The Impact of Sticky Supply Chain Relationships in International Soybean Trade Upstream Manufactures' Pricing Decisions

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Abstract. Based on the sticky relationship in the supply chain of international soybean trade, this paper explores the reasons for the formation of buyer countervailing power, and at the same time, through constructing a two-stage dynamic game model, it discusses the manufacturer's choice of different pricing forms based on the consideration of buyer countervailing power. The study shows that: (1) when there is buyer resistance, the conclusion that two-part fee system and RPM can make manufacturers gain equal profits is no longer valid. The manufacturer's profits are higher with two-part toll pricing than with RPM. (2) When there is buyer resistance, two-part toll pricing can be implemented only when the buyer resistance is small. (3) When the resistance is small, the manufacturer chooses two-part toll pricing, and when the resistance is large, the manufacturer chooses RPM.

Keywords: International soybean trade; Supply chain stickiness; Buyer resistance forces; Pricing decisions.

1. Introduction

Since 2015, China's grain imports have been maintained at more than 100 million tons per year, and the cumulative grain imports in 2020 have been maintained at more than 100 million tons per year, of which 100,327,000 tons of soybeans have been imported, making it the world's largest importer of soybeans [1]. However, the uncertainty of the global soybean market environment is increasing. With the rise of anti-globalization and the impact of the new crown epidemic, the international trade environment has become more volatile, triggering abnormal fluctuations in the global food market, including soybeans, leading to the risk of supply disruption in the international food market [2]. On the one hand, global soybean producers are highly dominated by the United States, Brazil and Argentina, which makes the countries that mainly rely on soybean imports to meet domestic demand face serious economic dependence; on the other hand, frequent international political friction reflected in the economy is the ever-higher trade barriers, which greatly increase the import cost of importing countries, resulting in the loss of domestic consumer interests. Stable trade links are therefore a key factor in strengthening supply chain security and reducing external risks.

Supply chain stickiness, understood as the stability in trading relationships between supply chain actors, moderates the impacts of agricultural commodity production and the possibilities for supply-chain interventions[3]. However, what factors determine stickiness, how and why farmers, traders, food processors, and consumer countries, develop and maintain trading relationships with specific producing regions, remains unclear. Recent research finds four groups of factors to be important: economic incentives, institutional enablers and constraints, social and power dimensions, and biophysical and technological conditions. Among the factors explored, surplus capacity in soy processing infrastructure is important in increasing stickiness, as is export-oriented production. Conversely, volatility in market demand expressed by farm-gate soy prices and lower land-tenure security are key factors reducing stickiness, suggesting tailored supply-chain interventions are beneficial.

Pricing decision is one of the most important decisions of enterprises. To a certain extent, pricing strategy is the centralized embodiment of various competitive strategies of enterprises, which determines the business performance of enterprises[4]. The traditional enterprise pricing problem is mainly based on the single-level market structure as the object of research, focusing on how the enterprise can formulate the optimal pricing strategy according to the competitive environment in which it is located and the consumer's assessment of the value of the product. However, with the acceleration of economic globalization and the deepening of the international division of labor, the length of the industrial chain has been significantly stretched, and the business activities of enterprises are not only affected by competing enterprises but also by the behavior of their upstream and downstream enterprises, so the study of enterprise pricing behavior in the vertical relationship has received more and more attention [5]. Previous studies of firms' pricing strategies in vertical relationships have assumed that manufacturers have complete market power relative to retailers; however, with the rapid rise of large retailers and increasing market concentration [6-7], retailers have become more and more powerful, and the market power has been transformed from a seller-resistant to a buyer-resistant power.

The emergence of retailer buyer countervailing power has led to changes in the conclusions of vertical relationships in which the traditional manufacturer has complete power, most notably in the issue of manufacturer pricing decisions. However, there is a dearth of research on what factors lead to changes in these relationships. Another question is, if the retailer has buyer countervailing power, it will inevitably demand a portion of the profits in the supply chain; can the manufacturer still implement the previous form of pricing? If so, is it still optimal to do so? If not, what form of pricing does the manufacturer use if the retailer has buyer countervailing power?

