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FOOD CHAIN PRICE DIFFERENCES
– THEORETICAL AND METHODOLOGICAL ASPECTS

Key words: agricultural prices, retail prices, Pearson's correlation coefficient, farms, agriculture in Poland

ABSTRACT. The article is for illustrative purposes and presents the general situation of price differences in the food chain in theoretical and methodological aspects. The main objective of the research was to assess the market situation of the purchase of agricultural products against a background of prices in retail stores. The research was conducted using the observational method in mid-2021. The subject of the study were the 20 most popular agricultural products, purchased directly from the agricultural producer and through retail chains as products ready for sale unchanged from the moment of purchase. The volatility of prices between different links in the food chain was also determined using Pearson's linear correlation. The differences in the estimated percentage mark-up of selected retail chains in relation to the obtained values of the price relation index are presented. It was found that the analyzed price differences constituted a complex research problem and were conditioned by many determinants. The relation between the prices offered for agricultural products in purchase and retail prices was often 200%. The main reason for the price differences was the extensive supply chain between the farmer and the chain of stores. The results of the correlation of price volatility allowed to conclude that there was a phenomenon related to the transfer of price risk in the scope of subsequent links of the food chain.

INTRODUCTION

The issue of the formation of prices of agricultural raw materials and the products made from them is a difficult and, at the same time, controversial challenge in terms of its study, resumption and inference. Due to the presence of a number of stakeholder groups in the production and trade chain, we meet many of their expectations, which in economic reality are complicated as to their fulfilment. Włodzimierz Rembisz, from the Institute of Agricultural and Food Economics in Warsaw, in many of his studies, explored this issue

by capturing the issues in a quantitative and analytical way, ahead of the analyses of other researchers in this area, submitting them in an extremely useful way [Bezat-Jarzębowska, Rembisz 2018, Rembisz 2020]. For this reason, among others, in the Department of Organization Development at the Cracow University of Economics, a series of studies devoted to price differences of products in the food chain was initiated in 2021, also trying to present theoretical and methodological aspects of this issue.

Raw materials produced by farms, before they reach the final recipient, pass through various levels and organizational systems. The production of agricultural raw materials is a function of the volumes and productivity of basic production factors, as well as technical knowledge and management [Firlej 2008], and raw materials of agricultural origin used by food processing industry units have high quality characteristics, resulting from the lower chemicalization of agriculture compared to Western European countries and the widespread use of traditional methods of growing plants and animal husbandry [Firlej 2017]. In most cases, these raw materials must be properly treated by specialized entities before they become fit for consumption. The relationships that take place between suppliers and customers form the so-called food chain. As indicated by Sebastian Jarzębowski and Bogdan Klepacki [2013, p. 110], the food chain is considered to be: "cooperating in various areas of operation of agricultural producers, intermediary companies, processing, production, service enterprises and their clients, between which streams of agri-food products, information and financial resources flow". As indicated by Mariusz Hamulczuk and Stanisław Stanko [2016], the structure and length of the food chain depends on a number of factors. These include: the type and properties of the agricultural raw material; the possibility of storing agricultural raw materials; the degree of production concentration; the level of development of the country and individual markets; links between markets and links in the food chain; buyer preferences and technological progress. The degree of differentiation of existing links between different links in the food chain is shown in Figure 1.

It should be noted that, in practice, there are many additional possibilities of creating commodity links [Szymańska et al. 2018]. As a result, it may contribute to significant changes in the presented scheme. This is due to the fact that buyers are interested in the maximum utility of a good in relation to its price and, therefore, it depends on them which channels will be present on a given market.

