Chapter 3

# Trading of Licorice between Japan and China: Future Market Prospects

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Additional information is available at the end of the chapter

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**Abstract**

Recent years have seen changes in the trade of licorice between Japan and China. Particularly, the price of imported Chinese licorice has been increasing every year. As the price of Chinese licorice is expected to remain high, Japanese importers may find it increasingly difficult to import licorice from China, leading to a decline in the use of Chinese licorice in Japan. Instead of focusing on the pharmacological properties of licorice, we examine data such as the price and trading volume between China and Japan in order to analyze the licorice market from an economic perspective. From our analysis, we conclude that the recent increase in the price of Chinese licorice in Japan is mainly due to the combined effect of an increase in demand and a decrease in the supply of the product. We demonstrate the need for a cultivated strain as a substitute for native Chinese strains to ensure the continued supply of licorice in Japan.

**Keywords:** licorice, trade, supply, demand, cultivation, economics

## 1. Introduction

Licorice has been used as a medicine for over 2000 years. The first mention of its use as a drug for treating wounds is found in a Chinese traditional medicine book from the second century BC [1]. Similarly, licorice has been widely used in Japan, including in the pharmaceutical industry [2]. Despite the high demand, there is no strain of licorice that is native to Japan, meaning that the licorice used in Japanese pharmaceutical products is mostly imported from places such as China and the Middle East [2]. However, recent years have brought changes to the market, as excessive harvesting has depleted the licorice resources in China [3]. This has caused the price of licorice to increase year by year. As the price of Chinese licorice is expected to remain high, it

will become difficult for the Japanese pharmaceutical industry to continue to purchase Chinese licorice. In the worst case, the supply of Chinese licorice will be severely constrained.

To avoid this situation, consumers of Chinese licorice in Japan must seek an alternative source. However, this is not an easy task since other countries are hardly able to supply a substitute for Chinese licorice. This study focuses, instead, on attempts to cultivate licorice as a means to mitigate the high price of Chinese licorice.

In this paper, we examine data, such as the price and trading volume of licorice between China and Japan, to analyze the licorice market from an economic perspective. While numerous publications have analyzed the various properties of licorice, studies incorporating economic ideas are rare. To make this study understandable to readers who are unfamiliar with economics, we attempt to limit ourselves to basic economic concepts rather than more specialized ones.

The rest of this paper is organized as follows. In Section 2, we consider the recent situation surrounding Japanese licorice imports from China by examining relevant trade data. In Section 3, we briefly explain some basic economic ideas, which are then discussed in Section 4. Section 5 considers potential solutions, such as efforts to cultivate licorice, and Section 6 concludes the chapter.

## 2. Changes in the trading volume of licorice between Japan and other countries

Licorice is used in the manufacture of various pharmaceutical products and is indispensable for pharmaceutical industries in many countries, including Japan [2]. There is no variety of licorice that is indigenous to Japan [2]. Licorice used in the manufacture of pharmaceutical products is usually found in the grasslands and sandy soils of southern Europe, Central Asia, and China [4].

Because of this, Japanese pharmaceutical firms have had to rely on imports from abroad [2].

**Table 1** shows the cumulative total amount of licorice imported into Japan, in tons, from its 12 major trading partners in the period 2007–2015.[1]

Among the trading partners listed in **Table 1**, China is by far the largest exporter. This indicates that Japan is highly dependent on China for its supply of licorice.

A closer investigation of **Table 1** also reveals that among the listed trading partners, only China and Afghanistan continuously exported licorice to Japan during this period. China's large and continuous supply of licorice played an important role in the Japanese market.

On examining other data from **Table 1** (i.e., Japan's licorice imports from countries other than China), we find that a large proportion of imports is from Central Asian countries, such as

[1] **Table 1** is derived from Trade Statistics of Japan conducted by the Japanese Ministry of Finance (http://www.customs.go.jp/toukei/srch/index.htm?M=01&P=0) [Accessed: 2016-09-17].

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Afghanistan, Uzbekistan, and Turkmenistan. This is likely due to these countries' agricultural suitability for licorice (i.e., native strains of licorice grow well in sandy soils) [4]. However, closer examination reveals that the supply of licorice from these countries is not stable but varies from year to year. In addition, the amount of licorice supplied by these countries is much smaller than that supplied by China.

| Countries | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| **Azerbaijan** | | | | | 17.85 | 2 | | 10 | |
| **Afghanistan** | 300 | 495 | 396.57 | 288.84 | 199.9 | 104.04 | 311.57 | 100 | 210 |
| **Uzbekistan** | | | 21.5 | | 22.2 | 99 | 10 | | 8.1 |
| **Australia** | 144.71 | 48.52 | 7.47 | | | | | | |
| **Kazakhstan** | | | 20 | | | 21.25 | | | |
| **South Korea** | | | | | | | | 0.08 | |
| **China** | 932.5 | 1,138.38 | 868.95 | 1,239.26 | 1,770.6 | 2,181.58 | 1,936.88 | 1,547.86 | 1,397.55 |
| **Turkmenistan** | | | 100 | 100 | 517.5 | | | | |
| **Pakistan** | | | 8 | | 100 | 216 | 45.53 | 15 | |
| **Myanmar** | | 0.04 | | | | | | | |
| **Mongolia** | | | 3.3 | | | 0.23 | | | |
| **Russia** | | | | 3.87 | 30.55 | | 0.02 | 0.2 | 37.47 |

**Table 1.** Cumulative Total Amount of Licorice Imported to Japan, in tons,from its Major Trading Partners (2007–2015).

In addition to the listed Asian and Middle Eastern countries, Australia and Russia also export licorice to Japan. Australia and Russia are attractive trading partners for Japan since these countries are large, with abundant natural resources. However, the sharp fluctuations of trading volume seen in **Table 1** indicate that stable trading between those countries and Japan remains difficult.

As demonstrated above, China is Japan's most important trading partner for licorice.

This is not only due to China's large and stable supply of licorice but also because of its geographical advantage, that is, China is closer to Japan than other suppliers, thus reducing the time and cost of transportation.

However, there is a point of concern in the licorice trade between Japan and China. Particularly, on examining the data in **Table 1**, we find that the volume of Japanese imports of licorice from China peaked in 2012. This is likely an indication of a decrease in the supply of licorice in China.

From 2007 to 2015, Japanese imports of Chinese licorice far exceeded imports from Asia and the Mideast.

**Figure 1A** and **B** shows the proportions of Japanese imports of licorice from the exporters in 2007 and 2015, respectively. The latter figures incorporate data from **Table 1**.

