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# The microeconomic approach to food demand modelling: empirical results for Croatian households

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## ABSTRACT

This paper provides a detailed analysis of food expenditures of Croatian households by using microeconomic approach and food system modelling. The aim is to provide the in-depth research of Croatian food demand using a methodology that process household-level consumption data. Consequently, we estimate various economic and socio-demographic parameters affecting aggregate demand for food and empirically derive different food demand elasticities. QUAIDS model have been used in order to perform simultaneous modelling of a demand system with the assumption of a rational consumer, which behaves independently of other consumers. The research results show significant variability in household consumption, which is influenced not only by economic, but also by socio-demographic determinants of demand. The main findings do not deviate in large scale when compared with other (post)transition countries of a similar geo-political profile. These results provide a deeper understanding of Croatian households' behaviour and could be used as a powerful tool in simulating the effects of public policy changes on a range of indicators, from the consumer well-being to the effects on budget revenues.

## 1. Introduction

The research on personal consumption has come to the attention of scientists after Keynes's findings on the causes of the Great Crisis. Since then, the study of the original correlation between disposable income and consumption has progressed significantly. Theoretical knowledge has been supplemented by various dynamic macroeconomic models that track consumption trends over time. However, given that personal consumption as the most important component of aggregate demand can essentially be viewed as a set of all individual household consumption decisions, it becomes clear that the approach to personal consumption research at the aggregate level can be reduced to microeconomic models. Therefore, contemporary research is

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firmly grounded in microeconomic modelling, resulting in a deeper understanding and more powerful tools for simulating the effects of public policy changes on a range of indicators, from the well-being of an economy to the effects on budget revenues. The microeconomic approach to modelling demand thus becomes a less biased predictor of future demand and takes into account the heterogeneous characteristics of consumers in the system.

Households' decisions on consumption are particularly important in the short term (given the magnitude of personal consumption in aggregate demand), so better insight regarding the determinants of the demand can be crucial for effective management of fluctuations and the well-being of individuals. Consumers' preferences and purchasing decisions are in most situations a combination of many different determinants, but given the prices of all goods, the consumer has a limited income that allocates to different goods and services to maximize his utility. The average household income, the price of the observed good and the price of other goods are considered to be the most important factors of demand. In addition to economic factors of consumption, assessing the quantity of demand for food products, can also be subjected to certain non-economic determinants of demand - these determinants will be discussed further in the paper.

Analysing the approaches to modelling personal consumption in Croatia so far, we have established that they are mostly based on a predominantly macroeconomic view of the consumption problem, hence one of the goals of this paper is to incorporate the microeconomic approach in modelling aggregate consumption, more precisely, the demand for food products. The food industry in general is of great importance for the Croatian economy accounting for about 24% of the total manufacturing processing industry and employs about 20% of employees. These considerations address the primary motivation for this paper, which seeks to provide the in-depth research and modelling of Croatian food demand by a methodology that uses household-level consumption data. Our research is based on the hypothesis that Croatian households do not differ significantly in their demand for food products in comparison with other post-transition countries that are relatively similar regarding their economic, social, cultural and historical pattern. In order to test the hypothesis, we use the AIDS model (an almost ideal demand system) and its quadratic form QUAIDS. The advantage of modelling the demand system using this methodology is the ability to test axioms assumed by the microeconomic theory of consumer choice and to perform simultaneous modelling of a demand system with the assumption of a rational consumer, which behaves independently of other consumers.

The remainder of the paper is structured as follows. Second chapter continues with the literature review, while the data description and methodology is explained in the third chapter. The fourth chapter discusses the research results and the sixth chapter presents concluding remarks.

## 2. Literature review

Analysing current approaches to modelling personal consumption in Croatia, we found that they are mostly based on a predominantly macroeconomic view of this

