

## SENSITIVITY OF HOUSEHOLDS CONSUMPTION DEFLATOR TO CHANGES IN PRICES OF IMPORTED AGRICULTURAL PRODUCTS

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### ABSTRACT

The aim of the article is to assess the sensitivity of the deflator of households consumption to changes in prices of imported agricultural products. In addition to assessing the scale of this sensitivity, its changes in time and spatial diversification were tracked. The research used the input – output price model. It is a macroeconomic model based on the cost formula, and therefore price sensitivity is described through the prism of flows of intermediate products, ignoring adjustment mechanisms. The statistical material for the period 2000–2014 was taken from world input – output database (WIOD) covering information about 43 countries of the world. The analysis carried out shows that changes in world prices of agricultural products have a rather small impact on the purchasing power of households. The observed changes in time are varied, however, the upward trend prevails. The results confirm the thesis that the sensitivity to price impulses flowing from abroad decreases along with the size of the country. Very clearly, especially in European countries, a breakdown in 2009 can be noticed, resulting from the financial crisis, which also moved to the real sphere.

**Key words:** input – output price model, consumer price index, agricultural products, pass-through

### INTRODUCTION

Fluctuations in prices of consumer goods and services result in changes in the purchasing power of households. This phenomenon is discussed primarily when sudden increase in food prices occurs. A spectacular jump in prices of specific food products raises consumer concerns and becomes a topic often appearing in the media, the last example of which is the rise in the price of butter. In the developed countries, however, the scale of this problem seems to be small, as expenditure on basic goods, especially food, constitutes a not significant part of household expenditures. An important source of fluctuations in prices of food are changes in world prices of agricultural products. Determining how alarming consumers should be about fluctuations in world prices of agricultural products requires an empirical analysis. Prices of agricultural

products have their share in shaping the prices of other products in the consumers' baskets, mainly processed food and textiles. For that reason, the analysis should take into account the intermediate flows, or to put it differently – the role played by agricultural products in value chains.

The aim of the study is to assess the sensitivity of the deflator of household consumption to changes in the prices of imported agricultural products. This sensitivity depends on three basic factors:

- import intensity of the economy;
- production technology, i.e. the role played by agricultural products in the value chains;
- the role of agricultural products and derived products in the basket of consumer goods.

Price changes trigger many adjustment mechanisms resulting from the supply and demand game, mainly dependent on price elasticity. To a different

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extent, these mechanisms create the opportunity for domestic producers to raise prices, unjustified by the increase in costs. These other factors were omitted in the study.

The study applied a macroeconomic approach. Agricultural products are defined below in accordance with NACE as A01: Crop and animal production, hunting and related service activities.

Research on price sensitivity to external impulses is of great importance for inflation forecasting. Such analyzes, often commissioned or supported by central banks, focus on the examination of pass-through mechanisms of exchange rate fluctuations on domestic prices [Auer and Schoenle 2016, Pennings 2017]. The interest of economists is also aroused by the mechanisms of transmitting other price relations, especially the impulses coming from the raw materials market, mainly crude oil [Nazlioglu 2011]. Most of them use time series analysis tools. In general, these models are based on the cost formula in less [Zhang and Qu 2015, Bekkers et al. 2017] or more [Pennings 2017] direct way.

Slightly less popular are the applications of the input – output price model, idea of which dates back to the 1930s [Leontief 1937, 1946]. It is a model based strictly on the cost formula, where the initial impulse is a change in import prices [Wu et al. 2013, Aydoğuş et al. 2017] or unit value added [Lee et al. 2000, Sharify and Sancho 2011]. Price sensitivity is often investigated using more developed models, where the input – output price equation is only one of the elements [Boratyński et al. 2007].