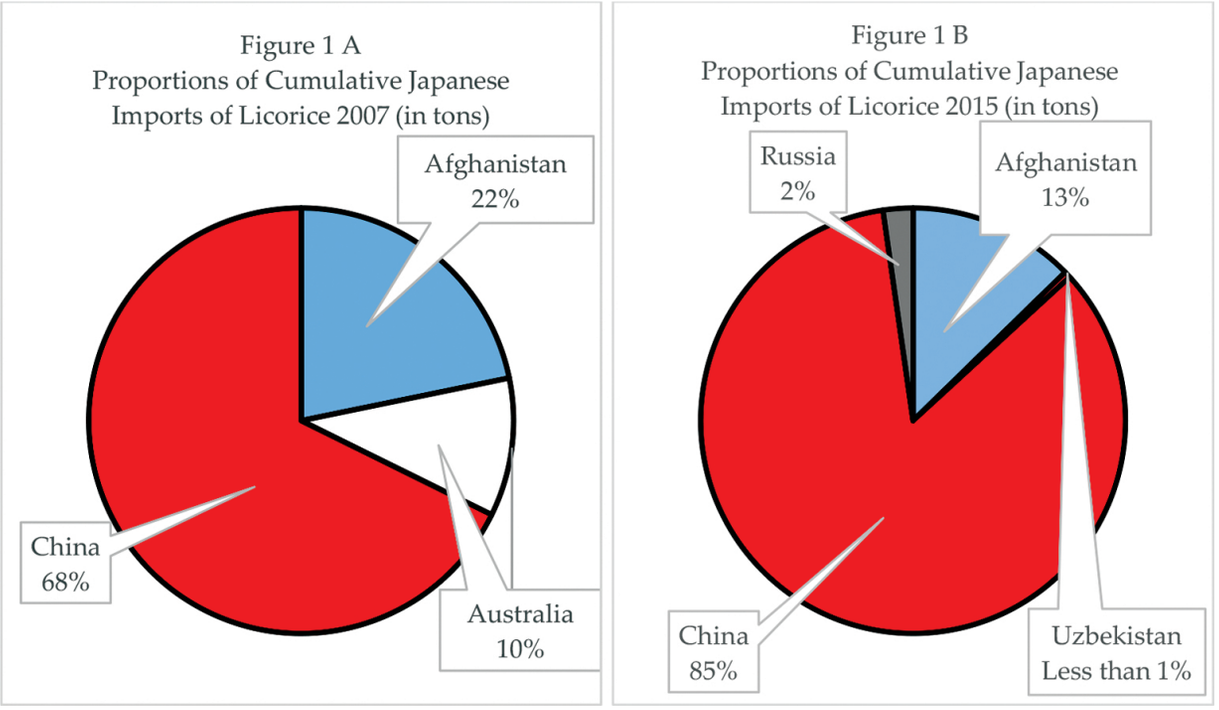


**Figure 1.** (A) Proportions of cumulative Japanese imports of licorice 2007 (in tons). (B) Proportions of cumulative Japanese imports of licorice 2015 (in tons).

**Figure 1A** and **B** reveals that Japan strongly relies on China to procure licorice. In addition, comparison of the latter figures also reveals that a proportion of Japanese licorice import from China increases from 2007 to 2015. In other words, in the period between 2007 and 2015, Japanese reliance of China to procure licorice became stronger.

To understand the current trading situation of licorice between Japan and other countries, we can also look at the total amount of money spent importing licorice. **Table 2** shows the cumulative total value (in 1000 yen) for the data presented in **Table 1**.[2]

As seen in **Table 2**, the cumulative total value of Japanese licorice imports from China is much greater than that from other countries and reflects the large trade volume with China.

In addition, we also provide **Figure 2A** and **B** which shows the proportions of Japan's cumulative total spending for importing licorice from the trading partners in relation to the data presented in **Table 2** in 2007 and 2015, respectively.

As can be seen from **Figure 2A** and **B**, in both 2007 and 2015, Japan's cumulative total spending for importing licorice is mostly for the one from China. However, as compared from the proportions in **Figure 1A** and **B**, the proportions of cumulative total spending for importing licorice from China in **Figure 2A** and **B** are larger. The latter indicates that, as compared from other trading partners, such as Afghanistan, Australia, Russia, and Uzbekistan, the price of licorice from China is relatively higher.

[2] **Table 2** is derived from Trade Statistics of Japan conducted by the Japanese Ministry of Finance (http://www.customs.go.jp/toukei/srch/index.htm?M=01&P=0) [Accessed: 2016-09-17].

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| Countries | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| **Azerbaijan** | | | | | 1,366 | 359 | | 598 | |
| **Afghanistan** | 21,887 | 50,839 | 37,641 | 27,571 | 27,915 | 15,968 | 35,282 | 21,052 | 49,048 |
| **Uzbekistan** | | | 1,789 | | 2,421 | 15,731 | 2,151 | | 2,230 |
| **Australia** | 12,463 | 3,809 | 2,178 | | | | | | |
| **Kazakhstan** | | | 5,936 | | | 1,900 | | | |
| **South Korea** | | | | | | | | 3,325 | |
| **China** | 372,387 | 490,492 | 379,673 | 549,186 | 883,138 | 1329,692 | 1836,353 | 1526,111 | 1558,603 |
| **Turkmenistan** | | | 11,054 | 9,831 | 53,789 | | | | |
| **Pakistan** | | | 502 | | 10,107 | 26,854 | 12,867 | 6,468 | |
| **Myanmar** | | 221 | | | | | | | |
| **Mongolia** | | | 1,985 | | | 250 | | | |
| **Russia** | | | | 1,393 | 13,980 | | 237 | 262 | 35,411 |

**Table 2.** Cumulative total value of Japanese licorice imports, in 1,000 yen, from its major trading partners (2007–2015).