The supply and demand relationships that occur at the moment of leaving the agricultural raw material from the farm shape the prices of agricultural raw material. Buyer prices, on the other hand, are determined by the supply and demand relations at a retail level. The existing distance between farms and end buyers causes that the relations of prices and quantities at these levels differ significantly. The main problem is the formation of prices through many different factors, which, in turn, translates into a lack of universal
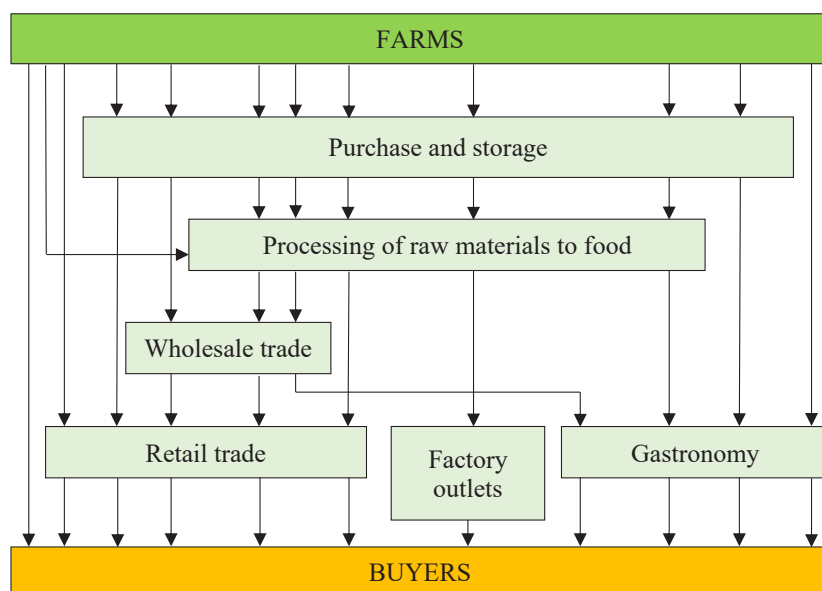
Figure 1. Diagram of selected connections in the food economy
Source: own study based on [Małysz 1985, s. 169]

criterion influencing the size of the price from a specific determinant [Firlej, Kubala 2019].

Relationships between individual links in the food chain are a relatively frequent topic of research. As pointed out by Roman Urban [2002], the share of agricultural commodity prices in the retail price is not significant. He additionally notes that there is a similarity between the structure of food prices in the USA and Germany. Krzysztof Firlej [2008] stated that, in the years 1990-2005, there were large price differences between agricultural raw materials in purchase and prices of food products in retail trade. A detailed analysis of price ranges was performed by Szczepan Figiel and Robert Popiołek [2009], who observed the existence of strong fluctuations in price ranges. Moreover, the later the link in the food chain was, the stronger these fluctuations became.

Numerous foreign researchers have also come to a similar conclusion, including Patrick Byrne et al. [1995], John Bernard and Lois Willett [1998], or Barry Goodwin and Daniel Harper [2000]. On the other hand, the research conducted by Jerzy Rembeza and Jadwiga Seremak-Bulge [2010] found that the real drop in the prices of agricultural products was much deeper than that of retail food prices. According to the work of Randy Schnepf [2013], it should be stated that the nature of price transmission between the link of a farm

and a retailer depends on the size of the share of the price of agricultural raw material in the retailer's price and the degree of market competition occurring at various levels in the food chain. Steve McCorriston et al., [2001] also draw interesting conclusions in their work, showing that the established transmission patterns differ in terms of the strength of the impact of price signals and the speed of adjustments. On the other hand, the author's research indicates that, in some markets, the increase in the prices of agricultural raw materials reduces the level of food consumption [Kubala 2019]. These dependencies occur in the case of the impact of purchase prices of cereals on the consumption of bread and cereal products and the purchase prices of cow's milk on its consumption.

These issues are important, especially from the point of view of the development of individual agricultural markets. For this reason, the main goal of the article was to assess the market situation of purchasing agricultural products in relation to the prices in retail stores.

MATERIAL AND METHODOLOGY OF THE RESEARCH

The implementation of the set research goal was carried out in three stages.

Research on price differences of selected agricultural products. The subject of the study were the 20 most popular agricultural products, characterized by a lack of further processing. This approach was aimed at excluding additional costs related to its processing and subsequent storage. Therefore, products that were purchased from the producer (mainly a farmer) were considered and were transferred directly to store shelves, with possibly minor interventions (e.g., mechanical cleaning). The data set was prepared on the basis of the prices of agricultural products offered through classifieds websites, on which farmers submit offers for their sale, e.g., "Agro-Market24", "Internet Agricultural and Commodity Exchange". It should be noted that the prices presented as retail prices came from popular hypermarket chains selling products in stationary points (in Cracow) and offering online shopping with home delivery. The analysis did not include reduced prices of products (special offer) from so-called shop leaflets.

