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The panel data regression concept in consumption modelling

Abstract. Panel data research constitutes a new methodological approach to studies covering the area of food consumption. The modelling procedure described in this article was carried out taking into account the cross-section of individual types of households and product categories. Product categories included: bread and cereals, cakes and bakery products, meat, fish, milk, yoghurts and dairy drinks, cheese, oils and other vegetable fats, animal fats, fruits, vegetables, confectionery products and juices. Surveys focusing on households' budgets in the period of 2003-2019 and provided by the Central Statistical Office of Poland (CSO) were the source of information used for the panel data analysis applied in this work.
The author has undertaken the task of building all the presented models for panel data, namely fixed effects, random effects and pooled regression. It turned out that the correct models are those with fixed individual effects.
In conclusion, it was established that panel models are a useful tool for modelling the consumption of food products. When analysing the constructed models, it is possible to observe significant differences in the consumption of the examined products between the correspondent quintile groups. This study confirms the tendency in food consumption in Poland, observed in 2003-2015.
Keywords: Panel Regression; Households' Budgets; Individual Effects for Product Categories; Modelling the Consumption of Food Products
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Концепція панельної регресії в моделюванні споживання
Анотація. Аналіз панельної регресії – це новий методичний підхід до досліджень, що охоплюють область споживання харчових продуктів. Процедуру моделювання, описану в цій статті, було проведено з урахуванням окремих типів домогосподарств і категорій товарів. Категорії досліджуваних товарів включають: хліб та крупи, торти та хлібобулочні вироби, м'ясо, рибу, молоко, йогурти та молочні напої, сири, олії та інші рослинні жири, тваринні жири, фрукти, овочі, кондитерські вироби, соки. Джерелом інформації, яка використовувалася для панельного аналізу даних, що містяться в цій роботі, є опитування домогосподарств, проведені Центральним статистичним офісом Польщі в період 2003–2019 років,
Завданням дослідження стала побудова моделей для аналізу панельних даних, а саме: моделі з фіксованими ефектами, моделі випадкових ефектів та моделі об'єднаної регресії. Результати дослідження показали, що коректними є моделі з фіксованими індивідуальними ефектами.
Було встановлено, що моделі аналізу панельних даних є корисним інструментом для моделювання споживання харчових продуктів. Аналізуючи побудовані моделі, можна спостерігати суттєві відмінності в споживанні досліджуваної продукції між відповідними квінтильними групами. Це дослідження підтверджує тенденцію споживання їжі в Польщі, яка спостерігалась у 2003-2015 роках.
Ключові слова: панельна регресія; бюджети домогосподарств; індивідуальні ефекти для категорій товарів; моделювання споживання харчових продуктів.

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Концепция панельной регрессии в моделировании потребления
Аннотация. Анализ панельной регрессии являет собой новый методический подход к исследованиям в области потребления продуктов питания. Описанная в статье процедура моделирования проводилась с учетом отдельных типов домохозяйств и товарных категорий. Категории исследованных товаров включают: хлеб и крупы, торты и хлебобулочные изделия, мясо, рыбу, молоко, йогурты и молочные напитки, сыры, масла и другие растительные жиры, животные жиры, фрукты, овощи, кондитерские изделия, соки. Исследования бюджетов домохозяйств, проведенные Центральным статистическим офисом Польши в период 2003–2019 гг., являются источником информации, использованной для панельного анализа, представленного в данной работе.
Задачей исследования стало построение моделей для анализа панельных данных, включая модель с фиксированными эффектами, модель случайных эффектов и модель объединенной регрессии. Результаты исследования показали, что корректными моделями являются модели с фиксированными индивидуальными эффектами.
Было установлено, что панельные модели – полезный инструмент для моделирования потребления пищевых продуктов. Анализируя построенные модели можно наблюдать существенные различия в потреблении исследуемых продуктов в среде соответствующих квинтильных групп. Это исследование подтверждает тенденцию потребления продуктов питания в Польше, наблюдавшуюся в 2003-2015 годах.
Ключевые слова: панельная регрессия; бюджеты домохозяйств; индивидуальные эффекты для товарных категорий; моделирование потребления продуктов питания.

