Chapter 5
EWs/MSCs: An Overview

5.1 Introduction

In the warranty literature there confusion regarding the usage of the term "extended warranty" (EW). In the case of standard consumer products, customers prefer this term whereas providers of EWs have used a plethora of terms including maintenance service contracts (MSCs). EWs and MSCs are similar in many respects but there are also differences. A proper understanding of EWs requires concepts from base warranties (BWs). Similarly a proper understanding of MSCs requires concepts from outsourcing in general. This chapter starts deals with these two topics, looks at the different aspects of EWs and MSCs and their similarities and differences.

The outline of the chapter is as follows. We start with a brief discussion of BWs and their different aspects in Sect. 5.2. This is followed by a general discussion of EWs in Sect. 5.3 where we highlight some of the key issues. Section 5.4 gives a brief introduction to outsourcing and Sect. 5.5 deals with maintenance outsourcing where we focus on the key elements of MSCs and the similarities and differences between EWs and MSCs. In Sect. 5.6 we present some real EWs and MSCs for consumer and industrial products. Section 5.7 looks at MSCs in the context of infrastructures.

5.2 Base Warranty

As mentioned in Chap. 1, a BW is integral to the sale of a product and the customer does not pay anything extra for it. Most standard products (consumer, commercial and industrial) are sold with either a one- or two-dimensional BW. The two most common types are the free replacement warranty (FRW) and the pro rata warranty (PRW) policies. The terms of the BW policy are formulated by the manufacturer. In contrast, the warranty terms for custom built and complex expensive products are jointly decided by the manufacturer and the customer and

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can include reliability performance guarantees which require the manufacturer to improve reliability should the targets be not met. These are referred to as reliability improvement warranty (RIW) policies.

5.2.1 Standard Products

One-Dimensional BWs: A one-dimensional BW policy is characterized by an interval defined in terms of a single variable—time or age.[1] The two most common warranties are the following.

Policy 1: Non-renewing FRW Policy

The seller agrees to repair or provide replacements for failed items free of charge up to a time W from the time of the initial purchase. The warranty expires at time W after purchase.

Policy 2: Non-renewing PRW Policy

The seller agrees to refund an amount $\alpha(T)C_s$ if the item fails at age T prior to time W from the time of purchase, where C_s is the original sale price and $\alpha(T)$ is a non-increasing function of T, with $0 < \alpha(T) < 1$.

Two-Dimensional BWs: A two-dimensional BW is characterized by a region in a two-dimensional plane, usually with one axis representing time or age and the other representing item usage. The most common are the following two policies with a rectangular warranty region.

Policy 3: Two-dimensional Non-renewing FRW Policy.

The seller agrees to repair or provide a replacement for failed items free of charge up to a time W or up to a usage U, whichever occurs first, from the time of the initial purchase. W is called the warranty period and U the usage limit. The warranty region is a rectangle given by $[0, W) \times [0, U)$.

Comment: If the usage is heavy, the warranty can expire well before W, and if the usage is very light, then the warranty can expire well before the limit U is reached. Should a failure occur at age T with usage X, it is covered by warranty only if T is less than W and X is less than U. If the failed item is replaced by a new item, the replacement item is warranted for a time period $W - T$ and for usage $U - X$. Nearly all car manufacturers offer this type of policy, with usage corresponding to distance driven.

Policy 4: Two-dimensional Non-renewing PRW Policy

The seller agrees to refund the buyer a fraction of the original sale price if $T < W$ and $X < U$ at failure. The fraction refunded is a function of $W - T$ and/or $U - X$.

[1] The variable can also be usage—for example, number of copies made in the case of photocopiers and number of hours flown in the case of jet engines.

5.2.2 Custom Built and Complex Products

The basic idea of a RIW is to extend the notion of a basic consumer warranty (usually the FRW) to include guarantees on the reliability of the item and not just on its immediate or short-term performance. This is particularly appropriate in the purchase of complex, repairable equipment that is intended for relatively long use. The purpose of a RIW is to negotiate warranty terms that will motivate a manufacturer to continue improvements in reliability after the product is delivered.

Under a RIW, the manufacturer's fee is based on his/her ability to meet the warranty reliability requirements. These often include a guaranteed mean time between failures (MTBF) as a part of the warranty contract. The following is an illustrative example:

Policy 5: RIW Policy [Gandara and Rich (1997)].

Under this policy, the manufacturer agrees to repair or provide replacements free of charge for any failed parts or units until time W after purchase. In addition, the manufacturer guarantees the MTBF of the purchased item to be at least M. If the computed MTBF is less than M, the manufacturer will provide, at no cost to the buyer (1) engineering analysis to determine the cause of failure to meet the guaranteed MTBF requirement (2) engineering change proposals (3) modification of all existing units in accordance with approved engineering changes, and (4) consignment spares for the buyer to use until such time as it is shown that the MTBF is at least M.

5.2.3 Study of BWs

BWs have been studied from three different perspectives—(1) customer (individual, business, or government agency) (2) manufacturer (or distributor, retailer, and so forth) and (3) societal (including legislators, consumer affairs groups, the courts, and public policy decision-makers, etc.).

5.2.3.1 Customer's Perspective

As indicated in Chap. 1, from the customer's point of view, the main role of a BW in product purchase transactions is *protectional*—it provides a means of redress if the item, when properly used, fails to perform as intended or as specified by the manufacturer. A second role is *informational*—a product with a relatively longer warranty period signals a more reliable and longer lasting item than one with a shorter warranty period.

5.2.3.2 Manufacturer's Perspective

From the manufacturer's point of view a BW also serves a protectional role. A warranty contract specifies the use, and conditions of use, for which the product is intended and provides for limited coverage or no coverage at all in the event of misuse of the product. Another role is promotional—as buyers often infer a product to be more reliable when a long BW is offered. As such, the warranty serves as an effective advertising tool and it has become an instrument, similar to product performance and price, used in competition with other manufacturers in the marketplace.

5.2.3.3 Societal Perspective

Civilized society has always taken a dim view of the damage suffered by its members that is caused by someone or some activity, and it has demanded a remedy or retribution for offences against it. Consequently, manufacturers are required to provide compensation for any damages resulting from failures of an item. This has serious implications for manufacturers of engineered objects. Product-liability laws and warranty legislation are signs of society's desire to ensure fitness of products for their intended use and compensation for failures. In the USA during the last century, the Congress passed a sequence of Acts (the Uniform Commercial Code, the Magnuson-Moss Warranty Act, the TREAD Act, and so on).

5.2.3.4 Different Aspects

There are many aspects to a warranty and these have been studied by researchers from diverse disciplines. Some of the warranty issues that have been studied include the following:

1. Historical: origin and use of the notion
2. Legal: court action, dispute resolution, product liability
3. Legislative: Magnusson-Moss Act; Federal Trade Commission, Warranty requirements in government acquisition (particularly military) in the USA and the latest EU legislation
4. Economic: market equilibrium, social welfare
5. Behavioural: buyer reaction, influence on purchase decision, perceived role of warranty, claims behaviour
6. Consumerist: product information, consumer protection
7. Engineering: design, manufacturing, quality control, testing
8. Statistics: data acquisition and analysis, data-based reliability analysis
9. Operations Research: cost modelling, optimization
10. Accounting: tracking of costs, time of accrual

11. Marketing: assessment of consumer attitudes, assessment of the marketplace, use of warranty as a marketing tool, warranty and sales
12. Management: integration of many of the previous items, determination of warranty policy, warranty servicing decisions
13. Societal: public policy issues.