issue. One of the macroeconomic study is the one from Obadić and Globan (2015). According to them, the spending structure has changed significantly for the Croatian population during post-war period, disclosing an increase in living standards - much of personal consumption today is focused on the consumption of luxury goods and services, while consumption was previously oriented towards meeting the essential needs such as food, clothing and accommodation. Namely, Croatian consumers are moving closer to the trends already present in most developed countries of the European Union. However, while trends suggest a certain level of convergence in the structure of the personal consumption, the structure of food consumption is extremely "smooth" – in other words, the share of individual expenditure on food is largely stable. Macroeconomic modelling of the food consumption function based on 2005-2013 population consumption data resulted in a positive impact of GDP and real wages on food consumption, while the CROBEX stock index showed a negative relationship with food consumption (Obadić & Globan, 2015). Interestingly, variables such as consumer confidence index, real estate prices, unemployment rate and household debt did not have a significant impact on consumption trends - the authors conclude that a large share of food consumption is a necessity, therefore not much dependent on macroeconomic trends such as other consumption categories. These insights might imply that a more appropriate model should be developed in order to analyse the demand for food products more accurately. The microeconomic approach to modelling demand thus becomes a less biased predictor of future demand and takes into account the heterogeneous characteristics of consumers in the system. A better understanding of consumer behaviour and aggregate elasticities of demand for food products is important for two reasons - the elasticity of demand is directly related to company's profit margin, which can ultimately affect the market structure and producers' surplus on one end, and on the other end, consumer surplus and their welfare (Kufel, 2017).

The range of research interests using demand model is wide - the researchers focus on different simulations, for example Janský (2014) analysed the effects of change in the value added tax rate, Blundell and Stoker (2005) analysed the various exogenous shocks affecting the population's income, while Dybczak et al. (2014) investigated their impact on prices of goods. Cseres-Gergely et al. (2017) analysed the effects of the income redistribution policies on inequality and Lührmann (2005) focused his research on changes in the population structure such as aging. Obviously, the spectrum of demand model application is very broad and significant, for the scientific as well as for the general public because of the applicability of the model in economic policy management. Due to the important role of food that represents the largest household expenditure with a significant impact on well-being and, according to the Maslow's hierarchy of needs, located at the very bottom of the pyramid, there have been a growing body of research dealing with various determinants of food demand.

For the purpose of this paper, literature review has been focused on other transition and post-transition countries of Central and Eastern Europe that share a similar geo-political, socio-economic, historical or cultural framework such as Slovenia (Verbič et al., 2014), Slovakia (Rizov et al., 2014), the Czech Republic (Smutná, 2016, Kučerová, 2017), Romania (Alexandri et al., 2015; Cupák et al., 2014) and Kosovo (Braha et al., 2018).

Cupák et al. (2014) conducted a demand survey applying AIDS model for Romania during three different periods − 2004, 2007 and 2011. The survey is particularly interesting because it addressed the consumption in the "pre-EU" period (2004), the period when Romania joined the European Union (2007), and the year 2011, when the effects of the last recession were still present. In order to avoid zero consumption, their aggregation resulted in five aggregate product groups - bread and cereals, meat and fish, dairy products and eggs, fruits and vegetables and other products. Estimated income elasticities for all groups except bread and cereals resulted in luxury goods and price elasticities except dairy products and eggs represented inelastic demand. Compensated price elasticities are mostly positive, i.e. they indicated substitutable goods, which the authors attribute to the high level of aggregation. Food demand modelling in Romania was also carried out for 2011, but for different aggregates of food products. Alexandri et al. (2015) applied the LA/AIDS methodology for modelling the food demand in the following eight categories: bread and cereals, meat and fish, milk, cheese and eggs, oils and fats, fruits, vegetables, sweets and soft drinks, and coffee and spirits. The results reveal that Romanian consumers consider milk, cheese and eggs, fruits and vegetables as luxury products, while income elasticities for other goods are inelastic. The price elasticities of demand for most food products are greater than 1, except for meat and fish and fruits for which demand is inelastic.

Similar to the findings of Cupák et al. (2014), Rizov et al. (2014) conducted the demand analysis for Slovak Republic by using five food aggregates - cereals, meat and fish, dairy products and eggs, fruits and vegetables and other products. The period of analysis is based on consumption data from 2004-2011. During the aforementioned period, Slovak income and price levels rose sharply, while consumed quantities remained relatively stable. The results show that for fruits and vegetables Slovak consumers are highly income-elastic (1,771). Compensated price elasticities of demand indicate inelastic demand for all categories of foodstuffs. Uncompensated price elasticities in the Slovak example show that demand is elastic to price change for meat and fish, as well as fruits and vegetables. Authors conclude that a great deal of food products differ in signs of compensated and uncompensated elasticities, suggesting that when making purchasing decisions, income effects are significant for Slovakia households.