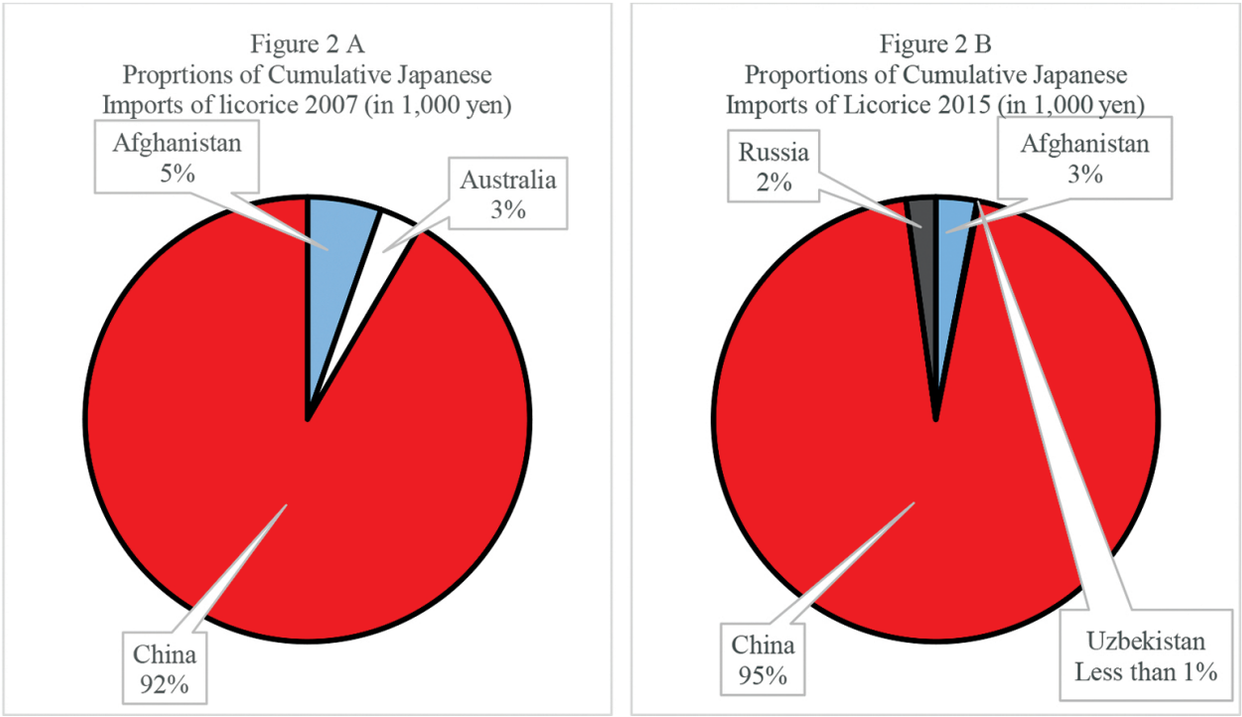


**Figure 2.** (A) Proportion of cumulative Japanese imports of licorice 2007 (in 1,000 yen). (B) Proportion of cumulative Japanese imports of licorice 2015 (in 1,000 yen).

However, closer investigation reveals a problem that Japan may face in the near future.

**Figure 3** shows the import price of Chinese licorice per kilogram (in 1,000 yen).[3] These data show that the import price of licorice from China has been increasing for several years. In particular, the dramatic rise in the price of imported Chinese licorice after 2012 is remarkable, with the price in 2015 being nearly three times that in 2007.

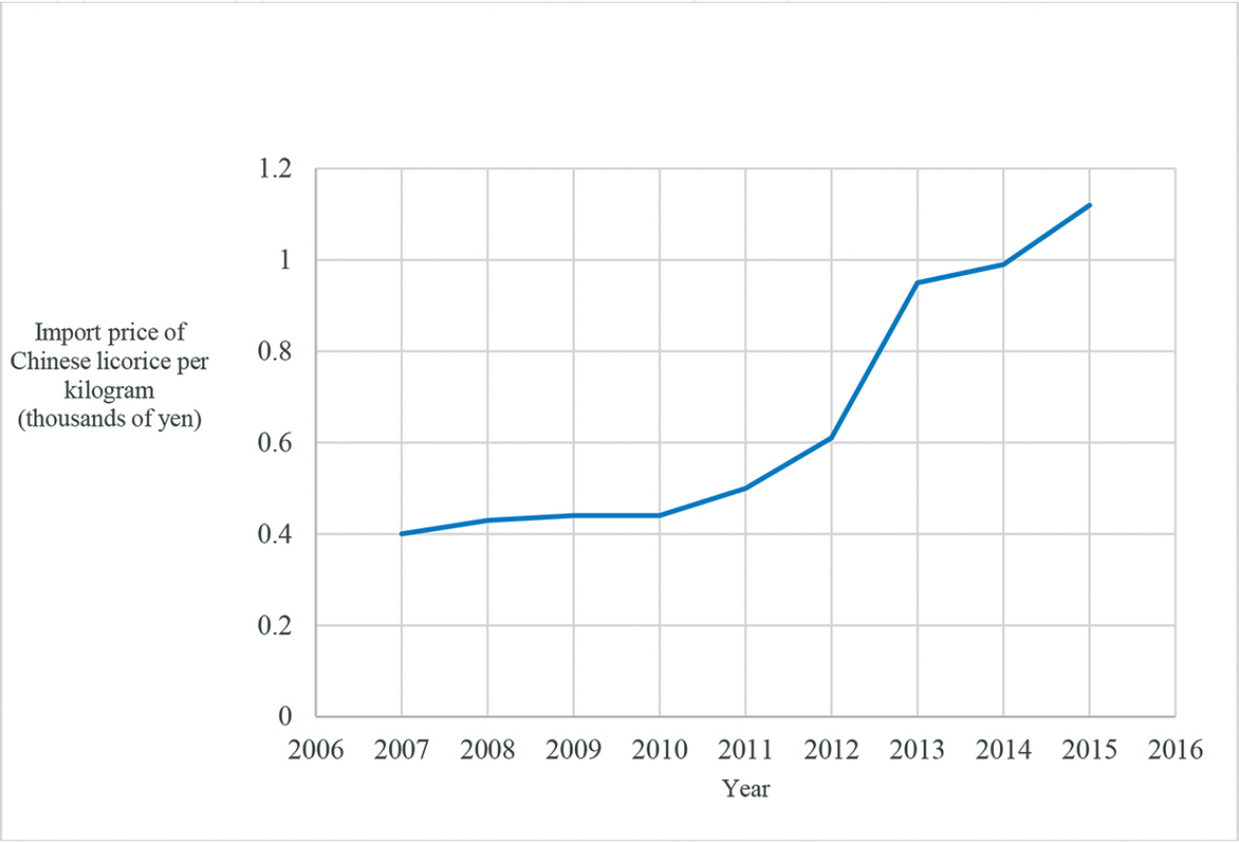


**Figure 3.** Trend in the import price of Chinese licorice (2007–2015).

As shown in **Figure 3**, there has been an increase in the price of licorice imported from China. As seen in **Tables 1** and **2**, Japan relies heavily on China for its supply of licorice, with the result being that the high price of licorice imported from China has led to high prices for licorice in the Japanese market.

Because licorice is an important raw material for manufacturing pharmaceutical products, the high price of licorice in the Japanese market causes increased costs for the manufacturing of pharmaceutical products. If this high price continues, then the pharmaceutical industry in Japan may be affected by budget constraints in the production of medical products containing licorice.

[3] **Figure 3** is derived from Trade Statistics of Japan conducted by the Japanese Ministry of Finance (http://www.customs.go.jp/toukei/srch/index.htm?M=01&P=0) [Accessed: 2016-09-17]. Import prices in **Figure 3** are calculated as cumulative amount spent on Japanese imports of licorice from China in **Table 2** divided by the cumulative total volume of Japanese import of licorice from China in **Table 1**. For detail, we amend per-unit data in **Table 1** from tons to kilograms.

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## 3. Basic economic concepts

### 3.1. Economics terms used

As discussed in the previous section, China is the most important source of licorice for the Japanese market. In addition, the price of licorice from China has been increasing in recent years. In this section, we try to understand this situation in economic terms by considering the potential causes for the increasing price of Chinese licorice and its impact on the Japanese market.

We attempt to use basic, rather than highly specialized terminology[4] in this chapter as many of its readers will be experts in pharmacology, but unfamiliar with economics.