To answer the above questions, this paper takes the international soybean trade as the research object, firstly analyzes the factors affecting the stickiness of the international soybean supply chain, and then demonstrates the way these factors affect the pricing decision of the upstream manufacturers and provides theoretical guidance for the international soybean manufacturers to choose the optimal pricing decision under different conditions by comparing the different pricing forms.

The remainder of this study is organized as follows. Section 2 describes factors that affecting supply chain stickiness in soybean trade. Section 3 introduces manufacturer’s pricing decision including linear pricing, resale price maintenance and two-part tariff considering buyer's countervailing power. The last part is the conclusion of this study.

2. Factors affecting supply chain stickiness in soybean trade

Through a review of the relevant literature and the authors' own understanding, there are four main categories of factors that influence the stickiness of the relationship between manufacturers and retailers in the international soybean supply chain: economic factors, institutional factors, social and power factors, and biophysical and technological factors. See Table 1 for details.

Table 1 Factors affecting supply chain stickiness

Tier I indicators	Tier II indicators	Direction of Indicators (+ for increased stickiness, - for decreased stickiness)
Economic factors	Soybean processing infrastructure and its capacity	+
	Financial capital participation	/
	Level of indebtedness of farmers	+
	Market demand and price volatility	-
	Market preferences for specific products	+
Institutional factors	Land prices and tenure	-
	Environmental and land use regulations	+

Social and power factors	Intermediary power	+
	Concentration of ownership and control of soybean storage facilities	+
Biophysical and technical factors	Average productivity	+
	Degree of stability of natural conditions	+
	Use of agricultural technology tools	+
	Potential for expansion of agricultural land	-

2.1. Economic factors

The completeness of soybean processing infrastructure and its capacity, such as storage and crushing and transportation equipment, are key factors that influence the level of stickiness of manufacturers and retailers. The stronger the crushing capacity, the stronger the stickiness in the region. This is mainly since the infrastructure of soybean processing, i.e., fixed cost inputs, is large and processors cannot risk running out of stock of crushing equipment. At the same time, since the price paid by crushers tends to be higher than that paid by exporters of raw beans, the only way to improve the operational efficiency of the equipment, to recoup capital, and to carry out repetitive production is to speed up the flow of manufactured soybeans, and hence prefer to establish stable linkages with both upstream manufacturers and downstream retailers.

The level of financial capital participation is thought to influence supply chain stickiness; however, the direction of its impact may not be fixed. On the one hand, financial capital enables greater use of machinery, production technologies, precision agriculture, inputs, fertilizers, and rural insurance, which implies more control over the stability of production leading to increased stickiness, but it also implies more freedom to negotiate harvests, including control over infrastructure (e.g., silos), which reduces stickiness.

The level of indebtedness of the farmer may also determine stickiness. It is important to note that manufacturers in this paper are farmers or firms that produce on a large scale and have strong acquisition capabilities within the originating region. Because soybeans are a primary, low-value consumer good, farmers often do not have direct access to retailers or direct exports and need to rely on large local manufacturers. Debt increases stickiness by locking farmers into local banks and manufacturers, reducing their negotiating leverage, and thus losing control over soybean production and negotiations.

In terms of market demand and its volatility, when prices reflect an increase in demand for soybeans, farmers are encouraged to open new farmland, which promotes the expansion of soybeans and attracts new entrants to the farmland area. If demand decreases, marginal land becomes unprofitable and may even experience abandonment of soybean fields. As a result, demand and price fluctuations lead to a reconfiguration of business relationships, which reduces stickiness.

Market preferences are reflected in the demand for particular products that originate in markets that are sticky to begin with. Market preferences increase supply chain stickiness as the production of specialized products is separated from regular production from the outset, with long-term investments in related facilities.

2.2. Institutional factors

Scholars argue that land prices and tenure insecurity tend to reduce stickiness because they open space for opportunistic business and reduce incentives for long-term investment. In addition, environmental and land-use regulations, such as areas embargoed by environmental enforcement agencies, protected areas or local indigenous territories are thought to affect stickiness. Because these areas cannot be further expanded due to difficulties in development, companies and farmers tend to consolidate and maintain business relationships with each other.

