

# Price transmission and estimations of price elasticity of secondary demand functions: application on commodity market for food grains

## *Cenová transmise a odhady cenové elasticity sekundárních poptávkových funkcí: aplikace na komoditní trh s potravinářským obilím*

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**Abstract:** The paper is focused on the quantitative analysis of the price transmission and on its use for the estimations of the direct price elasticity of the vertical-derived demand functions. The price transmissions were examined between the commodity markets for the food grain and the consumer markets for the bakery products and flour. The data (1995–2002) were taken over from the Czech Statistical Office (CSO), the Price Statistics (PS) and the Statistics of Family Budgets (SFB). The intensity of the inter-market price transmission was assessed by means of the coefficients of the price transmission elasticity (*EPT*). For enumerating of *EPT*, the regression linear models were developed. The explicit as well as the implicit time-definition in the models was tested. The explicit dynamic construction was carried out on the basis of the stationary process with the parabolic trend. After the determination of trend functions, the seasonal component in used time-series was thoroughly investigated by means of the harmonic analysis (*G*-tests of the individual extremes of the developed periodograms). The implicit dynamization of the linear models was solved on the basis of the first differences of appropriate commodity prices, respectively price levels on the consumer market. For the quantification of the price transmission elasticities, directly dynamized models there were only used only because the model unambiguously achieved better values of characteristics of the statistic verification (correlation index, *F*-test, *T*-test). These models also satisfied the economic assumptions in the sense of the vertical price transmissions between the observed market levels and the preservation of the law of diminishing demand. Based on the linear models of the price transmission with parabolic-trend stationarization, it was found out that within the observed period (1995–2002) *EPT* between commodity market with the food wheat and consumer market with the bakery products and flour reached the average level of +0.1602%. Within the same period, the value of *EPT* between commodity market with the rye and consumer market with the bakery products and flour reached the average level of +0.1067%. These coefficients were subsequently used together with coefficients of the own price elasticity of consumer demand for the bakery products and flour ( $\epsilon$ ) to the estimations of the own price elasticity of the commodity demand for food wheat and rye ( $e$ ). In accordance with the construction of these estimations:  $e = \epsilon \times EPT$ , it was found out that the average level of the own price elasticity of the demand for food wheat (respectively rye) is about –0.0659% (respectively –0.0441%). Both observed secondary demand functions are therefore strongly inelastic with respect to the reaction on the direct price changes. The commodity demand for the rye seems to be more inelastic.

**Key words:** price transmission, elasticity of price transmission, consumer demand for bakery products and flour, direct price elasticity of consumer demand, direct price elasticity of secondary demand

**Abstrakt:** Příspěvek je zaměřen na kvantitativní analýzu cenové transmise a na její využití při odhadech přímé cenové pružnosti u vertikálně sekundárních poptávkových funkcí. Cenové transmise byly zkoumány mezi komoditními trhy s potravinářským obilím a spotřebitelskými trhy s pečivem a s moukou. Údaje za roky 1995 až 2002 byly pro tyto rozborů převzaty z ČSÚ, Statistika rodinných účtů a Cenová statistika. Intenzita mezitržního cenového přenosu byla posuzována prostřednictvím koeficientu elasticity cenové transmise (*EPT*). Pro vyčíslení *EPT* byly sestaveny regresní lineární modely.