Consequently, the BW literature is very large[2] and Blischke and Murthy (1996) integrate the many different issues that have been addressed. Four topics from BWs, that are relevant in the context of EWs later on, are the following:

5.2.3.5 Warranty Cost Analysis

Whenever an item is returned under warranty, the manufacturer incurs various costs (handling, material, labour, facilities, etc.) and these costs are random (unpredictable) quantities. The following three types of cost are of importance to both customers and manufacturers:

1. Warranty cost per unit sale
2. Life cycle cost per unit sale
3. Life cycle cost over repeat purchases.

Blischke and Murthy (1994) discuss models to determine these costs for many different types of BWs.

5.2.3.6 Warranty and Marketing

The interaction between consumers and manufacturers defines the market for a product. For most products (such as consumer durables, industrial and commercial products), a manufacturer will have several competitors who are producing similar products and attempting to sell them to a given set of consumers, so that the market (for the product) is competitive. For some specific products (mainly industrial and commercial products), the manufacturer has no competitor so that the market is monopolistic rather than competitive. The market outcome depends on the interactions between several variables. On the manufacturer side, the variables include price, promotion, warranty etc. On the consumer side, product choice (no purchase/purchase; which of the competing brands to purchase) depends on several variables such as product features, perceived risk, brand, reputation, etc.

Warranties are seen as reducing perceived performance risk by providing protection against product defects leading to failures within the warranty period.

[2] See Djamaludin et al. (1996) for a bibliography listing over 1,500 papers up to 1996. Reviews of the later literature on warranty can be found in Thomas and Rao (1999) and Murthy and Djamaludin (2002).

Financial risk to the consumer is also reduced, as the repair costs to rectify failures occurring under warranty are covered by the manufacturer.

Blischke and Murthy (1996) discuss these issues in more detail.[3]

5.2.3.7 Warranty Management

Warranty management needs to be done at two different levels—strategic and operational. Strategic Management deals with decision-making with regard to all aspects of the product from an overall business viewpoint and over the product life cycle, which is the period from initial conception to manufacture and marketing to product obsolescence. As such, this is a long time frame and the decision-making needs to take into account the uncertain nature of the impact of external factors (for example, the economy, competitors actions, etc.) and some internal factors (for example, outcome of research and development). Warranty decisions must be integrated with decisions relating to technical issues such as design, development and manufacturing, and to commercial issues such as marketing, price, sales, revenue, etc. so as to ensure that the business objectives—profits, return on investment, market share, and so forth—are achieved, while at the same time providing adequate assurance to customers and ensuring customer satisfaction. Operational management deals with the implementation and execution of actions needed to achieve the business goals. It involves monitoring and making the changes needed over shorter time intervals. For more details of warranty management, see Brennan (1994) and Murthy and Blischke (2000, 2005).

5.2.3.8 Warranty Logistics

Warranty logistics deals with all the issues relating to warranty servicing and has an impact on the warranty costs. The manufacturer's ability to service a warranty is affected by the geographical distribution of customers and by the level of their demand for prompt response. The manufacturer needs a dispersed network of service facilities that store spare parts and provide a base for field service. This service delivery network requires a diverse collection of human and capital resources and careful attention must be paid to both the design and the control of the service delivery system. This involves several strategic and operational issues. The strategic issues are (1) the number of service centres and their location (2) the capacity and manning for each service centre (to ensure desired response time for customer satisfaction), and (3) whether to own these centres or outsource them so that the service is carried out by an independent agent. The tactical and operational issues are (1) transportation of the material needed for warranty servicing (2) spare parts inventory management (3) scheduling of jobs and (4) optimal repair/replace decisions. Murthy et al. (2004) discuss this topic in detail.

[3] More recent papers dealing with pricing are Huang et al. (2007) and Zhou et al. (2009).

5.3 Extended Warranty

An EW is a similar concept to a BW The difference between a BW and an EW is that the latter is entered into voluntarily and is purchased separately—the customer may even have a choice of terms for an EW, whereas a BW is part of product purchase and is integral to the sale.

Confusion in Terminology
According to Mancuso[4]

> Consumers seem to prefer the term EW. But industry professionals prefer the term service contract, even when they work for companies with the word warranty in their name.

He remarks that describing something as an extension of the manufacturer's warranty is inviting trouble.

> The word warranty only applies to the underlying manufacturer's product warranty, which came with the product. That's what Legal would say to us. If I went in and said, 'We're extending the warranty,' they'd say, 'No, you're not!' Warranty comes from the manufacturer. It ends, and we're asking, 'Would you like a service contract?' They're two distinctly different elements.

There is no consistency in the terminology used in industry. In the automobile industry alone there are 35 different terms used.[5]

5.3.1 Key Elements of an EW

An EW may contain some or all of the elements listed below.

[4] Warranty Week January 21, 2010.

[5] The terms used are: service agreement; extended warranty; service contract; maintenance agreement; after-market warranty; extended service plan; vehicle protection plans; extended vehicle coverage; extended auto warranty; vehicle service agreement; extended vehicle service contract; car service contract; vehicle maintenance contract; extended car warranty; extended service contract; vehicle extended warranty; aftermarket warranty; car extended warranty; auto extended warranty; automobile service contract; vehicle service contract; mechanical breakdown insurance; extended service coverage; extended vehicle warranty; auto service contract; extended automobile warranty; automotive extended warranty; motor vehicle service agreement; automotive service contract; power-train extended warranty; vehicle service protection; mechanical breakdown protection plan; service contracts for vehicles; auto extended service contract; automotive service plan.

5.3.1.1 EW providers

EW providers can be

- Manufacturers
- Retailers
- Third parties—insurance companies, credit card providers, etc.

5.3.1.2 Purchase Date and Duration

Often the customer has to purchase an EW at the time the product is purchased. Sometimes the customer has to the option to purchase the EW before the BW expires. In either case the EW starts from the time the BW expires.

In the case of a 1-D EW policy, the duration refers to additional time period W_1 of coverage provided by the EW. In the case of a 2-D EW policy the duration includes the additional time period W_1 and usage limit U_1 provided by the EW.

5.3.1.3 Terms

The terms define what the EW covers in relation to labour and material.

- Labour—full, partial or not covered
- Material—components or parts covered.

With full coverage (for both labour and material) the customer incurs no additional cost during the period of the EW. With partial coverage the cost to the customer depends on the terms of the EW policy.

5.3.1.4 Transferability

This defines whether the EW is transferrable or not should the customer decide to sell the product before the EW expires.

5.3.1.5 Exclusions and Limits

The exclusions and limits refer to claims over the EW period and include the following:

- Transport or freight costs excluded and paid by the customer
- Parts of the product not covered
- Limits are placed on the total number of claims
- Cost limits—limit on each claim, limit on total claims.

5.3.1.6 Price

- Purchase prices of different EW options
- Deductibles—the customer pays a certain fixed amount for each claim.