In mainstream economics, the price and quantity traded of goods and services are determined mainly by supply and demand. To understand this concept properly, we first introduce definitions of several important economic terms. We refer specifically to reference [5] to define the terms market, quantity demanded, the law of demand, quantity supplied, the law of supply, and market equilibrium. We define these terms as per reference [5] as follows:

A market is defined as "a group of buyers and sellers of a particular good or service."

Quantity demanded is defined as "the amount of the good that buyers are willing and able to purchase."

The law of demand is defined as "the claim that, other things being equal, the quantity demanded of a good falls when the price of the good rises."

Quantity supplied is defined as "the amount of a good that sellers are willing and able to sell."

The law of supply is defined as "the claim that, other things being equal, the quantity supplied of a good rises when the price of the good rises."

Market equilibrium is defined as "a situation in which the market price has reached the level at which quantity supplied equals quantity demanded."

**Figure 4**[5] summarizes the definitions above. The curves here are referred to as the demand curve and the supply curve of a good.[6] We can see that the demand curve and the supply curve are downward-sloping and upward-sloping, respectively. The shapes of the curves are due to the aforementioned laws of demand and supply.

As seen in **Figure 4**, there is a point at which the demand curve and the supply curve intersect. This intersection is the graphical representation of the market equilibrium. The actions of

[4] The discussion in Section 3 derives primarily from Ref. [5].

[5] **Figure 4** is prepared by the author on the basis of Ref. [5].

[6] In Ref. [5], the demand and supply schedules are determined as a graph of the relationship between the price of a good and the quantity demanded and a graph of the relationship between the price of a good and the quantity supplied, respectively. In **Figure 4**, a good's price and quantity traded are indicated on the vertical and horizontal axes, respectively. The demand schedule, supply schedule, equilibrium, price at equilibrium, and quantity at equilibrium are labeled D, S, E, Pe, and Qe, respectively.

buyers and sellers naturally move markets toward the equilibrium of supply and demand [5].
[7]

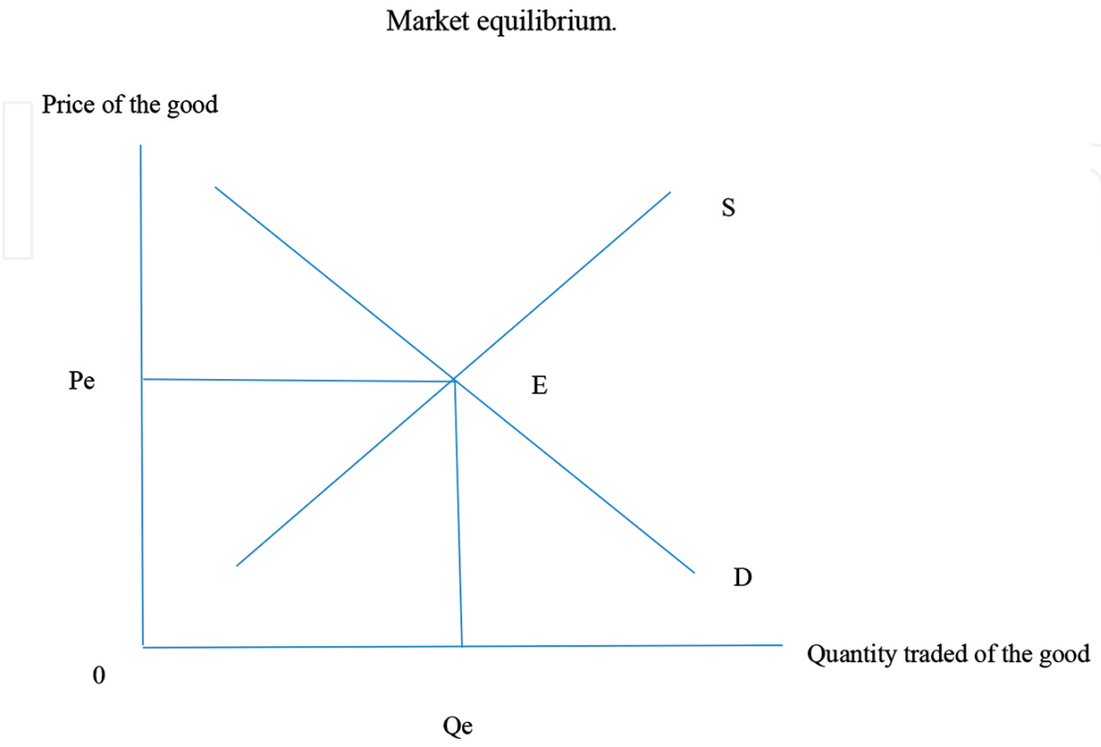


**Figure 4.** Market equilibrium.

### 3.2. Shifts of the demand and supply curves

Up to this point, we have understood that the price and quantity traded of a good are determined by its market equilibrium. However, as mentioned in the definitions of the laws of demand and supply, this is true if and only if all factors other than the price and quantity traded of the good are held constant. This is unrealistic because there are numerous factors affecting a good's price and traded quantity [5].

In this subsection, therefore, we try to understand a case when the aforementioned assumption is relaxed.

As described in reference [5], if something happens to alter the quantity demanded at any given price, then this is expressed through a shift of the demand curve. Specifically, any change that increases the quantity demanded at every price shifts the demand curve to the right. This shift is due to factors other than price that may increase the consumers' willingness to consume the good at any given price. Buyers now want to purchase a larger quantity of the good, with the opposite holding true as well.

[7] In the short run, there are possibilities to have price and quantity traded of the good at points other than the market equilibrium. However, these occurrences are often accompanied by excess demand and supply, and market settles at equilibrium in the long run. For a more detailed description, see Ref. [5].

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To help understand how shifts in the demand curve occur, below we refer to three representative examples of the factors used in economics as presented in reference [5].

The first factor relating to demand for a good is income. Suppose that consumers' incomes fall and they have less money to spend, as a result, consumers' consumption of a good will be lower at a given price. Conversely, if consumers' incomes rise, then they take the opposite action.

The second factor relating to demand for a good is the price of related goods. When consumers purchase something, they often compare its price to that of its substitutes (i.e., ice cream and frozen yogurt). If the price of a substitute is cheaper, then the consumers may choose to buy the substitute and vice versa.

A third factor relating to demand for a good is the number of buyers. If the number of consumers in the market increases, then the quantity demanded in the market will increase at any given price. Conversely, if some consumers stop consuming the good, the quantity demanded will decrease.

In addition to the factors discussed above, public policy makers can also influence the quantity demanded. One way to influence demand is to impose a tax. If policy makers consider consumption of a good to be unsuitable (e.g., cigarettes), then they may impose a tax on that product on for the purpose of raising its price [5].

The shift in the demand curve discussed above is depicted in **Figure 5**.[8] We can see that the demand curve can shift to the right or to the left. As shown in the figure, the former leads to an increase in quantity demanded while the latter leads to a decrease in quantity demanded [5].