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U těchto lineárních modelů cenového přenosu byla zkoušena explicitní a implicitní forma dynamizace. Explicitní dynamická konstrukce byla provedena na základě parabolické trendové stacionarizace, které ovšem předcházelo důkladné prošetření sezónní složky harmonickou analýzou (*G*-testy jednotlivých vrcholů v periodogramech). Implicitní dynamizace lineárních modelů byla řešena na základě prvních diferencí příslušných komoditních cen, respektive úrovní cenové hladiny na spotřebitelském trhu. Pro kvantifikaci elasticity cenových přenosů byly nakonec využívány pouze přímo dynamizované modely, které jednoznačně vykazovaly lepší hodnoty statistických verifikačních charakteristik (index determinace, *F*-test, *T*-testy). Tyto modely rovněž vyhovovaly ekonomickým předpokladům ve smyslu vertikálních cenových přenosů mezi sledovanými úrovněmi trhů a zachování zákona klesající poptávky. Na základě lineárních modelů cenového přenosu s parabolickou trendovou stacionarizací bylo zjištěno, že v rámci sledovaného období 1995 až 2002 dosahovala *EPT* mezi komoditním trhem s potravinářskou pšenicí a spotřebitelským s pečivem a s moukou průměrnou úroveň +0,1602 %. Ve stejném období dosáhla dle analogického modelu hodnota *EPT* mezi komoditním trhem s žitem a spotřebitelským trhem s pečivem a s moukou průměrnou úroveň +0,1067 %. Tyto koeficienty elasticity zkoumaných cenových transmisí byly následně využity spolu s koeficienty přímé cenové elasticity spotřebitelské poptávky po pečivu a po mouce ( $\epsilon$ ) k odhadům vlastní cenové elasticity u komoditní poptávky po potravinářské pšenici a po žitě ( $e$ ). V souladu s konstrukcí těchto odhadů:  $e = \epsilon \times EPT$  bylo zjištěno, že průměrná úroveň přímé cenové elasticity se u komoditní poptávky po potravinářské pšenici pohybuje okolo -0,0659 % a průměrná úroveň přímé cenové elasticity u komoditní poptávky po žitě okolo -0,0441 %. Obě zkoumané sekundární poptávkové funkce jsou tedy z pohledu reakcí na změnu přímé ceny silně neelastické, přičemž více cenově nepružná se jevila komoditní poptávka po žitu.

**Klíčová slova:** cenová transmise, elasticita cenové transmise, spotřebitelská poptávka po pečivu a mouce, přímá cenová pružnost spotřebitelské poptávky, přímá cenová pružnost sekundární poptávky

## INTRODUCTION AND AIM OF THE PAPER

In connection with the analysis of the agri-food chains and their partial markets, the economists dealing with this field of study often focus on the research of the inter-market price transmissions (Revoredo et al. 2004). For enumerating of the intensity of the price transmissions, the elasticity coefficients are used most frequently. If we suppose two levels of the partial markets within the selected commodity chain and we denote them  $i$  and  $j$ , the coefficient of the price transmission elasticity (*EPT*) between these two market levels can be defined by entirely common way (McCorrison 2002):

$$EPT_{ij} = \frac{\partial [p]_i}{\partial [p]_j} \times \frac{[p]_j}{[p]_i} \quad (1)$$

Quite common is also its percentage interpretation (see f. e. Hušek 1999).

It is possible, at least to some extent, according to the magnitude of the price transmission elasticity to assess the market structure performed within the given commodity chain, respectively its partial markets (McCorrison 2002). By means of the price transmission coefficients, it is also possible to evaluate market power of the individual links of the chain or their groups (McCorrison et al. 2001). But basically right from the beginnings, the coefficients of the price

transmission elasticity were used especially for the estimations of the price elasticity of the secondary demand functions (George, King 1971). In this case, the estimations of the price elasticity of the selected secondary demand function were assessed on the basis of the price relations between primary market (consumer market) and the appropriate secondary market (processing market, commodity market, market with production inputs). The constructing of the estimations of the price elasticity of the secondary demand function results from the relationship (2):

$$[e]_j = [\epsilon]_0 \times PT_{j0} \quad (2)$$

where:

$[e]_j$  is estimated direct price elasticity of  $j^{\text{th}}$  secondary demand function within selected commodity chain,  
 $[\epsilon]_0$  is direct price elasticity of primary (consumer) demand,

$EPT_{j0}$  is elasticity of price transmission between  $j^{\text{th}}$  market within selected commodity chain and consumer market.

