

Analysing protein consumption patterns and determinants in Indonesia: a probit model approach

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ABSTRACT

Limited research attention has been given to understanding the determinants of household protein consumption demand in Indonesia. This study investigated the determinants of household protein consumption patterns in Indonesia, focusing on ten major protein groups: fish, seafood, beef, mutton, poultry, eggs, milk, tofu, tempeh, and other meat. Utilising a probit model and data from SUSENAS 2022 encompassing 327,795 households, this study aimed to identify the factors that influence household protein consumption patterns in Indonesia. The findings highlight the significance of socio-demographic variables, such as income, and household size, as key drivers of protein consumption. Higher household income positively impacts household protein consumption, indicating a potential market for premium products catering to affluent consumers. Additionally, higher income levels correlate with increased protein consumption, suggesting the importance of tailored marketing strategies targeting educated consumers. Furthermore, the presence of children in the household emerges as a significant determinant, indicating distinct preferences and consumption patterns for families with school-aged children. Leveraging this information, marketers can develop value-added products that cater to the specific needs and tastes of this consumer segment. Moreover, the prices of the ten protein groups are identified as a crucial determinant of household protein consumption. Consumer price beliefs serve as influential perceived barriers to consumption. Understanding the role of price in shaping consumption behaviour enables marketers to devise effective pricing strategies that align with consumers' willingness to pay, thereby maximising product value. Targeted marketing strategies tailored to address these regional differences can enhance product value and effectively meet consumer demands. Understanding the determinants of household protein consumption demand in Indonesia is crucial for policymakers as it provides insights into the factors that drive consumption patterns, allowing them to design effective policies to promote healthy and sustainable food choices. Additionally, the findings regarding the influence of socio-demographic factors can inform targeted interventions and initiatives aimed at improving food security, nutrition, and public health outcomes.

Introduction

In recent years, fluctuations in food prices have increasingly become a focal point of discussions surrounding household consumption patterns. Among various food items, protein stands out as a critical component of diets worldwide, playing a crucial role in human health and well-being. However, as prices of protein sources fluctuate, households often adjust their consumption behaviours, potentially leading to implications for nutrition and food security.

The rising prices of animal food in Indonesia has been a persistent issue that has significant implications for households ability to afford and consume animal-based protein sources (Khoiriyah et al. 2020, 2023). Empirical data from various sources, such as national surveys and market reports, have indicated that the consumption of animal-based foods in Indonesia is below the global protein adequacy standards, which suggests potential concerns regarding food security and nutritional status (Dammann and Smith 2009). The Indonesian government has mandated that the daily per

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capita protein consumption should be around 57 g, however, consumption is far below this amount, especially in rural areas (Khoiriyah et al. 2023). The increasing prices of animal food have outpaced the growth in household incomes, resulting in reduced purchasing power for many households in Indonesia. As a result, households are facing challenges in affording and consuming animal protein food, which is an important source of essential nutrients such as protein, iron, and vitamins. The declining consumption and demand for animal protein food can have negative impacts on household nutrition, particularly for vulnerable groups such as children, pregnant women, and the elderly (Armagan and Akbay 2008; Hult et al. 2018; Mahmudiono et al. 2018).

The issue of rising prices of animal food in Indonesia can be attributed to various factors. These may include increasing production costs, supply chain disruptions, changes in global market prices for key feed ingredients, and policy interventions such as changes in import tariffs or export restrictions. These factors have contributed to the increasing price of animal food, making it less affordable for households, particularly those with limited purchasing power, including low-income households and vulnerable populations. To address this issue, it is crucial to understand the consumption patterns of households in Indonesia with respect to animal protein food and estimate the elasticity of household demand. The elasticity of demand measures how responsive the quantity demanded is to changes in prices. Estimating the elasticity of demand for animal protein food can provide valuable insights into the sensitivity of households consumption behaviour to changes in prices, income, and other socio-demographic factors; among studies which have used this approach are Angelucci and Attanasio 2013; Khoiriyah et al. 2020, 2023. This knowledge can help inform the development of effective policy interventions to address the declining consumption and demand for animal source protein food in Indonesia (Agus and Widi 2018).