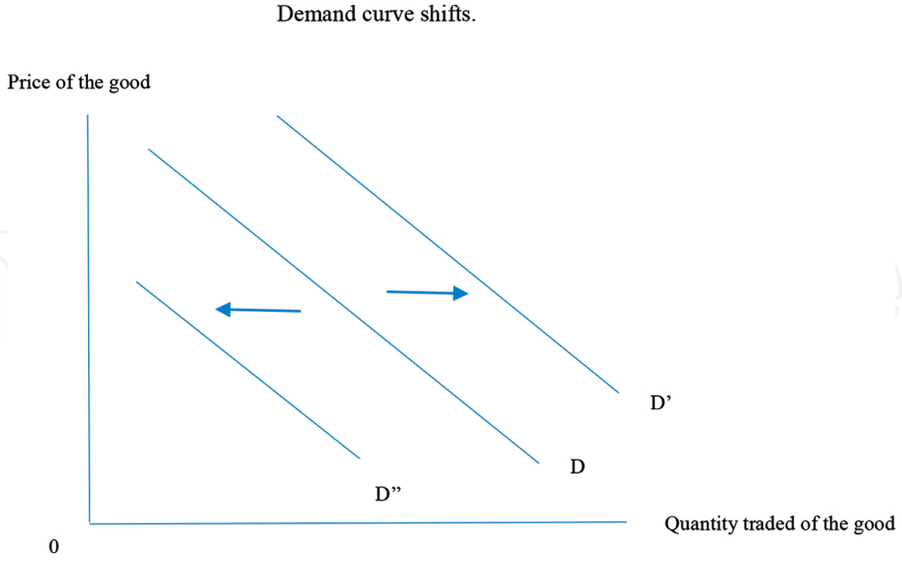


**Figure 5.** Demand curve shifts.

[8] **Figure 5** is drawn from Ref. [5]. Price and quantity traded of the good are indicated on the vertical and horizontal axes, respectively. The initial demand schedule, a rightward shift, and a leftward shift are labeled D, D', and D", respectively.

In reference [5], if something occurs that alters the quantity supplied at any given price, then the supply curve is shifted. This shift is due to the following factors. If there are factors other than price that increase the suppliers' willingness to supply the good at any given price, then sellers are willing to produce a larger quantity, and the supply curve shifts to the right, with the opposite also holding true.

We also refer to three representative examples of the economic concepts presented in reference [5].

The first factor determining the supply of the good is its input price. To produce the good, suppliers incur costs such as material and labor costs. If these costs increase, then the suppliers' profit from selling the good at the given price will decrease, thus lowering the quantity supplied.

The second factor to consider is technology. If the technology for turning inputs into a final product is improved (e.g., new machinery or methods are developed and fewer inputs and time are required to produce a given quantity of the good), production costs will be reduced, helping to increase supply.

A third factor relating to the supply of a good is the number of sellers. If the number of sellers in a market increases (i.e., new suppliers enter the market), then the quantity supplied in the market will be increased.

Similar to the case of the demand curve, public policy makers can also influence the quantity of the good supplied. This can be accomplished in several ways, including through regulations. Policy makers regulate the supply of the product when they consider the supply of the good to be socially undesirable [5].

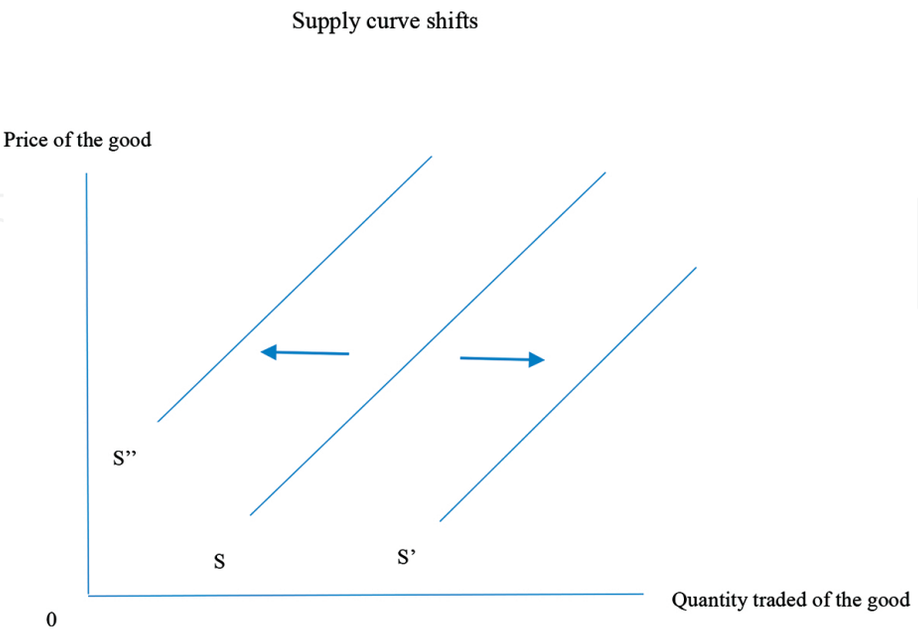


**Figure 6.** Supply curve shifts.

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The shift in the supply curve discussed above is depicted in **Figure 6**. As in the case of the demand curve, the supply curve can shift to the right or to the left. As shown in this figure, the former leads to an increase in quantity supplied while the latter leads to a decrease in the quantity supplied [5].[9]

In this subsection, we referred to reference [5] to describe the basic terms and concepts of economics. In economic market analysis, the price and quantity traded of a good are determined by its market equilibrium (i.e., the point where demand and supply meet). In addition, factors other than price may shift the demand and supply of a product. We also gave examples of the factors influencing demand and supply in reference [5]. However, there are numerous other factors affecting the demand and supply of a good.

## 4. Potential causes of the high price of imported Chinese licorice

Our aim in this section is to understand the recent high prices of imported Chinese licorice using the economic concepts explained in the previous section. More specifically, we consider the potential causes of the high price of Chinese licorice in Japan and how it can be understood in economic terms by looking at changes in its supply and demand.

One of the potential major causes of the high price of Chinese licorice is the fluctuation of the exchange rate between the Japanese yen and the Chinese yuan. In the period 2007–2015, the value of the Japanese yen fell against Chinese yuan. This caused Chinese products to become more expensive in Japan. Viewed in the context of the market analysis from Section 3, we find that from the suppliers' point of view, there has been an increase in their input costs (i.e., a leftward shift of the supply curve). However, it is simplistic to assume that the high price of Chinese licorice in Japan is solely a result of the depreciation of Japanese yen. There are, in fact, several other matters that can potentially affect the price and trading volume of Chinese licorice in the Japanese market.