The quality of the estimations according to the relationship (2), optionally the extent of its distortion, can be easily demonstrated on the following relationships, respectively on their alteration: (3), (4), (5), (6). Let the level of the price elasticity of the secondary demand function have its value:

$$[\varepsilon]_j = \frac{\partial[Q]_j}{\partial[p]_j} \times \frac{[p]_j}{[Q]_j} \quad (3)$$

Now we will itemize the relationship (2) by means of the general definition of appropriate elasticity coefficients to the following form (4):

$$[e]_j = [\varepsilon]_0 \times EPT_{j0} = \frac{\partial[Q]_0}{\partial[p]_0} \times \frac{[p]_0}{[Q]_0} \times \frac{\partial[p]_0}{\partial[p]_j} \times \frac{[p]_j}{[p]_0} = \frac{\partial[Q]_0}{\partial[p]_j} \times \frac{[p]_j}{[Q]_0} \quad (4)$$

The notations (3) and (4) imply that estimations of price elasticity of secondary demand function according (2) are absolutely exact:

$$[\varepsilon]_j = [e]_j \quad (5)$$

when the equation (6) is valid:

$$\frac{\partial[Q]_j}{[Q]_j} = \frac{\partial[Q]_0}{[Q]_0} \quad (6)$$

Thus relatively expressed changes in the demanded quantity are within the observed commodity chain vertically transmitted from the primary market to the derived secondary markets without any deviation (increase/decline). Regarding the accuracy of the estimations according to (2), it is necessary to mention the condition of the fixed proportions of the production inputs, i. e. the subject of demand on certain level of the secondary markets. First this limitation of constructing the estimations was discussed within publications of B. L. Gardner (1975), at the same time the author adds, that this condition need not be unreal for many practical examples of the agri-food chains. Especially, when the time period of the analysis is not very long. In short term, we can expect – with high level of probability – nearly rigid proportions of the demanded inputs at appropriate market level (Wohlgenant 1989).

On the other hand, this method of the price elasticity estimations offers the significant advantages. The first advantage reclines upon very low number of the characteristics or variables needed for doing quantitative estimations of the price elasticity of the selected secondary demand function – see relationship (2). There is second advantage connected with the first one; for the estimating of the price elasticity of the secondary demand functions, that are more distant from the final consumer demand within the chain, there is no need to know neither coefficients of the price elasticity of directly foregoing demand

or other demand characteristics. In other words, for estimations according to (2) there is no need to keep the recurrent form of algorithm.

The paper aims to analyse the process of the price transmission between the consumer market with the bakery products and flour on one side and the commodity market with the food grains on the other side. By means of suitable dynamic model, the intensity of the price transmission between selected markets will be analysed and its value will be expressed by the elasticity coefficient (*EPT*). Besides the elasticity analysis of the inter-market price transmission, this paper also shows the possibility of use of coefficients *EPT* for the estimation of the price elasticity of the secondary demand relationships. The direct price elasticities of the secondary demand functions are estimated for the commodity market with the food wheat and rye.

## METHODOLOGY AND DATABASES

With regard to the focus of this paper, first the intensity of the price transmission between the consumer market with the bakery products and flour and the commodity market with the food wheat and rye was assessed. For this purpose, it was necessary to obtain data about prices of the bakery products and flour on the consumer markets as well as prices of the food wheat and rye on the commodity markets. Prices of the bakery products and flour were expressed by computing the relevant price level. Price level was determined as a ratio of the total quarterly expenditures of the Czech average household for the bakery products and flour ( $x_t$ ) and the purchased quantity of this kind of the food ( $q_t$ ):

$$[P_t]_0 = \frac{x_t}{q_t} \quad (7)$$

Data records about the quarterly expenditures for the bakery products and flour (in CZK) and about the purchased quantities of the bakery products and flour (in kg) for the average Czech household are at disposal within the Czech Statistic Office (CSO), Statistics of Family Budgets, publications, edition 30 – Life Costs. Information about prices of the food wheat and rye were obtained from the monthly records of the Price Statistics of the CSO. With regard to the different time dimension of obtained data, the monthly prices of the food cereals had to be transformed by means of the simple arithmetic average on the average quarterly data. The average quarterly level of the food-wheat price on the commodity market was denoted  $[p1_t]_b$  and average quarterly level of food rye price was denoted  $[p2_t]_b$ .