## THE METHOD AND DATA SOURCE

In the study, a classic input – output price model was used. It is described by the formula:

$$p^K = A^{K'}p^K + A^M p^{M-1}v \quad (1)$$

where:  $p^K$  – vector of domestic prices, which elements are output deflators;

$A^{K'}$  – input – output matrix (coefficients of direct material flows, domestic products only);

$A^M$  – matrix of direct import coefficients (coefficients of direct material flows, imported products only);

$p^M$  – vector of import prices;

$v$  – vector of unit value added (including taxes on products).

The transformation of the above formula leads to a reduced form of the price model:

$$p^K = (I - A^{K'})^{-1} A^M p^M + (I - A^{K'})^{-1}v \quad (2)$$

According to the equation (2), domestic prices change in response to changes in import prices and changes in unit value added. The transposed import-intensity matrix  $\Pi' = (I - A^{K'})^{-1} A^M$  determines the strength with which import prices will influence the prices of domestic products. Thus, the impact of import prices on the prices of domestic products depends on the import intensity of individual branches, but also on the flow of intermediate products in the domestic economy.

Assuming that all product prices are equal 1, the price transfer mechanism can be interpreted as follows: An increase in the prices of imported products of  $i$ -branch by 1 (or 100%) will cause the prices of all domestic products to increase according to the values of the elements in the  $i$ -th row of the matrix  $\Pi$ .

The changes in domestic prices recorded in this way affect the deflator of consumption in proportion to the structure of the basket of goods and services. At the same time, the increase in import prices of products of the  $i$ -th branch causes a direct (i.e. by 100%) increase in the prices of products of this branch in the “imported” part of the basket, without affecting prices of other imported goods in this basket. The unit value added does not change. Thus model response of the household consumption deflator to the change in external prices of agricultural products is calculated as a weighted average of two components:

- domestic – being the average of the elements of the  $i$ -th row of the matrix  $\Pi$  weighted by the structure of consumption of domestic products,
- imported – representing the average import prices weighted by the consumption structure of imported products.

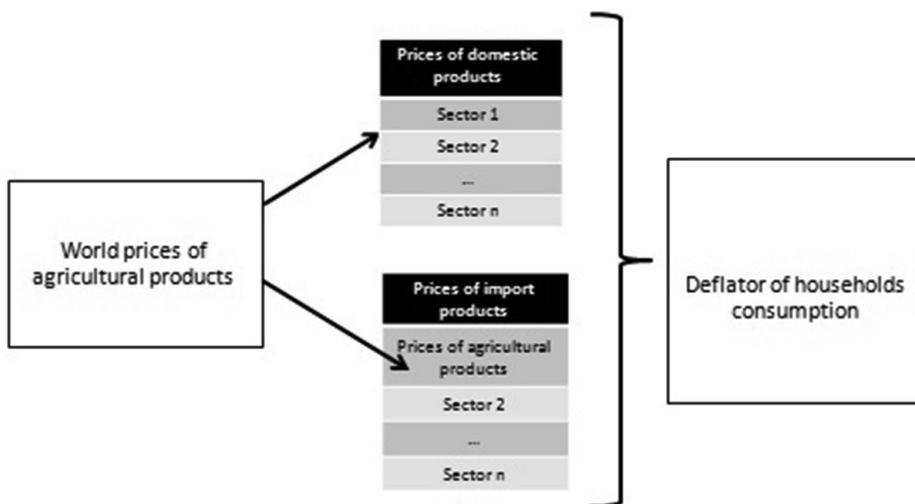
This might be written as formula (3). It is also presented in Figure 1.

$$\Delta P_i = \frac{1}{C_D + C_M} \sum_{j=1}^n \pi_{ij} C_{Dj} + \frac{C_{Mi}}{C_D + C_M} \quad (3)$$