5.3.1.7 Special Requirements

- Regular preventive maintenance (PM) actions that need to be carried out during the EW period for the EW to be valid
- Nominated agents (e.g. retailers) authorised to carry out the PM actions
- Procedure for making a claim—restricted to a particular repairer.

5.3.2 Three Perspectives

As was the case with a BW, the customer's (an individual, business, or government agency) point of view of an EW is different from that of the EW provider (a manufacturer, retailer or third party). Another perspective is the societal point of view, including that of legislators, consumer affairs groups, the courts, and public policy decision-makers.

5.3.2.1 Customer Perspective

From the customer's point of view, the main role of an EW is assurance for a period after the BW expires. Specifically, the warranty assures the buyer that a faulty item will either be repaired or replaced at no cost or at reduced cost. This is important as the cost to repair a failed item can be high. As such, an EW is like an insurance to cover the high repair costs. In the case of consumer products it provides "peace of mind" which has been exploited by EW providers in their marketing efforts. Two other factors that sometimes influence a customer's decision to buy an EW are the following:

- Without an EW the customer needs to find a repair facility to get a failed item fixed. This is avoided with the purchase of an EW for the duration of the warranty
- The option to choose a particular response and service time when there are several EWs on offer with different response and service times.

5.3.2.2 EW Provider Perspective

EWs are a major source of revenue for many manufacturers and retailers. Over twenty years ago, Sears reported in excess of $1 billion in revenues from EWs

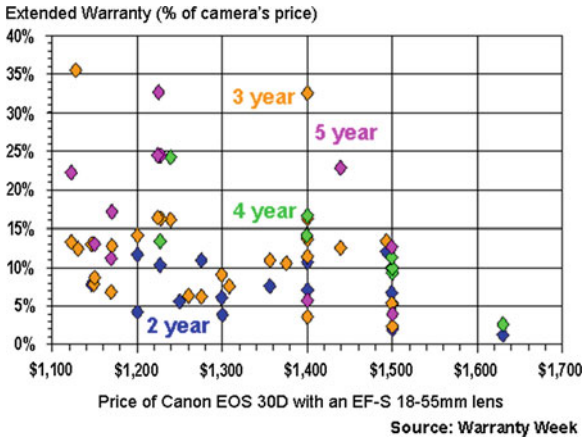

Fig. 5.1 EW price (as percentage of sale price) for four different EW periods

alone[6] and they accounted for over 50 % of profits for some major appliance store chains.[7] The major focus of EW providers is to maximise their profits.

The percentage of consumers buying EWs varies across product categories—from 20 % on products such as automobiles to 75 % on products such as home electronics and appliances.[8] For a given product brand the price charged by EW providers can vary considerably—for example, in the case of the EW for the Canon EOS 30D camera sold in the USA both the sale price and price of the EW (as a percentage of sale price) varied considerably. The figures for four different EW periods are given in Fig. 5.1.[9]

Other benefits are:

- EWs provide a unique mechanism (for both manufacturer and retailer) to build customer loyalty and encourage repeat product purchasing
- EWs help the manufacturer keep in touch with customers long after the expiry of the BW
- EWs create brand-authorised spare parts and allied services
- The servicing of EWs provides valuable information about product reliability that is useful for R&D and Design activities.

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[6] *San Francisco Chronicle*, January, 1992.

[7] *Business Week*, January 14, 1991.

[8] Padmanabhan and Rao (1993), *PC World*, March 2003, *Wall Street Journal*, November 12, 2002, *Automotive News*, November 26, 2001.

[9] *Warranty Week*, October 24, 2006.

5.3.2.3 Societal Perspective

In the case of EWs, rip-offs can arise in numerous ways, including:

- Overcharging for policies
- Non-payment of valid claims
- Skimping on coverage.

Some retailers and dealers charge relatively high prices (compared to the price of the product the policies cover) because they have a monopoly of opportunity and a monopoly of information.[10]

There have been legislations passed in the USA and UK to protect customers' interests and reduce the exploitation by some of the EW providers.

5.3.3 Some Simple EW Policies

5.3.3.1 One-Dimensional Policies

The warranty coverage for an EW (in the non-renewing case) is to time $W + W_1$, with W_1 being the duration of the EW and W the duration of the BW. The terms of the EW can be the same as those of the BW provided by the manufacturer for a new product (in which case there is no additional cost to the customer), or they may differ in the sense that the EW may include additional features. We list a few EW policies which contain such additional features.

Policy 6: Cost Sharing EW Policies.

Under the cost sharing EW the customer and the service agent (SA) share the repair cost. The basis for sharing leads to several different scenarios;

Policy 6(*a*): Specified parts excluded (SPE).

Let I denote the set of components that are included and $\bar{I}$ the set of components excluded. The SA rectifies all failures of components belonging to the set I at no cost to the customer. The cost of rectifying failures of components belonging to the set $\bar{I}$ is borne by the customer.

Policy 6(*b*): Lump sum cost sharing (LCS).

The cost of repairing a failure is borne by both the customer and the SA. The function characterising the cost sharing can differ depending on the policy. Figure 5.2 shows one such function where the fraction of the cost borne by the customer increases once within the EW period.

Policy 6(*c*): Material or labour cost sharing (MLS).

There are two possible situations. In the first case, the customer pays for the material needed to repair a failure and the SA pays for the labour cost. In the second case, the reverse arrangement applies.

[10] In the case of 1-D warranties some EW providers mislead the public by claiming that the warranty period is $W + W_1$ when it is actually W_1.

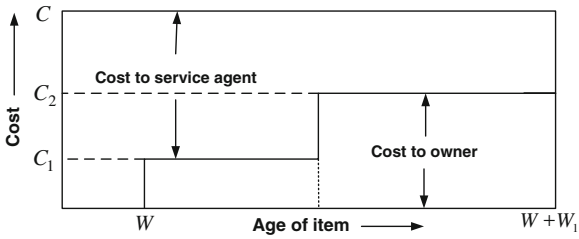

Fig. 5.2 An illustrative example of a cost sharing EW

Policy 7: Cost limit warranty (CLW) Policies

The cost limits can be on each individual claim or on total claims over the EW period.

Policy 7(*a*): Limit on individual cost (LIC).

If the cost of a rectification is below a specified limit c_I then the cost is completely borne by the SA. If the cost exceeds this limit, then the customer pays the excess—the cost of rectification less c_I.

Policy 7(*b*): Individual cost deductible (ICD).

For each claim under an EW the customer pays an amount c_E to the SA. As a result, the SA makes money on an EW claim if the cost of repair is less than c_E and incurs a cost (given by the difference between the actual cost and c_E should the cost of rectification exceed the limit).

Policy 7(*c*): Limit on total cost (LTC).

Under this policy the EW expires when the total rectification cost to fix claims under the EW exceed a limit c_T. Note that in this case the EW can cease before W_1.

5.3.3.2 Two-dimensional EW Policies

As in the 1-D case, several different 2-D EW policies can be formulated involving cost sharing, limits, exclusions, etc. When the EW is purchased at the sale of a product the warranty region is bigger than that for the BW. In the case where the warranty region is a rectangle it is given by $[0, W + W_1) \times [0, U + U_1)$ as indicated in Fig. 5.3.

