

# 2

## The Elements of the Natural Rubber Industry Supply Chain

**Abstract** This chapter the elements of the natural rubber industry supply chain are presented. This chapter aims to introduce the reader to the physical transformation of rubber and categories of natural rubber products. The common definitions for each rubber supply chain entity and their relevant process are presented along with logistics and marketing activities and decision making. Moreover, supply and demand mechanisms are discussed in order to understand how price is formulated in the natural rubber industry.

**Keywords** Rubber industry · Supply chain management  
Logistics management · Rubber farmer · Rubber production  
Rubber price

This chapter gives an overview of the natural rubber industry supply chain. It also outlines the process of the physical transformation of rubber and categories of natural rubber products. The common definition for each rubber supply chain entity and its relevant processes is presented, along with logistics and marketing activities and decisions. The supply and demand mechanisms are also discussed in order to demonstrate how price is formulated in the natural rubber industry.

## 2.1 The Physical Transformation of Rubber

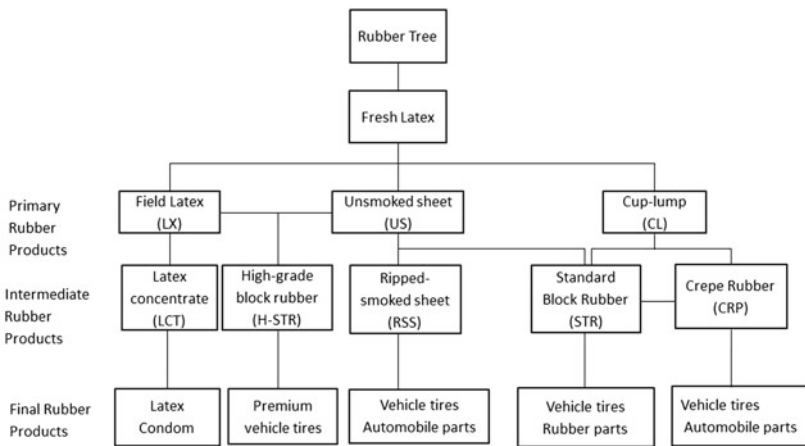
Natural rubber can be harvested as fresh latex. It is extracted by tapping into a long cut made in the rubber tree, and extracting the white liquid latex contents. This fresh latex can then be processed into primary rubber products that can be divided, according to the method of initial preparation, into three main categories: field latex (LX), unsmoked sheet (US) and cup-lump (CL). Field latex consists of rubber lattices collected from the tapping process. Unsmoked sheet is dry rubber which is made by adding acid to field latex and then rolling it and flattening it into sheet form. Cup-lump is solid dry rubber collected from the tapping cup. These three primary rubber products can be subsequently processed into different intermediate rubber products to eventually produce consumer goods.

Intermediate rubber products include latex concentrate (LCT), ripped-smoked sheet (RSS), air-dried sheet (ADS), high-grade block rubber (H-STR), standard block rubber (STR) and crepe rubber (CRP). (Details of the processing techniques for these products, including types and grades, will be discussed in Sect. 2.5). Latex concentrate is the raw material used for dipped products such as latex examination gloves, surgical gloves, condoms, elastic threads and adhesives. Ripped-smoked sheet and air-dried rubber are used to produce vehicle tyres and industrial rubber parts (Korwuttikulrungssee 2002). Block rubber and high-grade block rubber are the raw materials used for vehicle tyres, rubber parts and high viscosity products such as shoe soles and belts. Different categories of natural rubber products are shown below in Fig. 2.1.

## 2.2 The Schematic Framework of the Natural Rubber Industry Supply Chain

In general, the rubber supply chain starts at the farm level where rubber farmers produce fresh latex before processing it into the primary rubber products. The products include field latex, unsmoked sheet and cup-lump. They are sold through established local first-tier market traders and then

to second-tier traders in sub-provincial regions. Some of the products may go to a third-tier market trader if the farmers are located far from the intermediate rubber processing factories. Primary rubber traders then deliver the primary products down the chain to the factories that process the intermediate rubber products, which include latex concentrate, ripped-smoked sheet, air-dried sheet, high-grade block rubber, standard block rubber and crepe rubber. The products are then delivered to the final rubber processing factories for use as main raw materials in different consumer products (see Fig. 2.1). After the final rubber processing stage, these products will be sold through distribution channels to end users in different markets around the world. Figure 2.2 presents the schematic framework of the natural rubber industry supply chain. In the next section, the common definition for each rubber entity and its relevant process is explained.



