supply chains; in the banking systems; in financial markets; in consumers associations; in integrated retail commercial networks with stores, warehouses and supplier organized as franchises (of various sorts and contracts); in health supply networks; in a transportation system; in electrical grids; to model contagions, to model an internet system, etc. A network model is defined by a set of inter connected entities (nodes) defined by lines that connect their nodes (explicitly, this is a mapping of nodes onto themselves. These lines may be uni-directional or be directional, with connections potentially random or quantitatively defined. Networks may also be cyclic or be acyclic (namely, with potential feedback loops or none). A network may be *arborecent*, in which case, each node has a single predecessor but any number of successors (which is the opposite of the assembly process); *Acyclic*, with nodes of connected by any number of predecessors and successors, with no return; *Cyclic* or general, with no restriction on the flows connectedness. Networks and Graphs, whether modeled as a set of deterministic connections or as a set of random and interacting elements (nodes or lines) are in general complex systems that can be analyzed sometimes analytically but mostly using simulation techniques (see Chap. 3). Numerous books and papers in Operations Research, Queuing Theory, Transportation and Management Science, Biomathematics, Engineering Systems, etc. are published referring to network and graph models. For example, Economides (1996) considers economic issues that pertain to networks, FMS are modeled as randomly connected networks of queues while Capobianco (1973), Tapiero et al. (1975), Boots and Tapiero (1973), provided a sampling statistical approach to estimate networks and graphs characteristics (for example, to estimate the connectedness of underground water flows connectivity). Networks may also be used to models to model the interconnectivity of supply chain, international banks as well the operational flow associated to financial transactions. Some of these networks are not easily observable. For example, networks of underground rivers (Boots and Tapiero 1973) but also of banking relationships which can be extensive some of which may in certain cases be unknown even to bank executives. For example, with the demise of Lehman Brothers, it turns out that there were thousands of financial and legal

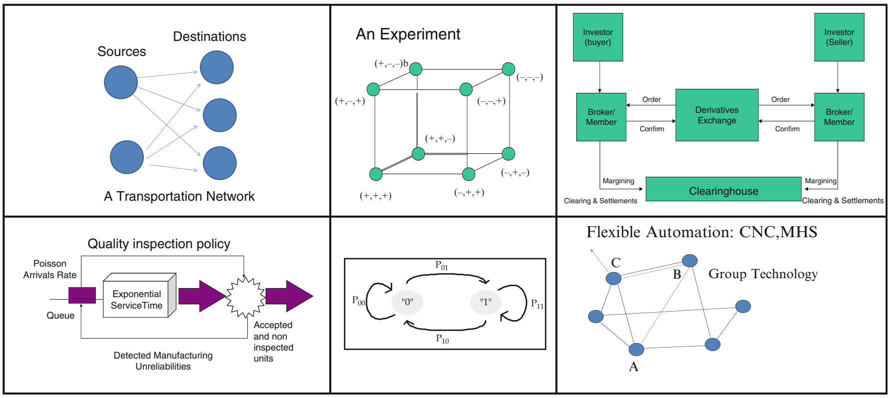

Fig. 2.4 A sample of networks and their use

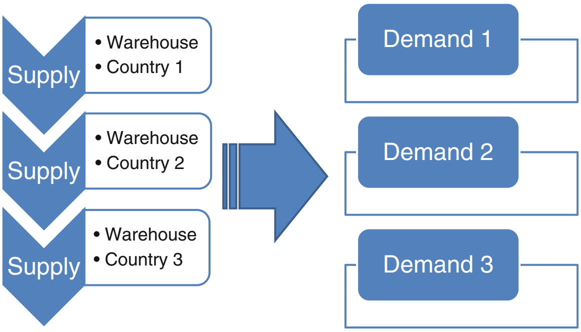

Fig. 2.5 The transportation model

entities in Lehman Brothers that were in fact unknown to the corporate center of Lehman Brothers!

A network can be used to model a system of components parts, each defined by a reliability function; a transportation network defining the flow from a given set of sources to a set of destinations (with flows or times to travel subject to breakdowns or delays); an industrial automatic process such as flexible manufacturing Systems; a network of queues (see Fig. 2.4); a sequence of events leading to a polluting event or used to highlight a causal or a dependent structure; a model of contagion; a supply chain, a set of networked stake-holding firms, communications and telecommunication networks; a cellular pattern; the internet network, social media networks, etc. Networks risk models are abundant, are complex, occur for many reasons and proliferate in all professions. Below specific network models are considered—both to express quantitative relationships and risks.