When an EW is bought just before the BW expires then there can be two scenarios. The first is similar to that discussed above so that parts covered by the EW have a total age limit $W + W_1$ and usage limit $U + U_1$ irrespective of the age and usage when BW expires. In the second, the EW is a rectangle given by $[0, W_1) \times [0, U_1)$ as indicated in the Fig. 5.4.

5.3.4 Study of EWs

In contrast to BWs the literature on EWs is limited and can be broadly grouped into four categories.

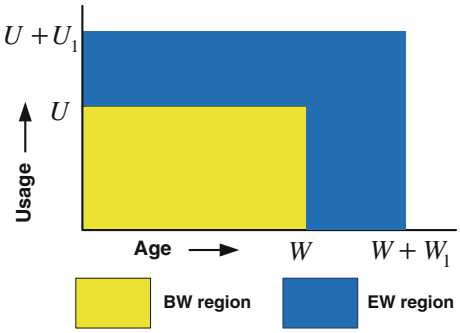

Fig. 5.3 BW and EW regions for an EW purchased at product sale

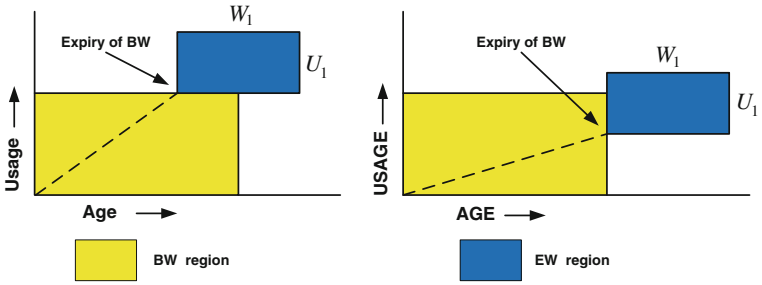

Fig. 5.4 EW regions dependent on the situation at the expiry of the BW

5.3.4.1 Operational Research

Here the focus is on estimating the EW costs from both the EW provider and customer perspectives and optimal customer decisions are based on the cost analysis. The costs can be

- Cost per unit sale and/or time
- Life cycle cost.

Other issues include such as the terms (price, warranty coverage, etc.) offered by EW providers and the maintenance actions carried out by the customer during the EW period and their implications for the optimal decisions. These will be reviewed in Chap. 8.

5.3.4.2 Economics

The EW research in economics is at the microeconomic level and deals mainly with EW market related issues. The EW market is the outcome of interactions between EW providers (manufacturer and others) and customers purchasing EWs.

The focus is on the economic efficiency of the EW Market.[11] Inefficiency occurs due to distortions created either by the market (actions of EW providers and/or customers) and/or government actions (through legislation) or inactions. For the market to be economically efficient information plays a critical role. Asymmetry in the information that different parties in the market possess can lead to market inefficiency due to the problems of *adverse selection*[12] and *moral hazard.*[13] The difference between these two terms is that adverse selection is caused by hidden information whereas moral hazard is the result of hidden actions which are either unobservable or costly to observe. Some examples of hidden information in the context of EW markets are the following:

- The inability of the EW provider to service EW claims either due to lack of expertise, or an unsound financial state so that bankruptcy can take place before the EW ceases. This situation is known to the EW provider but is not communicated to potential customers and can lead to adverse selection by customers.
- The customer's maintenance effort and usage mode which might not be revealed to the EW provider and can lead to adverse selection by providers.

Some hidden actions in the context of EW markets are the following:

- The EW provider not doing the EW servicing properly and the customer being unable to observe this—EW provider moral hazard.
- The customer not investing in the due maintenance effort and care and the EW provider being unable to observe this—customer moral hazard.

There are two other EW issues that are dealt with in the economic literature. Warranties can signal product quality to consumers when quality (reliability) is unobservable. This is called '*signalling*', with a longer warranty assumed to signal a better product. When consumers are heterogeneous, offering different price/warranty combinations to the market and allowing consumers to self-select increases the EW providers' profit and this process is referred to as '*screening*'. There are several papers that focus on screening taking into account moral hazard and adverse selection resulting from information asymmetry.

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[11] In economics, the term *economic efficiency* refers to the use of resources so as to maximize the production of goods (products and services). A situation can be called *economically efficient* if:

- No one party can be made better off without making some other worse off (commonly referred to as Pareto efficiency).
- No additional output can be obtained without increasing the amount of inputs.
- Production of goods proceeds at the lowest possible per-unit cost.

[12] In economic theory adverse selection refers to a class of problems where pre-contractual opportunism by parties possessing private information leads to inefficiency in the operation of a market. Hollis (1999) deals with the effect of adverse selection on market outcome.

[13] In economic theory moral hazard is a situation where the behaviour of one party may change to the detriment of another after the transaction has taken place.

Heterogeneity in the customer population can be due to one or more of the following:

- Valuation of the product—some customers value a working item more than others and are willing to pay extra for an EW that provides a faster service [see, Lutz and Padmanabhan (1998) and Huysentruyt and Read (2010)].
- Attitude to risk: Risk-averse customers are willing to pay more for an EW compared to less risk-averse customers. [see, Padmanabhan and Rao (1993)].
- Usage: Product usage (e.g. km/year travelled in the case of a car; copies made per week in the case of a photocopier) can vary considerably [see, Padmanabhan (1995) and Hollis (1999)].
- Income: Customer income also varies across the population and, in general, those with higher income are more likely to purchase an EW than those with lower income [see, Lutz and Padmanabhan (1994)].

The bulk of the EW literature in economics is dominated by insurance theory which assumes that customers are more risk-averse than EW providers and EWs are a form of insurance to compensate for product failures.[14] The bulk of the papers have very stylised models in a non-dynamic setting with a warranty being viewed as monetary compensation.

Accounting for EWs is another important issue from the service provider perspective. Graves and Levitin (1990) discuss this.

5.3.4.3 Marketing

The focus of the marketing literature is on the following two topics:

1. Design of EW policies: The design of an EW policy includes terms and price and the aim is to make it more appealing to customers. Day and Fox (1985) conduct a qualitative study of consumer perceptions and decision making with regards EWs. Most customers view EWs as being overpriced and a way for EW providers to make huge profits. Fox and Day (1998) suggest the use of conjoint analysis[15] to design better EW policies which make them more appealing. They suggest two ways of doing this—the first is to provide a rebate (where the customer is given a refund at the end of the EW period should there be no warranty claims) and the second is by deductibles (where the customer pays a fixed amount to get each claim made under the EW serviced). This latter case

[14] Two other theories of warranty are—(1) the signalling theory (warranty serving as a signal of product quality) and (2) the incentive theory (to effectively address the double moral hazard issues).

[15] Conjoint analysis is a measurement technique that has been widely used by market researchers for new product development across many different product and service categories. For more details, see Green and Srinivasan (1978).

allows for the option of lowering the price of an EW and to make it more appealing to customers.[16]
2. Channel coordination: This concerns the different channel arrangements that a manufacturer can use to sell EWs (e.g. direct to customers or through a retailer). Desai and Padmanabhan (2004) consider the impact of these different arrangements on EW sales. This topic is discussed further in Chap. 8.