First, the periodical component in time series  $[P_t]_0$ ,  $[p1_t]_b$ ,  $[p2_t]_b$  was thoroughly tested by means of the harmonic analysis with respect to considered methods of dynamical construction of the models for price transmission. Based on the realised *G*-test of the individual extremes in constructed periodograms, the quarterly seasonal component of the price development on the consumer market with the bakery products and flour was found to be statistically significant (more than 95% level). The seasonal indices of this time series gradually gained for individual quarters these values: I Q: 1.0147; II Q: 1.0156; III Q: 1.0034; IV Q: 0.9663. Computed values were used for removing the seasonal component from the price development on consumer markets  $[P_t]_0$ . Seasonally purged time series was marked  $[P_t^*]_0$ . In the rest of time series  $[p1_t]_b$  and  $[p2_t]_b$  the seasonal components were not statistically significant according to the *G*-test. The values of the quarterly average prices on consumer markets with food grains and the quarterly average values seasonally purged price level on consumer markets with bakery products and flour are depicted in Table 1.

For the quantitative expressing of the price transmission between selected markets, the linear models with dynamic structure were tested, which corresponds partly with the requirements of the used database (Hušek 1999), but mainly with the conclusions of already-made analysis from this field of the research (Revoredo et al. 2004). First, the dynamic construction of the linear models of the price transmission was solved explicitly. For the price transmission between the consumer market with the bakery

products and flour and the commodity market with the food wheat, the dynamic model was defined as follows (7.1):

$$\left[ P_t^* \right]_0 = A1 + B1 \times [p1_t]_b + \tau(t) \quad (7.1)$$

Explicit-dynamical model of the price transmission between the consumer market with the bakery products and flour and the commodity market with the rye was formulated in the following form:

$$\left[ P_t^* \right]_0 = A2 + B2 \times [p2_t]_b + \tau(t) \quad (7.2)$$

By incorporating of the trend function  $\tau(t)$  directly to the equation of the model, the trend-stationary process of the price transmission was carried out (Hušek 1999). As trend functions, three types of polynomial functions in models (7.1) and (7.2) were tested: straight line, parabola and cubic parabola. The time variable (*t*) for the trend functions was introduced by the following way:

$$\begin{aligned} t = 1 & \quad \text{I Q 1995} \\ t = 2 & \quad \text{II Q 1995} \\ & \dots\dots\dots \\ t = 32 & \quad \text{IV Q 2002} \end{aligned} \quad (8)$$

As the second method for the dynamics in the price transmission process between the consumer and the commodity market, models with differentially expressed variables were tested. For trend<sup>1</sup> elimination in time series  $[P_t^*]_0$ ,  $[p1_t]_b$ ,  $[p2_t]_b$  first differences were tested:

Table 1. Quarterly average prices of food wheat and rye, quarterly average values of price level on consumer markets with bakery products and flour