2.3. Social and power factors

Another key factor in increasing stickiness is the power of intermediaries, defined here as large manufacturers that buy primary agricultural products from individual farmers upstream and sell manufactured goods to retailers downstream. The more powerful the intermediary, the larger its commercial footprint, the more dependent the farmer is on it, and the more inclined the retailer is to establish a long-term, stable relationship with it.

Ownership or control of soybean infrastructure also becomes an important factor, with ownership or control of port and railroad facilities also seen as a key determinant of stickiness. As one logistics expert and operator for a major trader put it, "Companies that control port terminals can control the entire area of a logistics operator. They can offer the best prices, so it is difficult for other companies to compete."

2.4. Biophysical and technological factors

Biophysical conditions and the control of biophysical factors through biotechnology determine the stability of production and supply, and the use of technology improves average productivity, and regions with higher average productivity have higher bulk yields, greater profit margins for companies, and therefore a stickier supply chain. At the same time, soybean companies are more likely to locate their production activities in regions where the climate is stable and more predictable, and more suitable for growing soybeans.

Stability in production is achieved using technological tools such as efficient machinery, irrigation systems, and precision agriculture that ensure smooth production and greater resistance to pests and weather shocks. Stability of supply is a key business principle that ensures efficiency, predictability, and profitability of business operations. Beyond this, technology influences stickiness by creating locked-in relationships; for example, companies that supply seeds of a particular technology require that the sale and purchase of crops be negotiated only with them, which is bound by contract.

Active agricultural frontiers - or areas with more land suitable for arable expansion and where rapid agricultural growth is occurring - are constantly being joined by new entrants as expansion unfolds and stickiness tends to be lower.

Overall, the regulation of soybean supply chain stickiness is a key factor in the profitability of upstream and downstream firms when analyzed at various economic, institutional, social, and technological levels. Nowadays, factors disturbing world peace keep appearing, and food security has become an urgent problem for all countries. Based on this, grain manufacturers in all countries also prefer to carry out stable business activities with larger retailers, which increases the stickiness of the supply chain to a certain extent, and confers unequal forces on buyers and sellers, which not only affects the pricing decisions of manufacturers, but also determines the wholesale quantity decisions of retailers.

Therefore, this paper will next analyze the manufacturer's optimal pricing decision under different conditions specifically from the assumption of having retailers with buyer-resistant power.

3. Manufacturer's pricing decision based on buyer's countervailing power

Suppose there is a monopolistic manufacturer upstream who produces a single product and sells it by two retailers downstream. Retailer 1 is assumed to be a chain retailer and Retailer 2 is a local retailer who compete in a decentralized market. The manufacturer's marginal cost of production is c, normalized to 0, and fixed and selling costs are assumed to be 0. The products sold by the two retailers are not fundamentally different from each other, however, due to differences in marketing techniques, after-sales services, etc., the two retailers sell differentiated products with imperfect substitutability for consumers.

The utility function of the consumer is assumed to be a squared utility function:

$$u(q_1, q_2) = q_1 + q_2 - \frac{1}{2}(q_1^2 + q_2^2 + 2\alpha q_1 q_2) + X \tag{1}$$

where q_1, q_2 are the number of products purchased by consumers from retailer 1 and retailer 2, respectively, and X denotes the utility gained by consumers from consuming other products. The parameter $\alpha \in (0,1)$ measures the degree of substitutability between retailer 1 and retailer 2, and the larger its value, the greater the substitutability between the products sold by the two retailers, i.e., the greater the homogeneity of the products, and the more intense the competition between retailers. From the consumer's utility function, the retailer's inverse demand function can be derived:

$$p_i = 1 - q_i - \alpha q_j \tag{2}$$

where $i, j = 1{,}2$ $i \neq j$, p_i is the price of retailer i, and q_i is the quantity sold by retailer i.

Chain retailers have stronger market power due to their large scale, as well as information and sales advantages. Therefore, this section assumes that retailer 1 (chain retailer) has buyer countervailing power, and that retailer 1 can obtain a wholesale discount r, which reflects the size of retailer 1's buyer countervailing power, and the larger the value of r, the larger the buyer countervailing power is. The larger its value, the greater the buyer's countervailing power, and vice versa. All other assumptions remain unchanged.