Studies for Slovenia are especially interesting because Croatia and Slovenia are similar in many aspects, from sharing common economic history, macroeconomic path and transition models. Erjavec and Turk (1998) used the LA/AIDS model on data from the Slovenian Bureau of Statistics for 1988 and 1993, while RegoršEk (2005) applied the same methodology on 2001 data (Verbič et al., 2014). Verbič et al. (2014) conducted a survey using the AIDS methodology on consumption data in 1988, 1998, and 2008, thus covering the transition period and the effects it could potentially have on consumer behaviour. The available data were aggregated into seven groups of goods: bread and cereals; meat and fish; milk, cheese and eggs; oils and fats; fruit; vegetables and finally, sugar and confectionery. The most relevant findings of Verbič et al. imply that meat and fish are luxury products and there are not many variations in elasticities between different income brackets. The price elasticity of demand for most products indicates inelastic demand, as expected. In the

aforementioned twenty-year period, the Slovenian population has become much more resilient to the price of meat and fish products, with an initial price elasticity of demand from −0,65 in 1988 to −1,07 in 2008.

The Kosovo case study by Braha et al. (2018) applies the QUAIDS methodology to household consumption from 2005 to 2012, and aggregates goods as in the case of Romania (Cupák et al.), with the aim of eliminating zero consumption problems. Income elasticities of significant magnitude are evident in fruits and vegetables (1, 35) and meat and fish (1,01), while the negative income elasticity for bread and cereals is surprising, suggesting bread and cereals as an inferior good in Kosovo. Price elasticity coefficients are in line with economic theory, with a highly elastic demand for bread and cereals. The authors attribute this phenomenon to the fact that Kosovo households are highly dependent on the consumption of this food group, and lately, prices have increased significantly. On the other hand, there is also a change in the structure of the Kosovo's diet, with an obvious increase of the consumer preferences toward more nutritionally valuable foods.

There is a vast body of research regarding the Czech demand analysis, which also significantly progressed. The study from Smutná (2016) used household consumption data collected in 2013, with the aggregation of food products into eleven groups - bread and cereals; meat; fish; milk, cheese and eggs; oils and fats; fruit; vegetables; sugar and confectionery; other food products; coffee, tea and cocoa; water and juices. Upon final censored QUAIDS model, the Czech demand reveals rather unexpected results for a country at such level of development. The income elasticities are high, which indicates that all food items are luxurious. According to Smutná, this is not in line with the first Engel law, which stipulates that food expenditure decreases as income increases, that is, demand elasticity should be between 0 and 1. Price elasticities of demand indicate elastic goods in vegetables, non-alcoholic beverages and other products, while the coefficients of price elasticities of demand for all other goods except oils and fats, fruits and sugar and confectionery products range around 1. Another study conducted for Czech Republik (Kučerová, 2017) aimed to quantify the relationship between rates of value added tax and consumer behaviour regarding food. Her sample covers ten basic food items at the reduced rate of VAT. The elasticity coefficients show that consumers react strongly to the VAT rate changes. However, the reaction of customers is not proportional to the change in the VAT rate due to the unproportional behaviour of sellers. Kučerová measured the price elasticities and found out that the price elasticity of demand at the level of individual items is higher than the price elasticity of the whole group of the same product. This effect is related to the substitution and compensation possibility when a decrease in demand for one product is compensated by an increase in demand for another one from the same product group.

## 3. Methodology and data

Modern models define the demand for good as a system of interacting functions, hence the empirical part of the research is developed using the AIDS model (an almost ideal demand system) and its quadratic form QUAIDS. The advantage of

modelling the demand system using the AIDS and QUAIDS methodology is its flexibility, that is, the ability to test axioms assumed by the microeconomic theory of consumer choice. Practically, the simultaneous modelling of the entire demand system is enabled, and all factors that have been defined as a potential influence on quantity of demand for a given good are taken into account when estimating the model parameters. The obvious advantage of modelling a demand system over single or multiple linear regressions is the rational consumer which behaves independently of other consumers, but his decision on the demanded quantity will be influenced (in addition to the available budget) by the price of the observed good and prices of other products that make up a particular "system". Given that, a more complex model was applied to model the entire food demand system, while meeting the constraints assumed by the theory.