This research aimed to provide evidence-based policy recommendations to address the challenges in affording and consuming animal protein food faced by households in Indonesia. These recommendations may include targeted subsidies, income support programmes, and price stabilisation measures to improve affordability and accessibility of animal protein source food, particularly for households with limited purchasing power. By employing a data-driven approach this research can contribute to the development of effective strategies to enhance household consumption of animal protein source food, ultimately improving the nutritional status and food security of households in Indonesia. Therefore, the aim of this research was to analyse household consumption patterns for protein source food in Indonesia using data from the 2022 Indonesian National Socio-Economic Survey (SUSENAS) and develop evidence-based policy recommendations to address the challenges of declining household consumption for animal source protein food due to increasing food prices.

However, there is limited research on the impact of increasing food prices on household consumption patterns and demand for animal source protein food in the Indonesian context. Furthermore, the utilisation of the probit model in estimating the elasticity of household demand for animal source of protein food has not been extensively explored in previous research in Indonesia. Therefore, this research will contribute to the existing literature by analysing household consumption patterns using a probit model which provides a comprehensive and flexible framework for estimating demand responses to price changes. The findings of this research are expected to provide novel insights into the factors influencing household consumption of animal source of protein food and the potential policy scenarios to enhance protein consumption in Indonesia.

Materials and methods

The probit model

The probit model is suitable for binary dependent variables, in this case whether or not a household consumes certain food protein groups (Finney 1947). Probit models were used to estimate the study's goal, which was to identify the variables that affect consumption. A total of ten models were fitted how the consumption of fish, seafood, beef, mutton, poultry, eggs, milk, tofu, tempeh and other meat was affected by the price of these commodities, household size and household income using similar methodology as Beyene et al. 2023; Kolog et al. 2023 and Rusere et al. 2023. For example, the model for fish consumption is as follows:

$$Y = \beta_0 + \beta_1 P_{\text{seafood}} + \beta_2 P_{\text{beef}} + \beta_3 P_{\text{mutton}} + \beta_4 P_{\text{poultry}} + \beta_5 P_{\text{eggs}} + \beta_6 P_{\text{milk}} + \beta_7 P_{\text{tofu}} + \beta_8 P_{\text{tempeh}} + \beta_9 P_{\text{other meat}} + \beta_{10} \text{HHsize} + \beta_{11} \text{income} + \varepsilon$$

Where:

$Y = 1$ if household consumes fish; 0 if household does not consume fish

$\beta_0 =$ constant

$\beta_1, \beta_2, \beta_3, \dots, \beta_{11} =$ probit regression coefficients (parameters)

$\varepsilon =$ error term

P_{seafood} is price of seafood, P_{beef} is price of beef, P_{mutton} is price of mutton, P_{poultry} is price of poultry, P_{eggs} is price of eggs, P_{milk} is price of milk, P_{tofu} is price of tofu, P_{tempeh} is price of tempeh, $P_{\text{othermeat}}$ is price of other meat, HHsize is number of household members, and income is income of household. Similar models were fitted for the consumption

of the other nine protein food types.

The β coefficients represent the effects of each independent variable on the probability of consumption of the food type. Positive coefficients indicate an increase in the probability of consumption, while negative coefficients indicate a decrease.

Data and source

SUSENAS data refer to the data collected from the national socio-economic survey (Survei Sosial Ekonomi Nasional) in Indonesia. SUSENAS is a large-scale household survey carried out periodically by the Indonesian Central Bureau of Statistics (Badan Pusat Statistik, BPS Indonesia) to collect data on various socioeconomic aspects of Indonesian households and individuals. SUSENAS data provides valuable information on a wide range of topics, including household income and expenditure, employment, education, health, housing, agriculture, and other social and economic indicators. SUSENAS data is widely used by researchers, policymakers, academics, and other stakeholders for conducting socio-economic research, policy analysis, and evidence-based decision-making. It serves as a crucial source of data for understanding the socio-economic dynamics and trends in Indonesia and informing policy interventions to address socio-economic challenges and promote inclusive development.