**Fig. 2.1** Categories of natural rubber products

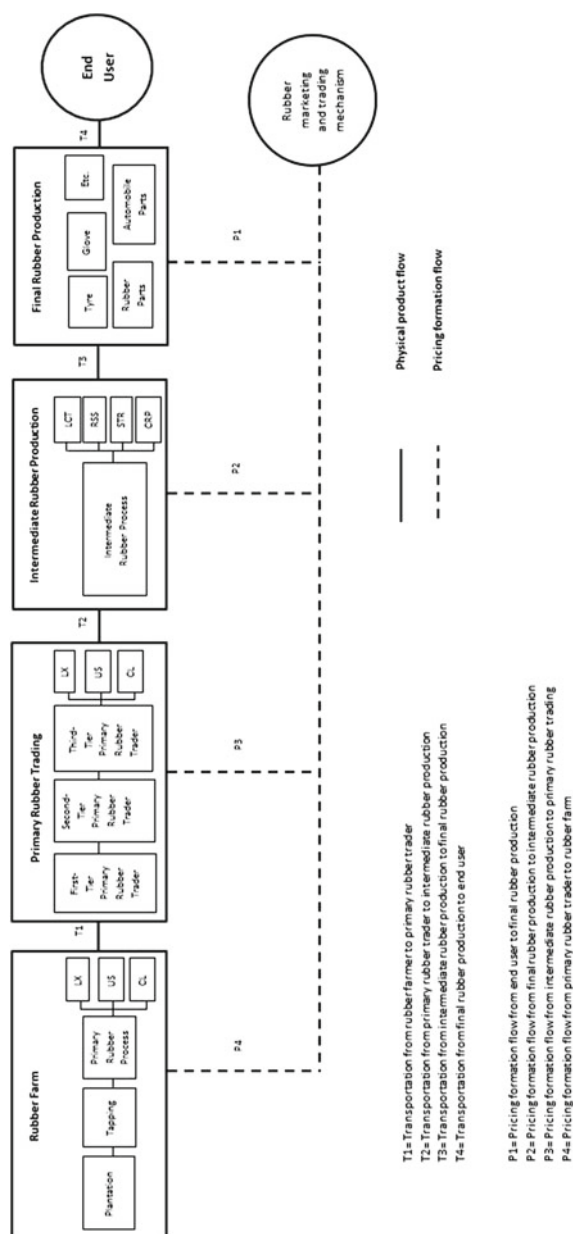


Fig. 2.2 Natural rubber supply chain framework

## 2.3 Rubber Plantation

### 2.3.1 Rubber Farmer

Kaiyoorawong and Yangdee (2006), as cited in Chanchaichujit (2014), have defined the rubber farmer as:

- Someone with land rights to plant rubber trees on state land
- Someone who uses their own labour, or that of waged workers, to grow, manage and tap rubber trees
- Someone who is a producer of rubber latex and sheets but who is not involved in high-technology rubber processing or export processing

There are two organisational structures of rubber farm: estate and small holding. Estate rubber farms are run by large investment companies who own land ranging from hundreds to thousands of hectares of planted rubber, and they pay their estate farm labourers in wages. This structure was set up by British investors when rubber plantations in the Malaysian peninsula spread in the early twentieth century (Hagan and Wells 2005). Estate farm producers are served by central processing facilities that are directly linked to rubber goods manufacturers. The structure of estate farms entails activities in vertical integration from upstream to downstream (Barlow et al. 1994). The estate farm therefore has the advantage of bringing in the field latex for further processing and then moving the products downstream for intermediate and final rubber processing for domestic and export markets, with a sizeable economy of scale.