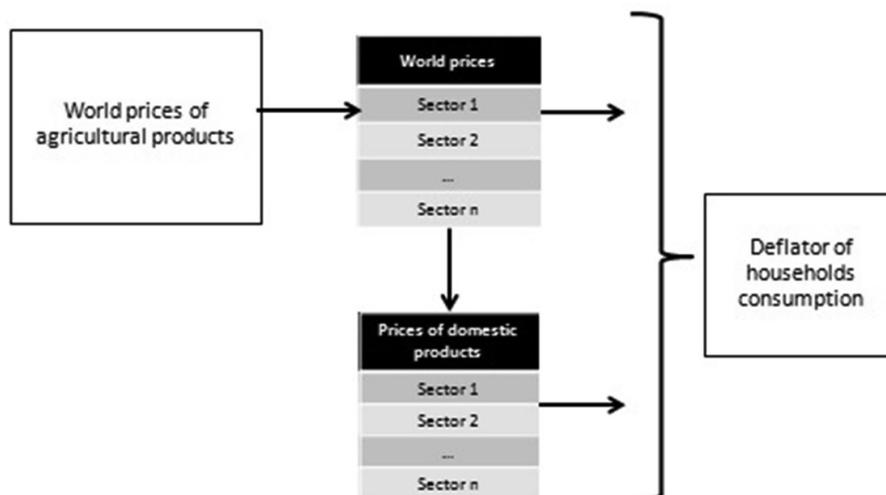
where:  $\Delta P_i$  – change in households’ consumption deflator in response to 100% change in import prices of products of  $i$ -th branch;  
 $C$  – household consumption, subscripts D and M denote domestic products and imported products respectively.

There are two sources of movements of import prices. The first is an exogenous change in the price

expressed in a foreign currency (world price), the second is the exchange rate fluctuations. In the first case, the change is isolated, but it has, as a result of the existence of intermediate flows (value chains), the consequences for prices of other products on the world market. In the second case, the price movement applies to all imported products. The presented research aims to analyze the first of these two cases. Consist-



**Fig. 1.** Transmission of world price movements to the consumption deflator – a classic input – output price model  
 Source: Own elaboration.



**Fig. 2.** Transmitting world price changes to the consumption deflator, taking into account adequate changes in world prices of other products  
 Source: Own elaboration.

ently using the cost formula it has been assumed that the price change of other products on the world market will be proportional to the share of agricultural products in the production costs for these products. Figure 2 shows this mechanism. The change in world prices of agricultural products moves the world prices of other products. In the next step, these changes are transmitted to the domestic prices and, proportionally to the basket structure, cause changes in the household consumption deflator.

To assess the scale of transmission shown on Figure 2, data from the WIOD, release 2016 were used. This database includes input-output tables for 43 countries (including the EU-28 countries) and covers the period 2000–2014. Each table presents the economy divided into 55 industries (branches) in an industry-industry system [Timmer et al. 2015, 2016]. This database includes high and medium developed countries only. For this reason, it is a great tool for analyzing value-added chains in industrial production, propagation of modern technologies, etc. Lack of countries with the lowest national income means that the statistical material used cannot be treated as a representative sample, so the conclusions from the study are limited. Unfortunately, in poorer countries, the quality of statistical surveys is lower and input – output tables are not constructed there.

## RESULTS

The estimates of price sensitivity for all analyzed countries and years according to the method described in Figure 2 are presented in the table. Here the presentation is limited to the example of five selected economies. This set includes large (US and China), medium (Germany and Poland) and small economies (Lithuania, where price sensitivity turned out to be the highest).

Presentation of the results should be preceded by an assessment of the role that the analyzed branch plays in the economy. In Figure 3, the layout of the lines suggests that the role of the agricultural sector in the economy decreases with the increase of GDP per capita. The exception here is Lithuania, a country with a level of development similar to Poland, where the importance of agriculture is significantly higher.

Figure 4 presents one of the factors shaping the price sensitivity. It clearly confirms the validity of Engel's law. For the US and Germany, the share of agricultural products in household consumption stabilized at a very low level, not above 1%. For Poland and Lithuania it drops at a pace that promises the achievement of such a level in two to three decades. The decrease in this share in the case of China is surprisingly strong. This surprise is explained in Figure 5.

