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**Article**

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Economic and Environmental Studies (E&ES)

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*Suggested Citation:* Gorzalczyński, Artur (2019) : Production costs structure as a determinant of the deflator of household consumption: The Input-Output approach, Economic and Environmental Studies (E&ES), ISSN 2081-8319, Opole University, Faculty of Economics, Opole, Vol. 19, Iss. 2, pp. 237-248, <https://doi.org/10.25167/ees.2019.50.4>

This Version is available at:

<https://hdl.handle.net/10419/284692>

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# Production costs structure as a determinant of the deflator of household consumption. The Input-Output approach

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**Abstract:** In the presented considerations, the author attempts to verify the possibility of using input-output tables for modelling and, as a consequence, forecasting inflation. The study is a continuation of previous simulation experiments performed on a limited statistical material and it uses input-output tables expressed in current and constant prices, describing the economy of Denmark. This is the richest available set of tables of this type. Thanks to these tables it was possible to trace long-term changes in the structure of production costs and their impact on the deflator of household consumption.

**Keywords:** input-output model, inflation, cost structure of production

**JEL codes:** C67, C43, E31

## 1. Introduction

The present considerations make an element of broader research on the possibility of using the input-output price model for modeling and, consequently, for forecasting inflation. This model is based on the cost formula, according to which changes in prices result from changes in the structure of production costs. The work focuses on the analysis of tendencies in prices of output and the influence of changes in the structure of production costs on the deflator of household consumption. The study also verifies the hypothesis about the substitution effect of inputs towards a reduction in production costs. According to this hypothesis, substitution mechanisms cause a decrease in the share of these intermediate inputs which prices relatively increase.

Research on prices changes and inflation forecasting play a key role in policymaking, especially with regard to policymaking of central banks. The current subject of many analyses supported or commissioned by central banks is the mechanism for transferring (pass-through) exchange rate fluctuations to domestic prices (Pennings 2017; Cholewiński 2008). The interest on the part of economists is also raised by price changes caused by international price shocks and the effects of these changes. From the point of view of every economy, aspects related to price changes in world markets for such commodities as food (Bekkers et al. 2017) or oil (Zang, Qu 2015) are crucial for its proper functioning. In most of the conducted research, models based on analyses of time series are used, in which the cost approach is less (Bekkers et al. 2017) or more (Pennings 2017) emphasized.

Applications of the input-output price model in inflation process analyses are less numerous than the commonly used econometric methods, and its concept dates back to the 1930s (Leontief 1937, 1946). This model is based on the cost formula, where the initial impulse is the change in import prices (see e.g. Gorzałczyński, Przybyliński 2018; Aydoğuş et al. 2018; Wu et al. 2013) or unit value added (Sharify, Sancho 2011; Lee et al. 2000). Nevertheless, research using the presented approach is still being carried out and developed worldwide (Xu 2018, Przybyliński 2012) and the input-output price model is often an important element of simulation models of national economies (Bardazzi, Ghezzi 2018; Boratyński et al. 2007, Rormose Jensen 1999).

## **2. The method and data source**

The study uses input-output tables describing Danish economy in terms of product by product, distinguishing 117 sectors of the economy. In the first quadrant of the table describing the demand for intermediate products, raw materials from domestic production and imported raw materials were separately listed. The same applies to the final demand described in the second quadrant, where the consumption of goods from domestic producers and the consumption of imported goods were included separately. The third quarter of the table contains information about taxes and value added. Such an arrangement of the tables allowed detailed determination of the structure of production costs as well as the structure of household consumption in macroeconomic terms. The database of the Danish Statistical Office contains input-output tables covering the years 1966-2014,

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expressed separately in current prices and constant prices from the previous year. Currently, it is the only statistical material of this type available that allows making analyses in a wider time horizon.

The study involved determination of an alternative deflator of household consumption, in which prices for the  $i$ -th product did not change, only the structure of production costs did.

In the first step, with the use of the tables expressed in constant prices and current prices, chain price indices were determined for particular flows in the tables:

$$I_{ij} = x_{ij} / q_{ij} \quad , \quad (1)$$

where:

$I_{ij}$  – price index,

$x_{ij}$  – use of intermediate products of  $i$ -th branch to produce products of  $j$ -th branch: value in current prices,

$q_{ij}$  - use of intermediate products of  $i$ - th branch to produce products of  $j$ -th branch: value in constant prices.