As was mentioned before, licorice is one of the most commonly used herbal medicines in the production of pharmaceutical products [2]. In recent years, the production of pharmaceutical products using licorice as a raw material has increased steadily. **Figure 7** shows the value (in millions of yen) of pharmaceutical production using licorice as a raw material in Japan in the period 2007–2014.[10]

As seen in **Figure 7**, the value of the pharmaceutical production using licorice as a raw material in Japan in this period increased. This is likely due to the growing need for pharmaceutical products in the Japanese medical field. This trend can be understood from an economic point of view in the following manner. This growing need for pharmaceutical products increases

[9] **Figure 6** originates from Ref. [5]. In this figure, price and quantity traded of the good are indicated on the vertical and horizontal axes, respectively. The initial supply schedule, a rightward shift, and a leftward shift are labeled S, S', and S'', respectively.

[10] **Figure 7** is prepared by the author from the statistics of production by pharmaceutical industry conducted by the Japanese Ministry of Health, Labour and Welfare (http://www.mhlw.go.jp/toukei/list/105-1.html) [Accessed: 2016-09-17]. Data limitations prevent us from introducing 2015 data.

demand for certain materials (e.g., Chinese licorice). Applying this to the market analysis discussed in Section 3, we find an increase in the demand for Chinese licorice, causing the demand curve to shift to the right.

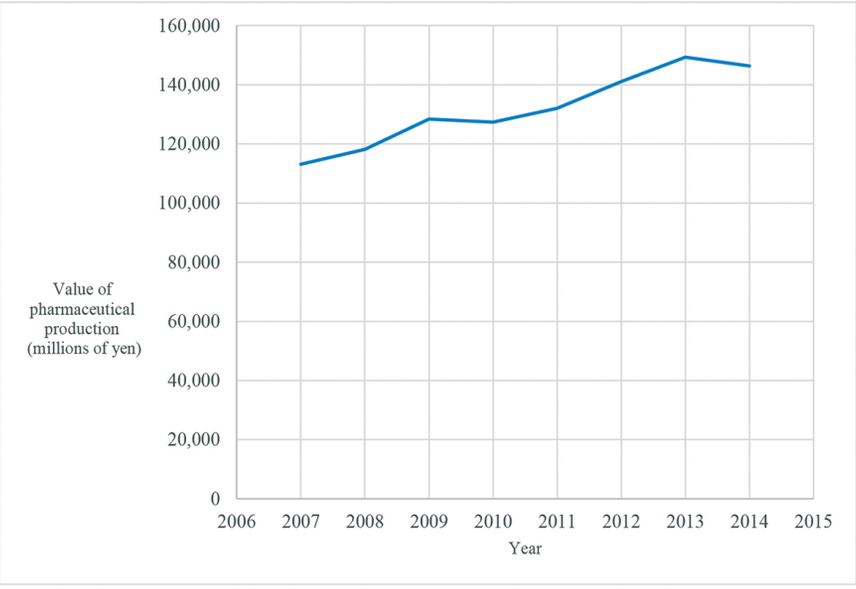


**Figure 7.** Trend in the value of pharmaceutical production using licorice in Japan (2007–2014).

By examining the supply of licorice in China, we find certain factors leading to the increased price. So far, almost all licorice produced in China involves its native strains, as cultivation methods for licorice are not widely established in China [1]. As with natural resources, the amount is limited, and continuous collection causes their depletion. In addition, excessive harvesting can also cause desertification of that area [3]. To prevent the depletion of native licorice and the destruction associated with its harvest, the Chinese government began to restrict the harvest of native licorice in 1984. These restrictions did not apply to three northern regions (the province of Gansu and the two autonomous regions of Neimenggu and Ningxia) [1]. These restrictions were tightened in 2000 [1]. This reduced the supply of native licorice as a herbal medicine in China. Using the market analysis from Section 3, we find a leftward shift of the supply curve of Chinese licorice.

There are other issues that had negative impacts on the supply of Chinese licorice. For example, China has recently been experiencing rapid economic growth, which may bring about an increase in the price of commodities, including licorice. Moreover, Chinese economic growth also increases the labor costs of licorice production. Labor costs are considered part of the input price of licorice. As a result, the input costs of licorice become more expensive at any given price. From the market analysis in Section 3, there is a leftward shift of the supply curve.

As discussed above, there are several issues affecting the supply and demand of Chinese licorice. We now try to simulate the price and quantity traded of Chinese licorice in the Japanese market by examining the changes in its demand and supply. As noted in the discussion of

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economic concepts, the price and amount traded of a product are generally determined by its supply and demand [5]. We also discussed how supply and demand are potentially affected by factors such as the growing needs of pharmaceutical producers, restrictions on the harvesting of licorice, and increases in labor costs. The current situation for Chinese licorice in Japan can be visualized in **Figure 8**, where market equilibrium is determined by a demand curve with a rightward shift and a supply curve with a leftward shift.[11]

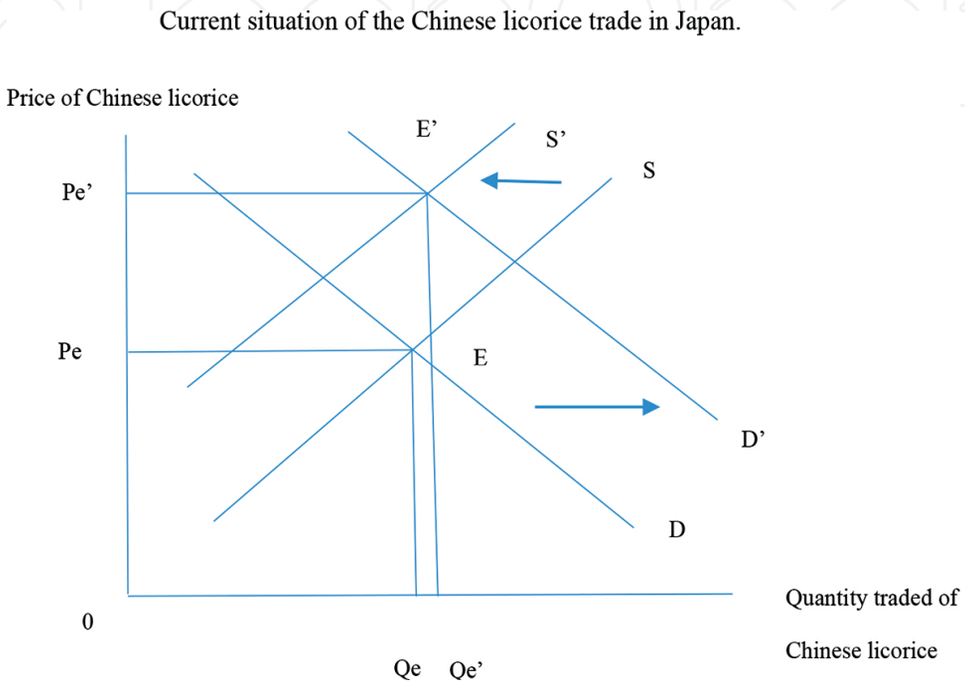


**Figure 8.** Current situation of the Chinese licorice trade in Japan.

As seen in **Figure 8**, at the new equilibrium (E′), the price of licorice is higher than it was previously considered. There is a possibility that this simulation in our market analysis describes the recent rise in the price of Chinese licorice in the Japanese market.[12]

## 5. Necessity of alternative sources of supply

As was discussed in the previous section, the recent increase in the price of Chinese licorice in the Japanese market is considered to be due to a combined effect of an increase in its demand

[11] **Figure 8** presents Japanese demand and supply of Chinese licorice following [5]. The price and quantity traded of Chinese licorice are indicated on the vertical and horizontal axes, respectively. The initial demand schedule, a rightward shift in demand, the initial supply schedule, a leftward shift in the supply schedule, the equilibrium, the equilibrium price, the equilibrium quantity, the new equilibrium, the new equilibrium price, and the new equilibrium quantity are labeled D, D′, S, S′, E, Pe, Qe, E′, Pe′, and Qe′, respectively.