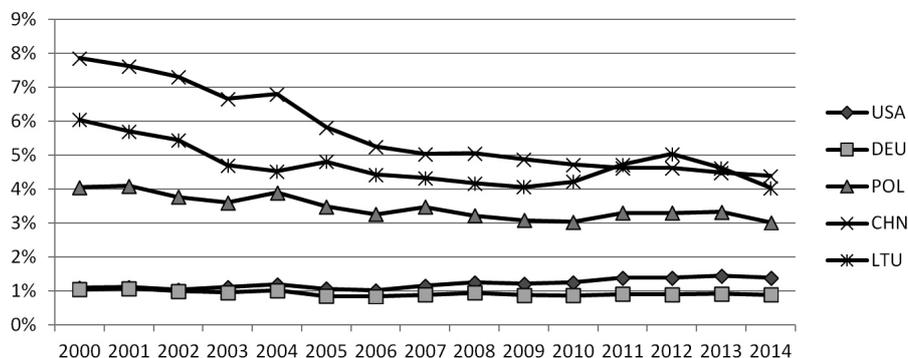
It turns out that this decline is largely due to the shift of Chinese households from consumption of agricultural products to the consumption of processed food. Figure 5 also shows that the products of the food industry are more important in the household basket than agricultural products. This means that the prices of agricultural products affect the deflator of consumption not only directly, but also as a cost factor for the production of the food industry (and, to a lesser extent, other branches).

Observing the downward trends in Figure 4 and stable shares (except the case of China) in Figure 5, one can expect results indicating a decline in the sensitivity of the deflator of household consumption to changes in the prices of agricultural products. Figure 6 shows something quite opposite. This means that the other two factors have definitely worked: import intensity and production technology. The importance of import intensity is confirmed by the observation that the sensitivity is inversely proportional to the size of the country. As shown in the table, this observation applies not only to selected five economies. Lithuania, Latvia, Estonia, Slovenia, Slovakia and Luxembourg show the greatest sensitivity (over 4% in 2014); the smallest (less than 1%) can be noticed for India, USA, Brazil and Australia.

When estimating the linear trend model for each of 43 countries, a significant upward trend was recorded in 32 cases, in only 2 (Russia and Indonesia) the trend was decreasing, while in the remaining 9 the long-term changes were not confirmed. Figure 6 is therefore not completely representative for the entire group covered by the study, as it shows only countries where the price sensitivity increases. However, this is the predominant picture.

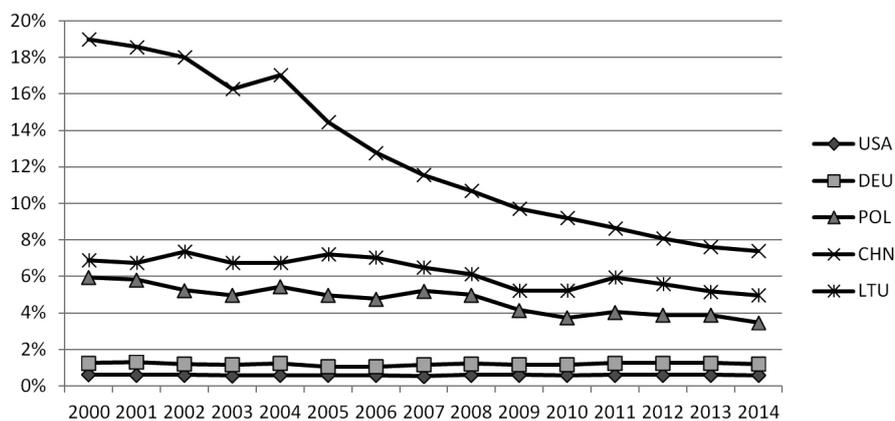
**Table.** Changes in deflator of households consumption (in %) as the reaction of a unit change in world prices of agricultural products in 2000–2014