In contrast to the estates, small holding farms are operated by families that produce rubber as an agricultural cash crop. Currently, small holding farmers form the majority in all major rubber producing countries, such as Thailand, Indonesia, Malaysia, Vietnam and China. Thailand, unlike other rubber producing countries, does not have any estate farms. Therefore, Thailand's farm structure comprises only independent smallholders. The smallholding rubber farmer can be classified according to the plantation area the farmer occupies. There are three sizes of smallholding rubber farms; small, medium and large, with areas 25 to 500 rais of land occupation (ORRAF 2012). The proportion of large to small farm size

in Thailand is 2%, 8% and 90%, respectively. However, due to the high rubber prices from 2010 to 2012, there has been a dramatic increase in independent farms, which produce rubber as part of their business rather than just a daily cash crop.

Therefore, it can be observed that there has been a shift of smallholding rubber farms from small to medium, medium to large and large to larger of a size up to 5,000 rais. Hence, the current proportions of farm size in some countries such as Thailand and Indonesia have been shifting by 80%, 15%, 10% and 5% of S, M, L and XL, respectively. For smallholdings which use labour to work in rubber plantations, the income is shared with the labourer. The income percentage sharing varies according to each farm's conditions and agreements, which may range from 20% to 50% paid to the labourer. For example, the 80:20 system means 80% of income goes to the owner and 20% to the labourer. Although estate and smallholdings have different organisational structures, they play the same role in contributing to the industry at the farm level to supply primary rubber products.

### 2.3.2 Planting

The commercial rubber tree *Hevea brasiliensis* contains a latex vessel system in its bark. *Hevea brasiliensis* is a tropical tree, and is best grown in equatorial zones with well-distributed rainfall. After seeding and planting, it takes 5–7 years for a tree to reach maturity before tapping can commence. The planting process starts by clearing uncultivated land in order to prepare the rubber plantation. Budding plants and selected seedlings from nurseries are planted. The density of rubber trees varies from 400 to 700 trees depending on each farm's allocation. As the rubber yield depends on the area planted and the clonal seed of the rubber tree, the planting is a very important stage in ensuring the highest yield to the farmer.



(a)



(b)

Fig. 2.3 Rubber tapping

### 2.3.3 Tapping

Tapping is the extraction of rubber liquid from the tree by cutting the bark on the trunk of the tree to sever the latex vessels. It begins when the tree reaches maturity, which takes approximately 5–7 years from initial planting, depending on the conditions of each farm and breeding clone. A cut is made with a knife to allow the latex to flow along the cut and into a cup attached to the trunk (see Fig. 2.3). It takes about 3 h for the latex flow to stop. The extraction of rubber can continue for 15–20 years depending on the standard of tapping. The tapping is normally done on alternate days or on every third day. Some small farmers may tap their trees daily. During winter, when the leaves of the tree die and fall off, its latex yield is reduced and tapping must cease for around 2–3 months. Generally, a rubber tree can be tapped for around 9–10 months a year. The usual procedure in tapping begins with the farmer tapping in the early morning around 3–5 AM, when the rate of latex flow is higher. Each farmer will tap for about 4 hours, which accounts for approximately 300–500 trees depending on the tapping skills and technique. The same farmer will then return to collect the fresh latex from the latex collecting cups on the tree. The latex is then transferred to a bigger container for further processing into primary rubber products.

### 2.3.4 Primary Rubber Processing

After the fresh latex has been tapped and collected, the farmer has three options for processing the fresh latex into primary rubber products: field latex, unsmoked sheet and cup-lump. These products are sold through the trading system. If farmers decide to sell their product as cup-lump, instead of collecting the fresh latex from the cup in the tapping process, they will add formic acid to the fresh latex in the cup and leave it to dry. The cup-shaped solid rubber, hence the name “cup-lump”, is then collected. For field latex, after the fresh latex is collected, the farmer will add ammonia as a preservative before storing the latex in drums or tanks until a buyer is found. For unsmoked sheet rubber, the farmer adds water and formic acid to fresh latex until it coagulates, dries and becomes soft solid rubber.





**Fig. 2.4** Field latex production process

It is then manually flattened with a roller and becomes a white unsmoked rubber sheet. The farmer dries the sheets on a rack in the open air for 1–2 days before selling it along the chain to the intermediate rubber processor for further processing. See Figs. 2.4, 2.5 and 2.6. The whole process is represented in Fig. 2.7.