5.3.4.4 Consumerist and Legislative

Most customers view an EW as insurance. Their perception of repair far exceeds actual repair experience as they over estimate the cost of repair as well as the probability of failure. As a result they pay a price which is well in excess of the fair insurance price and in many industries (for example, consumer electronics) EWs have been highly profitable to manufacturers—see Padmanabhan (1996) and the UK Competition Commission Report (2003). According to *Consumer Reports*, EWs are not needed except in a few cases. Others (such as *Warranty Week*) say they provide good value at a reasonable price. EW legislation aims to address this problem. The new laws governing EWs in UK include the following:

1. Retailers must display the price of EWs alongside the price of the relevant products in both the storefront and in any advertisements,
2. Customers must be told of their right to cancel the EW contract within 45 days and to expect a full refund if no claims have been made during that time,
3. Customers must be informed in writing that the EW being offered to them at the time of sale remains available on the same terms for 30 days, and
4. Customers must be informed in writing that alternatives exist, both from third party EW providers and the product manufacturer, and perhaps even from their existing household insurance provider.

5.4 Outsourcing

Businesses producing goods (products and/or services) need to come up with new solutions and strategies to develop and increase their competitive advantage. Outsourcing is one of these strategies that can lead to greater competitiveness (Embleton and Wright 1998). It can be defined as a managed process of acquiring goods from an external agent under a contract rather than doing it in-house. The agent charges a fee

[16] More recent papers dealing with consumer perception are Maronick (2007) and Albaum and Wiley (2010); designing and price—Brooks and White (1996) and Hartman and Laksana (2009); adoption of EW—Bouguerra et al. (2012); options to consumers—Lam and Lam (2001); flexible warranty—Jack and Murthy (2007); purchase—Chen et al. (2009).

and in exchange the business (henceforth called the *customer* and recipient of the goods) is provided with the goods at a guaranteed quality or service level.

Most contracts stipulate specific, measurable metrics called *Service level agreements* (SLAs). These depend on the goods involved. Often SLAs also have penalties associated with not meeting the specified metrics, and sometimes rewards as incentives for exceeding the metric. Needless to say, there is a multitude of ways of constructing outsourcing agreements.

5.4.1 Reasons for Outsourcing

The conceptual basis for outsourcing (Campbell 1995) is as follows:

1. Domestic (in-house) resources should be used mainly for the core competencies of the company.
2. All other (support) activities that are not considered strategic necessities and/or whenever the company does not possesses the adequate competences and skills should be outsourced (provided there is an external agent who can carry out these activities in a more efficient manner).

There are a number of reasons that drive businesses to outsource. The list of reasons include

- Reduce costs: Sometimes achieved through lower wages costs, but also achieved through economies of scale when the external agent provides the goods to multiple businesses.
- Improve service: This often requires better educated or skilled people which either is not available in-house or not economical to have.
- Obtain expert skills: An external agent is often a business that is allegedly an expert in the delivery of the goods under consideration and thus should be able to do it better than the customer.
- Improve processes: For complex processes often external sources have expertise with similar processes that is needed to improve the process.
- Improve focus on core activities: Outsourcing frees management from having to worry about the inner-workings of a non-core activity. The customer focuses on the internal core competencies, and the others are outsourced.

Comment: Unfortunately, many businesses do not look at all these factors and often the primary reason for outsourcing is to reduce their costs.

5.4.2 Problems with Outsourcing

Outsourcing may not be appropriate for some businesses. Some of the reasons for this are the following.

- The business may be too small to effectively outsource.
- The culture within the business may not be appropriate for outsourcing.
- Other reasons (such as confidentiality) may limit or prevent the business's ability to outsource.
- The changes needed to the organisational structure make it difficult.

5.4.3 Issues in Outsourcing

Issues that need to be addressed before deciding on outsourcing are the following:

1. Is there a well-defined set of achievable business objectives?
2. Does outsourcing make sense?
3. Is the organisation ready?
4. What are the outsourcing alternatives?
5. What activities should be outsourced?
6. How should the best external agents be selected?
7. What are the negotiating tactics for contract formation?
8. How to decide on the fee?[17]
9. How to decide on incentives and/or penalties in the contract?
10. What systems are needed for effective monitoring?
11. What are the potential risks?

Agency theory (discussed in Sect. 4.6) provides the framework to discuss these issues. The business that seeks goods from an external source is the Principal and the provider of the goods is the Agent.

5.5 Maintenance Outsourcing

Most businesses tend not to view maintenance as a core activity and have moved towards outsourcing it. For these businesses, it is no longer economical to carry out the maintenance in house. There are a variety of reasons for this including the need for a specialist work force and diagnostic tools that often require constant upgrading. In these situations, it is more economical to outsource the maintenance (in part or total) to an external agent through a service contract. Campbell (1995) gives details of a survey where it was reported that 35 % of North American companies had considered outsourcing some of their maintenance.

[17] The fee can take many forms—based on the transaction, labour hour, cost per unit, cost per project, annual cost, cost by service levels, etc.

The advantages of outsourcing maintenance are as follows:

1. Better maintenance due to the expertise of the service agent.
2. Access to high-level specialists on an "as and when needed" basis.
3. Fixed cost service contract removes the risk of high costs.
4. Service providers respond to changing customer needs.
5. Access to latest maintenance technology.
6. Less capital investment for the customer.
7. Managers can devote more resources to other facets of the business by reducing the time and effort involved in maintenance management.

However, there are some disadvantages and these are indicated below.

1. Dependency on the service provider.
2. Cost of outsourcing.
3. Loss of maintenance knowledge (and personnel).
4. Becoming locked into a single service provider.

For very specialised (and custom built) products, the knowledge to carry out the maintenance and the spares needed for replacement need to be obtained from the original equipment manufacturer (OEM). In this case, the customer is forced into having a MSC with the OEM and this can result in a non-competitive market. In the USA, Section II of the Sherman Act (Khosrowpour 1995) deals with this problem by making it illegal for OEMs to act in this manner.

When the maintenance service is provided by an agent other than the OEM often the cost of switching prevents customers from changing their service agent. In other words, customers get "locked in" and are unable to do anything about it without a major financial consequence.

As a result, it is very important for businesses to carry out a proper evaluation of the implications of outsourcing their maintenance. If done properly, outsourcing can be cheaper than in-house maintenance and can lead to greater business profitability.

5.5.1 Different Scenarios for Maintenance Outsourcing

Maintenance of a product or system involves carrying out three sequentially linked activities as indicated in Fig. 5.5. The activities are

- Work Planning (D-1): **What** (components) need to be maintained?
- Work Scheduling (D-2): **When** should the maintenance be carried out?
- Work Execution (D-3): **How** should the maintenance be carried out?

There are three different scenarios (S-1, S-2 and S-3) depending on which of these activities are outsourced and they are shown in Table 5.1.

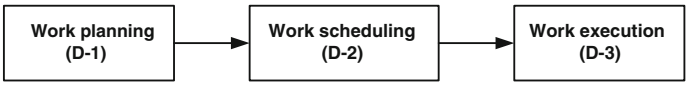

Fig. 5.5 Maintenance activities

Table 5.1 Different maintenance outsourcing scenarios

Scenarios	Decisions	
	Customer	Service agent
S-1	D-1, D-2	D-3
S-2	D-1	D-2, D-3
S-3	–	D-1, D-2, D-3

In scenario S-1, the SA is only providing the resources (workforce and material) to execute the work. This corresponds to the minimalist approach to outsourcing. In scenario S-2, the SA decides on **how** and **when** and **what** is to be done is decided by the customer. Finally, in scenario S-3 the SA makes all three decisions.