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
AUS	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9
AUT	1.7	1.8	1.8	1.8	1.8	1.9	2.0	2.1	2.2	2.1	2.3	2.4	2.4	2.5	2.5
BEL	3.5	3.4	3.4	3.6	3.7	3.7	3.7	3.9	4.1	3.7	3.1	3.4	3.4	3.4	3.5
BGR	1.8	1.8	1.8	2.0	2.3	2.5	2.7	3.0	3.3	2.6	2.8	3.0	3.2	3.4	3.3
BRA	0.6	0.6	0.6	0.7	0.6	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
CAN	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.4	1.5	1.5	1.5	1.7	1.7	1.8	1.9
CHE	1.5	1.5	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.6	1.6	1.6	1.5	1.6	1.6
CHN	0.7	0.7	0.7	1.0	1.3	1.3	1.4	1.3	1.5	1.3	1.6	1.6	1.7	1.5	1.4
CYP	3.2	3.2	3.2	3.1	3.2	3.2	3.3	3.4	3.7	3.2	3.2	3.2	3.0	3.2	3.3
CZE	2.2	2.2	1.8	2.2	2.6	3.0	2.9	3.1	2.9	2.9	3.0	3.2	3.4	3.6	3.6
DEU	1.8	1.8	1.8	1.8	1.8	1.8	1.9	2.1	2.2	2.1	2.2	2.3	2.3	2.5	2.4
DNK	2.2	2.3	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.4	2.4	2.6	2.6	1.8	2.3
ESP	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.7	1.6	1.7	1.9	2.0	2.0	2.0
EST	3.3	3.3	3.3	3.5	3.9	4.0	4.1	4.3	4.3	3.5	4.0	4.4	4.7	4.6	4.7
FIN	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.8	1.9	1.8	1.8	1.9	2.0	2.1	2.2
FRA	1.5	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.7	1.5	1.5	1.6	1.6	1.7	1.7
GBR	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	1.7
GRC	1.9	1.9	1.7	1.7	1.8	1.7	1.9	2.1	2.2	1.8	1.9	2.0	2.0	2.0	2.1
HRV	2.6	2.8	2.9	3.0	2.9	2.8	2.9	2.9	2.9	2.5	2.6	2.7	2.8	2.9	3.0
HUN	1.5	1.5	1.4	1.5	1.9	2.0	2.3	2.3	2.6	2.7	2.7	3.0	2.9	3.1	3.2
IDN	2.0	2.5	2.0	2.0	2.0	1.7	1.7	1.9	1.7	1.5	1.5	1.9	1.7	1.7	1.9
IND	0.4	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.4	0.5	0.5	0.5	0.5	0.5	0.5
IRL	2.2	2.6	2.6	2.4	2.4	2.5	2.7	2.7	2.8	2.0	1.4	2.1	2.4	2.3	2.1
ITA	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.4	1.6	1.8	1.7	1.8	1.9
JPN	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.1	1.2	1.0	1.0	1.2	1.2	1.4	1.5
KOR	1.3	1.4	1.3	1.4	1.5	1.2	1.2	1.3	1.8	1.7	1.8	2.1	2.1	2.0	1.9
LTU	3.4	3.7	4.0	4.3	4.5	4.8	5.3	5.6	5.9	4.6	5.2	6.2	6.8	7.2	6.8
LUX	3.9	3.9	4.1	3.9	4.1	4.2	3.9	3.8	3.7	3.9	4.2	4.4	4.1	4.2	4.3
LVA	3.7	4.0	4.0	4.3	4.7	5.0	5.1	5.3	4.9	4.1	4.6	5.3	5.6	5.5	5.3
MEX	1.2	1.2	1.2	1.3	1.3	1.2	1.2	1.4	1.6	1.6	1.6	1.9	1.8	1.8	1.8
MLT	3.3	3.0	3.0	3.0	3.1	3.2	3.5	3.8	4.2	3.7	3.9	4.0	4.0	4.0	3.7
NLD	3.3	3.1	3.0	2.6	2.5	2.5	2.5	2.8	3.0	2.8	2.8	2.9	2.9	4.0	3.8
NOR	1.5	1.6	1.7	1.6	1.6	1.6	1.7	1.8	1.9	1.8	1.7	1.9	1.9	2.1	2.1
POL	1.5	1.4	1.4	1.4	1.5	1.5	1.6	1.8	1.9	2.0	2.1	2.4	2.4	2.5	2.6
PRT	2.9	2.9	2.8	2.7	2.9	2.8	3.0	3.1	3.2	2.8	2.9	3.2	3.1	3.2	3.3
ROU	2.3	2.3	2.4	2.5	2.7	2.7	2.8	2.9	2.7	2.4	2.6	2.7	2.7	2.7	2.8
RUS	3.1	2.6	2.6	2.6	2.2	2.0	1.9	1.7	1.8	2.2	2.2	2.1	2.0	2.1	2.2
SVK	2.5	2.8	2.8	2.9	3.4	3.7	3.8	4.0	4.0	3.3	3.6	4.0	4.3	4.5	4.6
SVN	2.9	2.9	2.9	3.0	3.4	3.6	3.9	4.1	4.2	3.6	3.8	4.1	4.2	4.3	4.4
SWE	1.9	2.0	2.0	2.0	2.0	2.1	2.2	2.2	2.4	2.3	2.3	2.3	2.4	2.4	2.5
TUR	0.6	0.8	1.0	1.1	1.0	0.8	0.9	1.0	1.2	1.1	1.3	1.8	1.6	1.6	1.8
TWN	1.5	1.6	1.6	1.7	1.8	1.8	1.8	2.0	2.2	2.0	2.2	2.3	2.3	1.7	2.2
USA	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.6