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Koncepcja regresji panelowej w modelowaniu konsumpcji
Streszczenie. Badania panelowe stanowią nowe podejście metodologiczne do badań obejmujących obszar spożycia żywności. Procedura modelowania opisana w artykule została przeprowadzona z uwzględnieniem przekroju poszczególnych typów gospodarstw domowych i kategorii produktów. Kategorie produktów obejmowały: pieczywo i produkty zbożowe, wyroby ciastkarskie, mięso ogółem, ryby ogółem, mleko, jogurty i napoje mleczne, sery ogółem, oleje i pozostałe tłuszcze roślinne, tłuszcze zwierzęce, owoce ogółem, warzywa ogółem, wyroby cukiernicze, soki ogółem. Źródłem informacji wykorzystanych do analizy panelowej zawartej w niniejszej pracy były badania budżetów gospodarstw domowych GUS w latach 2003–2019.
Autor podjął się zadania zbudowania wszystkich zaprezentowanych modeli panelowych (model szacowany KMNK, model ze stałymi efektami – REM, model z efektami losowymi – FEM). Okazało się, że prawidłowe są modele z ustalonymi efektami indywidualnymi.
Podsumowując, ustalono, że modele panelowe są użytecznym narzędziem do oceny spożycia produktów żywnościowych. Analizując skonstruowane modele można zaobserwować istotne różnice w spożyciu badanych produktów pomiędzy odpowiadającymi im grupami kwintylowymi. Niniejsze badanie potwierdza tendencję konsumpcji żywności w Polsce obserwowaną w latach 2003-2015.
Słowa kluczowe: regresja panelowa; budżety gospodarstw domowych; efekty indywidualne dla kategorii produktów; modelowanie spożycia produktów żywnościowych.

1. Introduction

At present, the methods which are most frequently applied to examine the rate of development of food consumption and changes occurring with regard to its structure are those which belong to the category of econometric analyses. The studies to date have focused on the substantive analysis of the development processes of food consumption, and they were mainly related to the assessment of the adequacy of various econometric models to describe the empirical processes of food consumption development in Poland. It emerges that the most adequate measures to describe and analyse food consumption processes are those that include demand functions with the asymptote which determines the empirical level of consumption saturation with the assumption that consumer income increases unlimitedly.

As far as the food market is concerned, regularities formulated by Keynes and Engel, referring to the specific expenditure trends consisting in a change in the general relations in consumption expenditure and savings as well as the change in the structure of expenditure, have been confirmed many times. Studies verifying the abovementioned Engel's law are of interest to many scientists, and this tendency has been reflected in numerous Polish and foreign scientific publications (Kehlbacher, 2012; Kwasek, 2015; Szwacka-Mokrzycka, 2018), including Klonaris (2001, pp. 31-41) and Kwasek (2008, pp. 39-51). The studies carried out so far have confirmed the adequacy of the logarithmic-hyperbolic model for establishing a hierarchy and general assessment of the direction of changes related to food consumption needs in 2003-2015. When assessing the degree of satisfaction of basic food needs, we may observe the occurrence of Engel's regularity. At the same time, the research confirmed that income elasticity coefficients of demand are the basic measures for assessing the level of consumers' meeting their food needs, the scope of qualitative changes and the degree of substitution within individual product categories.

Subsequent studies have pointed to the importance of econometric models estimated on the basis of panel data in order to identify unobservable factors. This method creates a possibility to apply them in the analysis of critical economic problems. It is important to point out that the research carried out by N. Islam (1995, pp. 1127-1170) is of pivotal importance in terms of using panel data in order to estimate a dynamic growth model. When we consider the use of the dynamic panel model in the area of microeconomic research, the dynamic specification of Cobb-Douglas production function played a significant role in the development of research in this area (Blundell & Bond, 2000).

In this paper, the author presents the relevance of the use of panel regression models in food consumption research based on panel data obtained from the statistics on households' budgets. The use of panel data in modelling food consumption constitutes its new application (Szwacka-Mokrzycka, 2018). In this study, the author uses panel models for econometric modelling of the consumption of selected food products. This work is a continuation of the panel research initiated in 2017. The correctness of the findings has been confirmed for the models with fixed individual effects.

