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ARTICLE

Unequal Exchange and Food Terms of Trade for China

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ABSTRACT

This article aims to analyze the repercussions of food trade between China and various regions of the world to understand the dynamics of food flows and offer a novel perspective on the contemporary globalization process. Understanding these flows involves analyzing the global production and commercialization of food and the effects of these movements on exporting and importing countries in economic terms and food security. The concept of unequal caloric exchange is applied to the case of China, which allows for an understanding of how its economic growth and participation in international trade have transformed its global and internal commercial dynamics by establishing links with self-sufficiency and the composition of its population's diet. The results show that China is increasingly dependent on international markets for its food supply. From 1961 to 2021, food consumption in China has tripled in calories and experienced qualitative changes, with a reduction in high-quality carbohydrates and vegetable proteins and an increase in cereals, vegetable oils, alcohol, and vegetables. This dietary transformation is related to economic growth and greater dependence on international trade. From

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1987 to 2022, China has shown a growing deficit in the food trade balance, with imports exceeding exports in volume, value, and calories, although it maintains favorable terms of trade. Food self-sufficiency has decreased from 95% in 1961 to 76% in 2022, and the diet has diversified, replacing traditional foods with products demanded in international trade.
Keywords: Unequal Exchange; Food; Terms of Trade; Self-Sufficiency; China

1. Introduction

The political reforms and economic liberalization initiated in China since 1978 [1, 2], further reinforced by its entry into the World Trade Organization (WTO) in 2001 [3, 4], have enabled the nation to establish itself as a major development hub and a key player in the globalization process. This status is evidenced by its emergence as a leading world economy, challenging the economic, technological, and military dominance of the United States, particularly in the years following the COVID-19 pandemic [5–7]. According to the World Bank [8], China surpassed the United States in terms of GDP measured by purchasing power parity (PPP) in 2017. In the realm of international agricultural trade, China is the world's largest importer and the third-largest exporter [9].

The significant economic growth over recent decades, coupled with population increases and rising material living standards, has led to substantial growth in food consumption, increasingly reliant on international trade. China experienced an agricultural trade deficit for the first time in 2004 [10], ending its status as a net exporter of agricultural products, a position it had held since the mid-1990s [11]. However, China's substantial market size allows it to secure better commercial terms, reflected in improved terms of trade for food products, as this study will demonstrate.

Given the importance of China's expanding food trade, this article examines exports and imports, the growth in trade balance surplus, and the terms of trade, all measured in caloric terms, as well as volumes and their monetary translations.

To analyze this, we focus on two hypotheses regarding food trade:

- China's growing international presence and WTO membership have positively impacted external food trade, measured in caloric terms, altering the global market dynamics.
- China is reducing its food self-sufficiency and altering its diet, partly due to rapid urbanization and industrialization, which modifies international trade relations and reevaluates agricultural exporting countries.

In theoretical debates, a decline in the relationship between export and import prices over time is known as a deterioration in the terms of trade. This concept was explored by Latin American structuralist economists such as Prebish [12, 13], Singer [14], Furtado [15, 16], Cardoso and Faletto [17], Emmanuel [18], Marini [19], Amin [20], and Serra and Cardoso [21]. They argued that the deterioration in terms of trade resulted from the income inelasticity of demand for raw materials, the substitutability of raw materials, and labor market differences between the Global North and South [22].

The concept later evolved to include the environmental dimension, analyzing international trade in biophysical terms, such as the number of tons exported and imported. This led to the concept of unequal ecological exchange, which posits that the export of natural resources does not account for the externalities caused by this activity in the extracting and exporting countries [23–34]. Essentially, poorer countries transfer wealth to richer countries while bearing the environmental costs [35].

Building on the concepts of unequal exchange and unequal ecological exchange, the notion of unequal caloric exchange arose [36, 37], which is used here to analyze China's food trade. This is defined as "a deterioration in the terms of trade for foodstuffs when considering the cost of exported and imported calories". The importance lies in the fact that China records a physical surplus, meaning it imports more tons than it exports. Consequently, exporting countries, including those in Latin America, consistently lose natural resources in the form of soil and essential nutrients. This even leads to social and environmental conflicts in areas of extraction or monoculture production [38].

This metric links studies of unequal exchange with aspects such as food security, sovereignty, self-sufficiency, nutrition, and diet quality. Applying these concepts to China is crucial, given its economic growth and participation in international trade, which have transformed its commercial dynamics and led to changes in food self-sufficiency and diet quality. Additionally, China's shift from raw material exports to industrialized goods exports makes it pertinent to explore how these transformations reflect theories of unequal exchange globally.

China's economic growth over recent decades has seen the average per capita income rise from $2,639 in the 1990s to $17,857 for the period 2014–2023, measured in PPP, constant 2021 international dollars [8]. This increase in purchasing power and consumption has significantly reduced poverty rates (using the 2.15 USD per day [2017 PPP] threshold), from 72 % in 1990 to 0.1% in 2020 [8].

However, this economic growth has brought three main challenges, as highlighted by authors such as Sachs [39]. First, increased inequality due to stagnant rural incomes compared to urban areas, reflected in a rise in the Gini index from 0.322 to 0.371 between 1990 and 2020 [8]. Second, increased air pollution from industrial production and intensified agriculture. Third, lifestyle changes as the population migrates from rural to urban areas and shifts from agriculture to industry and services. In the 1960s, 84% of the population was rural, compared to 35% in 2023 [8].

This rural population decline, coupled with population growth, economic expansion, and the conversion of arable land to non-agricultural uses, has reduced China's ability to feed itself solely through domestic production [40]. This is evident in the declining growth rate of food production, which fell from 4.4% per year in the 1960s to 3.9% per year during 2009–2017 [41, 42].

One might argue that lower food self-sufficiency, defined as meeting food requirements through domestic production [43], does not necessarily compromise the country if it maintains a trade surplus, as is the case for China. However, the loss of food self-sufficiency undermines food security [11, 44], increasing vulnerability to external factors such as international prices or production capacity. Food security depends on the evolution of the terms of trade in food, which this study analyzes. Additionally, changes in international food trade patterns affect domestic consumption in both importing and exporting countries, potentially leading to diet impoverishment, as will be discussed later.