This study used SUSENAS household data for 2022; this comprised 327,795 households consisting of both rural and urban. The research used data of eight animal-sources of protein: fish, seafood, beef, mutton, poultry, eggs, milk, and other meat and two plant-based sources of protein tofu and tempeh brisket. Table 1 shows the foods in each protein group.

Table 1: Protein source food groups in Indonesia

Protein source food group	Foods
Fish	Yellow tail, cob, tuna, cakalang dencis, mackerel, selar, lema or tatare, banyar or banyara, wet anchovies, milkfish, cork, mujaer, goldfish, tilapia, catfish, snapper, other wet fresh fish, pomfret, gourami, baronang, preserved buffalo or peda, preserved mackerel, preserved cob, tuna or skipjack, preserved anchovies, preserved selar, preserved sepat, preserved milkfish, preserved cork, canned fish, canned tuna, etc.), other preserved fish, squid, cuttlefish, preserved octopus, preserved shrimp and other aquatic animals, and cooked fish
Seafood	Shrimp, lobster, squid, cuttlefish, octopus, clams, snails, mussels, preserved shrimp, and other freshwater animals
Beef	Beef
Mutton	Mutton, lamb, and sheep
Poultry	Purebred chicken meat and free-range chicken meat
Eggs	Purebred chicken eggs, free-range chicken eggs, duck or manila duck eggs
Milk	Factory liquid milk, sweetened condensed milk, powdered milk, baby milk powder, other milk, and other milk products
Tofu	Tofu
Tempeh	Tempeh
Other meat	Other fresh meat, other cured meat, other (liver, offal, ribs, legs, oxtail, head, etc.), cutlets, and brisket

Results and discussion

Testing probit models of protein consumption

Table 2 presents the test results from ten models of household protein intake in Indonesia: 1) fish consumption; 2) seafood consumption; 3) beef consumption; 4) mutton consumption; 5) poultry consumption; 6) eggs consumption; 7) milk consumption, 8) tofu consumption, 9) tempeh consumption, and 10) other meat consumption models. The models examine how the consumption of the ten sources of protein food can be explained by prices and household size and income. All ten protein consumption models goodness of fit values were highly significant ($P \leq 0.01$). Likewise, all the Wald χ^2 tests were significant. It is clear from these two model tests that the fitted models are all appropriate indicators of the Indonesian household protein consumption.

Households in Indonesia typically consume two types of protein foods: animal protein source foods and plant-based protein foods (Bazoche et al. 2023; Floret et al. 2023; Van Der Meer et al. 2023). This study examined every food source containing animal source protein food, except for pork, which is only consumed by a small percentage of Indonesian households. Tofu and tempeh are the plant-based protein sources included in this study since most Indonesian households eat these two types of protein. Ten protein costs were used to create the protein consumption models: the price of fish, seafood, beef, mutton, poultry, eggs, milk, tofu, tempeh, and other meat alternatives. In addition to the price of the item food, there are other price relationships, such as those for complementary and alternative goods (Chen et al. 2015; Chen et al. 2023; Chen 2022). Household income was also included in the models (Shah 2020; Yarbaşı and Çelik 2023) and household size (Wang et al. 2023).

Table 2: Testing probit models of protein consumption protein

Protein consumption model	Wald chi ²	Goodness of fit	Loglikelihood	Pseudo R ² _L
Fish	7479.04	0.000	-95574.15	0.171
Seafood	14034.35	0.000	-118462.32	0.138
Beef	10884.20	0.000	-49143.37	0.231
Mutton	642.79	0.000	-2325.69	0.068
Poultry	11698.14	0.000	-193713.92	0.146
Eggs	4367.82	0.000	-122878.83	0.062
Milk	18784.31	0.000	-188288.64	0.132
Tofu	7221.57	0.000	-197318.73	0.059
Tempeh	8762.25	0.000	-193942.31	0.074
Other meat	6722.79	0.000	-89651.01	0.080

Factors affecting consumption patterns of protein in Indonesia

Probit models examine whether the effect of protein prices is to increase or decrease protein consumption (Dong et al. 2024; Gao et al. 2023; Ortiz et al. 2024; Williams and Jorgensen 2023). Table 3 displays the data analysis outcomes for the protein consumption models examining the effect of prices, household size and household income.