Year	I Q			II Q			III Q			IV Q		
	$\left[ P_t^* \right]_0$	$[p1_t]_b$	$[p2_t]_b$	$\left[ P_t^* \right]_0$	$[p1_t]_b$	$[p2_t]_b$	$\left[ P_t^* \right]_0$	$[p1_t]_b$	$[p2_t]_b$	$\left[ P_t^* \right]_0$	$[p1_t]_b$	$[p2_t]_b$
1995	19.97	2.97	2.62	20.21	3.01	2.70	20.62	2.77	2.41	21.34	2.99	2.42
1996	21.59	3.36	2.65	23.56	3.67	3.03	24.65	4.07	3.53	26.06	4.22	3.85
1997	26.35	4.57	4.04	26.70	4.81	4.03	27.41	4.37	3.69	27.77	4.34	3.86
1998	28.43	4.35	4.03	28.82	4.21	4.01	29.33	3.97	3.55	29.27	3.94	3.37
1999	30.39	3.86	3.28	30.00	3.70	3.19	30.06	3.29	2.69	29.87	3.11	2.45
2000	30.38	3.12	2.41	30.21	3.22	2.44	30.59	3.44	2.70	31.58	3.82	3.28
2001	31.96	4.04	3.67	32.96	4.17	3.96	33.36	3.82	2.41	33.51	3.70	3.85
2002	33.39	3.70	3.99	33.74	3.38	3.96	33.90	3.27	3.36	34.25	3.24	3.48

Source: CSO – Price Statistics, prices of agricultural commodities and CSO – Statistics of Family Budgets

<sup>1</sup>With respect to the use of 1<sup>st</sup> differences there are only linear trends eliminated in selected time series.

$$\begin{aligned} \left[ \Delta^1(p1_{t+1}) \right]_b &= [p1_{t+1}]_b - [p1_t]_b \\ \left[ \Delta^1(p1_{t+1}) \right]_b &= [p1_{t+1}]_b - [p1_t]_b \\ \left[ \Delta^1(p2_{t+1}) \right]_b &= [p2_{t+1}]_b - [p2_t]_b \end{aligned} \quad (9)$$

as it is recommended in many publications from this field research, f. e. Mc Corrison, Morgan and Rayner (2001) etc. However, this way of expressing the dynamics of the observed relationship does not bring trend-stationary process, but only its differential level, which could result in deteriorated statistic characteristics of these models, see Hušek (1999). In accordance with keeping the linear form of the models, the model of the price transmission between the consumer market with the bakery products and flour was described by this equation (10.1):

$$\left[ \Delta^1(P_{t+1}^*) \right]_0 = A1 + B1 \times \left[ \Delta^1(p1_{t+1}) \right]_b \quad (10.1)$$

and differentially stationarized model of the price transmission between the consumer market with the bakery products and flour and the commodity market with the rye was described by the equation (10.2):

$$\left[ \Delta^1(P_{t+1}^*) \right]_0 = A2 + B2 \times \left[ \Delta^1(p2_{t+1}) \right]_b \quad (10.2)$$

With regard to the application of the models (10.1) and (10.2) by analysis of the elasticity of the researched price transmissions, where it is also needed to determine the absolute level of theoretical price level, the assignment of inter-quarterly theoretical differences was done to subsequent period of time, i.e.  $t + 1$ .

The values of individual parameters in regression models of inter-market price transmission (7.1) and (7.2), respectively (10.1) and (10.2) were determined on the basis of ordinary least square (OLS). Statistical verification of the constructed dynamic models of the analysed inter-market price transmission was done according to the traditional testing criterions. Therefore, values of the multiple correlation index  $I1^2$  a  $I2^2$  were determined for all regression models (7.1), (7.2) respectively (10.1), (10.2). By means of  $F$ -test statistical conclusiveness of calculated correlation indices was evaluated;  $F(I1^2)$  a  $F(I2^2)$ , including the calculation of significance level of these  $F$ -tests; i.e. determination of  $\alpha(F1)$  respectively  $\alpha(F2)$ . By means of  $T$ -tests;  $T|A1|$ ,  $T|B1|$ ,  $T|C1|$ ,  $T|D1|$ ,  $T|E1|$  resp.  $T|A2|$ ,  $T|B2|$ ,  $T|C2|$ ,  $T|D2|$ ,  $T|E2|$ , together with determination of their significance levels again;  $\alpha(T|A1|)$ ,  $\alpha(T|B1|)$ ,  $\alpha(T|C1|)$ ,  $\alpha(T|D1|)$ ,  $\alpha(T|E1|)$  and

$\alpha(T|A2|)$ ,  $\alpha(T|B2|)$ ,  $\alpha(T|C2|)$ ,  $\alpha(T|D2|)$ ,  $\alpha(T|E2|)$ , statistical significance of individual parameters of tested pairs of price transmission models was tested. The details for statistical verification are at disposal f. e. in publications: Dufek (1989) or Hušek (1999).