The study of the percentage mark-up as a method of determining the price. The differences of the estimated percentage mark-up of selected retail chains in relation to the obtained values of the price relation index determined in the 1st stage are presented. The selected amounts of the financial analysis were determined on the basis of financial statements of analyzed companies.

In the final stage of the analysis, the degree of correlation of price volatility coefficients between different links in the food chain was examined. For this purpose, the Pearson linear correlation coefficient was used.

RESEARCH RESULTS

Table 1 shows the average price values of the products offered by the manufacturer in relation to retail prices. The averaging of values consisted of downloading data from internet portals, allowing the purchase/sale of goods at least 3 times a week and, in the case of stationary outlets, 2 times a week. The data were collected over a period of 3 weeks and the arithmetic mean of prices was calculated on their basis.

Table 1. Prices of agricultural products offered by collection points
(or individually by the farmer) and by retail stores (average values of
product prices – as of 08/18/2021)

Product	Agricultural/ buying-in prices [PLN]	Retail price [PLN]	Index of price relations [%]
Blueberry [kg]	11.50	20.76	181
Peach [kg]	4.50	10.98	244
Onion [kg]	1.38	2.84	206
Garlic [pieces]	0.80	1.40	175
Poultry (carcass) [kg]	4.49	7.99	178
Apple [kg]	1.30	4.99	384
Eggs (class M) [pieces]	0.29	0.43	148
White cabbage [pieces]	1.50	2.99	199
Raspberry [kg]	13.00	59.62	459
Carrot [kg]	1.00	2.79	279
Milk 3.2% [l]	1.49	2.95	198
Field cucumber [kg]	3.00	4.88	163
Red pepper [kg]	4.87	5.62	115
Champignons [kg]	4.75	8.98	189
Parsley [kg]	3.10	11.49	371
Raspberry tomato [kg]	4.64	7.45	161
Leek [kg]	3.40	5.98	176
Iceberg lettuce [pieces]	2.30	3.94	171
Celery [kg]	1.41	3.99	283
Potatoes [kg]	1.05	1.98	189

Source: own study based on data from internet portals, classifieds
websites, selected prices in agriculture (CSO) and grocery stores –
averaged data

The highest price relation index can be observed in the case of raspberries, where the value was 459%. Such a price discrepancy may result from high interest in the processing market and the impact of the export of a given product [Money.pl 2021]. In addition, it should be noted that the purchase prices of raspberries more than doubled in 2021 compared to the previous year. Due to the high price of raspberries in retail trade, sales in 1 kg packages would probably not be encouraging, therefore the product, in terms of marketing, is most often found in a container with a capacity of 100-250 grams. In the case of apples and parsley, the value of the price relation is also significant and amounted to 384% and 371%, respectively. Parsley deserves attention here, the increase of which is over 300% y/y (value calculated in relation to 2020 based on the archive of quotations of the website Wiescirolnicze.pl), approaching the record prices of 2019, when prevailing drought caused record increases in the value of this product. However, the list is dominated by products close to twice the price difference between agricultural and retail markets. The index of price relations in the case of the analyzed products ranges from 115% to 459% whereby the vast majority exceeds values of 150%. The calculated arithmetic mean for all 20 products in this range was 223%. The average value of the ratio of prices of agricultural products offered in purchase and at the marketplace in August 2021 (for the month of the survey) was 132% [GUS 2021]. Therefore, a fundamental change in the price value of agricultural products between the producer (in this case a farmer) and the company finalizing the sale with the final customer is visible.

One of the elements of financial statements is the profit and loss account. It provides a range of information on the company's financial performance. In its structure, you can find values related to revenues from the sale of goods and materials, as well as the cost of their acquisition or remuneration of employees. Table 2 presents the most important results (from the point of view of analysis) read from the profit and loss account for popular retail chains. One of the methods of determining prices in the store is the method of mark-up on the purchase price [Dyhdalewicz 2011], thanks to which the calculated values allow to compare the obtained results with the values from Table 1. Unfortunately, this is not always the right way to get the right price for a product, because determining the price in this way does not take into account other, usually key factors, such as demand. It should be noted that the store also incurs costs directly related to the product, e.g., labor costs or the cost of renting floor space, which will not be included in the statement, and the presented results are an estimated mark-up on the purchase price based on sales revenues and purchase value.