As a result, the tables for the years 1967-2014, containing year-to-year price changes for particular flows were obtained.

Then, using a fixed cost structure from year  $t-1$  and previously obtained price indices, output deflators were determined for each ( $i$ -th) branch of the economy ( $I\_OUT^*_i$ ):

$$I\_OUT^*_i = \frac{\sum Q_{ijt-1} * P_{ijt}}{\sum Q_{ijt-1} * P_{ijt-1}} \quad , \quad (2)$$

where:

$I\_OUT^*_i$  – deflator of output determined on the basis of the structure of the year  $t-1$  ( $Q_{ijt-1}$ ) and the price chain index.

The obtained output deflators were compared with actual deflators ( $I\_OUT_i$ ), which were determined in the same way as the chain indexes:

$$I\_OUT_i = \frac{\sum Q_{ijt} * P_{ijt}}{\sum Q_{ijt} * P_{ijt-1}} = \frac{XOUT_i}{QOUT_i} \quad , \quad (3)$$

where:

$I\_OUT_i$  – deflator of output based on the structure from year t,

$XOUT_i$  – output of i-th branch expressed in current prices,

$QOUT_i$  – output of i-th branch expressed in constant prices.

Differences between the above ones reflect changes in prices resulting from changes in the production cost structure.

The next step was to take into account the deflators of output ( $I\_OUT^*_i$ ) in changes in the prices of consumption of domestic goods. The price dynamics of imported products remained at the original level. As a result, the changes in the cost structure have been incorporated as follows:

$$IHC_i^* = I\_OUT^*_i * \frac{IHC_i}{I\_OUT_i} \quad , \quad (4)$$

where:

$IHC_i^*$  – deflator of consumption of products of i-th branch, adjusted by changes in cost structure,

$IHC_i$  – deflator of consumption of products of i-th branch with actual cost structure,

$I\_OUT_i$  – deflator of output of i-th branch with actual cost structure.

The last stage of the study was to determine households deflators IHC and  $IHC^*$  in line with the constant structure of the basket of household goods and services:

$$IHC = \sum IHC_i * \frac{C_i}{\sum C_i} \quad , \quad (5)$$

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$$IHC^* = \sum IHC_i^* * \frac{C_i}{\sum C_i} , \quad (6)$$

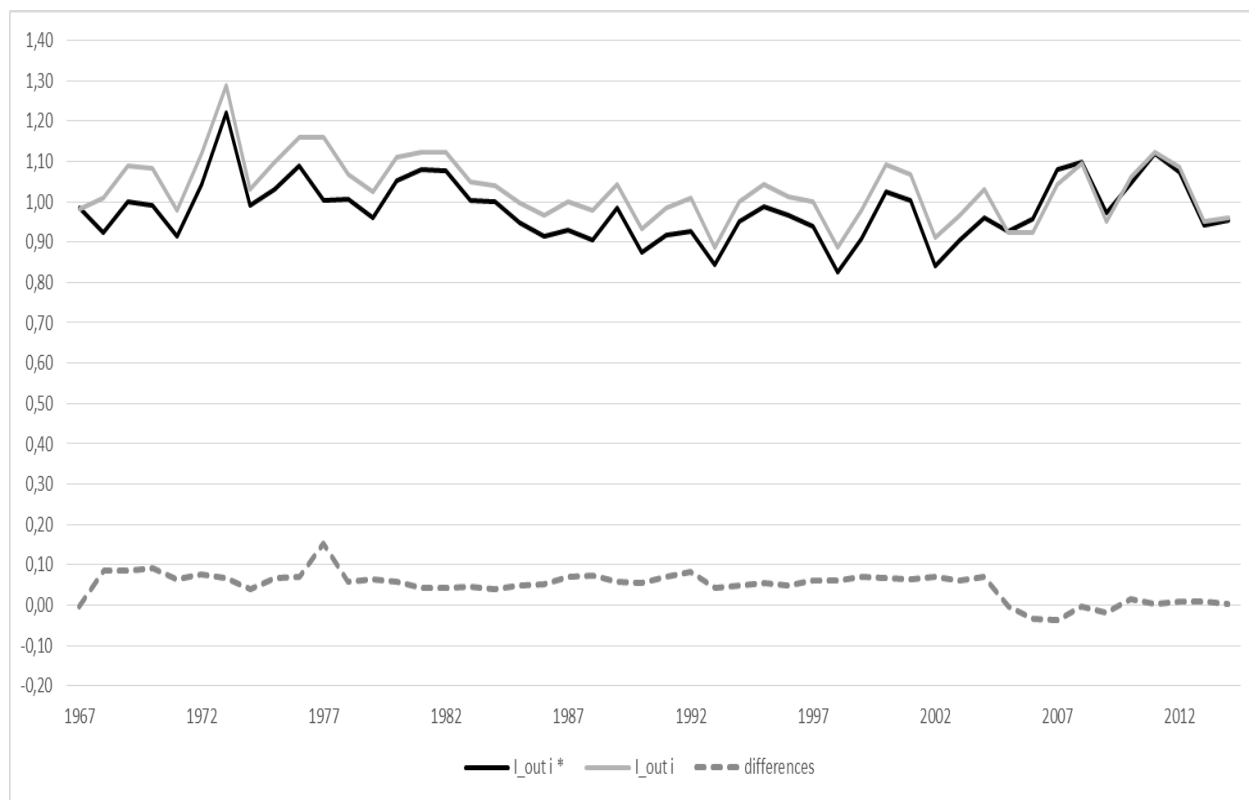
where:

$C_i$  – value of consumption of good coming from the  $i$ -th branch from the period  $t-1$ .

### 3. Results

The differences in selected sector prices are presented below. Figures 1-4 show chain indices of the output prices, calculated under different cost structures. Due to the large number of sectors described in the input-output tables (117 sectors), 4 examples were selected, representing sectors with different business specifics. The figures show product prices in comparison with the hypothetical prices assuming the estimated cost structure from the previous period. A positive difference means that the change in the cost structure has contributed to price increases.

**Figure 1. Changes in prices of output in the agricultural sector in p.p.**

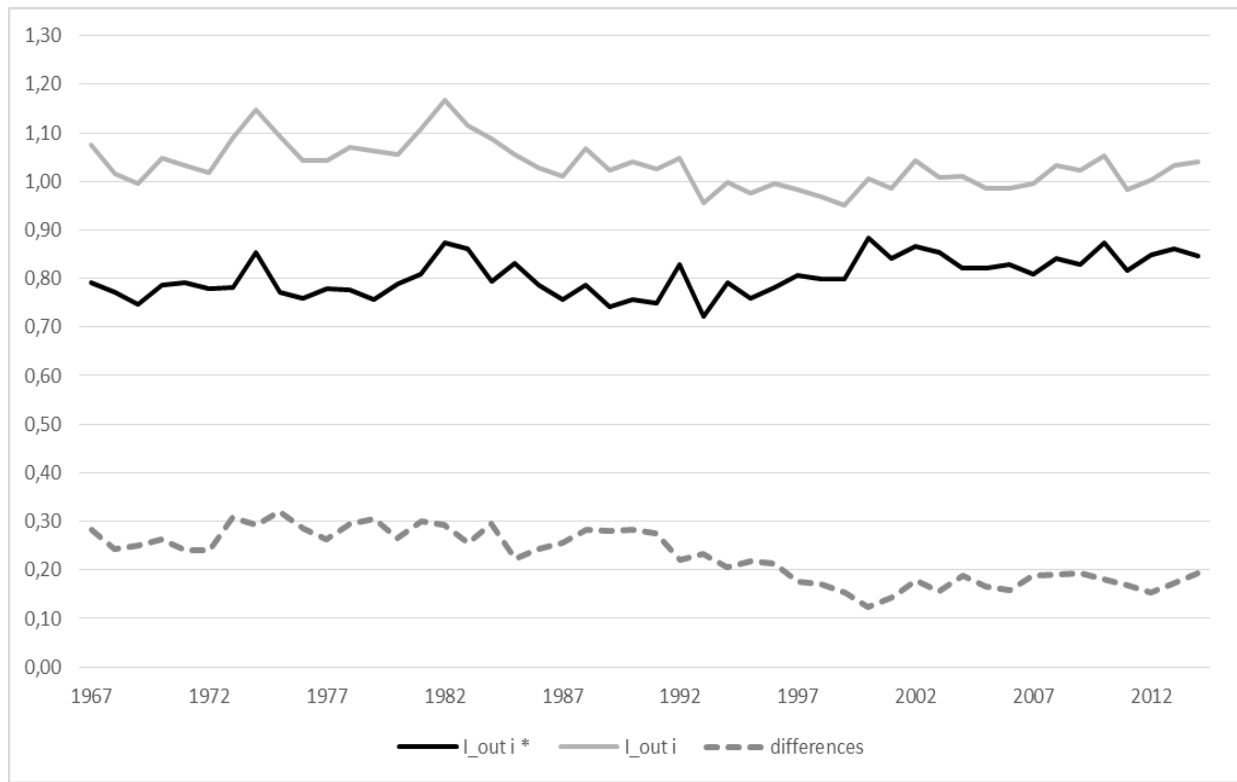