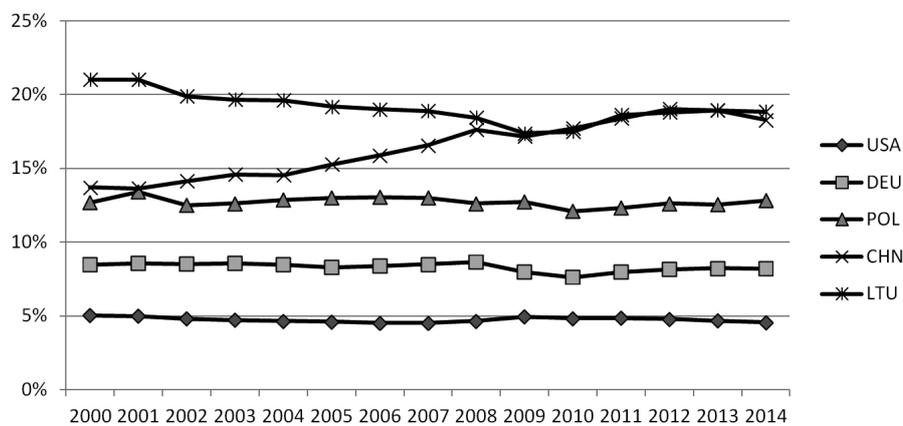
**Fig. 3.** Share of agricultural sector in domestic output in 2000–2014

Source: Own study based on WIOD.