### 2.3.5 Logistics

At the farm level, the lead time to transportation of the rubber is relatively short, occurring on a daily basis. Therefore, storage is not an issue at this level. The main modes of transportation for delivering the products to traders are motorcycles and small trucks (Fig. 2.8).



**Fig. 2.5** Cup-lump production process

### **2.3.6 Marketing Decisions**

There are three main factors influencing the farmer, farm owner or estate owner in choosing which products they should produce and sell. These include price, labour skill and plantation location. Price appears to be the main factor affecting decisions. However, the price of primary rubber products also depends on the ease of each production. For example, cup-lump requires less activity, less labour and less processing time, which means that the price of cup-lump in general is the lowest in comparison to the other two products. In contrast, the price of unsmoked rubber sheet is the highest due to the method of processing which requires higher labour skills. Therefore, even though price is extremely important, the farmer must trade-off processing time and labour skill against price. Plantation location is another factor affecting processing, in that some plantations are located in remote mountain areas. In these cases cup-lump is the most suitable product as it is easier to transport than liquid latex.



Fig. 2.6 Unsmoked sheet production process

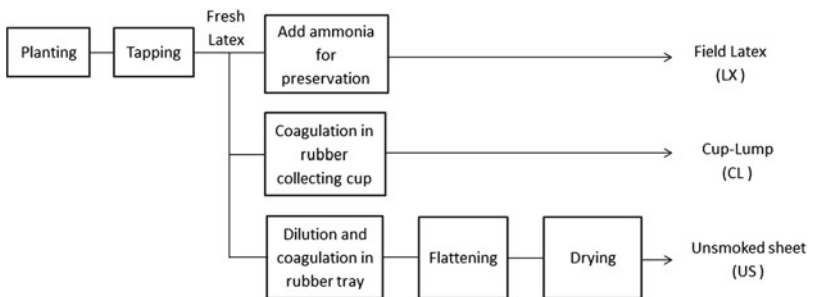


Fig. 2.7 Primary rubber production process



**Fig. 2.8** Small trucks for transporting primary rubber products to traders

## 2.4 Primary Rubber Product Trader

At the primary rubber trading level, trader groups collect and buy primary rubber products from rubber farmers and then sell them down the chain to the manufacturer to process into intermediate rubber products. Primary rubber traders can be classified by network level into first-tier, second-tier and third-tier. The more efficient the network, the fewer trading tiers. In some networks, those that have the capability to implement a vertical integration from upstream to downstream, there may not be a dealer involved. This means that the product is delivered directly from the plantation to the manufacturer. This is the case with estate farms in Malaysia, Indonesia and India, and manufacturing or exporting subsidiary farms in Thailand.

In Thailand, major rubber exporters integrate the upstream business in plantations to secure their supply. This makes them similar to the estate structures that aim to increase the efficiency of the supply chain, reduce costs and increase the quality of products. In contrast to estate and subsidiary farm structures, smallholders with small size plantations run by

families which produce rubber as a daily cash crop are heavily reliant on trader networks. The smallholder has to pass up through the tiers of the network until the product is delivered to the manufacturer. Smallholding farmers at the village level can be at a disadvantage in terms of selling their rubber products to dealers. However, governments in all the major producing countries such as Thailand, Malaysia and Indonesia have intervened by establishing cooperatives in villages where there are approximately 30–50 smallholding farmers. In addition, some cooperatives have organised group-processing centres to produce intermediate rubber products. These centres are mainly for ripped-smoked sheet, as the process does not require high-technology machinery. In the process, each cooperative sets up smokehouse facilities to smoke the unsmoked sheet before selling it directly to the exporter. In this way, the cooperative members benefit from producing a value added product (intermediate rubber products) by bypassing the dealer. In Thailand, the government has also established a general market along with cooperatives. This supports the rubber industry by improving trading networks and marketing channels. The general market in Thailand is also called the central rubber market. It serves the industry by being the auction centre for primary rubber products and provides funding, knowledge and techniques related to plantations.

Despite government support, private dealers still dominate in the collection and moving of products down the chain. According to the Thai Rubber Research Institute (RRIT 2015), there were 2553 registered dealers in Thailand. There were 550 rubber cooperatives throughout Thailand in 2011 (ORRAF 2015).