Source: own calculations based on StatBank Denmark

Figure 1 shows price changes in the agricultural sector. Throughout the period considered it can be seen that the impact of changes in the cost structure has a positive effect on price changes and oscillates between 0 and 0.1 percentage points.

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**Figure 2. Changes in global production prices in the pharmaceutical sector in p.p.**

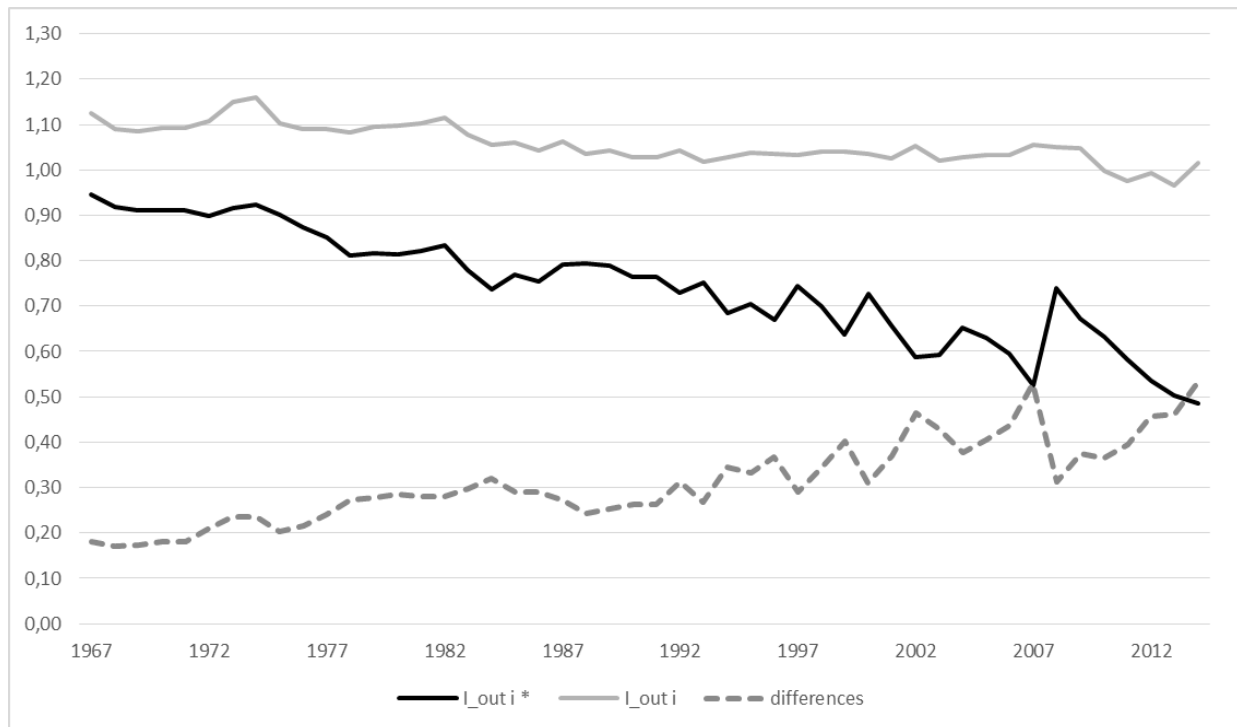


Source: own calculations based on StatBank Denmark

A similar tendency can be seen in the pharmaceutical sector described in Figure 2. In this sector, the impact of changes in the cost structure also causes a rise in prices. However, it is higher and stays within the range of 0.1 and 0.3 percentage points.