3.1. Linear Pricing

When the manufacturer adopts a linear pricing approach, the following two-stage game exists between the manufacturer and the two retailers. In the first stage, the manufacturer sets the wholesale price of the product w_H^L. Since retailer 1 has buyer countervailing power, he can negotiate with the manufacturer and obtain a discount r. Retailer 2, on the other hand, does not have power and must accept the manufacturer's price to continue operating in the market. In the second stage, there is volume competition between the two retailers.

The subgame refinement Nash equilibrium is computed by backward induction. Retailers make decisions based on profit maximization, Retailer 1's profit is: $\pi_{1H}^L = (p_{1H}^L - (1-r)w_H^L)q_{1H}^L$. Retailer 2's profit is: $\pi_{2H}^L = (p_{1H}^L - w_H^L)q_{2H}^L$.

This can be found by substituting equation (2) and solving for the first order condition for profit maximization:

$$p_{1H}^L = \frac{\alpha - 2 + w_H^L[(1-r)(\alpha^2 - 2) - \alpha]}{\alpha^2 - 4} \tag{3}$$

$$p_{2H}^L = \frac{\alpha - 2 + w_H^L[\alpha^2 - 2 - \alpha(1-r)]}{\alpha^2 - 4} \tag{4}$$

$$q_{1H}^L = \frac{\alpha - 2 - w_H^L[\alpha - 2(1-r)]}{\alpha^2 - 4} \tag{5}$$

$$q_{2H}^L = \frac{\alpha - 2 + w_H^L[2 - \alpha(1-r)]}{\alpha^2 - 4} \tag{6}$$

In the first stage, the manufacturer's profit $\Pi_H^L = (1-r)w_H^L q_{1H}^L + w_H^L q_{2H}^L$, the manufacturer's equilibrium wholesale price at this point can be derived by solving the first-order condition for profit maximization:

$$w_H^{L^*} = \frac{(2-r)(2-\alpha)}{4[1 - \alpha(1-r) + (1-r)^2]} \tag{7}$$

Substituting the above equations into $\Pi_H^L = (1-r)w_H^L q_{1H}^L + w_H^L q_{2H}^L$, the manufacturer's profit at equilibrium can be found to be:

$$\Pi_H^{L^*}=\frac{1}{2(\alpha+2)}-\frac{r^2}{8[r^2-(2-\alpha)r+2-\alpha]} \tag{8}$$

In this equation, the first term represents the profit that the manufacturer can earn when it adopts linear pricing when the retailer does not have buyer countervailing power, and the latter term represents the reduction in the manufacturer's profit when the retailer has countervailing power, which translates into excess profit for the powerful retailer.

Substituting $w_H^{L^*}$ into equations (5) and (6) yields the equilibrium quantities sold by retailer 1 and retailer 2, $q_{1H}^{L^*}$ and $q_{2H}^{L^*}$, and for ease of computation, differing $q_{1H}^{L^*}$ and $q_{2H}^{L^*}$ yields $q_{1H}^{L^*}-q_{2H}^{L^*}>0$, and thus $q_{1H}^{L^*}>q_{2H}^{L^*}$. That is, when linear pricing strategy is used, the optimal sales volume of chain retailers with buyer-resistant power will be larger than that of ordinary retailers, which is consistent with the reality. Side by side, it reflects that chain retailers will have greater incentives to grab more market share to obtain excess profits and maximize their own profits.

3.2. Resale Price Maintenance (RPM)

Resale Price Maintenance (RPM) is when a manufacturer enters a purchase and sale contract with a retailer, agreeing that when the retailer resells the goods, the seller will be required to sell them at a fixed price. The manufacturer then charges the retailer the corresponding wholesale price according to the quantity purchased by the retailer to maximize its profit. The model in this paper assumes that when the retail price is the same, the quantity sold by both retailers is also the same.