Example: Networks and Markov Chains Markov chains (see Chap. 5) are used to define the transition probabilities between a set of notes (called sates) as shown in Fig. 2.4. They are modeled as follows. Let there be n states, $i = 1, 2, \ldots n$.

For two states $i = 0, 1$ might denote that a risk event has occurred (i = 0) or not (i = 1). The transition probabilities p_{ij} define the probabilities of moving from one state (i) to another (j). For a two states process, we have four possible transitions as indicated below:

00: Initial state "0", subsequent state "0" with probability p_{00}
01: Initial state "0", subsequent state "1" with probability p_{01}
10: Initial state "1", subsequent state "0" with probability p_{10}
11: Initial state "1", subsequent state "1" with probability p_{11}

Example: A Flexible Manufacturing Systems (FMS)
A flexible manufacturing system may be defined by:

- "Cells" consisting of regrouped technologies (means of production, machines, expertise, a combination of resources)
- A material handling system (MHS) connecting the "cells", either automatically using a robotized system or not
- Systems to direct and control flows from cell to cell. Usually an integrated IT control system

In a FMS a pre-defined path set through a number of work stations defines a production process for a part or a product. As a result, by altering the path to follow, numerous (and different types) of parts may be attended to. Such systems are usually technology intensive. Their advantage is their economy of scope in attending to simultaneously to multiple parts or services. These system, although complex (and therefore prone to operations risks) provide an economic advantage due to their ability to produce with small lots, allowing the sharing of equipment and technologies. The complexity and the interdependence of such systems require however far more information, far more computer aids, far more automation, greater reliability and risk controls for their operations.

Planning and constructing such systems are an engineering challenge however. The planning of cells is also a complex process based on using a GFT (Group Technology). GT is essentially an approach that considers all the variables relevant to process and its scope. It is in principle applicable to organizational design. In manufacturing it consists in grouping multi-components (technologies, grouping of people, process functions) into cells with similar or complementary characteristics to improve the network ability to respond to needs and various demands. A cell or a group is thus the basic unit in a process that seeks to "more" with "less". The principles of GT is due to the Russian S.P. Mitranov suggested a formal proposal for GT in 1940. It is however in Germany where an Opitz classification system was accepted for GT and widely implemented. Its underlying assumption is that "many problems" have common characteristics and can therefore have a similar solution.

Network risks, whether in a FMS, in transportation, in a banking system or other networks can be classified into the following categories:

- Nodes integrity risks
- Flows-Communications-linkages-line risks
- Coordination risks

- Complexity risks
- Contagion risks

*Nodes integrity risk*s relate to cell malfunctions, breakdown and misprocessing. When a cell malfunctions it is critical if the network as a whole malfunctions (for example, it hinders a needed flow to all other nodes). Node integrity may be directly observable or unobservable (but revealed through either statistical controls or through observables elements.

Flows or line risks assume various forms such as a loss (of money, or a transaction cost, an information imbued with noise, a misinformation), an unexpected time delay when moving from one node to another is random.

Network risk dependence—statistical and contagious are expressed by the statistical relationships that exists explicitly or in a latent and stealth manner between the nodes and the flows from node to node. When malfunction in one node induces a malfunction in another, a contagion risk materializes. For example, say that a network consists of n connected banks and say that one firm defaults. Given its connectedness, to what extent are neighboring banks affected? Similar situations arise in electric network-grid, in supply lines, in health contagions in dense cities etc.

Are certain risks critical and causing a network failure? For example, if the failure of a particular service can cause a global networked failure, then that service may be considered too important to fail (and therefore requiring special attention), while other services may not.

To manage network risks, we design the "network structure": (for example, a transportation system in Fig. 2.5), "manage its content and relationships" and "control the random and dependent factors" that define the flows and the exchanges that occur in the network. In this sense, network risks are generic risk models that may be applied to a wide variety of problems and contexts.

Example: Queues and Networks The mathematical theory of queues has its origin in the study of telephony systems (that are necessarily highly interconnected networks) initiated by Erlang, a mathematician with the phone company in Copenhagen in 1917. In the 1950s numerous applications of queuing models and networks have been used to model an extremely large number of practical problems. The mathematical theory of queues is a subfield of discrete events stochastic processes (for example, see Gross and Harris 1985 and Chap. 5) in its elemental quantitative form. It is based on interacting models of independent stochastic processes.