The AIDS model is based on a set of equations estimating $w_i$

$$w_i = a_i + \sum_{j=1}^{K} \gamma_{ij} ln p_j + \beta_i ln\left\{\frac{m}{P(p)}\right\} \tag{1}$$

with

$$w_i = \frac{p_i q_i}{m} \tag{2}$$

and

$$ln P(p) = \alpha_0 + \sum_{i=1}^{K} \alpha_i ln p_i + \frac{1}{2} \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{ij} ln p_i ln p_k \tag{3}$$

where $w_i$ stand for share of item $i$ in the total expenditures $m$, $p$ are the prices and $P(p)$ is the price index. Parameters $\alpha$, $\beta$ and $\gamma$ are the coefficients to be estimated by the model, and ought to fulfil the following necessary conditions of additivity, homogeneity and symmetry imposed by consumer behaviour theory:

$$\sum_{i=1}^{K} \alpha_i = 1 \quad \sum_{i=1}^{K} \gamma_{ij} = 0 \quad \sum_{i=1}^{K} \beta_i = 0 \quad \sum_{j=1}^{K} \gamma_{ij} = 0 \quad \gamma_{ij} = \gamma_{ji} \tag{4}$$

Another model which can be considered as an extension of the AIDS model is Quadratic Almost Ideal Demand System (QUAIDS) developed by Banks et al. (Banks et al., 1997), so the food demand modelling was carried out using QUAIDS. Namely, a certain good can be luxurious at lower levels of income, necessarily at medium income levels or inferior at very high levels of income (Benić, 2012). The QUAIDS model is an AIDS model that allows for more flexible Engel curves precisely by allowing the demand for the observed good to be differentiated depending on the level of consumer income (Banks et al., 1997). According to the QUAIDS methodology, the function of the share of good $i$ now takes the following form:

$$w_i = a_i + \sum_{i=1}^{K} \gamma_{ij} ln p_j + \beta_i ln\left\{\frac{m}{P(p)}\right\} + \frac{\lambda_i}{b(p)}\left[\left\{\frac{m}{P(p)}\right\}\right]^2 \qquad (5)$$

Therefore, another limiting condition is added to the previously mentioned axiom of additivity

$$\sum_{i=1}^{K} \lambda_i = 0 \qquad (6)$$

The parameters that will be econometrically evaluated and analysed are thus $\alpha$, $\beta$, $\gamma$ and $\lambda$. In line with the socio-demographic variables that affect the household purchase decision as stated earlier, the parameter $\alpha$ takes the next form

$$\alpha_i = \alpha_{0i} + \alpha_{size} + \alpha_{age} + \alpha_{gender} + \alpha_{education} + \alpha_{children} \qquad (7)$$

where the socio-demographic variables are incorporated as follows:

- Size – number of household members
- Age – age of the household head stated in five-year intervals
- Gender – dummy variable that equals 1 if the head is female, 0 otherwise
- Education – dummy variable that equals 1 if the head finished or still is attending a higher education level, 0 otherwise.
- Children – dummy variable that equals 1 if members of the household are children aged 14 or less.

The data used in this research is collected by Croatian Bureau of Statistics on a multi-year basis, thus including data on household income, expenditure and various socio-demographic characteristics. The research used data collected in 2014, with survey being carried out on 2029 private households (Croatian Bureau of Statistics, 2016). The consumption expenditures are collected and presented according to the Classification of Individual Consumption by Purpose (COICOP). After thoroughly analysing and cleaning the data from outliers that could potentially influence the parameter bias, the data was aggregated into eight categories of food products acknowledging the specific aggregation requirements (Deaton and Zaidi, 2002), after which such a database was subjected to a statistical analysis. Although the data was aggregated into larger classes of food products, there is still a certain level of zero consumption - every aggregated category of food product contains censored data, and only two groups have a negligibly low level of zero consumption ((a) bread and cereals and (b) milk, cheese and eggs category). Obviously, this issue should not be neglected in the econometric assessment of the food demand system and should be solved by one of the following methods: by (1) omitting zero consumption and estimating parameters only for existing consumption; (2) adding non-existent data (so-called data imputation), and (3) including several different methods dealing with the analysis of censored models. In this cross-section data research, the missing quantities were imputed to each household by adding the average quantities of consumption.

The imputation process should not affect aggregated values, although it could reduce variability in the data which could lead to underestimation of some effects.