The rest of this article is structured as follows: the second section presents the materials and methods used; the results obtained are presented and analyzed in the third section; and finally, the fourth section concludes with the evidence of the improvement in the terms of trade for the Chinese economy and some policy implications.

2. Materials and Methods

This study analyzes food trade to and from China at the national level, with the rest of the world and selected trading partners. The time window considered depends on the availability of data. For data on consumption, self-sufficiency, and diversity of consumption, we use the period 1961–2021, sourced from FAO's food balance sheets [41, 42]. For data on trade and terms of trade, we use the period 1987–2022, based on the availability of a detailed food matrix [45]. We present data in terms of volume, monetary values (in constant 2015 USD), and calories (kcal).

Several steps for processing data were followed, as described below.

First, data from the detailed matrix on food trade are grouped into the 98 product groups found in FAO's food balance sheets. We then use FAO's 14 vegetal product groups: cereals (excluding beer), sugar crops, sugars and syrups, pulses, tree nuts, oil crops, vegetable oils, vegetables, fruit (excluding wine), roots and tubers, stimulants, spices, alcoholic beverages, and miscellaneous. This allows us to focus our analysis on groups relevant to the country in terms of consumption.

Second, we use FAO's food composition tables [46] to calculate the energy content of traded goods. It is worth noting that our analysis only accounts for the calorie content of food products and does not include the energy required for production, as discussed in Arizpe, Ramos-Martin and Giampietro [47].

In this way, trade indicators for China can be expressed as:

$$X \vee M = \sum p_{it,j} \tag{1}$$

Where X denotes total exports of China, M total imports of China, *t* the year, *i* the product *(i = 1, ..., n)*, *j* the country *(j = 1, ..., n)*.

For trade calculations, in addition to the rest of the world, the United States, Latin America and the Caribbean, Europe, and Asia are also considered trading partners (using the definitions by FAO).

Third, using the coefficients described above, we convert trade data in volume (exports and imports) into calories. To analyze the Prebisch-Singer hypothesis of the deterioration of the terms of trade in caloric terms, the average caloric content per 100 grams reported in the food composition tables is used as a proxy for expressing exports and imports in terms of calories, for product *i* and country *j* in year *t*.

Fourth, using 2015 USD prices, adjusted to FAO's value-added deflator by country for agriculture, silviculture, and fishing, the values of exported and imported calories are used to calculate the unit cost of calories exported and imported. This allows us to compute the terms of trade as follows:

$$ToT_t = \frac{\sum X\ kcal\ \ (US\$\ 2015)_{t,j}}{\sum M\ kcal\ \ (US\$\ 2015)_{t,j}} \quad (2)$$

Where *ToT* stands for terms of trade, X denotes exports, M denotes imports, *t* the year, *j* the country.

The interpretation of the indicator is as follows: A value of 1 means that exported calories have the same cost as imported calories. A value greater than 1 indicates positive terms of trade, meaning exported calories are more expensive than imported ones, so the country needs fewer exports to cover its imports. A value less than 1 indicates negative terms of trade, meaning the country must export larger quantities to cover its imports.

Fifth, an indicator for self-sufficiency in food consumption for China was calculated as one minus the share of imported calories over domestic consumption in terms of calories:

$$Self-sufficiency_t = 1 - \frac{\sum M\ kcal_{t,j}}{\sum C\ kcal_{t,j}} \quad (3)$$

Where C denotes domestic consumption, M denotes imports, *t* the year, *j* the country.

Sixth, we calculated the level of concentration of products in domestic food consumption, measured in kcal, by a cumulative distribution of the relative share in consumption of each of the 74 products reported in the food balances.

3. Results

3.1. Terms of Trade for Food and Caloric Unequal Exchange

Table 1 shows food consumption in China from 1961 to 2021, categorized by product group. The table includes total calorie consumption, the relative weight of each product group in the caloric intake, and the average per capita daily calorie consumption for each product group. During the analyzed period, calorie consumption tripled. However, economic growth has also led to qualitative changes in diet composition. Notably, there has been a decrease in high-quality carbohydrates (starchy roots) and vegetable proteins (pulses). Lower-quality carbohydrates (cereals) still constitute 59% of the diet, while vegetable oils and alcohol have seen significant increases. On a positive note, vegetable consumption has quintupled when considering average per capita consumption. Another noteworthy aspect is sugar consumption. In 2021, sugars and sweeteners accounted for 3% of total caloric food consumption, about half the share in Latin America. This proportion is well below the World Health Organization's recommendation that caloric intake from sugars should be less than 10% of the total .

This growth in food consumption in China is increasingly dependent on international trade and rising imports. **Table 2** shows food exports and imports between China and the rest of the world, in terms of volume, monetary value, and calories, from 1987 to 2022. In 1987, China imported twice as many tons of food as it exported; by 2022, it imported seven times more than it exported, indicating a growing reliance on foreign trade to feed its population. The value of these imports in 2022 was just over triple the value of exports, suggesting favorable terms of trade for China. From a calorie perspective, China's advantages become more apparent. In 1987, the number of imported calories was double that of exported calories; by 2022, imported calories were 14.6 times higher than exported, reflecting how China has leveraged international trade to secure increasing quantities of food at relatively lower costs over time.

The commercial opening of China, as discussed in the introduction, shows a stark contrast between food trade and other products. While China's overall trade balance shows growing surpluses, the food trade balance exhibits a growing deficit in physical, monetary, and caloric terms. Imports have increased significantly, but since 1993, export volumes have remained stable, primarily due to a decline in maize exports, which fell from 3.7 million tons in 1987 to only 0.9 million in 2022. Consequently, in 2022, China's physical food deficit stood at 164.8 million tons, translating into a food trade deficit of USD 94.6 billion and a calorie deficit of

Table 1. Food consumption by product group for China, measured in kcal, 1961–2021.