### 2.4.1 Logistics

First-tier trading is where the lower network traders in each village deal with the collection, handling and delivery of product to either the trader at the next level up or to the manufacturer for further production. As travel distance at this trading level is short, the buying and selling activities are on a daily basis. Farmers deliver their product by motorcycle or four-wheel truck to the dealer facility. In some cases, the dealer may collect the product directly from the plantation. The private dealer will then deliver

the product to either their upper level network dealer at a provincial level or directly to the manufacturer. The second and third-tier dealers are larger dealers at the provincial level, and therefore have greater and more efficient means of transport to move the product directly to the manufacturer. At this stage, the traders may keep their private stock instead of selling the product daily. Private stock at this level may be investigated with regard to rubber price speculation as opposed to logistic activities (Chanchaichujit et al. 2016b). In this case, price is driving the buying and selling activities. As mentioned above, the government also plays an important role at this stage in setting up the general rubber market to be the intermediary trader between farmer and factory. The government can intervene by creating buffer stock in the general rubber market in order to manipulate supply and demand and control the price.

### 2.4.2 Marketing Decisions

In terms of price, lower-tier traders usually offer a lower price to farmers compared to the higher-tiers, due to their proximity to the farmers. This accounts for the lack in economies of scale volume, transportation cost and quality control. The trader's profit comes from the buying and selling price. Therefore it is up to the farmer to judge whether they sell their products to a nearby trader at a lower price or move further up to the higher-tier traders for a better price. A justification has to be made between price and logistics. Likewise for the trader, they can choose whether to sell their products to an upper level trader or directly to the manufacturer.

## 2.5 Intermediate Rubber Production

Manufacturers process primary rubber products into intermediate rubber products. There are three types of intermediate rubber manufacturing processes:

- Ripped-smoked Sheet (RSS) process
- Block rubber (STR) process
- Latex concentrate (LCT) process



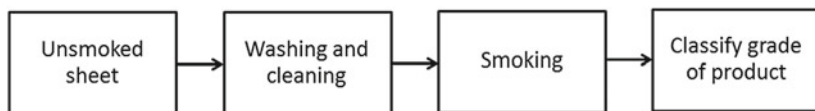
### 2.5.1 Ripped-Smoked Sheet (RSS) Process

Ripped-smoked sheet is rubber sheet which has undergone the smoking process at a controlled temperature before being classified according to level of quality. There are five grades of RSS products: RSS1, RSS2, RSS3, RSS4 and RSS5. RSS grade is classified by dirt percentage. The higher grades are ranked from RSS1 to RSS5. Higher-grade RSS is mainly used to manufacture pharmaceutical products, while lower grades are used as raw materials in the manufacture of products such as tyres, shoe soles and automobile parts. Figure 2.9 shows the ripped-smoked sheet production activities.

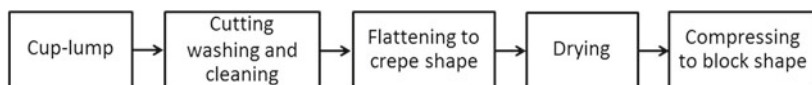
### 2.5.2 Block Rubber (STR) Process

There are two types of block rubber (STR) products: high-grade block rubber and standard block rubber. Standard block rubber is produced from a mixture of cup-lump, crepe cup-lump and unsmoked rubber sheet. High-grade block rubber is produced from a mixture of field latex and unsmoked rubber sheet. In general, the more field latex in the product, the higher the grade of the block rubber. The amount of production of these two products varies according to customer requirements.

In the block rubber production process, the raw materials are cut and washed before being flattened into a crepe shape. The material then goes through the dryer process to remove excess water and is then compressed into a block shape for storage or shipment. Block rubber is the raw material used in the production of tyres for automobiles and aeroplanes. The block rubber production process is shown in Fig. 2.10.



**Fig. 2.9** Diagram of the ripped-smoked sheet production process



**Fig. 2.10** Diagram of the block rubber production process



**Fig. 2.11** Diagram of the latex concentrate production process

### 2.5.3 Latex Concentrate (LCT) Process

Latex concentrate is derived from field latex in liquid form. In the latex concentration process, the raw materials are centrifuged to separate out the impurities. Ammonia is then added to prevent coagulation before packing for storage or shipment. Concentrated latex is used primarily in the manufacture of various products such as latex examination gloves, surgical gloves, condoms, elastic threads and adhesives. Figure 2.11 shows the latex concentrate production process.