The economic verification of the constructed models of types (7.1), (7.2), respectively (10.1), (10.2) results from the logical assumption, that the price transmission will have positive value from the commodity market with food grains towards the consumer market with the bakery products and flour. Therefore, the parameter  $B1$ , possibly  $B2$ , will be positive for the constructed models of price transmission:

$$B1 > 0 \quad (11.1)$$

$$B2 > 0 \quad (11.2)$$

Positive value of  $B1$  and  $B2$  parameters in models of inter-market price transmission is logical also with respect to the construction of estimations (2) of price elasticity of secondary demand and holding the law of diminishing demand for this function.

After the statistical as well as economic verification of the constructed dynamic models of the price transmission (7.1), (7.2), (10.1), (10.2), it was proceeded with their application, i.e. with the determination of the values of elasticity coefficients in the relevant periods. Based on the relationship (1) coefficients of the price transmission, elasticity ( $EPT$ ) was expressed for both construction of the dynamic linear models (7.1), (7.2) a (10.1), (10.2). For the explicit dynamic model with linear definition of the price transmission between consumer market with the bakery products and flour and the commodity market with the food wheat, the coefficient of elasticity was derived in the following form (12.1):

$$\begin{aligned} [EPT1_t]_{b0} &= B1 \times \frac{[p1_t]_b}{\left[ P_t^* \right]_b} = \\ &= B1 \times \frac{[p1_t]_b}{A1 + B1 \times [p1_t]_b + \tau(t)} \end{aligned} \quad (12.1)$$

Analogically, the elasticity coefficient of the price transmission between the consumer market with the bakery products and flour and the commodity market with the rye was determined (12.2):

$$\begin{aligned} [EPT2_t]_{b0} &= B2 \times \frac{[p2_t]_b}{\left[ P_t^* \right]_b} = \\ &= B1 \times \frac{[p1_t]_b}{A1 + B1 \times [p1_t]_b + \tau(t)} \end{aligned} \quad (12.2)$$

Within differentially stationarized linear models, i.e. models in the form of (10.1) a (10.2), the coefficient of elasticity was defined for the price transmission between the consumer market with the bakery products and flour and the commodity market with the food wheat (13.1):

$$\begin{aligned} [EPT1_{t+1}]_{b0} &= B1 \times \frac{[p1_{t+1}]_b}{\left[ P_{t+1}^* \right]_b + \left[ \Delta^1 (P_{t+1}^*) \right]_b} = \\ &= B1 \times \frac{[p1_{t+1}]_b}{\left[ P_{t+1}^* \right]_0 + A1 + B1 \times \left[ d^1 (p1_t) \right]} \end{aligned} \quad (13.1)$$

For the price transmission between the consumer market with the bakery products and flour and the commodity market with rye expressed by differentially stationarized model in form of (10.2), the elasticity coefficient was derived (13.2):

$$\begin{aligned} [EPT2_{t+1}]_{b0} &= B2 \times \frac{[p2_{t+1}]_b}{\left[ P_{t+1} \right]_b + \left[ d^1 (P_{t+1}) \right]_b} = \\ &= B2 \times \frac{[p2_{t+1}]_b}{\left[ P_{t+1}^* \right]_0 + A1 + B1 \times \left[ d^1 (p2_{t+1}) \right]} \end{aligned} \quad (13.2)$$