Product Group	10^{12} kcal per Year					% kcal by Product Group					Consumption kcal per Person per Day				
	1961	1976	1991	2006	2021	1961	1976	1991	2006	2021	1961	1976	1991	2006	2021
Cereals - Excluding Beer	193	431	661	702	836	59	72	72	64	58	800	1269	1531	1451	1607
Starchy Roots	71	90	73	73	72	22	15	8	7	5	296	264	168	151	138
Pulses	25	16	6	5	8	7	3	1	0	1	102	47	15	11	16
Vegetables	15	11	29	91	156	4	2	3	8	11	61	33	68	188	300
Oilcrops	10	14	21	31	77	3	2	2	3	5	43	40	49	65	148
Vegetable Oils	7	15	59	91	115	2	2	6	8	8	28	43	136	189	220
Sugar & Sweeteners	5	10	33	30	41	1	2	4	3	3	19	29	76	61	78
Alcoholic Beverages	2	6	25	39	49	1	1	3	4	3	7	19	58	80	94
Fruits - Excluding Wine	1	2	8	33	74	0	0	1	3	5	5	7	18	69	143
Other[a]	0.5	0.3	0.9	3.9	9.9	0	0	0	0	1	3	2	4	10	23

Source: FAO [41, 42].

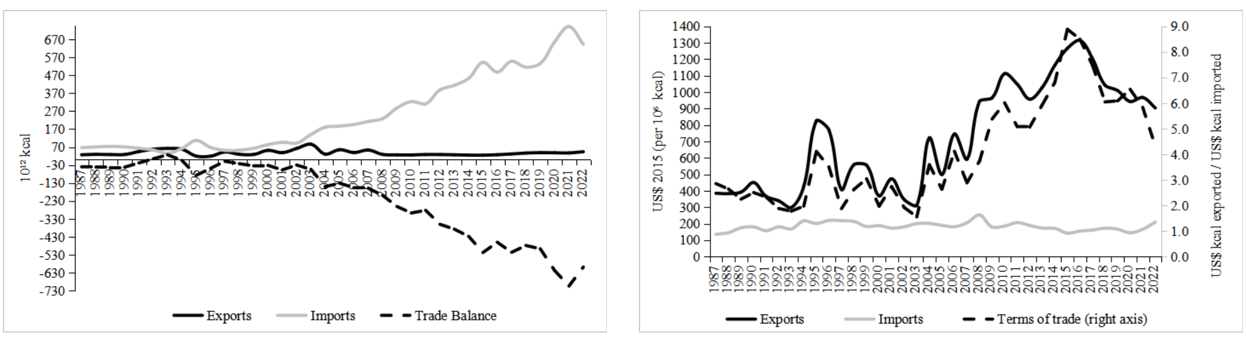
Table 2. Food trade balance for China with the rest of the world, volume, value and calories, 1987–2022.

Year	Exports (10^6 Tn)	Imports (10^6 Tn)	Exports (10^6 US$ 2015)*	Imports (10^6 US$ 2015)*	Exports (10^{12} kcal)	Imports (10^{12} kcal)
1987	10.4	19.0	10337	9031	26.9	66.9
1992	19.3	14.5	19586	9571	57.8	53.1
1997	14.8	12.4	17322	11266	42.5	51.7
2002	25.5	23.4	21518	16654	62.1	92.3
2007	28.3	52.1	31551	43663	53.3	212.3
2012	21.7	105.9	26982	73387	28.2	388.2
2017	26.0	159.9	38001	88137	31.6	547.7
2022	29.0	193.8	39777	134395	44.0	642.5

Note:
* Adjusted to the value added deflator by country for Agriculture, silviculture and fishing (value US$, 2015 prices).
[1] Data is obtained from trade matrix
Source: FAO [45].

598.5 trillion calories (or 16.2% of consumption), as shown in **Figure 1a**.

Figure 1b illustrates the unit cost (per million kcal) of China's food exports and imports (left axis), as well as the terms of trade for food, measured by the ratio of the unit cost of exported calories to the unit cost of imported calories (right axis). As previously explained, a value above 1 indicates favorable terms of trade. Notably, China has maintained stable costs per imported ton during the analyzed period, while the value of exported tons has increased, leading to a significant improvement in the terms of trade, which rose from 2.9 in 1987 to 8.9 in 2015, but decreased to 4.3 in 2022. Thus, the growing deficit shown in **Figure 1a** has been mitigated by increasingly favorable terms of trade, allowing China to reduce the relative cost of its growing external food dependence.



(**a**) (**b**)

Figure 1. (**a**) Chinese exports, imports, and trade balance for food products (10^{12} kcal), 1987–2022. (**b**) Cost of Chinese exports and imports and terms of trade, 1987–2022.

Source: FAO [45].

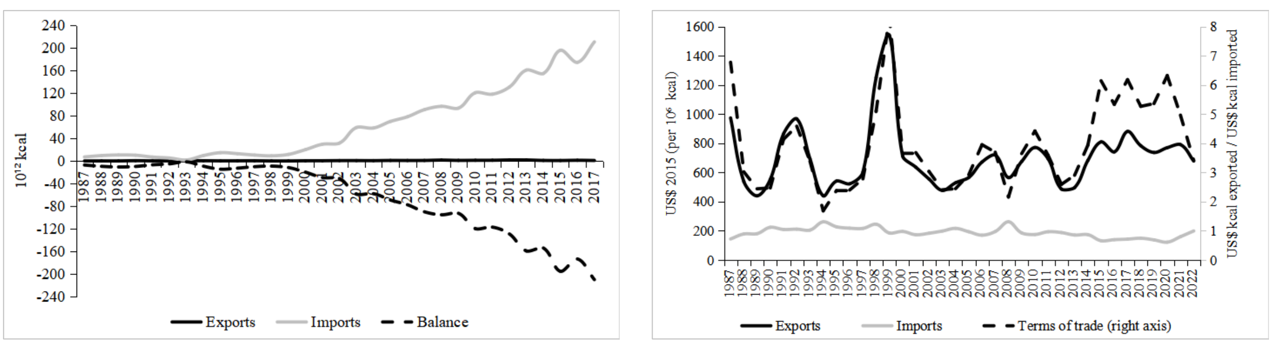
The evolution of international food trade varies by product group. **Table 3** shows the relative weight of different product groups in China's exports and imports, measured in calories, from 1987 to 2022. The share of cereals in exports has notably decreased, from 55% in 1987 to 8.6% in 2022. In terms of imports, the share of cereals has significantly reduced, and to a lesser extent, sugars, while the share of vegetable oils has remained stable, and oil crops have grown substantially, explaining the increase in consumption seen in **Table 1**. These changes have become particularly evident since China's entry into the World Trade Organization (WTO) in December 2001. These results vary depending on the trading partner, so we now analyze the terms of trade with different groups of countries.