Assuming that the retail price set by the manufacturer is p_N^{RPM}, the quantity sold by the two retailers is $q_{1N}^{RPM}=q_{2N}^{RPM}=\frac{1-p_N^{RPM}}{\alpha+1}$. For the powerful retailer 1, the manufacturer gives a discount of r on the wholesale price, while for the non-powerful retailer 2, the manufacturer will charge a wholesale price equal to the retail price for the full profit, i.e., $w_H^{RPM}=p_H^{RPM}$.

The manufacturer's profit at this point is:

$$\Pi_H^{RPM}=(1-r)p_N^{RPM}q_{1N}^{RPM}+p_N^{RPM}q_{2N}^{RPM} \tag{9}$$

By the first-order condition of profit maximization, we can find $p_H^{RPM^*}=\frac{1}{2}$, then $q_{1H}^{RPM^*}=q_{2H}^{RPM^*}=\frac{1}{2(\alpha+1)}$, and the wholesale price of retailer 2 is:

$$w_H^{RPM^*}=\frac{1}{2} \tag{10}$$

The manufacturer's profit is:

$$\Pi_H^{RPM^*}=\frac{1}{2(\alpha+1)}-\frac{r}{4(\alpha+1)} \tag{11}$$

A comparison of manufacturers' profits under linear and RPM pricing shows that RPM is optimal for upstream manufacturers.

3.3. Two-part Tariff

The Two-part Tariff (Two-part Tariff) means that the manufacturer charges the retailer a fixed fee for a certain quantity first, and then charges the retailer a wholesale fee for the quantity purchased by the retailer, Two-part Tariff Contract $(w_{iH}^{TP},F_{iH}^{TP})$, where $i=1{,}2$ ..., w_{iH}^{TP} is the wholesale price of the product per unit for retailer i , and F_{iH}^{TP} is the fixed fee paid by retailer i. Provided that retailer 1 has power, the manufacturer needs to give it a wholesale discount r, and retailer 2 will purchase at the wholesale cost set by the manufacturer. Therefore, $w_{1H}^{TP}=(1-r)w_{2H}^{TP}$.

The second stage equilibrium is solved first using backward induction, where retailers first decide on their respective purchase quantities based on the principle of profit maximization, and retailer 1's profit is: $\pi_{1H}^{TP}=(p_{1H}^{TP}-(1-r)w_{2H}^{TP})q_{1H}^{TP}-F_{1H}^{TP}$, retailer 2's profit is: $\pi_{2H}^{TP}=(p_{1H}^{TP}-w_{2H}^{TP})q_{2H}^{TP}-$

F_{2H}^{TP}. The equilibrium solution for the retailer's price and quantity can be found through the first-order condition of profit maximization:

$$p_{1H}^{TP} = \frac{\alpha - 2 + w_H^L[(1-r)(\alpha^2 - 2) - \alpha]}{\alpha^2 - 4} \tag{12}$$

$$p_{2H}^{TP} = \frac{\alpha - 2 + w_H^L[\alpha^2 - 2 - \alpha(1-r)]}{\alpha^2 - 4} \tag{13}$$

$$q_{1H}^{TP} = \frac{\alpha - 2 - w_H^L[\alpha - 2(1-r)]}{\alpha^2 - 4} \tag{14}$$

$$q_{2H}^{TP} = \frac{\alpha - 2 + w_H^L[2 - \alpha(1-r)]}{\alpha^2 - 4} \tag{15}$$

In the first stage the manufacturer formulates $(w_{iH}^{TP}, F_{iH}^{TP})$ to maximize the manufacturer's profit, i.e.:

$$max\Pi_H^{TP} = (1-r)w_{2H}^{TP}q_{1H}^{TP} + F_{1H}^{TP} + w_{2H}^{TP}q_{2H}^{TP} + F_{2H}^{TP} \tag{16}$$

$$s.t.\pi_{1H}^{TP} \geq rw_{2H}^{TP}q_{1H}^{TP} \tag{17}$$

$$rw_{2H}^{TP}q_{1H}^{TP} \geq 0 \tag{18}$$

$$\pi_{2H}^{TP} \geq 0 \tag{19}$$

Since retailer 1 has power, it can obtain cost savings compared to retailer 2: $rw_{2H}^{TP}q_{1H}^{TP}$, and if retailer 1 does not have power, then the manufacturer will obtain all of its profits under the two-part fee system, so it is advantageous to stay in the market as long as retailer 1 obtains profits that are not less than its cost savings compared to the no-power case. In the case of retailer 2, since it has no power, it will not leave the market if its profit is non-negative.