5.5.2 Maintenance Service Contracts

A MSC is a legal document that is binding on both parties (the business or customer and the service agent) and it needs to deal with technical, economic and other issues.

5.5.2.1 Technical Issues

There is a growing trend towards *functional guarantee contracts*. Here the contract specifies a level for the output generated from equipment, for example, the amount of electricity produced by a power plant, or the total length of flights and number of landings and take-offs per year. The SA has the freedom to decide on the maintenance needed (subject to operational constraints) with incentives and/or penalties if the target levels are exceeded or not.[18] However, these contracts need to take into account restrictions such as usage intensity, operating conditions, etc.

5.5.2.2 Economic Issues

There are a number of alternative contract payment structures as indicated below:

- Fixed or Firm price.
- Variable Price.

[18] For more on this, see Kumar and Kumar (2004a).

- Price ceiling incentive.
- Cost plus incentive fee.
- Cost plus award fee.
- Cost plus fixed fee.
- Cost plus margin.
- Other issues are cost deductibles and cost limits (for individual and total claims).

Each of these price structures represents a different level of risk sharing between the business (customer) and the SA.

5.5.2.3 Other Issues

Some other issues are as follows:

Requirements: Both parties might need to meet some stated requirement. For example, the customer needs to ensure that the usage intensity and operating loads of the asset do not exceed the levels specified in the contract. These can lead to greater degradation (due to higher stresses on the components) and higher servicing costs to the service agent. Similarly, the SA needs to ensure proper data recording.

Contract Duration: This is usually fixed with options for renewal at the end of the contract.

Moral hazard (*Cheating*): In maintenance outsourcing cheating by both owner and SA are issues that need to be addressed. Cheating by the owner occurs when the nominated usage is higher than the actual usage and the SA is not able to observe this. Similarly, cheating by the SA occurs when the actual maintenance is below the nominated maintenance and the owner cannot observe this. Information, monitoring and penalties/incentives can reduce and eliminate the potential for cheating.

Dispute Resolution: This specifies the avenues to follow when there is a dispute. The dispute can be resolved by going to a third party (e.g. an arbitration tribunal or a court).

Unless the contract is written properly and relevant data (relating to the equipment and collected by the service agent) are analysed properly by the customer the long-term costs and risks will escalate.

5.5.3 Key Elements of a MSC

A MSC document contains some or all the elements listed below.

- Parties involved—SA supplier of service and customer (recipient of the service), their names and addresses, etc.
- Definitions—glossary of frequently occurring words in the document.
- Description of the service (maintenance actions, materials, labour, etc.).

- Performance levels.
- Delivery of the service (single or multi locations).
- Term—start date and period of agreement.
- Pricing details (these can vary considerably from contract to contract).
- Pricing adjustment (e.g. annual increases linked to inflation or some other index).
- Payment details—annual, monthly, after each service, etc.
- Responsibilities of the SA—details of services to be performed and SLAs if applicable.
- Responsibilities of the customer—usage of product or system.
- Indemnification and insurance.
- Bankruptcy.
- Confidentiality.
- Force majeure.
- Dispute and arbitration process.
- Termination.
- Renegotiation/renewal.

5.5.4 Two Perspectives

There are two parties (players)—the customer (recipient of the maintenance service) and the MS Provider (the SA providing the maintenance service). There are three different scenarios (1–3) depending whether both are equally dominant or one is more dominant (leader) than the other (follower) as indicated in Table 5.2.

The decision making process for both parties depends on the particular scenario and this is discussed in more detail in Chap. 8.

5.5.5 Classification of MSCs

Maintenance requires materials, parts and labour to carry out the various activities discussed in Sect. 5.5.1. As a result there are several different kinds of MSCs. These can be broadly grouped into three types as indicated below.[19]

[19] Martin (1997) uses a different way of classifying MSCs. It also involves three types as indicated below:

1. *Work Package Contract*: The customer performs all planning and scheduling and the SA carries out the execution. This corresponds to Scenario S-1 and Type II in our classification.
2. *Performance contract*: This corresponds to Type III in our classification.
3. *Facilitator contract*: This corresponds to a lease contract in our definition and is discussed in Chap. 9.

Table 5.2 Three different scenarios

Scenario	Customer	MS provider
1	Leader	Follower
2	Follower	Leader
3	Neither leader nor follower	

Type I: SA only responsible for supply of material and parts (includes reconditioned parts).

Type II: SA responsible for material and parts + and carrying out some or all maintenance.

Type III: SA is responsible for complete maintenance + operations.

Comment: Type III contracts are also referred to as *functional guarantee contracts* which were discussed in Sect. 5.5.2.

5.5.6 Comparison of MSCs and EWs

As mentioned earlier there is some confusion in the literature regarding the terms EW and MSC. There are lots of similarities but also some differences as indicated in Table 5.3.

5.5.7 Study of Maintenance Outsourcing and MSCs

The literature on MSCs is large and can be divided into three categories—general, customer perspective, and industry sector. For the second and third categories the literature deals with a variety of topics. We give a small illustrative sample of the literature.

5.5.7.1 General[20]

- Justification for outsourcing: Campbell (1995) and Levery (2002).
- Critical issues: Dunn (1999).
- Enhancing appeal: Fox and Day (1998).
- Learning effects: Tarakci et al. (2009).
- MO and evolving technologies: Tseng et al. (2009).

[20] Maintenance outsourcing survey results, available at: www.plant-maintenance.com/maintenance_articles_outsources.html.

Table 5.3 Comparison of EWs and MSCs

Factors	EW	MSC
Product type	Standard products (consumer, commercial and industrial)	Standard products Custom built products/systems Infrastructure
Contract formulation	OEM	MS provider MS provider + customer
Relationship to BW	Similar Different (more restrictions)	Different
Time of purchase	At product sale Before BW expires	Any time after the BW (or EW) expires
Customisation to meet customer needs	Choosing between few options with no customisation Limited customisation (for industrial and commercial products)	Level of customisation can vary to meet the different customer needs
Complexity of contract	Low–medium	Medium–high
Initiator	EW provider	Customer
Process of selection	Simple	Simple (for standard contracts) Complex involving auctions, tendering, etc. (for complex systems and infrastructure)

5.5.7.2 Customer Perspective

- Decision models: de Almeida (2001, 2005, 2007).
- Selection of MS provider: Bertolini et al. (2004), Brito et al. (2007).
- Competition: Karmarkar and Pitbladdo (1995).
- Cost of MS: Jensen and Stonecash (2009), Datta and Roy (2010).
- Demand: Bryant and Gerner (1982).
- Implications for design and reliability: Guajardo et al. (2012), Laksana and Hartman (2010).
- Management: Sundarraj (2004), Bollapragada et al. (2007).
- Market channels: Chen et al. (2008), Desai and Padmanabhan (2004), Li et al. (2012), Tarakci et al. (2006).
- Market segmentation: Bolton and Myers (2003).
- Mass customisation: Dausch and Hsu (2003).
- Pricing: Bowman and Schmee (2001), Huber and Spliner (2012).