The next step following the data preparation involves the calculation of the price (in this case unit values) using the available data on quantity and expenditures for their purchase. The method of computing and using unit values as prices in the analysis is commonly used when modelling the demand system hence for their ease of use, especially in the particular case where scientists have available data on consumption and expenditures respectively (Deaton, 1986; Deaton & Grosh, 1997; Stavrev & Kambourov, 1999).

Having the data on the expenditures for a particular food category, we can easily calculate their relative shares in total expenditures. According to the COICOP classification, the food aggregation process in this research therefore resulted in eight aggregate groups, taking into account total expenditure on food consumption, along with non-alcoholic beverages - (1) bread and cereals, (2) meat and fish, (3) milk, cheese and eggs, (4) oils and fats, (5) fruits and vegetables, (6) sugars and confectionery products, (7) other food products and (8) non-alcoholic beverages.

The abovementioned parameters of both models were estimated using the nonlinear seemingly unrelated equations (NLSUR) approach by an iterative procedure (Poi, 2008). The NLSUR model is well suited for estimating parameters that influence the quantity of demand because it allows for modelling of systems of related functions simultaneously. The first objective implies testing the validity of both models applied to Croatian data. The likelihood ratio test (LR) was conducted to compare the estimates of both models (AIDS and QUAIDS) under the assumption that the AIDS model is more consistent and efficient in estimating Croatian food demand. The results of the likelihood ratio test show that the null hypothesis can be rejected at the significance level of 1%, thus the QUAIDS model estimates are more appropriate in describing Croatian food demand.

Econometric modelling of both demand models has shown that QUAIDS is more appropriate for describing Croatian food demand, therefore, the results of quadratic modelling of food demand have been used in the calculation of demand elasticity. In line with the model, the following elasticities of demand for a set of $k$ goods will be estimated by performing partial derivatives of expenditures with respect to prices and income (Poi, 2012):

1.  Uncompensated price elasticity (Marshallian demand elasticity)

$$\epsilon_{ij} = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \left[\beta_i + \eta_i'z + \frac{2\lambda_i}{b(p)c(p,z)}ln\left\{\frac{m}{\overline{m}_0(z)a(p)}\right\}\right]\right.$$
$$\left. \times \left(a_j + \sum_l \gamma_{jl}lnp_l\right) - \frac{(\beta_i + \eta_i'z)\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{m}{\overline{m}_0(z)a(p)}\right\}\right]^2\right) \quad (8)$$

2.  Expenditure elasticity

$$\epsilon_M = 1 + \frac{1}{w_i}\left(\beta_i + \eta_i' z + \frac{2\lambda_i}{b(p)c(p,z)}ln\left\{\frac{m}{\overline{m}_0(z)a(p)}\right\}\right) \qquad (9)$$

3.  Compensated price elasticity (Hicksian demand elasticity)

$$\epsilon_{ij} = \epsilon_{ij} + \epsilon_M w_j \qquad (10)$$

## 4. Research findings and discussion

The calculated elasticities are in accordance with the theoretical principles - it can be confirmed that an increase in income (expenditure) will lead to an increase in demand for all categories of food products. Moreover, the price of the observed good and the quantity demanded are negatively related (Table 1).

According to our results, Croatian consumers' demand for bread and cereals, milk, cheese and eggs, fruits and vegetables and soft drinks is inelastic. Other product groups are characterized as luxury goods, but there is a weak demand response to a change in income as most expenditure elasticities are estimated to be around 1. Apart from non-alcoholic beverages, uncompensated demand elasticities for all food groups are inelastic, indicating that Croatian consumers are not ready to respond to a change in price by an equal change in the volume of demand. According to the presented data, many food products differ in signs of compensated and uncompensated elasticities, which could imply that income effects are significant for Croatian households when making purchasing decisions.

The results of cross price elasticities are presented in Table 2 and 3. Cross price elasticities indicate products that serves as substitutes or complements in the food demand system.