2. Brief Literature Review and Methodology

Panel studies have many advantages. They allow for conducting analyses both in terms of micro and macro consumption. Micro panels are conducted to cover the situations of individual households, while macro panels can cover a selected sector of the economy. A typical example of a micro panel is data obtained from households. In turn, macro panels are usually characterised by a limited number of cross-sectional observations and a longer timespan of the sample. Typically, these are data used in macroeconomic research. Panel studies provide the opportunity to increase the data set and thus expand the analysis. They make it possible to identify the causes of the phenomena examined in the study, observe the dynamics of these phenomena, as well as control unobservable individual effects in regression models. The term «panel data» refers to data sets that contain information about the same objects (cross-sectional information) in several periods in time (Maddala, 2001). B. Dańska-Borsiak (2009, pp. 25-41) considers panel data to be a specific type of cross-sectional data. In this case, the number of T periods is much smaller than the n number of objects. Literature studies (Baltagi, 2013) confirm the advantage of the panel data analysis over the analysis of cross-sectional data sets or several cross-sectional data sets containing unique, single-reference objects. Its advantage consists in observing units in subsequent periods. A data analysis carried out in this way allows for reducing measurement errors and problems that result from omitting unobservable variables or variables correlated with the explanatory variable in the constructed model (Osińska, 2007). Two approaches to modeling cross-sectional dependence in economic panel data are often used: the spatial dependence approach, which explains cross-sectional dependence in terms of distance among units, and the residual multifactor approach, which explains cross-sectional dependence by common factors that affect individuals to a different extent. Special attention is paid to the theory and estimation and statistical inference for stationary and nonstationary panel data with cross-sectional dependence, particularly for models with a multifactor error structure (Bruno, 2004; Karabiyik, Palm & Urbain, 2019). In addition, conducting this type of analysis enables the authors to identify the causes of certain phenomena.

Panel models can be divided into two types. The first is a balanced panel, i.e. a set of data where all information from each year of the examined period is available for each object. If the data set has deficiencies in observations, then the panel is unbalanced (Dańska-Borsiak, 2009, pp. 25-41). The easiest way to estimate panel data is to use the method of classical least squares

(CLS). The consequence of using this method is that the specific structure of the applied data is not taken into account. The estimation of the sample using this method does not take into account the division of observations by a unit of time and cross-section. In such a case, there is no division of observations, and they are all mixed. The model estimated in such a way is called the simple regression model or the pooled regression model. The condition for this model to be correct is the lack of correlation between the individual effect and the explanatory variable. The estimation of model parameters is considered acceptable if the model lacks an individual effect. The panel is then considered a cross-sectional data set.

Another model, the fixed effects model (FEM), assumes that there are differences between the objects. They are included in the constant term. Consequently, the constant term occurring in the model is different for each examined object and constant over time. When estimating the parameters of the model with fixed effects, zero-one variables are used. Then each of the binary variables represents the i-th object. When estimating the FE estimator, intra-group diversity is used. Consequently, the fixed effects estimator is also called the ***within estimator***. Estimating model parameters in this way can be challenging or troublesome if the explanatory variable does not change over time. In such a case, one cannot determine the effect of the independent variable on the dependent variable.

Another method of analysing panel data is the Random Effects Model (REM). In this model, the estimated parameters with explanatory variables are treated as variable coefficients, not as constants, as in the case of the FEM model. The REM model is used where differences between objects can be represented by different constants (Madala, 2001). In particular, when the cross-sectional units are randomly selected from among the population, then it is assumed that the individual effect is carried out by a random variable. The model with random effects is also called the variance component model.

A test which helps to establish the significance of the group effect, also called the Wald test, enables researchers to select the correct form of the model to be used in the case of panel data (Osińska, 2007). Thus, the group effect significance test should be applied to choose the correct form of the model, namely, to select between the regression model and the model with fixed effects. The test assumes that the random component has a normal distribution with an average equal to zero and a standard deviation. The pooled regression model should be used to perform the test. The pooled regression model takes the following form:

$$y_{it} = \alpha + x_{it}\beta + \varepsilon_{it}\,, \quad i = 1, \dots, n\,, \tag{1}$$

where:

y_{it} is the value of the response variable in the t period for the i-th object;
x_{it} is the value of the explanatory variable in the t period for the i-th of this object;
β is a vector with N structural parameters of the model;
v_{it} is the total random error, consisting of: pure random component ε_{it} and individual effect u_i, which is assigned to a specific i-th unit of the panel and FE model:

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \beta_2 x_{2it} + \dots + \beta_k x_{kit} + \varepsilon_{it}\,, \quad i = 1, \dots, n\,. \tag{2}$$

Analysing the significance of the group effect, the following hypotheses are formulated:

H0: $\alpha_1 = \alpha_2 = \dots = \alpha_n = \alpha$ (no differences between the examined objects); $i = 1, \dots, n$.