Table 3. Evolution of exports and imports measured in kcal by product group, China 1987–2022.

Product Groups	1987		1996		2005		2014		2022	
	% X	% M	% X	% M	% X	% M	% X	% M	% X	% M
Cereals - Excluding Beer	55	77	22	50	62	10	14	13	8.6	26
Oilcrops	28	1.4	18	5.6	7.8	49	8.8	60	6.2	51
Pulses	4.9	0.2	9.0	0.7	5.2	0.5	6.9	0.6	1.3	1.3
Starchy Roots	3.8	0.0	0.6	0.5	0.4	4.7	1.8	5.6	1.0	4.8
Vegetable Oils	2.9	11	22	34	3.8	31	7.4	17	34	11
Sugar & Sweeteners	1.7	10	14	7.1	4.9	2.9	17	3.0	16	3.7
Vegetables	1.3	0.0	5.7	0.0	7.4	0.0	22	0.0	15	0.0
Treenuts	0.6	0.0	1.1	0.1	1.1	0.1	2.7	0.1	2.9	0.2
Fruits - Excluding Wine	0.6	0.1	1.8	0.6	2.3	0.4	6.3	0.4	4.1	0.6
Other*	0.9	0.1	2.5	0.3	2.5	0.3	6.7	0.4	5.5	0.5

Note: * Includes: Spices, stimulants, alcoholic beverages, miscellaneous and sugar crops.
Source: FAO [45].

Figure 2a shows the exports, imports, and food trade balance between China and Latin America from 1987 to 2022, measured in kcal. The deficit remained stable for some years, reaching around 11.5 trillion kcal in 1999. However, by 2022, it had increased 20.4 times, reaching 236 trillion kcal, with a significant turning point marked by China's entry into the WTO. Latin America accounts for 36.9% of China's food imports, translating into USD 47.2 billion. This dependency is quite selective. In 1987, the main imports were wheat (37.3% of the total), soybean oil (29.5%), and sugar (22.4%). By 2022, soybean imports represented almost all, at 84.5%, indicating a marked territorial specialization in trade between China and Latin America. The growing dependence on Latin America is explained by increasingly favorable terms of trade for China (**Figure 2b**). In other words, China relies more on Latin America for its food imports, but it does so at constant unit costs and with very favorable terms of trade.

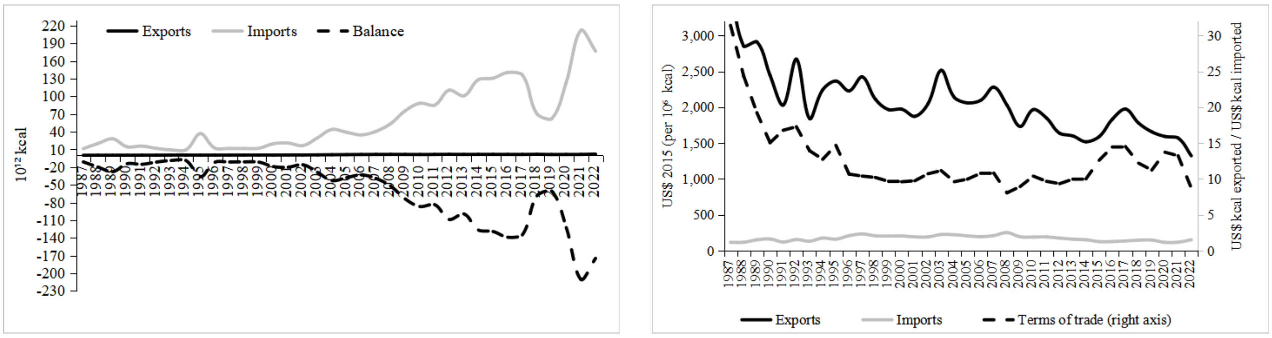


(**a**) (**b**)

Figure 2. (**a**) Chinese exports, imports and trade balance for food products with LAC (10^{12} kcal), 1987–2022. (**b**) Cost of Chinese exports and imports (left) and terms of trade (right) with LAC, 1987–2022.

Source: FAO [45].

The commercial relationship between China and the USA, shown in **Figure 3a**, is very different from that with Latin America. Exports are insignificant, while imports (and the trade deficit in kcal) have grown, especially since China's entry into the WTO. By 2022, the deficit reached 174.8 trillion kcal, with food imports from the USA representing 27.5% of total imports, translating into USD 26.8 billion. Additionally, the composition of imports has shifted from cereals, which in 1987 accounted for 45.9% (wheat) and 38.4% (maize), to soybeans, which in 2022 accounted for 62.8% of the total. Despite a downward trend in the terms of trade for food, they remain very favorable to China (see **Figure 3b**).

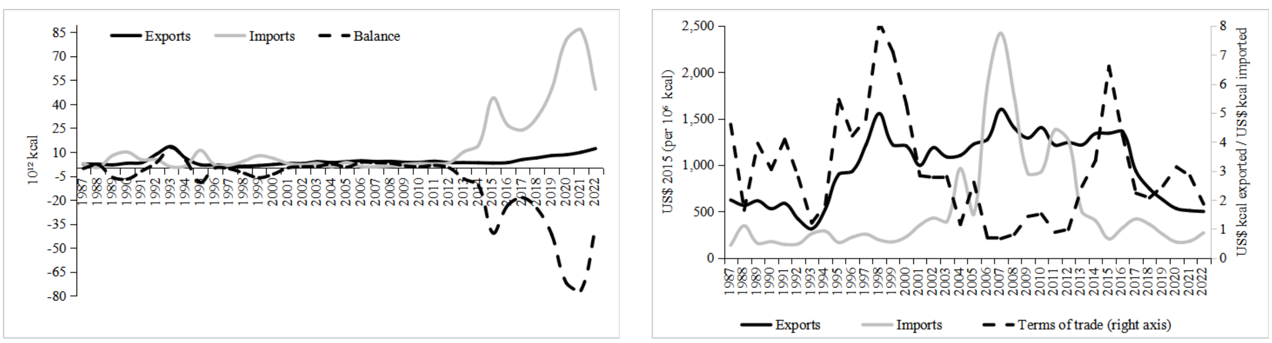


(**a**) (**b**)

Figure 3. (**a**) Chinese exports, imports and trade balance for food products with the USA (10^{12} kcal), 1987–2022. (**b**) Cost of Chinese exports and imports (left) and terms of trade (right) with the USA, 1987–2022.