Table 3 shows that all prices of animal and plant-based protein have a substantial impact on changes in protein consumption in Indonesia. Fish consumption is influenced by all protein

prices. Fish consumption declines when fish prices rise. The consumption of fish decreased due to increases in the price of seafood, beef, mutton, poultry, eggs, milk, tempeh, and other meats. Concurrently, the rising price of fish leads to a rise in the intake of tofu. This research demonstrates that households switch from consuming fish to tofu if fish prices rise. Based on data collected from the field, fish is less expensive than tofu. This validates the hypothesis that rising fish source of protein prices results in a decline in animal source protein intake, with households switching to cheaper plant-based protein.

Table 3: Probit models of protein consumption patterns in Indonesia related to prices, income and household size

Food group	Fish	Seafood	Beef	Mutton	Poultry	Eggs	Milk	Tofu	Tempeh	Other meat
Fish price	-0.448 (0.000)	0.232 (0.000)	0.114 (0.000)	-0.161 (0.174)	-0.140 (0.000)	-0.011 (0.000)	-0.217 (0.000)	-0.321 (0.000)	-0.401 (0.000)	-0.326 (0.000)
Seafood price	-0.029 (0.000)	0.028 (0.000)	0.029 (0.000)	-0.006 (0.815)	0.009 (0.000)	-0.000 (0.534)	-0.009 (0.000)	0.012 (0.000)	0.13 (0.000)	0.017 (0.000)
Beef price	-0.010 (0.000)	-0.007 (0.000)	-0.010 (0.000)	0.002 (0.797)	-0.006 (0.000)	-0.003 (0.000)	-0.005 (0.000)	-0.003 (0.000)	-0.003 (0.000)	-0.001 (0.023)
Mutton price	-0.005 (0.000)	0.004 (0.000)	0.010 (0.000)	0.001 (0.743)	0.015 (0.000)	0.012 (0.000)	0.006 (0.000)	0.001 (0.000)	0.005 (0.000)	0.005 (0.000)
Poultry price	-0.023 (0.000)	-0.010 (0.000)	-0.474 (0.000)	0.011 (0.200)	-0.042 (0.000)	-0.014 (0.000)	-0.014 (0.000)	-0.008 (0.000)	-0.012 (0.000)	-0.002 (0.000)
Eggs price	-0.075 (0.000)	-0.653 (0.000)	-0.012 (0.000)	0.087 (0.569)	-0.135 (0.000)	-0.013 (0.000)	-0.019 (0.097)	-1.040 (0.000)	-0.143 (0.000)	-0.091 (0.000)
Milk price	-0.025 (0.000)	-0.013 (0.000)	-0.001 (0.000)	-0.006 (0.002)	-0.002 (0.000)	-0.007 (0.000)	-0.001 (0.000)	-0.008 (0.000)	-0.001 (0.000)	-0.010 (0.000)

Table 3 continued...

Food group	Fish	Seafood	Beef	Mutton	Poultry	Eggs	Milk	Tofu	Tempeh	Other meat
Tofu price	0.005 (0.000)	0.001 (0.003)	-0.006 (0.000)	0.003 (0.731)	0.016 (0.000)	0.002 (0.336)	0.003 (0.440)	-0.007 (0.000)	-0.007 (0.000)	0.011 (0.000)
Tempeh price	-0.016 (0.000)	0.002 (0.000)	0.010 (0.002)	0.005 (0.757)	-0.007 (0.000)	0.002 (0.000)	-0.000 (0.106)	0.002 (0.423)	0.005 (0.000)	-0.002 (0.267)
Other meat price	-0.025 (0.000)	-0.002 (0.334)	-0.002 (0.000)	-0.005 (0.527)	-0.008 (0.000)	-0.002 (0.000)	-0.004 (0.767)	-0.001 (0.000)	-0.004 (0.000)	-0.014 (0.000)
HH size	-0.074 (0.000)	-0.014 (0.000)	-0.095 (0.000)	-0.018 (0.000)	-0.043 (0.000)	0.017 (0.000)	0.061 (0.000)	-0.024 (0.000)	-0.095 (0.000)	0.051 (0.000)
Income	0.010 (0.000)	0.004 (0.000)	0.004 (0.000)	0.002 (0.070)	0.007 (0.000)	0.004 (0.000)	0.006 (0.000)	0.003 (0.000)	0.003 (0.000)	0.003 (0.000)
Constant	4.963 (0.000)	-0.896 (0.000)	-1.920 (0.000)	-2.936 (0.000)	0.287 (0.006)	0.912 (0.000)	-1.118 (0.000)	0.996 (0.000)	0.717 (0.000)	-2.414 (0.000)

Values in parentheses are the P values for the model coefficients, HH size is household size.