An extremely large diversity of such models can be constructed, both based on realistic assumptions regarding the "randomness" of events (arrival, queuing, screening/processing/service, etc.) that define a queue's statistical operational characteristics. For example, queues can be considered as cells that are connected and together form a network with queuing systems connected randomly or following a pre-defined path. Such models are used to model power grids, patterns of migrations, communication systems, inter banks flows of money etc. A typical

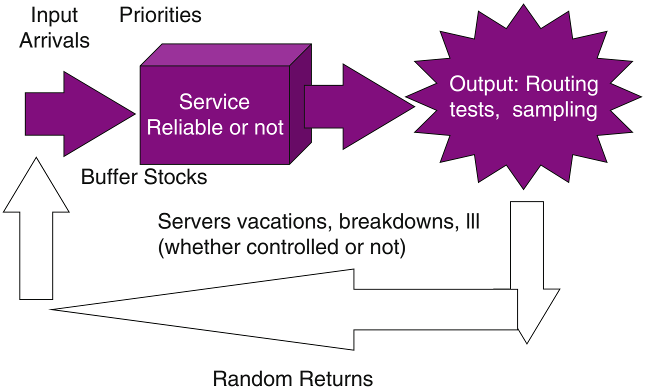

Fig. 2.6 A feedback queue

example includes the FMS (Flexible Manufacturing Systems) modelled as a network of queues where nodes are cells performing specific functions and final products (or services) defined by the path set for the product and its exit from the network. The generic mathematical definition of queues is thus defined in terms of the following:

1. An input or arrival (planned, random, etc.)
2. A waiting line (into a waiting space whether bounded or not)
3. A service (by one or a number of parallel "service stations, with a deterministic or a random service time).
4. Disciplines and priorities in seizing a waiting space, in the queues, in service, etc.

Figure 2.6 above represents a specific queue model where service may be reliable or not operating or not (in which case, it is "on vacation"), with a buffer defining its waiting capacity and routed to some other queue as a function of a pre-determined schedule that defines its requirements. An arrival may be well intended, seeking a "service" they may pay for (for example, entering a cinema) or not (such as going to a free beach). Some may be ill-intended, seeking to harm the arrival process, the service or pass through undetected to create great harm. Such an input might be persons arriving to a security line prior to entering an airport and ought to be prevented. Arrivals are usually random while preventive efforts may consist of inspections and controls as well as external efforts based on the detection of such elements prior to their arrival. Arrivals can of course be non-threatening, or "normal", in which case the time spent waiting for the desired service may be either null or due to controls imposed by threats to the queue system. For example, access to a beach might or might not be controlled, access to a concert hall might require controls at the entrance or not, etc. Awareness of threats is inducing a state of "uncertainty or un-safeness" that controls seek to reduce by their own existence, by their own actions, by their threat to ill-intended parties (even if the probabilities of such threats are very small). In this later case, queue controls are strategic.

References and Additional Reading

Additional references on risk management consulted in this chapter have included Cheng et al. (2004), Hale (2002), Hallikas et al. (2004) as well as Tapiero (1977b) (on dynamical problems), (1978a, 1996). Industrial risk processes references include numerous articles published by Hsu and Tapiero 1987a, b, 1988a, b, 1992, 1994, Hsu et al. 1993, Lee and Tapiero (1986, 1989) as well as Tapiero (1987, 1989, 1995a, 1996, 2007), Zsidisin (2003), Zsidisin et al. (2001) as well as Kogan and Tapiero (2007), Gattorna (1988), on Strategic Supply Chain Alignment, La Londe and Cooper (1989), on Partnership in providing customer service and Marvel (1982), on exclusive dealing. Additional references will be used in subsequent chapters. In particular, Chap. 11 on risk and strategic controls.

Risk processes and safety have extended this theme outlined in Chap. 1 including Blom et al. (2005, 2006), Bohn (2000), Bohn and Choi (1996), CAS (2001), FSA (2005, 2006a, b) and IMO (The International Maritime Organization) (2002).

References on Marketing applications include the paper by Ingene and Hughes (1985), Munier et al. (1999), Spence (on economic search), (1977), Nerlove and Arrow (1962) on advertising problems as well as numerous extensions to the stochastic domain reviewed in 1977 by Sethi and my own papers on these problems in 1975a, b, 1977a, 1978b, 1979, 1982a, b, 2005.

Application to risks externalities in this chapter were based on my own lecture notes and on papers by Greaker (2003a, b, 2006). Additional application on IPO, includes Culp (2006) on Structured Finance and Insurance, Yip (2007), Port Traffic Risks, Cox (2009) on Risk Analysis and Complex Uncertain Systems with applications to health care, Kogan and Tapiero (2007), on supply chains and games, my own book (Tapiero 1996) and the Management and the Control of Quality, Coles (1993) on the the price of quality and Yaniv (1991) on absenteeism and risk.

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