Source: FAO [45].

Food trade between China and Europe was insignificant until 2013, when imports (and the deficit) began to grow (see **Figure 4a**). Even so, in 2022, the food deficit in kcal with Europe was only 37.2 trillion kcal, or 6.2% of the total. Although China also shows favorable terms of trade in food with Europe, the level is low and highly variable (see **Figure 4b**).

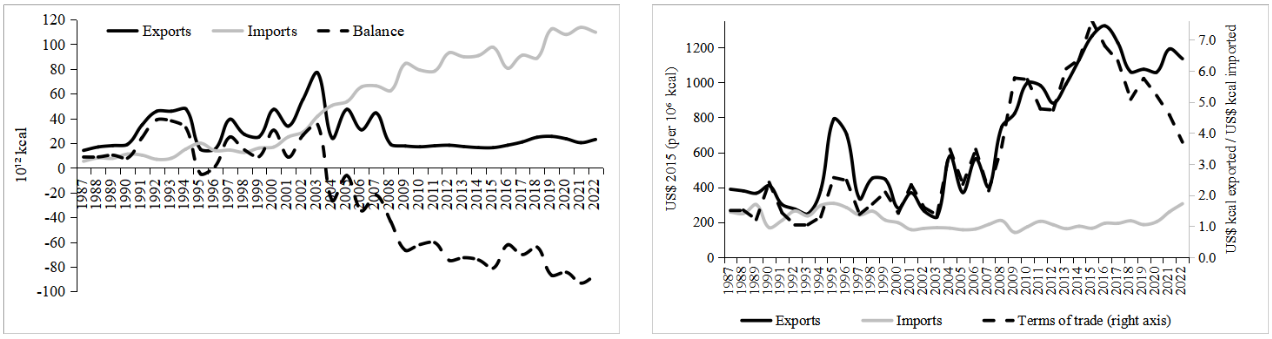


(**a**) (**b**)

Figure 4. (**a**) Chinese exports, imports and trade balance for food products with Europe (10^{12} kcal), 1987–2022. (**b**) Cost of Chinese exports and imports (left) and terms of trade (right) with Europe, 1987–2022.

Source: FAO [45].

Figure 5a illustrates the trade relations between China and its neighbors in the rest of Asia. There are two distinct periods. Between 1987 and 2003, China showed a surplus in food trade with Asia. However, from 2003 onwards, imports grew at an annualized rate of 7.6%, resulting in a deficit of 86.7 trillion kcal in 2022, or 17.1% of China's total food imports. As in the previous cases, except for the volatility shown in the trade relationship with Europe, the cost of imports from its Asian partners remained constant during the period (see **Figure 5b**), while the value of exports grew. This continuous improvement in the terms of trade meant that, despite importing five times more food than it exported in 2020, China showed a trade surplus in monetary terms with its Asian partners. However, in 2022, it showed a deficit.



(**a**) (**b**)

Figure 5. (**a**) Chinese exports, imports and trade balance for food products with Asia (10^{12} kcal), 1987–2022. (**b**) Cost of Chinese exports and imports (left) and terms of trade (right) with Asia, 1987–2022.

Source: FAO [45].

3.2. Effects of Food Trade on Self-Sufficiency and the Quality of the Diet

The growing dependence on international trade for China's food supply has impacted its level of self-sufficiency. **Table 4** shows the aggregate food self-sufficiency index in China and by product groups for the period 1961 to 2022, following the methodology outlined earlier. Self-sufficiency has declined from 95% in 1961 to 76% in 2022. Although most product groups maintain a high level of self-sufficiency, there have been notable drops in starchy roots (80%) and pulses (63%), and even more so in vegetable oils (62%) and oil crops (36%).

Another effect of China's integration into the international food trade, which often escapes standard analysis, is the concentration of consumption. The increased dependence on foreign countries, coupled with rising income levels and subsequent demand, has altered the composition of the main food groups in the country's consumption. **Table 5** shows the ranking of the main product groups in the diet composition and the percentage of accumulated calories for the years 1961 and 2022. On one hand, the 12 main product groups decreased from representing 88% of calories in 1961 to 80.7% in 2022, indicating an increase in diet diversification associated with greater availability and income levels, made possible by the favorable terms of trade previously discussed. On the other hand, trade liberalization and favorable terms of trade have induced changes in the composition and ranking of products. Notably, there has been a substitution of products such as millet, sorghum, pulses, barley, and peas with other products that were not previously among the most demanded, such as sugar, corn, soybean oil, groundnuts, and palm oil.

4. Discussion

International food trade between China and the rest of the world has been characterized by a growing deficit in monetary, volume, and calorie terms, which has accelerated since its entry into the WTO in 2001. Although exports have grown in physical and monetary terms, they have decreased in caloric terms, primarily due to the decline in cereal exports.

This increase in external dependence has not led to problems in terms of food security, as China enjoys a substantial trade surplus in its balance of payments, allowing it to manage the food trade deficit. Additionally, the very positive evolution of the terms of trade in food trade has been beneficial. Indeed, the relative cost of imported calories is much lower than that of exported calories. In some cases, such as trade with its Asian partners, this even leads to a surplus in monetary terms until 2020, despite a significant deficit in terms of calories. More importantly, the unit cost of imports remains very stable with all trading partners. The first conclusion is that China benefits from international food trade, especially since its entry into the WTO, due to improving terms of trade that greatly reduce the relative cost

Table 4. Food self-sufficiency index for China in kcal, (100 * (1 − (imports/consumption))), 1961–2021.