According to estimated calculations, Dino S.A., applies the highest price mark-up and the smallest chain Eurocash S.A., where the average value among 5 entities was 27.84%. Comparing the obtained results against Table 1, it can be concluded that only red peppers are below the specified price mark-up by the store, all other goods are characterized by a significant increase in value by over 200-300% on the purchase price. It can, therefore, be assumed that in the case of the supply chain between the farmer and the shop, the

Table 2. Selected values of financial analysis for the most popular retail chains including the results of financial statements for 2020

Selected financial indicators	Store name				
	Eurocash S.A.	Biedronka	Dino S.A.	Kaufland Polska	Netto sp. z o.o.
Revenue from the sale of goods and materials [thousand PLN]	25,411,042	61,216,804	10,125,815	9,825,839	3,849,889
Value of goods and materials sold [thousand PLN]	22,044,491	46,580,868	7,521,986	7,453,736	3,053,917
Purchase price mark-up (estimated) [%]	15.27	31.42	34.62	31.82	26.06

Source: own study based on financial statements of selected companies

process is based on at least one intermediary and in the case of some products, on a number of intermediaries (Figure 1). Assuming that the trading company bases the final prices on the mark-up, it is not right that it is mainly the store that imposes such high prices. The shaping of the price of a given commodity is already well-established in the logistics process. The solution to this situation may be establishing cooperation between the producer (farmer) and a retail store, bypassing intermediaries. Unfortunately, in the case of large hypermarket chains, this is often not possible, because the prices in such stores for the domestic area are usually identical, and the farmer would have to deliver the contracted quantity of goods, which is determined at a level higher than his production capacity. In addition, it would be necessary to determine who bears the losses associated with the too fast spoilage of goods, e.g., fruits. In the case of the delivery of goods to the collection point (after the transaction), the farmer is no longer interested in what will happen to the goods and this situation would be different in the case of the direct delivery of goods to the store. Probably, for these reasons, the current logistics structure together with intermediaries involved in the supply chain is easier to apply. It can, therefore, be clearly stated that the farmer often receives less than 50% of the final price of the product offered in the store. Similar research results were obtained in 2019 by the Office of Competition and Consumer Protection, checking how much producers, intermediaries and retail chains earn on fruit and vegetables [Dziennik.pl 2019].