H1: at least one of the parameters α_i is different from α_n.

The next step is to establish residuals for both models, i.e. the pooled regression and FE models. The value of the empirical statistics - F, which is the basis to verify the hypotheses, is calculated according to the following formula:

$$F = \frac{\left(\sum_{i=1}^{nT} e_i^2 - \sum_{i=1}^{nT} u_i^2\right) \Big/ (n-1)}{\sum_{i=1}^{nT} u_i^2 \Big/ (nT - k - n)}\,, \tag{3}$$

where:
e_i is a residual in the model of simple regression;
u_i is a residual in the FE model;
n is the number of objects;
T is the number of time periods;
k is the number of explanatory variables.

The test value should be compared with the $F_{\alpha,m1,m2}$ critical value from the Fisher-Snedecor distribution tables for the predetermined significance level α and $m_1 = n$-1 and $m_2 = nT$-k-n degrees of freedom. When the F statistic value is greater than the $F_{\alpha,m1,m2}$ critical value for a given significance level, the null hypothesis **H0** should be rejected. The regression model is not the correct model to be applied in this case. However, when $F \leq F_{\alpha,m1,m2}$, there are no grounds for rejection of the null hypothesis. It should then be concluded that the simple regression model better describes the studied phenomenon.

To compare the estimated classical least squares (CLS) model with the REM model, it is necessary to perform a test to establish the significance of the random effect. The Breusch-Pagan test can be carried out for this purpose. In this test, the following hypotheses are verified:

H0: $\sigma_u^2 = 0$ (no individual effects);
H1: $\sigma_u^2 \neq 0$ (with individual effects).

Based on the model estimated with the application of the least squares method, we determine the residuals and then calculate the λ test statistics according to the following formula:

$$\lambda = \frac{NT}{2(T-1)}\left(\frac{S_1}{S_2}-1\right)^2, \quad (4)$$

where:
$S_1 = \sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{u}_{it}\right)^2$, $S_2 = \sum_{i=1}^{N}\sum_{t=1}^{T}\hat{u}_{it}^{\;2}$;
$\hat{u}_{it}$ represents the residuals from the regression equation estimated by the least squares method.

The critical value χ_k^2 can be read from the Chi-square distribution tables for the predetermined significance level α and k = 1 degrees of freedom. If the value of λ test statistics is greater than the critical value for a given significance level, **H0** should be rejected. If $\lambda \leq \chi_k^2$, then there are no grounds for rejection of the null hypothesis. The consequence of rejecting the null hypothesis is the estimation of parameters using the random effects model. This does not mean, however, that this is the correct model. To verify whether the model with random effects is correct, it is necessary to perform the Hausman test. This test helps to establish the statistical significance of differences between parameter evaluations using random effects and fixed effects estimators. These estimators have the properties presented in Table 1.

Table 1:
Hypotheses for the Hausman test

Hypotheses	Random effects (RE)	Fixed effects (FE)
H_0: Cov(u_i, x_i) = 0	consistent, efficient	consistent, inefficient
H_1: Cov(u_i, x_i) ≠ 0	inconsistent	Consistent

Source: Biørn (2016)

Not rejecting the null hypothesis means that the estimates of both estimators should produce similar results. However, in the case where significant discrepancies in estimator values are observed, an alternative hypothesis should be adopted. To verify this test, empirical statistics are determined. They take the following form:

$$H = \frac{(\hat{\beta}_{FE} - \hat{\beta}_{RE})^2}{Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})} \rightarrow \chi_k^2, \quad (5)$$

where:

$\hat{\beta}_{FE}$ represents a fixed effects estimator;
$\hat{\beta}_{RE}$ is a random effects estimator;
$Var(\hat{\beta}_{FE})$ is a variance of the fixed effects estimator;
$Var(\hat{\beta}_{RE})$ is a variance of the random effects estimator;
χ^2_k is a critical value of the chi-square distribution, the k-number of model parameters, established using both estimators.

The H test statistics should be compared with the critical value of the chi-square distribution for a given significance level of α and k degrees of freedom (χ^2_k). If the value of the empirical statistics is greater than the critical value for a given significance level, then the null hypothesis should be rejected. The consequence of **H0** rejection is that it is not possible to estimate model parameters correctly using the random effects estimator. In such a case, the fixed effects estimator should be included in the analyses (it does not have to fulfil the requirements related to the lack of correlation between individual effects and explanatory variables - X_i).