[12] As in **Figure 8**, the rightward shift of the demand schedule and the leftward shift of the supply schedule counteract the respective effects on quantity traded. Hence, changes in quantity traded depend on the comparative strength of influences from demand and supply.

and decrease in its supply. Although the depreciation of the Japanese yen may be improved by changes in each country's economic situation, a decrease in the harvest of native licorice cannot be improved without taking precautionary measures. Leaving the market could potentially cause further increases in the price and a reduction of trading volume. Eventually, the trade of licorice in the Japanese market may become difficult to sustain.

To prevent such a situation, the price and trading volume of licorice must be maintained by increasing its supply. In this section, we discuss attempts to establish licorice cultivation methods, which could potentially serve as a supply source of an alternative to native Chinese licorice. If cultivated licorice can be used in Japanese pharmaceutical products in the same way as its native strains, then decreases in the supply of native licorice could be offset with cultivated licorice.

**Figure 9** visualizes the situation described above.[13]

As shown in **Figure 9**, due to the combined effect of an increase in demand and a decrease in supply, the current equilibrium condition of Chinese licorice in the Japanese market is considered to be at *E*′. Utilizing cultivated licorice as an alternative to native licorice could help shift the supply curve to the right, leading to an equilibrium point at *E*″. At *E*″, the price of licorice will be lower than in the previous situation (i.e., price at the equilibrium (*E*′)).

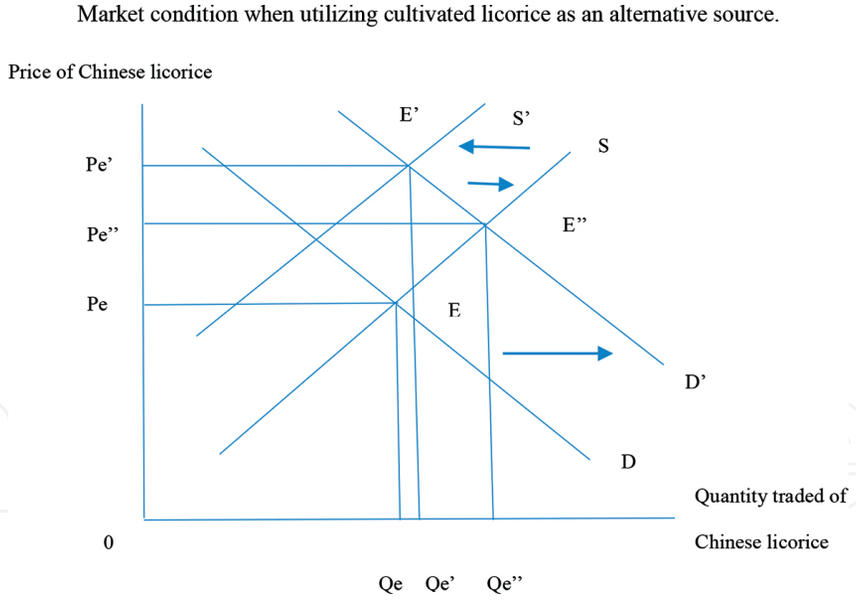


**Figure 9.** Market condition when utilizing cultivated licorice as an alternative source.

[13] Drawn from Ref. [5], **Figure 9** simulates Japanese demand and supply for licorice when cultivated licorice becomes an alternative. The price and quantity traded are indicated on the vertical and horizontal axes, respectively. The initial demand schedule, a rightward shift, the initial supply schedule, a leftward shift, initial equilibrium price and quantity, and new equilibrium price and quantity are labeled D, D′, S, S′, E, Pe, Qe, E′, Pe′, and Qe′, respectively. In addition, equilibriums following the introduction of cultivated licorice, the third equilibrium price, and the third equilibrium quantity are labeled E", Pe", and Qe", respectively.

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However, using cultivated licorice as an alternative to native Chinese licorice is not an easy task. This is because the amount of cultivated licorice needed as an ingredient in Japanese pharmaceutical products is often different from that of native licorice. More specifically, the glycyrrhizin content (an ingredient contained in licorice root) of cultivated licorice is often lower than that of native licorice [1].

Because of this, the content of pharmaceutical products produced using cultivated licorice must conform to the standards of official compendiums such as the Japanese Pharmacopoeia XIV (JP XIV)[14] (e.g., see Ref. [1]).

A number of groups are performing research on the production of cultivated licorice that can be used in pharmaceutical products in Japan.

Reference [6] reports an investigation of the quality variation of the licorice in the Japanese market in the period 1986–2000. The main contribution of this investigation was to propose a method of distinguishing the different types of Chinese licorice. More specifically, during the investigation period, the average glycyrrhizin content of Dongbei-Gancao, a type of licorice mainly traded in the Japanese market, was found to be higher than that of a different type of licorice, Xibei-Gancao. On the other hand, the root specific gravity of Dongbei-Gancao is often lower than that of Xibei-Gancao. The investigation also found that some Dongbei-Gancao has high root specific gravity, which is not consistent with the aforementioned characteristic of Dongbei-Gancao. The investigation suggests that the licorice that was thought to be Dongbei-Gancao seems to correspond to Ditou-Gancao, which is a Chinese licorice different from both the Dongbei and Xibei types.

Reference [7] reports a study of the cultivation of *Glycyrrhiza uralensis* (the scientific names of one type of licorice) in the eastern region of Neimenggu (Inner Mongolia). In this study, seeds of *G. uralensis* were sown in May 1998 and its seedling roots were transplanted to the field the following May. It was found that the glycyrrhizin content of 4-year-old lateral root newly grown from the transplanted seedling taproot exceeds the Japanese Pharmacopoeia XIV standard. However, the study concludes that utilizing the cultivated licorice as a substitute for the native licorice traded in the Japanese market is still difficult, because even though the glycyrrhizin content of the cultivated licorice satisfies JP XIV, it is still lower than that of the native licorice currently traded in the Japanese market. The study emphasizes the necessity of improvements in the selection of seedlings and cultivation methods.

In reference [3], the feasibility of the medicinal use of cultivated licorice was tested by comparing the licorice roots cultivated in eastern Neimenggu and that used in medical applications. According to this study, the 4-year-old adventitious licorice roots cultivated in eastern Neimenggu may be a suitable substitute for licorice conforming to JP XIV.