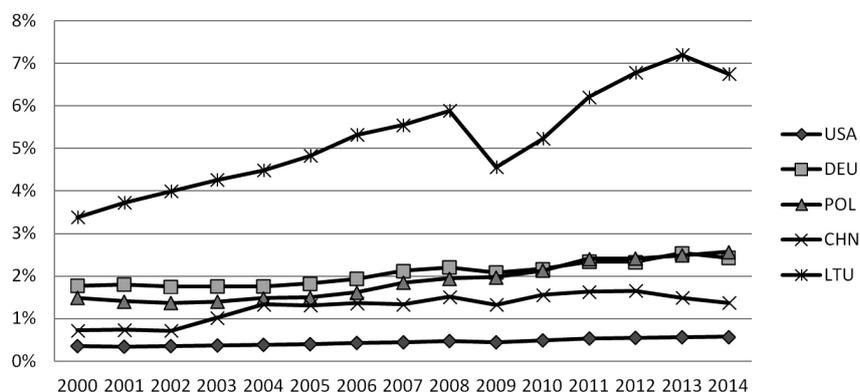
**Fig. 4.** Share of products of agricultural sector in households consumption in 2000–2014

Source: Own study based on WIOD.



**Fig. 5.** Share of food industry products in household consumption in 2000–2014

Source: Own study based on WIOD.



**Fig. 6.** The reaction of the deflator of households consumption to a unit change in prices of imported agricultural products, taking into account adequate changes in world prices of other products in 2000–2014

Source: Own study based on WIOD.

## CONCLUSIONS

The analysis carried out shows that changes in world prices of agricultural products have a small impact on the purchasing power of households. The highest sensitivity was found in the case of Lithuania, where the doubling of world prices of agricultural products causes an increase in the deflator of households consumption by 7.2% (in 2013). It should be remembered that the analysis covered only high and medium developed countries. It is also worth adding that the macroeconomic results lead to averaging conclusions. Certainly, in the poorest households, where food is an important part of the basket of goods and services consumed, the fluctuations of the discussed prices can be clearly felt.

In general, the obtained results confirm known economic laws:

- sensitivity to price impulses from abroad decreases with the size of the country;
- together with the increase in incomes, the share of food products (mainly agricultural) decreases in the basket of products purchased by households;
- in general, the share of imports in household consumption is growing (including indirect imports for households needs);
- in 2009 a breakdown can be noticed, especially in European countries, resulting from the financial crisis, which also moved to the real sphere.

The observed changes in time are varied, however, the upward trend clearly prevails, which means that the increase in import intensity of economies is generally stronger than the effect resulting from the Engle law. A precise decomposition of the impacts of individual factors on price sensitivity can be carried out. It is an interesting direction for continuing the research.

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## WRAŻLIWOŚĆ DEFLATORA SPOŻYCIA GOSPODARSTW DOMOWYCH NA ZMIANY CEN IMPORTOWANYCH PRODUKTÓW ROLNYCH

### STRESZCZENIE

Celem artykułu jest ocena wrażliwości deflatora spożycia gospodarstw domowych na zmiany cen importowanych produktów rolnych. Oceniono skalę tej wrażliwości i prześlędzono jej zmiany w czasie i zróżnicowanie przestrzenne. W badaniach wykorzystano model cen *input – output*. Jest to makroekonomiczny model stworzony na podstawie formuły kosztowej i w związku z tym wrażliwość cenowa jest opisywana przez pryzmat powiązań surowcowo-materiałowych, z pominięciem mechanizmów dostosowawczych. Materiał statystyczny z lat 2000–2014 zaczerpnięto z bazy światowych cen *input – output – WIOD* (ang. *world input – output database*), zawierającej informacje o 43 krajach na świecie. Przeprowadzona analiza wskazuje, że zmiany światowych cen produktów rolnych mają niewielkie przełożenie na siłę nabywczą gospodarstw domowych. Obserwowane zmiany w czasie są zróżnicowane, przeważa jednak tendencja wzrostowa. Wyniki potwierdzają tezę, że wrażliwość na impulsy cenowe płynące z zagranicy maleje wraz z wielkością kraju. Bardzo wyraźnie, zwłaszcza w krajach europejskich, zaznacza się załamanie w 2009 roku wynikające z kryzysu finansowego, który przeniósł się także na sferę realną.

**Słowa kluczowe:** model cen *input – output*, deflator spożycia gospodarstw domowych, produkty rolne, przenoszenie wahań cen