**Table 1.** Expenditure and own-price demand elasticities for Croatian consumers.

| | | Own-price elasticity | |
|---|---|---|---|
| Food category | Expenditure elasticity | Compensated | Uncompensated |
| Bread and cereals | **0.7468** | **−0.6427** | **−0.5106** |
| st. err. | 0.0175 | 0.0216 | 0.0211 |
| Meat and fish | **1.2040** | **−0.8538** | **−0.4638** |
| st. err. | 0.0160 | 0.0175 | 0.0164 |
| Milk, cheese and eggs | **0.8193** | **−0.9687** | **−0.8404** |
| st. err. | 0.0196 | 0.0211 | 0.0207 |
| Oils and fats | **1.1064** | **−0.5941** | **−0.5535** |
| st. err. | 0.0416 | 0.0346 | 0.0345 |
| Fruits and vegetables | **0.9904** | **−0.5526** | **−0.4225** |
| st. err. | 0.0249 | 0.0205 | 0.0200 |
| Sugars and confectionery products | **1.1092** | **−0.8035** | **−0.7429** |
| st. err. | 0.0391 | 0.0220 | 0.0223 |
| Other food products | **1.0240** | **−0.8953** | **−0.8546** |
| st. err. | 0.0441 | 0.0262 | 0.0264 |
| Non-alcoholic beverages | **0.9677** | **−1.0995** | **−1.0219** |
| st. err. | 0.0299 | 0.0152 | 0.0154 |

Source: Authors' calculation.

**Table 2.** Marshallian cross-price demand elasticities.

| Uncompensated cross-price demand elasticities | Bread and cereals | Meat and fish | Milk, cheese and eggs | Oils and fats | Fruits and vegetables | Sugars and confectionery products | Other food products | Non-alcoholic beverages |
|---|---|---|---|---|---|---|---|---|
| Bread and cereals | | **−0.074** | **0.050** | **−0.044** | **−0.077** | −0.008 | **0.005** | **0.046** |
| st. err. | | 0.018 | 0.015 | 0.009 | 0.012 | 0.008 | 0.008 | 0.008 |
| Meat and fish | **−0.120** | | **−0.050** | **−0.008** | **−0.120** | **−0.019** | **−0.020** | **−0.012** |
| st. err. | 0.010 | | 0.009 | 0.005 | 0.009 | 0.006 | 0.005 | 0.006 |
| Milk, cheese and eggs | **0.042** | **0.021** | | **0.005** | **−0.016** | **0.006** | **0.052** | **0.039** |
| st. err. | 0.017 | 0.020 | | 0.009 | 0.013 | 0.009 | 0.008 | 0.008 |
| Oils and fats | **−0.277** | **−0.041** | **−0.026** | | **−0.024** | **−0.057** | **−0.093** | **0.005** |
| st. err. | 0.043 | 0.045 | 0.038 | | 0.032 | 0.021 | 0.021 | 0.020 |
| Fruits and vegetables | **−0.149** | **−0.225** | **−0.046** | **−0.002** | | **0.006** | **−0.015** | **−0.006** |
| st. err. | 0.017 | 0.023 | 0.016 | 0.009 | | 0.010 | 0.009 | 0.010 |
| Sugars and confectionery products | **−0.091** | **−0.078** | **−0.029** | **−0.038** | **−0.001** | | **−0.032** | **−0.036** |
| st. err. | 0.029 | 0.037 | 0.027 | 0.015 | 0.024 | | 0.015 | 0.016 |
| Other food products | **−0.027** | **−0.108** | **0.175** | **−0.083** | **−0.055** | **−0.039** | | **0.007** |
| st. err. | 0.037 | 0.044 | 0.034 | 0.020 | 0.030 | 0.020 | | 0.019 |
| Non-alcoholic beverages | **0.061** | **0.027** | **0.053** | **0.007** | **−0.007** | **−0.017** | **0.006** | |
| st. err. | 0.018 | 0.026 | 0.018 | 0.009 | 0.017 | 0.011 | 0.009 | |

Source: Authors' calculation.