Year	Aggregate	Cereals-Excluding Beer	Starchy Roots	Sugar & Sweeteners	Pulses	Treenuts	Oil-crops	Vegetable Oils	Vegetables	Fruits-Excluding Wine	Stimulants	Spices	Alcoholic Beverages	Miscellaneous
1961	95	93	100	9	100	100	99	98	100	99		100	100	
1965	96	96	100	61	100	100	100	98	100	99		100	100	
1969	98	97	100	83	100	100	100	99	100	98		99	100	
1973	97	96	100	72	100	100	99	94	100	98		99	100	
1977	97	97	100	53	100	100	98	91	100	99		99	100	
1981	95	94	100	78	100	100	98	96	100	99		98	100	
1985	98	98	100	74	99	100	100	97	100	100		100	100	
1989	94	94	99	79	99	95	100	72	100	100		99	100	
1993	98	98	100	92	99	94	100	86	100	100		98	100	
1997	97	99	99	92	96	97	94	73	100	98		98	100	
2001	95	99	96	88	96	92	76	84	100	98	89	97	100	
2005	90	98	93	88	94	96	67	70	100	98	84	97	100	
2009	87	99	87	92	89	94	53	63	100	98	89	98	100	
2013	83	97	84	78	76	97	47	64	100	98	97	98	99	127
2014	82	96	81	82	81	96	43	70	100	98	97	98	99	129
2015	80	94	79	75	78	96	40	71	100	97	97	98	97	137
2016	82	96	81	81	79	97	38	73	100	98	96	98	96	145
2017	80	95	80	87	76	96	36	72	100	97	97	97	97	154
2018	82	96	85	83	67	94	41	70	100	97	97	81	95	158
2019	81	96	87	80	67	84	40	60	100	96	97	57	97	177
2020	79	94	85	67	59	85	38	62	100	96	99	52	98	175
2021	76	89	80	66	63	81	36	62	100	96	97	52	97	162

Source: FAO [41, 42].

Table 5. Cumulated share of products in consumption, in kcal, 1961 and 2021.

Number of Product	Name of the Product in 1961	% Acum 1961	% Acum 2021	Name of the Product in 2021
1	Rice and products	27.9	22.7	Maize and products
2	Sweet potatoes	43.1	36.0	Rice and products
3	Wheat and products	54.8	49.3	Wheat and products
4	Maize and products	65.9	61.0	Soybeans
5	Millet and products	69.8	65.4	Soybean oil
6	Soybeans	73.5	69.7	Vegetables, other
7	Sorghum and products	76.9	72.7	Pigmeat
8	Vegetables, other	79.7	74.9	Groundnuts (shelled equivalent)
9	Pulses, Other and products	82.1	76.4	Potatoes and products
10	Barley and products	84.2	78.0	Palm oil
11	Peas	86.2	79.4	Sugar (raw equivalent)
12	Potatoes and products	88.0	80.7	Cassava and products

Source: FAO [41, 42].

of its foreign dependence on food. However, this positive result must be clarified, as it also exposes the population to risks increasingly dependent on international markets and politics, and more volatile international prices [48, 49] which are less controllable. Examples include the impacts of both the COVID-19 crisis and the Russian invasion of Ukraine on global food markets, either directly affecting supply or through disruptions in transport chains, also pressured by high fuel prices. Some recent studies, though, suggest that long-term COVID-19-related impacts on food imports are not expected in China [9].

In terms of public policies, this greater dependence needs to be mitigated by existing policies. First, by strengthening the role of the China Grain Reserve Corporation (SINOGRAIN), established in June 2000 [11], to absorb temporary supply shocks. Second, by being more proactive with the policy of direct subsidies to farmers, introduced in 2004 [50]. Subsidizing domestic producers lowers domestic prices while increasing production, thereby also reducing trade deficits in agricultural products [49]. Third, by diversifying trade partners and the origin of food. An analysis of these and other measures and their effects on international markets for food products can be found in Hansen, Tuan and Somwaru [50].

The dependence on Latin America and the USA stands out, with both cases increasingly directed towards oil crops and soybeans to feed domestic meat production. However, this is offset by constant average costs of imports and very favorable terms of trade. Interestingly, the dependency on vegetable oils, although greater now than in the past, has shifted towards a dependency on oil crops, indicating that China has an increasing capacity to process these products internally. This allows imports to focus on raw materials and take advantage of favorable terms of trade, especially with the USA.

High volumes of food imports also affect food-exporting countries. In the case of Latin America, existing research shows how the growing exports of vegetable oils and oil crops are changing production patterns towards these export crops, eroding the food sovereignty of these nations and inducing changes in diet with notable increases in fat consumption due to greater local availability from increased production [36].

Another noteworthy result is the loss of self-sufficiency over time, which, although not very significant at present, appears to be growing. This is evident in products such as quality carbohydrates from starchy roots or vegetable proteins from pulses, as well as in oil crops and vegetable oils. This situation poses challenges not only for designing the country's trade policy but also its production policy, as greater dependence on international markets makes the Chinese economy more sensitive to shocks, as seen in recent years.

The diet has diversified over time, but towards lower-quality products, as the relative weight of quality carbohydrates, such as starchy roots, or vegetable proteins, such as pulses, decreases, while vegetable oils, sugars, and alcoholic beverages rise. These changes must be monitored for health reasons, and the link between a diversified diet and health needs further research. Additionally, it is important to understand if changes in consumption patterns are determined, in some way, by changes in trade patterns, as observed in other regions of the world [36, 37]. This analysis should inform the formulation of public policies that, through changes in prices or product availability, aim to prevent the introduction and consolidation of unhealthy consumption patterns and diets high in fat and low in vegetable protein.

In summary, although the Chinese population's dependence on foreign sources for food has greatly increased, it benefits from highly favorable terms of trade, which are concentrated in a few product groups. Moreover, from the perspective of ecologically unequal exchange, it is evident that China benefits from prices that do not internalize negative externalities (such as social and environmental liabilities) and from the use of environmental services and functions for food production (e.g., water). In this context, caloric unequal exchange complements the analysis of ecologically unequal exchange by demonstrating a close relationship with sustainable development, primarily due to the social and environmental conflicts driven by the intensification of agriculture in countries that export raw materials and food products.

5. Conclusions

This article provides an understanding of the dynamics of food trade between China and the world by examining the economic and nutritional implications of these global flows in the context of contemporary globalization. To this end, the concept of unequal caloric exchange has been used, which allows for an understanding of the asymmetries in international food trade relations and the internal dynamics of a country by establishing links with self-sufficiency and the composition of its diet. This represents an advance in the analysis of unequal exchange by introducing an indicator for terms of trade measured in calories, which enables future research to link patterns of food production and international trade with diet quality.