### 2.5.4 Logistics

The intermediate rubber market can be regarded as the channel bridging the producers and manufacturers of final rubber products to end-users. It entails the activities of transforming the raw product, further processing, packaging and transport. As mentioned earlier, the transportation from farmer to trader group, and from each trader group to factory, is undertaken mainly by road, as travel distance is short at the provincial level. At the intermediate rubber product stage, transportation from manufacturer to final destination (major rubber consumption markets such as China, India, USA and Europe) comprises different combinations of freight modes such as road, rail and sea (Chanchaichujit et al. 2016a). The logistics system depends heavily on the purchasing contract.



### 2.5.5 Marketing Decisions

Intermediate rubber marketing decision making is affected by buying, selling and trading; this is how price formation takes place. Decision criteria are affected by trading mechanisms which consist of market types, pricing formula and contract period.

There are three rubber marketing systems: bilateral, spot and exchange. The marketing mechanism is typically activated when the buyer issues a bilateral contract to the seller to lock in long-term sales and purchasing agreements. Once the volume is locked in, sellers can plan and manage their production capacity and inventory balance. The remaining stock volume can be traded on the spot and exchange markets. Under bilateral and spot rubber market systems, the buyer will purchase products from the listed seller with specifications and grade being tested and approved. According to Accenture analysis (Accenture 2014), the natural rubber bilateral trade volume accounted for 75–80% of trade, while spot and exchange trading volume represented 20–25% of total physical rubber trading markets in 2013. In terms of pricing formula, price will be negotiated on a rolling fixed-price basis. However, bilateral long-term contract prices have shifted from a fixed price basis to an indexed price from the exchange market. The indexed price is calculated based on the average closing price over the month prior to delivery. Each seller and buyer may agree to have further premiums or discounts according to quality of the product. The main natural rubber exchanges include the Singapore Commodity Exchange (SICOM), the Tokyo Commodity Exchange (TOCOM), the Shanghai Futures Exchange (SHFE) and the Agriculture Futures Exchange of Thailand (AFET). A natural rubber market structure and price discovery discussion can be found in (Accenture 2014).

## 2.6 Final Rubber Production

Natural rubber is used to manufacture more than 50,000 types of products (Rubberworld 2012). These range from household goods to transport, construction, recreation and sporting goods, to sophisticated products such as medical gloves and condoms. Products made from rub-

ber include footwear, mats, belts, hydraulic hoses, nets, roofing, toys, life-jackets, thermal insulation and tyres. The German Institute of Rubber Technology (GIRT [2010](#)) reported that world rubber consumption per person, per year, averages 10 to 15 kg. This demonstrates the significance of the rubber industry to the development of the world industrial economy. The rubber goods market can be classified into two groups of products: tyre products and non-tyre products (or general rubber goods). The tyres sector has always been a major rubber consumer. The demand for tyres basically depends on the number of new vehicles, both passenger cars and commercial vehicles, that require new or replacement tyres. Non-tyre products consist of a variety of categories of goods such as manufacturing products (conveyor belts, hoses, tubes, mats, etc.), consumer products (apparel, footwear, sporting goods and equipment), medical goods (gloves, syringes, droppers), and others (seals, rubber-covered fabrics). The development of natural rubber goods production and the tyre manufacturing process can be found in Barlow ([1997](#)). Tyre production and analysis has also been broadly discussed in Smith and Burger ([1992](#)).

## 2.7 Supply-Demand Mechanisms of the Rubber Industry

Figure [2.12](#) illustrates the supply-demand mechanism framework of the natural rubber industry. It can be seen that supply and demand drives the formulation of the rubber price in selling and buying activities.