At this stage of the study, an attempt was made to assess the transferability of price risk based on the level of price volatility. Figure 2 shows the values of the coefficients of price volatility of selected agricultural products in terms of retail price, purchase price and market price. Based on data analysis, it can be concluded that, in the analyzed period,
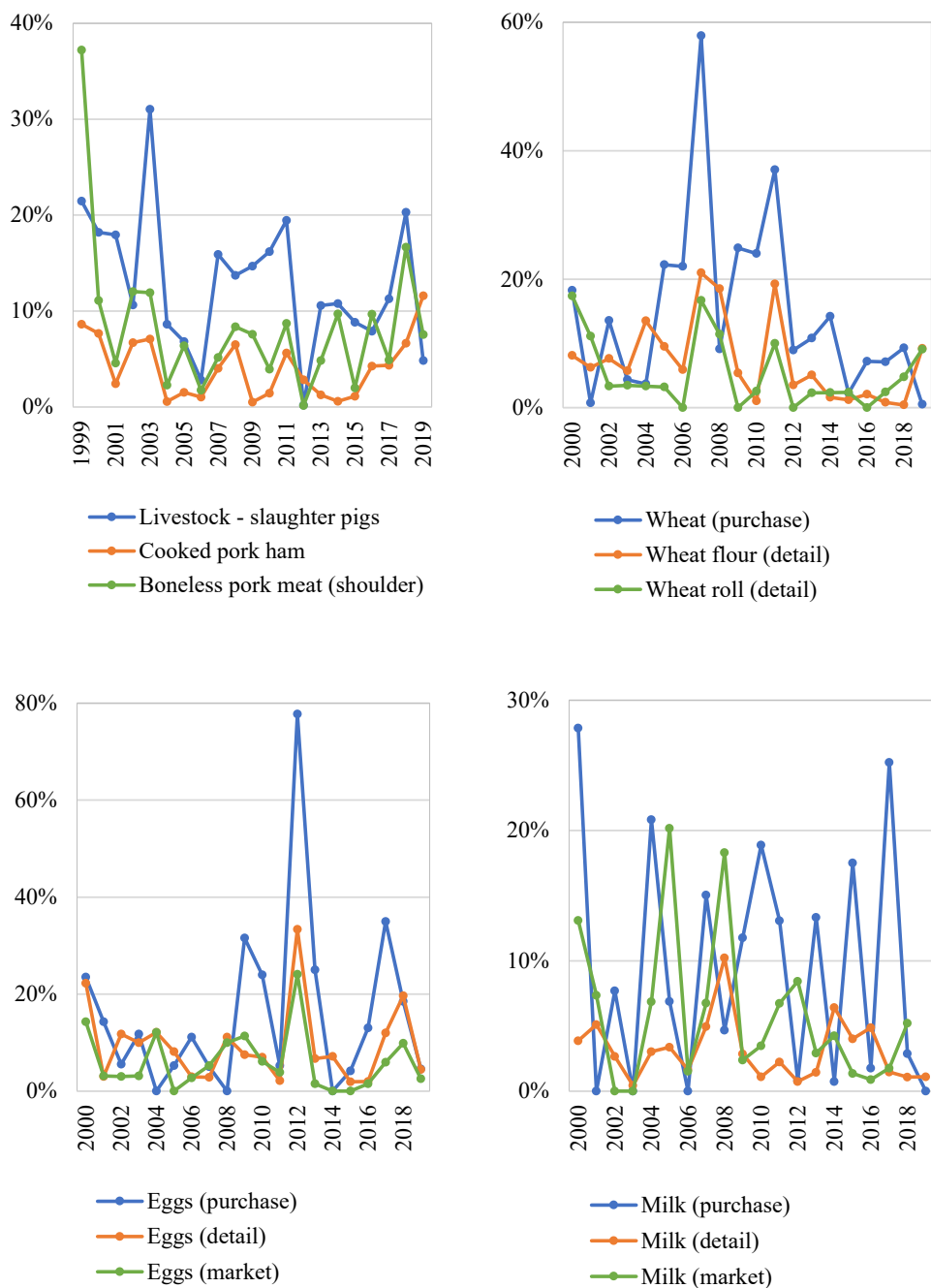
Figure 2. The level of price volatility [%] of selected products in the years 2000-2019
Source: own study based on [GUS 2022]

Table 3. Coefficient of correlation between the price volatility of selected agricultural products

Variables	Pearson's linear correlation results
Wheat – wheat flour	0.54
Wheat flour – wheat roll	0.65
Wheat – wheat roll	0.37
Livestock. slaughter pigs – cooked pork ham	0.34
Livestock – slaughter pigs – boneless pork meat (shoulder)	0.53
Boneless pork meat (shoulder) – cooked pork ham	0.56

Source: own study based on [GUS 2022]

the volatility of purchase prices of agricultural products was higher than in the case of retail price volatility. In the case of milk, a certain seasonality of dynamic price changes (in purchase) can be observed, amounting to 2-3 years on average. It was, therefore, observed that the price risk of an agricultural producer is relatively higher than that of processing companies. For this reason, it was necessary to assess how the level of price risk of a producer affects subsequent sectors in the food chain. For this purpose, the Pearson linear correlation coefficient was used, which was also used in studies on the value of correlation coefficients in prices [File 2008]. The formula for Pearson's linear correlation is described as follows:

$$Correl(X, Y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

The obtained values are in the range [-1.1], where the absolute value close to 1 means a stronger linear dependence, while values close to 0 signify its lack.