International trade has played a central role in the provision of food for China, leading to a growing deficit in the food trade balance from 1987 to 2022. In caloric terms, the deficit increased by 1,395% with the world, 3,238% with Latin America and the Caribbean, 1,459% with the United States, 13,497% with Europe, and 1,088% with Asia. The significance of this is that greater dependence on international markets induces changes in consumption patterns, with a concentration of calories in consumption that varies over time and tends to worsen diet quality.

Food consumption in China has experienced a notable increase and qualitative changes from 1961 to 2021. During this period, caloric consumption tripled, and there was a reduction in the intake of high-quality carbohydrates and vegetable proteins, while cereals, vegetable oils, and alcohol saw significant increases. Although vegetable consumption also increased significantly, the proportion of calories from sugars and sweeteners remained low compared to WHO recommendations. This dietary transformation is closely linked to economic growth and greater dependence on international food trade.

Although imports have significantly exceeded exports in volume, value, and calories, China has managed to maintain favorable terms of trade, which reduces the relative cost of imports. Between 1987 and 2022, the caloric terms of trade with the world increased by 1.5 times, while with Asia, they increased by 2.5 times. Improvements were observed with Latin America and the Caribbean and Europe only in certain years; however, with the United States, there was a deterioration in the terms of trade from 31.4 to 8.7 during this period. The reality of this situation is that as a new industrial power, China increasingly imports raw materials and exports value-added goods, which favors the terms of trade.

Finally, the dependence on imported food has affected food self-sufficiency, which has decreased from 95% in 1961 to 76% in 2022. Additionally, diet diversification has increased, although with a notable substitution of certain traditional foods for products more demanded in international trade, reflecting the impact of trade liberalization and rising incomes.

Author Contributions

P.C.: data curation and formal analysis, methodology, validation, visualization, writing—review & editing. F.F.B.: conceptualization, writing—review & editing supervision. J.R.-M.: investigation, writing—review & editing.

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Conflicts of Interest

The authors disclosed no conflicts of interest.

References

[1] Yu, M., 2018. China's international trade development and opening-up policy design over the past four decades. China Economic Journal. 11(3), 301–318. DOI: https://doi.org/10.1080/17538963.2018.1516275

[2] Fang, L., 2023. Gains and losses under economic reform: Understanding individual experience and the preference for state intervention in transition China. The Social Science Journal. pp. 1–19. DOI: https://doi.org/10.1080/03623319.2023.2168877

[3] Wang, Y., Zhang, H., 2015. Globalization and economic development in China. In: Otsubo, S.T. (ed.). Globalization and Development Volume II, 1st ed. Routledge: London, UK. pp. 44–63.

[4] Branstetter, L., Lardy, N.R., 2008. China's embrace of globalization. In: Brandt, L., Rawski, T. (eds.). China's Great Economic Transformation. Cambridge University Press: Cambridge, UK. pp. 633–682. DOI: https://doi.org/10.1017/CBO9780511754234.017

[5] Merino, G., 2021. Nuevo momento geopolítico mundial: La pandemia y la aceleración de las tendencias de la transición histórica-espacial contemporánea [New global geopolitical moment: The pandemic and the acceleration of trends in the contemporary historical-spatial transition]. Estudos Internacionais. 9(4), 106–130. (in Spanish). DOI: https://doi.org/10.5752/P.2317-773X.2021v9n4p106-130

[6] Cooley, A., Nexon, D., 2020. How hegemony ends: The unraveling of American power. Available from: https://www.foreignaffairs.com/articles/united-states/2020-06-09/how-hegemony-ends (cited 18 July 2024).

[7] Bingjie, L., 2022. The impact of Covid - 19 pandemic and the deepening of the US competitive China polic. Journal of China and International Relations. 9(1), 61–73.

[8] World Bank, 2024. World development indicators. Available from: https://databank.worldbank.org/source/world-development-indicators

[9] Cao, L., Li, T., Wang, R., et al., 2020. Impact of COVID-19 on China's agricultural trade. China Agricultural Economic Review. 13(1), 1–21. DOI: https://doi.org/10.1108/CAER-05-2020-0079