Attempts are also being made to cultivate licorice in Japan. In reference [8], a comparative study of 10 types of licorice strains cultivated in the Kyoto Herbal Garden of Takeda Pharma-

[14] JP XIV standards appear in the 14th edition of the Japanese Pharmacopoeia, which was published to regulate the properties and quality of drugs by the Japanese Minister of Health, Labor and Welfare after consultation with the Pharmaceutical Affairs and Food Sanitation Council. The 17th edition is the latest version. For details, see http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000066597.html [Accessed: 2016-09-17].

ceutical Co. Ltd. was undertaken to understand the differences of the features of licorice of different origins. According to this latter study, the 10 types of licorice belong to either the Chinese or the Kazakhstani types. These types show some differences, namely the glycyrrhizin content of Chinese type is higher than that of Kazakhstani type.

In reference [4], a study of the cultivation of licorice in Inner Mongolia was conducted. This study aimed to confirm the origin of the plant by comparing their cultivated strain to native strains in the Xinjiang Uygur Autonomous Region of China.[15] The study concludes that their cultivated strain of licorice is most likely the *G. uralensis*, which is the main raw material of licorice used in Japan.

In reference [9], a study investigated the use of cultivated licorice in Inner Mongolia as a method to compensate for the reduced supply of native licorice. Specifically, the chemical and pharmaceutical properties of cultivated licorice root and those of licorice prepared from its native plant were compared. In this study, boiled water extracts of cultivated and native licorice were found to have similar antispasmodic effect on carbachol-induced contraction in mice jejunum.[16] Moreover, the glycycoumarin content (one of the components contained in licorice) of boiled water extract of 4-year-old cultivated root and that of native licorice was also found to be similar. Thus, the study in reference [9] concluded that the cultivated licorice root could be considered an adequate substitute in the face of restrictions on the harvest of native licorice.

Some researchers are attempting to use the cultivation of licorice to prevent desertification, mainly in Mongolia. This is referred to as high-value-added greening, since it is effective in both providing a supply of licorice and combatting desertification. In reference [10], desertification is explained as an environmental problem caused by both natural environmental phenomena, such as irregular precipitation and the lowering of the ground water level, and anthropogenic causes such as overharvesting of native plants.

Many of the studies referenced here take advantage of greening soil materials (GSMs). In reference [11], GSMs are a mixture of sand and compost that can be inexpensively and easily applied to the ground. This material contains more water than ordinary soils and, therefore, can be thought of as a simple self-watering system that does not require artificial water supplies.

There have been various reports on the effect of using GSMs to cultivate licorice.

To prevent desertification, in reference [10], licorice was experimentally planted in arid areas of Mongolia. In this experiment, GSMs were used for planting licorice. As GSMs have more than 10 times the water and nutrient-holding capacity in comparison with desert ground, a correlation between the survival ratio of licorice and GSMs was demonstrated (i.e., a positive relationship between the amount of water in GSMs and the survival ratio of licorice).

Reference [11] reports field agricultural experiments conducted in areas where licorice did not grow naturally. In this experiment, researchers concluded that a larger volume of GSMs could

[15] Native strains of licorice in the latter area are *Glycyrrhiza inflata, G. glabra, and G. uralensis*.

[16] Carbachol is a kind of medicine (cholinergic agent).

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maintain the survival rate for licorice higher than smaller types. In other words, GSMs are helpful in increasing the survival rate of licorice.

In reference [12], a geo-environmental and climate survey was conducted to investigate the environmental conditions in the licorice-habitat area. In this study as well, GSMs were used experimentally to plant licorice in arid Mongolian land. This experiment reached several conclusions. First, there was a great difference between the licorice habitat and non-habitat areas in terms of the amount of water in the ground. Specifically, at points deeper than 20 cm below the surface, the water content was higher in the habitat area of licorice than in non-habitat areas. Second, covering the ground surface with vinyl-mulching sheets helps licorice to survive by maintaining a high water content. Third, GSMs help licorice to survive by maintaining a high water content. Fourth, licorice can survive if soil water content of at least 8% is maintained.

In reference [13], agricultural experiments were conducted in sandy ground to simulate arid regions and non-habitat regions of licorice in Mongolia, using GSMs to establish suitable soil water and calcium conditions, setting up outer layer processing for the survival and growth of licorice. In this experiment, some beneficial results were obtained. Notably, the active ingredient content of the cultivated licorice root tended to rise when using GSMs whose available moisture was three to 10 times higher than that in Mongolian soils.

In reference [14], the five bioactive components of licorice (liquiritin, liquiritigenin, glycyrrhizin, isoliquiritin, and isoliquiritigenin) were examined using four types of licorice grown in four distinct environments in Northern China during 2010–2011. This study explored how the five bioactive components are affected by various factors, such as climate (i.e., an increase in the duration of sunshine increases glycyrrhizin while declining rainfall promotes the accumulation of liquiritigenin and isoliquiritigenin).

As was discussed in this section, the effects of a decrease in the harvest of native Chinese licorice cannot be underestimated as it has the potential to cause further price increases and reductions in trading volume. Eventually, the trading of licorice in the Japanese market may become difficult to sustain.

To prevent such a situation, the price and trading volume of licorice must be maintained by increasing its supply. One of the potential solutions is to establish cultivation methods for licorice.

However, using cultivated licorice as an alternative supply source is not an easy task, since the amounts of active ingredients in cultivated licorice are often different from those in the native licorice used for pharmaceutical products in Japan [1].

As noted in this section, a number of groups are attempting to establish cultivation methods for licorice that can be used in the pharmaceutical industry in Japan.

However, to conclude that the quality of cultivated licorice is equivalent to that of native licorice, more demonstrations are required. More specifically, further studies are needed to devise methods for increasing the glycyrrhizin content of cultivated licorice.

## 6. Conclusion

Recent years have seen changes in the trade of licorice between Japan and China. Specifically, the import price of Chinese licorice has been steadily increasing. As the high price of Chinese licorice is expected to continue, the use of Chinese licorice in Japan will be constrained.

Unlike in pharmacological studies, here we investigated at data such as the price and trading volume between China and Japan to analyze the licorice market from an economic perspective. So far, publications analyzing licorice by incorporating economic concepts is rare. Our study constitutes a novel analysis of trends in the licorice market.

This study investigated changes in the supply, demand, and quantity traded of licorice. We concluded that the recent high price of Chinese licorice in Japan is likely due to the combined effect of an increase in demand and a decrease in supply.

To alleviate this situation, the price and quantity traded of licorice must be maintained by increasing its supply.

As the number of native strains in China is limited, its supply is unlikely to increase.

One way to increase the supply of licorice without relying on native Chinese strains is to establish methods of licorice cultivation. If cultivated licorice can be used to manufacture pharmaceutical products in the same way as native strains, then cultivated licorice will serve as a useful alternative supply source to compensate for the decrease in the supply of native strains.

However, to achieve this, there are many problems that must be solved, and a great deal of future research will be necessary.

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