This can be derived using the Kuhn-Tucker condition:

$$w_H^{TP^*} = \frac{(2-\alpha)^2(\alpha - ar - r)}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{20}$$

The price and quantity at equilibrium are respectively:

$$p_{1H}^{TP^*} = \frac{(\alpha^3 - 3\alpha^2 - 3\alpha + 8)r^2 - (2\alpha^3 - 5\alpha^2 - 3\alpha + 10)r + \alpha^3 - 3\alpha^2 + 4}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{21}$$

$$p_{2H}^{TP^*} = \frac{(6 - \alpha^2 - 2\alpha)r^2 - (\alpha^3 - 2\alpha^2 - 5\alpha + 10)r + \alpha^3 - 3\alpha^2 + 4}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{22}$$

$$q_{1H}^{TP^*} = \frac{(4 - 3\alpha)r^2 - (2 - 2\alpha)(3 - 2\alpha)r + (2 - \alpha)^2}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{23}$$

$$q_{2H}^{TP^*} = \frac{(2 - \alpha)[(3 + \alpha)r^2 - (3 - \alpha)r + 2 - \alpha]}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{24}$$

The manufacturer's profit at this point is:

$$\Pi_H^{TP^*} = \frac{(\alpha^2 - 6\alpha + 7)r^2 - 2(2 - \alpha)^2 r + (2 - \alpha)^2}{(12 - 5\alpha^2)r^2 - (3\alpha^3 - 8\alpha^2 - 4\alpha + 16)r + 2\alpha^3 - 6\alpha^2 + 8} \tag{25}$$

Based on the analysis above, the optimal form of pricing for the upstream manufacturer will change due to the emergence of the retailer's countervailing power, and a comparison of equations (8), (11), and (25) leads to the conclusion that the manufacturer obtains higher profits by adopting the two-part charging system than by linear pricing and RPM, and that the two-part pricing method is preferred when buyer's countervailing power is small, and that the manufacturer will choose the RPM pricing method when the countervailing power is large.

4. Conclusion

The emergence of countervailing forces has led to a change in the form of optimal pricing for international soybean manufacturers. This paper constructs a vertical relationship model with upstream monopoly and downstream duopoly competition. The following conclusions are found through the study: 1) The conclusion that the two-part fee system and RPM can make manufacturers equally profitable no longer holds when there are buyer countervailing forces. The manufacturer's profit from using two-part toll pricing is higher than that from using RPM. 2) When there is buyer resistance, two-part toll pricing can only be implemented when the buyer resistance is small. 3) When the resistance is small, the manufacturer will choose two-part toll pricing, and when the resistance is large, the manufacturer will choose RPM. 4) When there is no buyer resistance, the manufacturer will choose two-part toll pricing. 5) When there is no buyer resistance, the manufacturer will choose two-part toll pricing. 6) When there is no buyer resistance, the manufacturer will choose RPM. manufacturer's choice of pricing form.

This paper also provides theoretical guidance for manufacturers' pricing decisions in the context of buyer resistance. With the increase of retailers' buyer countervailing power, the vertical market environment for manufacturers has changed dramatically, and how to choose the optimal pricing strategy in the case of retailers' buyer countervailing power has become an important decision-making issue for manufacturers. The international soybean trade has been monopolized by a few major producers in the world for many years, and the existing literature has been mostly studied from the perspective of manufacturers with complete market power. However, the international trade pattern in today's world is constantly evolving, and the power of retailers is constantly increasing, so it is of practical significance to consider how manufacturers can cope with the buyer countervailing power of retailers. At the same time, there are many industries in China where buyer resistance exists, such as pharmaceuticals, telecommunications, iron and steel, and military procurement, etc. The conclusions of this paper are also instructive for pricing decisions in these industries.

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