**Table 3.** Hicksian cross-price demand elasticities.

| Uncompensated cross-price demand elasticities | Bread and cereals | Meat and fish | Milk, cheese and eggs | Oils and fats | Fruits and vegetables | Sugars and confectionery products | Other food products | Non-alcoholic beverages |
|---|---|---|---|---|---|---|---|---|
| Bread and cereals |  | 0.167 | 0.167 | −0.017 | 0.021 | 0.033 | 0.034 | 0.105 |
| st. err. |  | 0.016 | 0.014 | 0.009 | 0.012 | 0.008 | 0.008 | 0.008 |
| Meat and fish | 0.093 |  | 0.138 | 0.036 | 0.038 | 0.047 | 0.028 | 0.084 |
| st. err. | 0.009 |  | 0.009 | 0.005 | 0.008 | 0.006 | 0.005 | 0.006 |
| Milk, cheese and eggs | 0.187 | 0.286 |  | 0.035 | 0.092 | 0.051 | 0.085 | 0.105 |
| st. err. | 0.016 | 0.019 |  | 0.009 | 0.013 | 0.009 | 0.008 | 0.009 |
| Oils and fats | −0.081 | 0.318 | 0.147 |  | 0.121 | 0.003 | −0.049 | 0.094 |
| st. err. | 0.042 | 0.042 | 0.038 |  | 0.031 | 0.022 | 0.021 | 0.020 |
| Fruits and vegetables | 0.026 | 0.095 | 0.109 | 0.034 |  | 0.060 | 0.024 | 0.073 |
| st. err. | 0.016 | 0.021 | 0.016 | 0.009 |  | 0.010 | 0.009 | 0.010 |
| Sugars and confectionery products | 0.106 | 0.281 | 0.144 | 0.002 | 0.145 |  | 0.012 | 0.053 |
| st. err. | 0.027 | 0.034 | 0.026 | 0.015 | 0.023 |  | 0.015 | 0.016 |
| Other food products | 0.155 | 0.223 | 0.336 | −0.045 | 0.080 | 0.016 |  | 0.090 |
| st. err. | 0.035 | 0.040 | 0.033 | 0.020 | 0.029 | 0.020 |  | 0.019 |
| Non-alcoholic beverages | 0.233 | 0.341 | 0.205 | 0.043 | 0.120 | 0.036 | 0.044 |  |
| st. err. | 0.017 | 0.024 | 0.017 | 0.009 | 0.016 | 0.011 | 0.009 |  |

Source: Authors' calculation.

**Table 4.** Expenditure elasticities of demand presented by income quartiles.

| Food category | Croatia | I. quartile | II. quartile | III. quartile | IV. quartile |
|---|---|---|---|---|---|
| Bread and cereals | **0.7468** | **1.0339** | **0.9082** | **0.8967** | **1.0689** |
| st. err. | 0.0175 | 0.0638 | 0.0475 | 0.0633 | 0.0560 |
| Meat and fish | **1.2040** | **1.2394** | **1.1600** | **1.2015** | **1.1455** |
| st. err. | 0.0160 | 0.0678 | 0.0512 | 0.0645 | 0.0462 |
| Milk, cheese and eggs | **0.8193** | **0.8288** | **0.8424** | **0.8661** | **0.8543** |
| st. err. | 0.0196 | 0.0728 | 0.0598 | 0.0757 | 0.0593 |
| Oils and fats | **1.1064** | **1.2861** | **1.0806** | **0.9922** | **0.9036** |
| st. err. | 0.0416 | 0.1795 | 0.1187 | 0.1402 | 0.1229 |
| Fruits and vegetables | **0.9904** | **0.8952** | **0.7296** | **0.6763** | **0.4824** |
| st. err. | 0.0249 | 0.0963 | 0.0755 | 0.0847 | 0.0744 |
| Sugars and confectionery products | **1.1092** | **0.4116** | **1.1972** | **0.8520** | **0.8863** |
| st. err. | 0.0391 | 0.1788 | 0.1150 | 0.1441 | 0.1089 |
| Other food products | **1.0240** | **0.8625** | **1.2051** | **0.9079** | **1.1577** |
| st. err. | 0.0441 | 0.1823 | 0.1183 | 0.1747 | 0.1322 |
| Non-alcoholic beverages | **0.9677** | **0.8836** | **1.0470** | **1.3196** | **1.4012** |
| st. err. | 0.0299 | 0.1224 | 0.0840 | 0.1026 | 0.0872 |

Source: Authors' calculation.

The most of the Marshallian (uncompensated) elasticities are negative, i.e. these food groups act as complements, which are important information for the policy makers when taxing certain foods to make them more or less expensive and thus change consumer behaviour and improve their dietary quality. The idea of taxing unhealthy food products (for example sugar and non-alcoholic beverages) in order to stimulate consumption of healthy food (for example fruits and vegetables) can be successful only if they serve as substitutes. Our results on Marshallian elasticities show that fruits and vegetables are complementary to all other food groups including sugar and non-alcoholic beverages. Therefore, according to these results, the effects of policy-induced food price changes on consumer behaviour are quite limited regarding dietary quality.