### 2.7.1 Supply Factors

There are five major supply factors. These include the rubber price, plantation area, factory processing capacity, input price to produce rubber and technology. In the short term, the price of rubber is a key factor affecting the rubber supply through its profitability, while the price of other types of rubber is also a key factor indicating the attractiveness of choosing what product to produce. However, it must be noted that switching types of rubber production is not only subject to price but also to farmer

preference, which is driven by the ease of processing and farmer skill. As natural rubber plantations are still very labour-intensive, the ease of processing and labour skills can limit the ability to change the production type to other types of natural rubber, even though the price is different. Apart from farmer preference, weather and government intervention are two other elements that influence the price of natural rubber. Government intervention programs, such as the replanting program, subsidise rubber replanting for the small holding farmer and establish group processing for farmers to produce intermediate rubber products. The most important long-term factors are the supply, the price of natural rubber and the input price of each type of natural rubber. The costs of land, capital and labour are direct costs which affect long-term plantation and processing capacity investment. The plantation area can be used to determine the level of the primary rubber supply before differentiation into varying types of intermediate rubber through the processing stage. However, the specific level of rubber supply is established through the processing capacity for different types of intermediate rubber. This is the case for products such as latex concentrate, smoked rubber sheet and block rubber. Technology is another factor influencing supply through productivity, quality and cost.

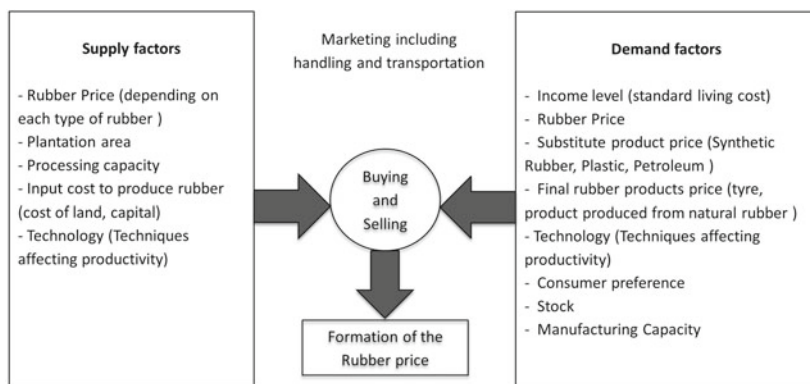


Fig. 2.12 Supply-demand mechanism framework of the natural rubber industry

### 2.7.2 Demand Factors

Before discussing demand factors in natural rubber, it is important to mention again that natural rubber products are intermediate goods used in producing final consumer goods from gloves to tyres. Therefore the demand for natural rubber depends on many factors influencing not only intermediate goods but also the demand for final goods. An example of this is that tyres as a final product depend very much on the demand for cars, which in turn depends on economics and the income of the consumer. As such, it can be seen that the factors influencing demand are more complex than that of supply. However, Barlow et al. (1994), have classified the main factors influencing demand as follows: income level, rubber price, substitute production price, final rubber product price, technology, consumer preference, stock and manufacturing capacity. With these influences, the level of stock and manufacturing capacity can be seen as short-term factors, as they can be used to limit the manufacturing output responses to increased demand. General income and the price of final goods are categorised as long-term factors. General income can be considered the major factor, as it reflects the world economic situation. General income impacts on the price of the final goods and on the price of rubber and its substitution.

### 2.7.3 The Formulation of the Rubber Price

Prices are determined by the interaction of supply and demand. As illustrated in Fig. 2.12, the supply of rubber is determined by its price in the marketplace, together with production capacity, input costs and technology. Rubber supply interacts and has a direct relationship with demand, which is influenced by price and income level in the overall economy, the price of rubber substitution, the price of final goods, technology, consumer preference, stock and manufacturing capacity utilisation. The organisational structure of production, marketing and consumption, and government measures around rubber also influence supply and demand but work through the formulation of price.

## 2.8 Summary

This chapter has given an overview of the natural rubber industry and outlined the process of the physical transformation of natural rubber products. The natural rubber supply chain framework presented in the chapter illustrates the complexities of this industry. It can be seen that the rubber industry starts at the farm level with millions of rubber farmers, and continues through a variety of trading channels into the manufacture of thousands of rubber products. The products are then processed into final consumer products in different regions around the world. In addition to complex physical transformation, logistics and marketing decisions, this industry is also influenced by many factors such as economics, capacity, stock level and technologies. Due to this complexity, a decision support tool that aids efficient decision making in this industry is clearly needed.

In the next chapter, the discrete event simulation (DES) technique will be introduced. The chapter provides the background on how to use this tool to model the rubber industry supply chain before actual model building commences.

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