5.5.7.3 Industry Specific

- Aircraft: Bowman and Schmee (2001), Smith and Bachman (2008).
- Defence: Ng et al. (2009), Ng and Nudurupati (2010).

- Industrial equipment and systems: Stremersch et al. (2001); Dausch and Hsu (2003), Kumar and Kumar (2004a, b), Kumar et al. (2004), Markeset and Kumar (2003a, b), Panesar and Markeset (2008).
- Mining: Kumar and Kumar (2004a).
- Mission critical and infrequent restoration: Kim et al. (2010).

5.6 Some Illustrative Examples of EWs and MSCs

We discuss a few EWs and MSCs from different industry sectors. These were obtained from the internet websites of the businesses and further details of some of them are given in Appendix D.

5.6.1 EWs for Consumer Products

Case 5.1 (*Manufacturer's EW for Electrical and Electronic Products [Sony Corporation]*)
Sony Corporation, commonly referred to as Sony, is a Japanese multinational corporation and one of the leading manufacturers of electronics products for the consumer and professional markets.

An EW purchased for a Sony product bought in Australia or New Zealand from a Sony Authorised Dealer contains details of the following five elements

1. EW Services
2. Making a claim
3. Repairs
4. EW Term duration
5. Limitations and exclusions to EW coverage.

Each element contains several items and the details are given in Appendix D.

Case 5.2 (*Retailer's EW for Electrical and IT Products [Harvey Norman]*)
Harvey Norman is a large Australian-based retailer of electrical, computer, furniture, entertainment and bedding goods. It is effectively a franchise and the main brand is owned by Harvey Norman Holdings Limited.

The brochure to market Harvey Norman EWs for electrical and IT products is given in Appendix D. As can be seen customers can choose EWs varying from 2 to 4 years and they must be bought within 14 days of the purchase of an item.

Case 5.3 (*Manufacturer's Warranty for Cars [Chrysler]*)
The Chrysler Corporation is a multi-national company producing a range of cars around the world.[21] Chrysler Service Contracts issued for new cars vary in duration from 3 to 7 years and are available with maximum covered distances of 36,000–100,000 miles. The four different types of EWs offered are:

- Powertrain Care.
- Powertrain Care Plus.
- Added Care Plus.
- Maximum Care.

The details of the components covered are given in Appendix D. The EWs must be bought within the first 48 months a car is purchased and within the first 48,000 miles of a new car's life, and are not transferable to a second owner.

Comment: Other car manufacturers (e.g. GM, Ford, Volkswagen, Chrysler, and Honda) offer a range of EWs.[22] All are available for an assortment of durations and distances varying from 12 to 84 months and from 12,000 to 100,000 miles.

5.6.2 EWs and MSCs for Industrial Products

Case 5.4 (*Computer Servers [Hewlett Packard]*)
Hewlett-Packard Company (commonly referred to as HP) is an American multi-national information technology corporation that provides products, technologies, software, solutions and services to consumers, small- and medium-sized businesses (SMBs) and large enterprises.

The HP service contract depends on the product and in its most generic form contains 19 elements and these are listed in Appendix D.

An interesting feature is the guarantee on service response time. The cost of the EW depends on the level of service offered as illustrated by the two EW options for the HP ProLiant ML 150 servers—"4 years, 4 h, 13 × 5, hardware support at an additional cost of $434.00" and "4 years, 4 h, 24 × 7, hardware support at an additional cost of $690.00".[23]

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[21] In 2007, Chrysler began to offer non-transferable vehicle lifetime powertrain warranty for the first registered owner or retail lessee in U.S., Puerto Rico and the Virgin Islands. After Chrysler's restructuring, the warranty program was replaced by five-year/100,000 mile transferrable warranty for 2010 or later vehicles.

[22] The GM Vehicle service contracts (VSCs) come in three types:

- Basic Guard: covers just the powertrain
- Value Guard: Basic Guard + coverage for the brakes, air conditioning, steering, and some other components
- Major Guard: Is the comprehensive exclusionary policy.

[23] Quote from Chu and Chintagunta (2009).

Case 5.5 (*Diesel Engines [Wärtsilä]*)
Wärtsilä is Finnish company and a global leader in complete lifecycle power solutions for the marine and energy markets.

Wärtsilä Marine

Is the leading provider of ship machinery, propulsion and manoeuvring solutions. It supplies engines and generating sets, reduction gears, propulsion equipment, control systems and sealing solutions for all types of vessels and offshore applications.

Wärtsilä Power Plants

It is a leading supplier of power plants for the decentralised power generation market. It offers power plants for base-load, peaking and industrial self-generation purposes as well as for the oil and gas industry.

Wärtsilä Services

It supports Wärtsilä customers throughout the lifecycle of their installations. It provides service, maintenance and reconditioning solutions both for ship machinery and power plants.

Wärtsilä offers the following four types of service contracts for its diesel and gas engines used in power generation and marine (ships)

MSC-I: Supply Agreement [Type I in the MSC classification[24]]
MSC-II: Technical Maintenance Agreement [Type II in the MSC classification]
MSC-III: Maintenance Agreement [Type II in the MSC classification]
MSC-IV: Asset Management Agreement [Type III in the MSC classification].

The key elements of each of these are given in Appendix D. Each MSC contracted is a complex document covering items discussed in Sect. 5.5.3

5.7 Infrastructure

In most countries, infrastructures used to be financed by the public sector (PUS), and were constructed, maintained and operated by agencies under the control of national, state or local governments. Over the last few decades there has been a trend towards the involvement of the private sector (PRS) in all stages—finance (capital needed), construction, maintenance and operation and maintenance.[25]

5.7.1 Public Private Partnership

In the context of infrastructures, the term 'public–private partnership' (PPP) was coined to reflect the involvement of the private sector as a partner of the public

[24] The classification is given in Sect. 5.5.5

[25] For more on privatisation in the transport infrastructure see Estache (2001).

sector. There are many different types of PPPs and Hall et al. (2003) group them into five categories as indicated below.

1. Outsourcing
2. PFI [Private financing initiative]
3. Concession
4. BOT [Build, operate, transfer]
5. Lease.

Comment: There are a range of terms used to describe variations of concessions, PFIs and BOTs.

A comparison of the five types is given in Table 5.4 involving the elements—Finance, Construction, Operation (including maintenance) and Ownership. The various symbols used are as follows:

- X: denotes the responsibility of the PRS
- Y: denotes the mode of recovery of the investment
- Z: denotes ownership status.

Variants of PPPs

A PPP can be viewed as a contract and the variants of the different PPPs are as follows[26]:

DBFO (*Design, Build, Finance and Operate*)

A contract made under the principles of the private finance initiative whereby the same supplier undertakes the design and construction of an infrastructure and thereafter maintains it for an extended period, often 25 or 30 years.

DB (*Design and Build*)

A contract where a single supplier is responsible for designing and constructing an infrastructure.

FM (*Facilities Management*)

Management of services relating to the operation of a building involving activities such as maintenance, security, catering and external and internal cleaning.