During the verification of the constructed model, researchers apply typical model fit measures used in standard regression (residual standard deviation, the coefficient of determination and information criteria (the Hannan-Quinn information creterion, the Akaike information criterion, etc.). During the statistical verification of the model, they also use standard tests, such as the t-test.

3. Purpose

The purpose of the paper is to present the possibility of using panel regressions in order to model the consumption of food products.

4. Results

The study covered the years 2003, 2009, 2015 and 2019. While conducting the study, the author used data from the research into households' budgets provided by the CSO. The analysed data are form a balanced panel. Panel models were used for econometric modelling of the consumption of selected food products. The author has undertaken the task of building all the presented models for panel data. In the course of the research it was discovered that the correct models are those with fixed individual effects. The presented study depicts panels for households in total in the analysed period of 2003-2019.

Based on the analysis of panel data for households in total, three categories of models were created. They include the estimated model of the method of classical least squares (CLS), the model with fixed effects and the model with random effects. The next step of panel research was the stage of statistical verification, which enabled the author to make the final decision regarding the choice of the correct model. At this stage of the study, the author used the tests described above. Table 2 presents the results of the tests for households in total, together with the final decision on the choice of the model applied in the study. The categories of products where it is justified to assign individual effects for each of the quintile groups are in bold (see Table 2). The final stage of the analyses of panel data for product consumption was the presentation and interpretation of established individual effects for selected product categories.

Table 2:
Statistical verification and adopted panel models - households in total

Product	Walda Test	Breuch-Pagan Test	Hausman Test	Selection of the model
Bread and cereals	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model
Cakes and bakery products	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model
Meat (in total)	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model
Fish (in total)	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Milk	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Yoghurts and dairy drinks	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model
Cheese (in total)	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Oils and other vegetable fats	**We reject H0**	**We reject H0**	**We reject**	**FEM**
Animal fats	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Fruit (in total)	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Vegetables (in total)	**We reject H0**	**We reject H0**	**We reject H0**	**FEM model**
Confectionery products	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model
Juices (in total)	We reject H0	No grounds for rejection of H0	No grounds for rejection of H0	REM model

Source: Compiled by the author

In households, the total consumption of six of the analysed food products is not differentiated according to the quintile group. They include bread and cereals, cakes and bakery products, meat, yoghurt, confectionery and juices. The statistical verification carried out for these product categories suggests that the use of the model with random effects would be a viable solution. It is not possible to interpret individual effects for these product categories.

After analysing the panels of each of the presented product categories using the Wald test, it emerges that individual effects should be considered in the study. However, only for some of the product categories, these effects are fixed and can be interpreted. Moreover, due to the change of consumption patterns among the Polish population (a higher level of meeting their needs with regard to food products), which is reflected in the consumers' behaviour towards certain products, such as cakes and bakery products, meat, yoghurt and dairy drinks, confectionery and partially milk and juices, the fixed individual effects cannot be determined.

Subsequently, the author calculated the predicted (average) level of consumption of the examined food products in the analysed period. The results of these calculations are presented in Table 3. The greatest diversity in the area of consumer behaviour can be observed for the product categories including fruits, vegetables, meat and juices. In turn, the smallest (expected) differences in consumer behaviour occur for the categories of milk, confectionery, oils and other vegetable fats and fish in total.

In the next stage of research, individual effects were determined for selected food products for each of the quintile groups - as presented in Table 4. The individual effects which are relevant from the point of view of the interpretation of the findings are presented in bold. If we treat the constant term as the expected consumption of a selected product category, then, as can be seen based on the presented data, the individual effects describe the consumption of these products in relation to the predicted level (Table 4). In other words, individual effects represent differences in consumption between individual quintile groups. Due to the lack of established individual effects it is not possible to interpret all the presented parameters. When examining the cross-section of households in total in the category of vegetables, considering the analysed period, the largest individual consumption effects were recorded for the first quintile group. The volume of the vegetable consumption in this group was 20.96 kilograms higher than the expected volume of vegetable consumption, which was estimated at the level of 8.73 kilograms for this quintile group. In subsequent groups one can observe a systematic decrease in the individual effects of

Table 3:
The expected (average) level of consumption of selected food products for households in total