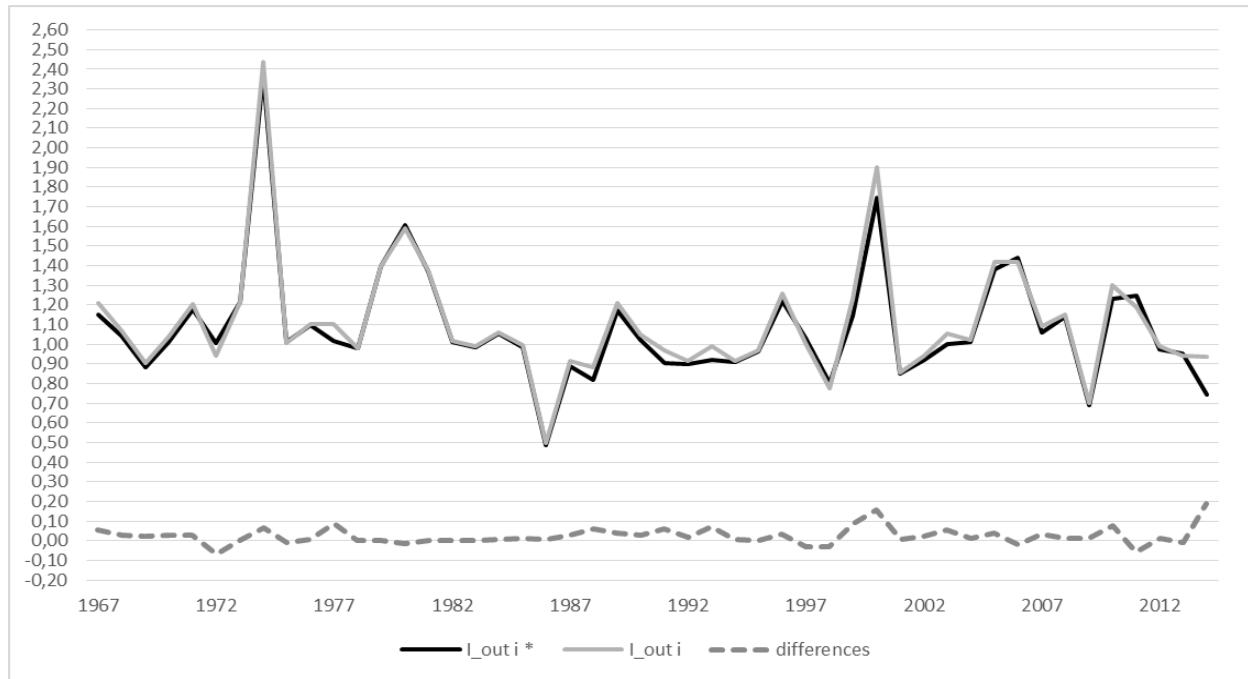
**Figure 3. Changes in global production prices in the business consulting sector in p.p.**



Source: own calculations based on StatBank Denmark

Another example concerns the business consulting sector. In this case, the price sensitivity to changes in the cost structure is significantly greater and consistently increasing over the whole period from a level of around 0.2 percentage points in 1967 to a level close to 0.5 percentage points in 2014. In 2008, this trend collapsed as a result of the global financial crisis. This is beyond doubt due to the specific nature of this sector's activities.

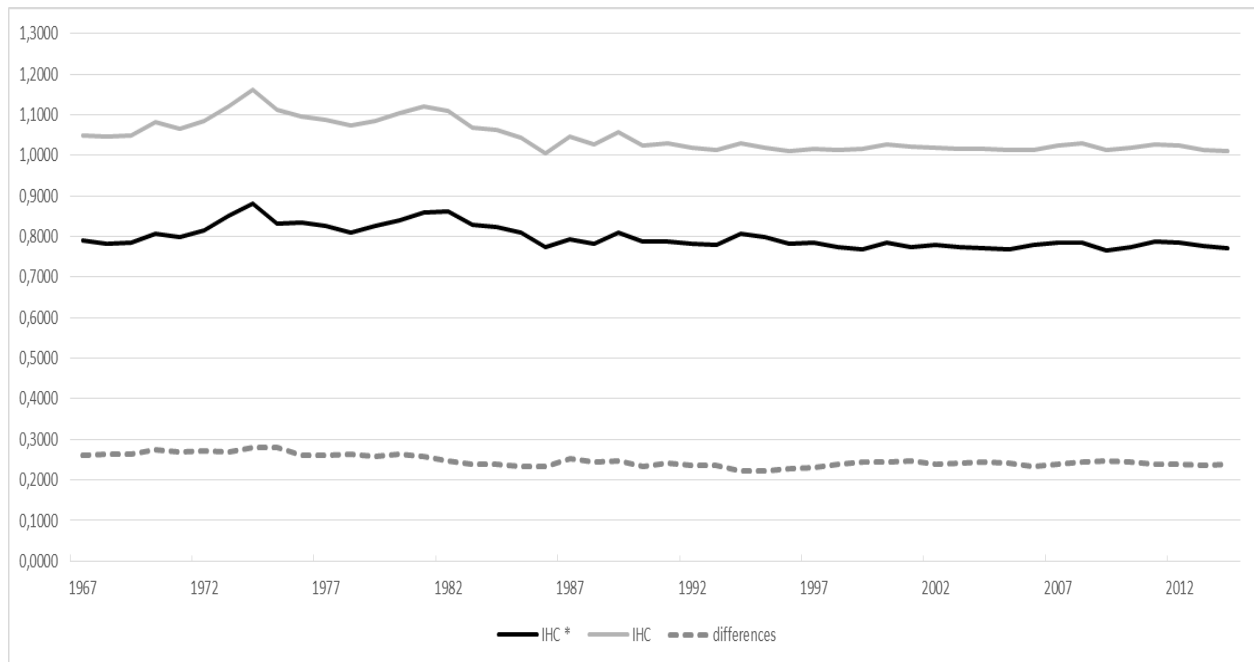
**Figure 4. Changes in global production prices in the oil refinery sector in p.p.**