Households in Indonesia consume less fish as a result of rising fish prices, and they also consume less items high in animal source of protein overall. Fish and any foods containing animal source protein are therefore complimentary. In this research, we included two food sources of vegetable protein that are very popular in Indonesia, namely tofu and tempeh. Compared to animal source protein, tofu and tempeh are less expensive. In Indonesia, every household may buy tofu and tempeh. Data analysis findings indicate that rising fish costs lead to a rise in tofu consumption. This implies that tofu and fish can be used in its place. When fish prices increase, households switch to tofu as an animal source protein. Not the same as seafood. In fact, Indonesian households are consuming more seafood as a result of the price hike. In Indonesia, seafood can be costly. Imports of seafood are fairly common. It can be inferred that households that eat seafood tend to be well-off. A positive coefficient indicates that when prices increase, so does consumption. According to the study's findings, Indonesian households that eat seafood continue to view it as extremely vital, therefore even as prices rise, they continue to eat more of it. Mutton and fish can be replaced with seafood. Additionally, seafood can be used in place of any plant-based protein,

including tofu and tempeh.

In Indonesia, beef is a strategic commodity. Out of all the protein sources, beef is the most expensive. National protein adequacy guidelines in Indonesia only allow non-poor households to afford beef consumption. The only quintile that can afford to eat beef is Q5, the highest income household. Only those households in the highest income quintile have elastic beef. This indicates that changes in the price of beef for the wealthiest quintile of households had no impact on the amount of beef consumed. The findings of the models using the Susenas data analysis for 2022 demonstrate that household socioeconomic characteristics and the price of all protein-containing foods have a significant impact on the household consumption model for beef. The increase in beef prices also reduces beef consumption. If the price of beef rises then households replace beef with fish, seafood and mutton. Tempeh is a vegetable protein food that is a substitute for beef.

The price of mutton in Indonesia is the second most expensive after beef. Mutton is also highly preferred by high-income households. The results of data analysis show that mutton consumption increases if prices increase. The results of this data analysis are the same as for seafood. This means that Indonesian households also really like mutton.

Animal source protein foods as substitutes for mutton are beef, poultry, eggs, while tofu and tempeh as a source of plant-based protein are also substitutes for mutton. An increase in poultry prices reduces poultry consumption. This is in accordance with economic theory that an increase in the price of goods reduces demand. Poultry is a food source of animal source protein consumed by middle to high income households in Indonesia. The general consumption pattern in Indonesia is that if the price of beef increases, households replace it with seafood. If the price of seafood increases, then households replace seafood with mutton. If the price of mutton rises, households replace animal food with poultry. This is the general order of consumption patterns for households in Indonesia. The result showed that poultry is a substitute for seafood, mutton and tofu.

Eggs are the cheapest animal protein source food in Indonesia. Eggs also don't require additional costs for spices or just boil them to be consumed. In contrast to other animal source protein foods, households have to pay additional costs to consume them, so eggs are elastic and are a source of animal source protein consumed by almost all households in Indonesia. The research results show that the increase in eggs prices is significant in reducing eggs consumption. The data means that if the price of eggs increases, then eggs consumption decreases. Animal source protein food as a substitute for eggs is mutton, while plant-based protein food as a substitute for eggs is tempeh. Due to its high cost, milk is still regarded as a luxury good in Indonesia. For infants and children, milk is essential since it is critical to their development. Milk consumption declines as a result of rising milk prices. Households switch to tofu as a source of milk protein if the price of milk increases. Although tofu is very popular among kids, stable milk prices are crucial to making milk affordable for Indonesian households, given how important milk is for kids.