Food product	Quintile group				
	1	2	3	4	5
Bread and cereals	6.62	6.66	6.90	7.09	7.01
Cakes and bakery products	0.51	0.62	0.73	0.86	1.03
Meat (in total)	4.56	4.99	5.47	5.88	5.93
Fish (in total)	0.23	0.29	0.36	0.44	0.53
Milk	3.52	3.52	3.63	3.74	3.62
Yoghurts and dairy products	0.29	0.37	0.44	0.53	0.70
Cheese (in total)	0.61	0.72	0.85	1.00	1.24
Oils and other vegetable fats	1.15	1.23	1.33	1.41	1.37
Animal fats	0.30	0.36	0.44	0.52	0.55
Fruits (in total)	2.44	2.97	3.58	4.37	5.52
Vegetables (in total)	8.73	9.24	9.82	10.57	10.67
Confectionery	0.49	0.52	0.57	0.60	0.65
Juices (in total)	0.55	0.76	0.93	1.12	1.64

Source: Compiled by the author

Table 4:
Individual effects for selected food products

Food product	Quintile group				
	first	second	third	fourth	fifth
Fish (in total)	**2.23**	**-0.10**	**-0.21**	**-0.33**	**-0.59**
Milk	**7.16**	**-0.36**	**-0.90**	**-1.58**	**-3.31**
Cheese (in total)	**2.44**	**-0.12**	**-0.25**	**-0.41**	**-0.67**
Oils and other vegetable fats	**3.43**	**-0.19**	**-0.41**	**-0.66**	**-1.17**
Animal fats	**2.44**	**-0.11**	**-0.25**	**-0.40**	**-0.68**
Fruits (in total)	**8.52**	**-0.59**	**-1.26**	**-2.13**	**-3.55**
Vegetables (in total)	**20.96**	**-1.43**	**-3.13**	**-5.29**	**-10.11**

Source: Compiled by the author

consumption in this category by quintile group (Table 4). A similar pattern can be observed in the categories of fruit, milk, oils and other vegetable fats. In the category referring to fish (in total), the first quintile group recorded the consumption level which was higher than expected by 2.23 kilograms. In contrast, referring to other groups, the findings indicate that consumption is at a lower level than it was predicted (Table 4). For animal fats, cheese and fish in the following quintile groups, the values are lower than the expected consumption levels by 0.68 for animal fats, 0.67 for cheese, 0.59 for fish, 3.31 and 3.55 kilograms for milk and fruit, respectively (Table 4).

To sum up, random effects models are useful for analysing the differences in food consumption at the level of quintile groups. For those food product categories that show random individual effects, fixed effects models are used. This indicates a changing trend in food consumption. Furthermore, the tendency in decreasing food consumption in relation to increasing incomes, concerns mainly basic products. They are characterized by a relatively high level of satisfaction of needs.

5. Conclusions

Based on the conducted research, it is established that panel models are a useful tool for analysing the consumption of food products. Some of the selected product categories manifest random individual effects. It is possible to note a changing tendency in the consumption of these products. When analysing the constructed models, it is possible to observe significant differences in the consumption of the examined products between the correspondent quintile groups. At this point, it is important to indicate that the above-mentioned disproportion is usually the largest for the two extreme groups. The findings of the present study point to the fact that the consumption behaviour of the Poles is significantly differentiated by their level of income. In the case of low-income households, the demand for food is relatively high, while the situation in high-income households is different. The latter exhibit low consumption sensitivity in relation to the increase in their income. Based on the panel research, the regularity of the increasing level of satisfaction of food needs depending on the increase in households' income has been confirmed. There is also a considerable differentiation in terms of shaping the consumption of food products depending on product categories. In relation to absolutely basic products, the author has observed a relatively small buyers' response to changes in their income, which could be regarded as an increase in consumption. However, the demand for products with a higher degree of food processing is still at a relatively high level. Changes in nutritional needs demonstrate that quality changes result in a large extent from the intensification of substitution processes relating to different groups of food products. The conducted analysis of changes in food consumption demonstrates that quality changes lead to the intensification of substitution processes between food products groups. The conducted analysis of the changes in food consumption of Polish households in the period of 2003-2019 demonstrates the continuation of the trend which emerged during the period of transformation of the Polish economy.

To sum up, an important observation which arises from the study is that, at present, the panel regression models based on panel data obtained from the CSO statistics are used in research on food consumption more and more frequently. This study constitutes a relatively new application initiated in 2017 in order to analyse the needs of the food market. All models for panel data were built as part of the procedure. Nevertheless, the research shows that only models with fixed individual effects are correct and can be considered relevant.

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