Source: own calculations based on StatBank Denmark

The examples presented in Figures 1-4 clearly show various trends in output prices in particular sectors of economy. This is due to the obvious fact that each branch of economy has its own specificity of activity and, consequently, also a different structure of production costs. However, some common tendencies can be seen. Namely, the differences resulting from changes in the cost structure within the whole analyzed period in most cases can be considered constant, and their impact on changes in output prices are generally positive. There are sectors such as oil refineries, where these changes are almost equal to 0 and do not have any clear impact on changes in output prices as can be seen in Figure 4.

**Figure 5. Changes in the deflator of household consumption due to changes in the production structure in p.p.**



Source: own calculations based on StatBank Denmark

Figure 5 shows tendencies similar to the majority of output deflators. In the years 1967-2014, the changes in the cost structure had a clear impact on those in household consumption prices and this impact can be considered constant. During the entire period under consideration the difference resulting from the changes in the cost structure was positive and fluctuated between 0.2-0.3 percentage points.

#### 4. Conclusion

The presented study analyzes the size of price changes resulting from changes in the structure of production costs. For this purpose, input-output tables describing Danish economy in the years 1966-2014 were used. As a result, it was observed that:

- differences in output prices resulting from changes in the cost structure of individual branches are generally constant for individual sectors of the economy,
- in case of the deflator of household consumption, one can also see a constant level of difference resulting from changes in the structure of production costs,

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- the impact of changes in the cost structure is positive (contributes to a price increase) and stable.

The obtained results do not confirm the hypothesis about the substitution effect of expenditures towards the reduction of production costs. According to this hypothesis, substitution mechanisms cause a decrease in the share of intermediates that become relatively more expensive, in the cost structure. On the contrary, the results suggest that the causal relation is the opposite: an increase in demand for intermediate products causes their prices to rise. In the context of further considerations, a detailed analysis of individual cost items should be undertaken, which would allow indicating those that played the crucial role in shaping the overall indices.

### Acknowledgments

This paper and the research behind it would not have been possible without the support of my supervisor, Prof. UŁ, dr hab. Michał Przybyliński, whose knowledge and exacting attention to detail were invaluable.

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### ***Struktura kosztów produkcji jako determinanta deflatora konsumpcji gospodarstw domowych.***

#### ***Podejście Input-Output***

#### ***Streszczenie***

Przedstawione rozważania stanowią próbę weryfikacji możliwości zastosowania tablic przepływów międzygałęziowych do modelowania a w konsekwencji – prognozowania inflacji. Badanie jest kontynuacją wcześniejszych eksperymentów symulacyjnych dokonywanych na ograniczonym materiale statystycznym. W badaniu wykorzystano tablice przepływów międzygałęziowych wyrażonych w cenach bieżących i stałych, opisujące gospodarkę Danii. Jest to najdłuższy dostępny szereg tablic tego typu. Umożliwiło to prześledzenie długookresowych zmian struktury kosztów produkcji i ich wpływu na kształtowanie się deflatora konsumpcji gospodarstw domowych.

***Słowa kluczowe:*** model cen input-output, inflacja, struktura kosztów produkcji