The calculated values in Table 3 show that there is a strong correlation between the volatility of wheat prices and the volatility of wheat roll prices (0.65). A weaker relationship is visible in the case of wheat price volatility and in the case of wheat roll retail price volatility (0.37). A similar situation was observed in the case of pork meat, where for a pair of variables: boneless pork meat (shoulder) and cooked pork ham, a stronger correlation was obtained than in the case of livestock, slaughter pigs – cooked pork ham. The correlation values for all the presented pairs of variables were positive, which enables to draw the conclusion that there is a transfer of the risk of price volatility within the subsequent links of the food chain.

CONCLUSIONS

The conducted analysis allowed to determine what the market situation of the purchase of agricultural products (from the producer) looks like in comparison with the prices in the aspect of retail stores. A study was also carried out on the strength of the price correlation between purchasing and marketplace products in relation to inflation. The conducted analysis allowed for the construction of the following conclusions:

1. Considering the price differences of products in the food chain in a holistic approach, it should be stated that they constitute a complicated research problem, the resolution of which depends on many determinants resulting from the arguments presented by individual groups of stakeholders and participants in the trade and food chain. This is evidenced by the difference in the scissors in the prices of products offered in the purchase and on the market compared to agricultural products offered directly by the farmer and in retail stores.

2. The ratio of prices offered for a product of agricultural origin in purchase and the prices of products presented on store shelves often amounted to 200%. This is due to the existence of an extensive supply chain between the farmer and the chain of stores, often based on a number of intermediaries. Such differences are justified in the decisions made by the Office of Competition and Consumer Protection, where checks are carried out on the prices of basic agricultural products offered by farmers, intermediaries and commercial networks [UOKiK 2022].

3. The results of the correlation of price volatility made it possible to conclude that there was a phenomenon concerning the transmission of price risk along the food chain. Such applications were determined on the basis of two selected agricultural products: wheat and pig meat.

4. It should be noted that the distribution chain process may vary depending on the goods offered. In the case of less demanding products, the process may be based on one or two intermediaries, while in other situations there may be more. The sale of goods is not only a profit, but also losses caused by the destruction or spoilage of the product. This is particularly evident in the case of agricultural products usually characterized by a short term of consumption (raspberries, blueberries, etc.). For this reason, companies, considering the frequent losses incurred in this respect, increase the prices of this product.

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RÓŻNICE CENOWE PRODUKTÓW W ŁAŃCUCHU ŻYWNOŚCIOWYM – ASPEKTY TEORETYCZNO-METODOLOGICZNE

Słowa kluczowe: ceny surowców rolnych, ceny detaliczne, korelacja liniowa Pearsona, gospodarstwa rolne, polskie rolnictwo

ABSTRAKT

Artykuł ma charakter poglądowy i przedstawia ogólną sytuację rynkową skupu towarów produkcji rolniczej w aspekcie teoretyczno-metodologicznym. Głównym celem badań była ocena różnic cenowych w łańcuchu żywnościowym na tle cen kształtujących się w sklepach detalicznych. Badania przeprowadzono metodą obserwacyjną w połowie 2021 roku. Przedmiotem badań było 20 najpopularniejszych produktów rolnych, nabywanych bezpośrednio od producenta rolnego oraz za pośrednictwem sieci handlowych, jako produktów gotowych do sprzedaży w formie niezmienionej od momentu zakupu. Określono zmienność cen pomiędzy różnymi ogniwami w łańcuchu żywnościowym przy zastosowaniu korelacji liniowej Pearsona. Przedstawiono również różnice szacowanego narzutu procentowego wybranych sieci handlowych względem uzyskanych wartości wskaźnika relacji cen. Stwierdzono, że analizowane różnice cenowe stanowiły skomplikowany problem badawczy i były uwarunkowane wieloma determinantami. Relacja cen oferowanych za produkt pochodzenia rolniczego w skupie i cen detalicznych wynosiła niejednokrotnie 200%. Główną przyczyną powstawania tych różnic cenowych był rozbudowany łańcuch dostaw pomiędzy rolnikiem a siecią sklepów. Wyniki korelacji zmienności cen pozwoliły wnioskować o występowaniu zjawiska dotyczącego przekazywaniu ryzyka cenowego w zakresie kolejnych ogniw łańcucha żywnościowego.

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