[10] Tian, D., Li, R., Yao, W., et al., 2014. Study on the

survival of China agri - food export trade relationships. China Agricultural Economic Review. 6(1), 139–157. DOI: https://doi.org/10.1108/CAER-03-2012-0029
[11] Dev, S.M., Zhong, F., 2015. Trade and stock management to achieve national food security in India and China?. China Agricultural Economic Review. 7(4), 641–654. DOI: https://doi.org/10.1108/CAER-01-2015-0009
[12] Prebisch, R., 1950. The economic development of Latin America and its principal problems. Economic Commission for Latin America (ECLA): New York, NY, USA. Report E/CN.12/89/Rev.1 27 April 1950.
[13] Prebisch, R., 1959. Commercial policy in the underdeveloped countries. American Economic Review. 49(2), 251–273.
[14] Singer, H.W., 1950. The distribution of gains between investing and borrowing countries. American Economic Review. 40(2), 473–485.
[15] Furtado, C., 1970. Obstacles to development in Latin America, Anchor Books: Garden City, NY, U.S. pp. 204.
[16] Furtado, C., 1964. Development and underdevelopment. University of California Press, Berkeley, CA, U.S. pp. 196.
[17] Cardoso, F., Faletto, E., 1969. Dependencia y desarrollo en América Latina [Dependency and development in Latin America], Siglo XXI: Buenos Aires, Argentina. pp. 213. (in Spanish).
[18] Emmanuel, A., 1972. Unequal exchange: A study of the imperialism of trade. New Left Books: New York, NY. U.S. pp. 453.
[19] Marini, R., 1973. Dialéctica de La Dependencia. [Dialectics of Dependency] Era: México, Russia. pp. 80. (in Spanish).
[20] Amin, S., 1976. Unequal development: An essay on the social formations of peripheral capitalism. Monthly Review Press: New York, NY, U.S. pp. 440.
[21] Serra, J., Cardoso, F., 1978. Las Desventuras de la dialéctica de la dependencia. [The Misadventures of the Dialectic of Dependency] Revista Mexicana de Sociología. 40, 9–55. (in Spanish). DOI: https://doi.org/10.2307/3539682
[22] Feenstra, R., Taylor, A., 2016. International trade. Worth Publishers: New York, NY. U.S. pp. 468.
[23] Bunker, S.G., 1984. Modes of extraction, unequal exchange, and the progressive underdevelopment of an extreme periphery: The Brazilian Amazon, 1600–1980. American Journal of Sociology. 89(5), 1017–1064.
[24] Bunker, S.G., 1985. Underdeveloping the Amazon: Extraction, unequal exchange and the failure of the modern state. University of Chicago Press: Chicago, IL, U.S. pp. 296.
[25] Bunker, S.G., 2007. The poverty of resource extraction. In: Hornborg, A., McNeill, J.R., Martinez-Alier, J. (eds.). Rethinking Environmental History: World-System History and Global Environmental Change. AltaMira Press: Lanham, MD, US. pp. 239–258.
[26] Dorninger, C., Hornborg, A., 2015. Can EEMRIO analyses establish the occurrence of ecologically unequal exchange?. Ecological Economics. 119, 414–418. DOI: https://doi.org/10.1016/j.ecolecon.2015.08.009
[27] Fitzgerald, J., Auerbach, D., 2016. The political economy of the water footprint: A cross - national analysis of ecologically unequal exchange. Sustainability. 8(12), 1263. DOI: https://doi.org/10.3390/su8121263
[28] Hornborg, A., 1998. Towards an ecological theory of unequal exchange: Articulating world system theory and ecological economics. Ecological Economics. 25(1), 127–136. DOI: https://doi.org/10.1016/S0921-8009(97)00100-6
[29] Hornborg, A., 2009. Zero - sum world: Challenges in conceptualizing environmental load displacement and ecologically unequal exchange in the world - system. International Journal of Comparative Sociology. 50(3–4), 237–262. DOI: https://doi.org/10.1177/0020715209105141
[30] Hornborg, A., 2014. Ecological economics, Marxism, and technological progress: Some explorations of the conceptual foundations of theories of ecologically unequal exchange. Ecological Economics. 105, 11–18. DOI: https://doi.org/10.1016/j.ecolecon.2014.05.015
[31] Jorgenson, A., 2016. Environment, development, and ecologically unequal exchange. Sustainability. 8(3), 227. DOI: https://doi.org/10.3390/su8030227
[32] Jorgenson, A.K., Rice, J., 2007. Uneven ecological exchange and consumption - based environmental impacts: A cross - national investigation. In: Hornborg, A., McNeill, J.R., Martinez-Alier, J. (eds.). Rethinking Environmental History: World-System History and Global Environmental Change. AltaMira Press: Lanham, MD, U.S. pp. 273–288.
[33] Muradian, R., Giljum, S., 2007. Physical trade flows of pollution - intensive products: Historical trends in europe and the world. In: Hornborg, A., McNeill, J.R., Martinez-Alier, J. (eds.). Rethinking Environmental History: World-System History and Global Environmental Change. AltaMira Press: Lanham, MD, U.S. pp. 307 - 326.
[34] Røpke, I., 2001. Ecological unequal exchange. Journal of Human Ecology. 10, 35–40.
[35] Muradian, R., Martinez-Alier, J., 2001. Trade and the environment: From a ‘southern’ perspective. Ecological Economics. 36(2), 281–297. DOI: https://doi.org/10.1016/S0921-8009(00)00229-9
[36] Falconi, F., Ramos-Martin, J., Cango, P., 2017. Caloric unequal exchange in Latin America and the Caribbean. Ecological Economics. 134, 140–149. DOI: https://doi.org/10.1016/j.ecolecon.2017.01.009
[37] Ramos-Martin, J., Falconi, F., Cango, P., 2017. The concept of caloric unequal exchange and its rele-

vance for food system analysis: The Ecuador case study. Sustainability (Switzerland). 9(11), 2068. DOI: https://doi.org/10.3390/su9112068

[38] Cango, P., Ramos-Martín, J., Falconí, F., 2021. Comercio Internacional Desigual y Pérdida de Autosuficiencia Alimentaria En Sudamérica. In: Azamar, A., Silva, J., Zuberman, F. (eds.). Economía Ecológica Latinoamericana. CLACSO y Siglo XXI: Buenos Aires, Argentina. pp. 254–281.

[39] Sachs, J.D., 2015. The age of sustainable development. Columbia University Press: New York, NY. U.S. pp. 544.

[40] Brown, L.R., 1995. Who will feed China?. W. W. Norton & Company: New York, NY, U.S. pp. 168.

[41] FAO, 2023. Food balances (2010 -). Available from: https://www.fao.org/faostat/es/#data/FBS (cited 23 May 2024).

[42] FAO, 2023. Food balances (-2013, old methodology and population). Available from: https://www.fao.org/faostat/es/#data/FBSH (cited 23 May 2024).

[43] FAO, 2002. Agua y Cultivos. Logrando el uso óptimo del agua en la agricultura.[Water and Crops. Achieving optimal water use in agriculture] (in Spanish)

[44] Anderson, K., Strutt, A., 2014. Food security policy options for China: Lessons from other countries. Food Policy. 49(1), 50–58. DOI: https://doi.org/10.1016/j.foodpol.2014.06.008

[45] FAO, 2023. Detailed trade matrix. Available from: https://www.fao.org/faostat/en/#data/TM (cited 23 May 2024).

[46] FAO, 2001. Food balance sheets, a handbook. FAO: Rome, Italy. pp. 95.

[47] Arizpe, N., Ramos-Martin, J., Giampietro, M., 2014. An assessment of the metabolic profile implied by agricultural change in two rural communities in the north of Argentina. Environment, Development and Sustainability. 16(4), 903–924. DOI: https://doi.org/10.1007/s10668-014-9532-y

[48] World Health Organization, 2015. Guideline: Sugars intake for adults and children. FAO: Geneva, Switzerland. pp. 1–59.

[49] Yang, F., Urban, K., Brockmeier, M., et al., 2017. Impact of increasing agricultural domestic support on China's food prices considering incomplete international agricultural price transmission. China Agricultural Economic Review. 9(4), 535–557. DOI: https://doi.org/10.1108/CAER-01-2016-0001

[50] Hansen, J., Tuan, F., Somwaru, A., 2011. Do China's agricultural policies matter for world commodity markets?. China Agricultural Economic Review. 3(1), 6–25. DOI: https://doi.org/10.1108/17561371111103516