Having in mind the difference in Marshallian demand that is based on constant nominal income, Table 3 shows Hicksian (compensated) demand elasticities that are based on the assumption of constant real income.

According to these results, the coefficients of elasticity observed in absolute terms are quite small, suggesting a poor correlation between products within the category of food and non-alcoholic beverages. Given the high level of food aggregation, such results are expected. The most important feature of Hicksian (compensated) elasticities is that they facilitate predictions about the substitutability of the food categories and these results indicate much larger space for policy measures. They show that most of the food categories act as substitutes and therefore enable policy makers to use differentiated taxes (VAT) in order to stimulate more healthy diet. The variation in expenditure elasticities of demand by income quartiles can be analysed in Table 4.

The expenditure elasticities of demand display interesting results. The first and fourth income quartiles (i.e. 25% of the lowest income and 25% of the highest income Croatian consumers) consider bread and cereals a luxury good. Although the indicator of expenditure elasticity is slightly above 1, it is interesting that there is a significant difference in expenditure elasticity compared to the second and third quartiles. Of course, it should be borne in mind that nutrition expenditure is considered as income in this research, and therefore the interpretation should be taken into

account. Although this indicator does not reflect the worrying trend in household demand as it is not much higher than 1, it is striking that the richest 25% do not comply with Engel's law. It could be explained by different quality of bread and cereals (whole grain vs. refined cereals) with significantly different nutrition facts and corresponding price.

In a tax policy context, evaluation of food demand elasticities is a very important factor in a policy simulation that asses the effects of tax policy regarding food products. Evaluating household response to such policy measures is crucial because food expenditure represents an important share in total household expenditures and affects its living standard. In many countries one can witness debates in scientific and general public regarding the role of diet in the development of the most common obesity-related diseases. Policy evaluation in such cases strongly depend on understanding the food demand system and its elasticities because introducing policy measures change consumers' total food behaviour.

Obviously, the spectrum of food demand model application is very broad and significant due to the applicability of the model in economic policy management. Besides tax policy, the contribution of this demand model can be found in predicting the effects of changes in other public policies. such as effects of the income redistribution policies on inequality or changes in the population structure such as aging population. As we have seen in 2020, various exogenous shocks like COVID-19 pandemia and economic crisis due to lockdown can affect households' income or prices of goods. A crucial element in predicting household response to such exogenous shocks is to evaluate demand elasticities.

## 5. Conclusion

An analysis of the Croatian food demand system showed the presence of significant variability in household consumption, which is influenced not only by economic but also by socio-demographic determinants of demand. Comparison of results with other transition and post-transition countries confirms that Croatian consumers do not deviate from the trends. Expenditure on food in countries of similar development level as of Croatia continues to make up the largest share of personal consumption. Our findings show that according to the Marshallian (uncompensated) elasticities, the most of food categories act as complements, which limits possible policy-induced food price changes on consumer behaviour. Still, results on Hicksian (compensated) elasticities indicate much larger space for policy measures because most of the food categories serve as substitutes. A possible application of this insights could be the tax policy related to the taxation of unhealthy products that contain high share of sugar. Generally, knowing the determinants of the demand for goods at the household level would allow the creation of more effective public policies that address not only the consumers' well-being, but also the achievement of other economic or social goals.

Unfortunately, the research conducted in this paper contains three limitations needed mentioning. Firstly, the data used in this analysis is limited to the year 2014 - considering the fact that the recession in Croatia was long-lasting and rather deep, this could have been reflected in household consumption and consequently in the

elasticity of demand. For a more accurate and relevant measurement of the effects of price and income changes, it is necessary to take into account a longer period of time. Secondly, since the similar analysis of the food demand has not been carried out in many countries (as has not been done so far in the case of Croatia), possibility of comparing the research findings is rather limited. Thirdly, we should emphasize that there is also a certain limitation in the form of insufficient information on the geographical location of households due to the use of anonymized data from the Household Budget Survey. Our intuition dictates that the Croatian population has significantly diversified dietary patterns in relation to the geographical location of the household, climate, lifestyle (rural and urban), etc. The availability of such information could significantly contribute to the greater precision and applicability of the demand model.

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