In contrast to earlier research, this study incorporates plant-based protein foods as a

source of protein in Indonesia due to the significant increase in the cost of animal source protein over the past five years, or after the Covid-19 pandemic. The extent to which households are substituting plant-based foods for animal source protein due to a fall in household purchasing power is thereby captured by this study. The research results show that the increase in tofu prices significantly reduces tofu consumption. Tofu and tempeh are substitutes, meaning that if the price of tofu rises then households consume tempeh. Field conditions show that the price of tempeh and tofu is almost the same and these two food sources of protein are very easy to find even though soybean is the main raw material for tofu and tempeh is more than 80% imported.

The tempeh coefficient is positive, in contrast to the negative tofu coefficient. This goes against economic theory, which states that household food consumption will decrease as prices rise. This result demonstrates that households continue to purchase tempeh despite price increases. It is understandable why households still believe that protein consumption is essential, even if it is plant-based protein, because the costs of all animal source protein foods are prohibitive and out of reach. For further information, rice is the main food in Indonesian households, and tofu or tempeh is served as a side dish. Other meat is a cheap source of protein food and is quite popular with households in Indonesia. The price of other meat is quite affordable for low-income households. The results of data analysis show that the increase in the price of other meat also has a high impact on the decrease in consumption of other meat. Other meat is a substitute for tofu and is complementary to tempeh.

This research also includes household socio-economic variables, namely income and number of household members or HHsize. Income greatly influences protein consumption, both animal source and plant-based protein, with positive findings. This means that the increase in income is highly

significant for the increase in protein consumption in households in Indonesia. Meanwhile, household members also have a high level of protein consumption with a negative coefficient for consumption of fish, seafood, beef, mutton, poultry, tofu and tempeh. This means that an increase in the number of household members reduces consumption of these six proteins. Meanwhile, regarding food consumption of eggs, milk and other meat, an increase in the number of household members increases protein consumption.

Conclusion

The findings highlight the significance of socio-demographic variables, such as income, and household size, as key drivers of protein consumption. Higher household income positively impacts household protein consumption, indicating a potential market for premium products catering to affluent consumers. Additionally, higher income levels correlate with increased protein consumption, suggesting the importance of tailored marketing strategies targeting educated consumers. Furthermore, the presence of children in the household emerges as a significant determinant, assuming that increased household size indicated the presence of children, indicating distinct preferences and consumption patterns for families with school-aged children. Leveraging this information, marketers can develop value-added products that cater to the specific needs and tastes of this consumer segment. Moreover, the prices of the ten protein groups are a crucial determinant of household protein consumption. Consumers' price beliefs serve as influential perceived barriers to consumption. Understanding the role of price in shaping consumption behaviour enables marketers to devise effective pricing strategies that align with consumers' willingness to pay, thereby maximising

product value. Targeted marketing strategies tailored to address these regional differences can enhance product value and effectively meet consumer demands. Understanding the determinants of household protein consumption demand in Indonesia is crucial for policymakers as it provides insights into the factors that drive consumption patterns, allowing them to design effective policies to promote healthy and sustainable food choices. Additionally, the findings regarding the influence of socio-demographic factors and regional variations can inform targeted interventions and initiatives aimed at improving food security, nutrition, and public health outcomes at a regional level.

Policy implications

Several policy implications emerge for addressing the challenges posed by price increases on household protein consumption, 1) Income Support: Targeted income support programmes can help mitigate the impact of price increases on vulnerable households, ensuring access to nutritious protein sources irrespective of economic circumstances. This may include cash transfers, food vouchers, or subsidies for essential food items, 2) Price Stabilisation Measures: Government interventions to stabilise food prices, particularly for protein sources, can help alleviate the financial burden on households and promote more stable consumption patterns. This may involve measures such as price controls, market interventions, or support for domestic food production, and 3) Nutrition Education: Public health campaigns and nutrition education programmes can raise awareness about affordable protein sources and strategies for optimising protein intake within budgetary constraints. Empowering households with knowledge and skills to make informed dietary choices can contribute to improved nutritional outcomes and resilience against price fluctuations.

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