O&M (*Operation and Maintenance Contract*)

This involves the private sector operating a publicly-owned facility under contract with the Government.[27]

LDO (*Lease Develop Operate*)[28]

This involves a private developer being given a long-term lease to operate and expand an existing facility.

BOOT (*Build Own Operate Transfer*)[29]

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[26] This section is based on material from Hall et al. (2003).

[27] In this contract, the private sector operator assumes the risks of operating and maintaining the infrastructure, and the government retains the investment risk.

[28] This type of contract is also referred to as a "*concession contract*" or "*franchise*".

[29] This type of contract is similar to a "*concession contract*" or "*franchise*".

Table 5.4 Comparison of different types of PPPs [adapted from Hall et al. (2003)]

		Outsourcing	PFI	Concession	BOT	Lease
Finance	Capital investment		X	X	X	
	Recouped by user charges			Y		Y
	Recouped from government	Y	Y			Y
Construction	By PRS		X	X	X	
Operation	Operation of service	X	X	X	X	X
Ownership	PUS (during and after contract)	Z	Z	Z		Z
	PRS during contract, PUS after			Z	Z	

This involves a private developer financing, building, owning and operating a facility for a specified period. At the expiration of the specified period, the facility is returned to the Government.

BOO (*Build Own Operate*)

This is similar to a BOT, except that the private sector owns the facility in perpetuity.

5.7.2 British Rail

Prior to 1994 British rail (BR) operated the rail system in Great Britain.[30] In 1994 a new government owned company, Railtrack, took ownership and responsibility for maintaining BR's railway infrastructure. BR's other activities were split into more than 100 companies which involved setting up "shadow" companies within BR. The ownership of railway assets was then transferred to the private sector as follows:

- Railtrack was sold in 1996 to the private sector through flotation on the stock market. BR's infrastructure support departments were geographically and functionally divided: seven infrastructure maintenance, seven infrastructure services design, and six track renewal companies. These were then sold by tender.
- BR's passenger rolling stock was sold as three rolling stock leasing companies ("ROSCOs"); these companies lease vehicles to passenger and freight train operators. The ROSCOs combined to buy the company owning the vehicle spare-parts pool. Their vehicles are maintained by seven ex-BR heavy maintenance suppliers.
- BR's freight train operations (including rolling stock) were split into six companies: three geographically-based bulk operations, container operations, non-bulk/international freight and postal contractor. These were then sold by tender to the private sector.

[30] This section is based on material from Kain (1998) and Fig. 5.6 is adapted from it.

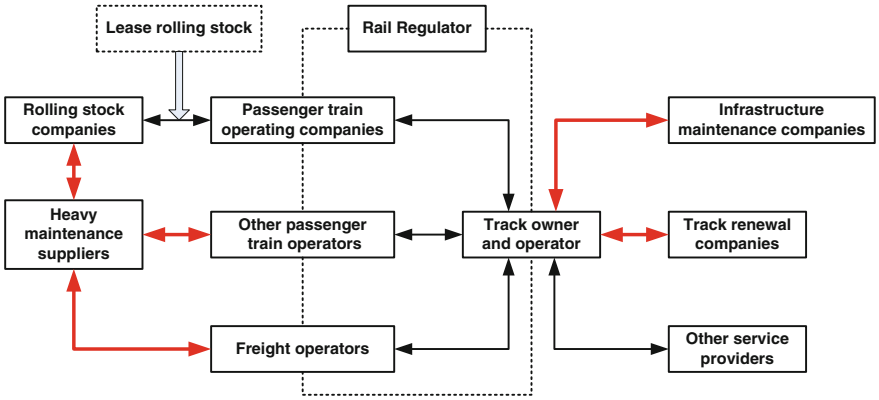

Fig. 5.6 Privatisation of rail infrastructure in UK

- In contrast to freight operations, passenger train operations were not sold; instead, the right to run the ex-BR passenger trains was franchised to 25 private sector train operating companies (TOCs), through the newly created (passenger) Passenger Franchising Director.

The government also set up the Office of Rail Regulator. As a result, several different parties are now involved in the operating and maintenance of the rail system in UK and the relationships between them are shown in Fig. 5.6.

The Regulator allocates the "Network Licence" to Railtrack, permitting Railtrack to be the operator of the network and binding it to the regulatory conditions set out in the Railways Act 1993. The Regulator's interests include:

- Maintaining network advantages: regulation is imposed on the twenty-five TOCs to ensure coordinated action between passenger franchisees.
- Setting and agreeing Railtrack's levels of passenger and freight track access charges.
- Appraising access contract terms and conditions.
- Setting the level of, and arbitrating on, open access.
- Reviewing Railtrack's investment levels and asset disposals.

The 25 franchises are subject to regulations overseen by the Franchising Director (of the Office of passenger rail franchising—OPRAF). OPRAF's activities are centred on drawing up franchise agreements and franchise plans with train operating companies, which set out TOC obligations. The agreements include:

- Given levels of service that franchisees must meet (including service connections).
- Government subsidies to (or premium from) franchisees based on service levels.
- The term of the franchise.
- The fares that are regulated (for example, "Savers" and "Weekly Seasons").
- Provision of data on train operation performance.
- Performance incentives on operational standards.

5.7.3 Study of Infrastructure MSCs

A complicating factor in the maintenance of infrastructures is that it needs to take into account the interests of all the stakeholders involved.[31] The government plays a critical role in terms of providing loans to and/or acting as a guarantor for the owner and the regulators are independent authorities responsible for ensuring public safety. The role of maintenance now becomes important in the context of safety and risk.[32]

For PFIs, Concessions and BOT contracts the responsibility for maintenance is with the PRS party involved. In contrast, in the case of outsourcing and leasing it is the responsibility of the PUS parties involved. The maintenance can be either done in-house or outsourced to some third party. This results in many different scenarios for the maintenance of infrastructures. The maintenance contracts are more complex and involve performance guarantees, incentives and penalties. An increasing issue in privatised infrastructures is the appropriate incentives needed to ensure adequate maintenance of the infrastructure as a public resource.

The literature on MSCs for infrastructures is vast. It can be broadly grouped into two categories—(1) general and (2) industry sector specific. We present a small illustrative list of the more recent literature.[33]

General

- Regulation and tendering: Hensher and Stanley (2008).
- Incentive contracting: Kraus (1996).
- Contract negotiations: Kuo and Wilson (2001), Ngee et al. (1997).
- Regulatory contracts: Marques and Berg (2010).

Industry Specific

- Buildings: Lai et al. (2004, 2006), Lai and Yik (2007).
- Highways and Roads: Anastapoulos et al. (2010), Ozbek et al. (2010), Tamin et al. (2011).
- Transport infrastructure: Estache (2001), Vickerman (2004).
- Pavements: Armstrong and Cook (1981).
- Rail: Macbeth and de Opacua (2010), Espling and Olsson (2004), Famurewa et al. (2011), Fearnley et al. (2004), Smith et al. (2010).

[31] Depending on the infrastructure one or more of the stakeholders might not be relevant. In some cases two or more of stakeholders might be the same—e.g. owner and operator being the same or service agent and operator being the same if maintenance is done in-house.

[32] The risk issue is discussed further in Chap. 11.

[33] Maintenance of items under a lease contract is discussed in Chap. 10.

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