From above the mentioned relationships (13.1) and (13.2), it is apparent that we can obtain one value of elasticity coefficient less by this way, because the computing begins with subsequent time period ( $t + 1$ ), i.e. second time period ( $t = 2$ ). The values of elasticity for the analysed price transmission for the first time period ( $t = 1$ ) for models (10.1) and (10.2) can be computed according to the following relationships:

$$[EPT1_1]_{b0} = B1 \times \frac{[p1_1]_b}{\left[ P_1^* \right]_0 + 0} \quad (14.1)$$

$$[EPT2_1]_{b0} = B2 \times \frac{[p2_1]_b}{\left[ P_1^* \right]_0 + 0} \quad (14.2)$$

Before with the estimations of direct price elasticity of the analysed secondary demand functions, it is, however, necessary to determine price elasticity of the consumer demand for the bakery products and for flour, see estimation construction (2). Values of these coefficients of demand elasticity were adopted from the previous researches of the consumer market with the bakery and milling products from 1995–2002

(Srovátka 2004)<sup>2</sup>. The mentioned researches in the field of the price elasticity were based upon dynamic linear formulation of price-income relationships within consumer demand for the bakery products and flour – see model (15):

$$Q_t = A + B \times P_t + D \times t \quad (15)$$

A time variable ( $t$ ) was introduced into the demand model (15) by this way (8) and naturally it was also reflected in dynamic structure of these price elasticity coefficients (16):

$$[\varepsilon_t]_0 = B \times \frac{P_t}{Q_t} = B \times \frac{P_t}{A + B \times p_t + C \times m_t + I} \quad (16)$$

The methodological approaches and all the details of this demand analysis, including material used, are published in Proceedings from the International Scientific Days 2004 with the title “The demand analysis on consumer market with bakery and milling products” (Srovátka 2004). The overview of coefficients of the direct price elasticity of the consumer demand for bakery products and flour obtained within this research is depicted in the following Table 2.

After the determination of both coefficients of elasticity – i.e. ( $EPT$ ) and ( $\varepsilon$ ) – it was possible to proceed with the determination of the price elasticity of investigated vertical-derived demand functions on the market with the food grains according to George and King (1971). The own price elasticity of the secondary demand for food wheat was estimated as follows (17.1):

$$[e1_t]_b = [\varepsilon_t]_0 \times [EPT1_t]_{b0} \quad (17.1)$$

Table 2. Direct price elasticity of consumer demand for bakery and milling products;  $[\varepsilon_t]_0$

Year	I Q	II Q	III Q	IV Q
1995	-0.2907	-0.2901	-0.2891	-0.2794
1996	-0.3104	-0.3358	-0.3575	-0.3508
1997	-0.3963	-0.3904	-0.4027	-0.3762
1998	-0.4250	-0.4269	-0.4306	-0.3931
1999	-0.4726	-0.4488	-0.4464	-0.4100
2000	-0.4893	-0.4584	-0.4685	-0.4430
2001	-0.5030	-0.5062	-0.5168	-0.4655
2002	-0.5365	-0.5259	-0.5283	-0.4884

Source: Srovátka (2004)

<sup>2</sup>Alternatively it is also possible to use some earlier researches (or their parts), see Srovátka, Blažková (2003).

The estimations of the direct price elasticity of the secondary demand for the rye were realized in accordance with the analogical relationship (17.2):

$$[e2_t]_b = [\varepsilon_t]_0 \times [EPT2_t]_{b0} \quad (17.2)$$

## RESULTS AND DISCUSSION

In relation to the selected methodology of the estimations of own price elasticity of the commodity demand for the food grains, it was necessary to determine the level of elasticity of the price transmission between the market with food wheat and rye and consumer market with bakery products and flour. For measuring the intensity of the inter-market price transmission, linear models of price transmission with two basic methods of dynamization were tested. The price transmission between the commodity market with food wheat and consumer market with bakery products and flour was firstly defined by linear model with explicit dynamization, see model construction

(7.1). Specifically, the linear model with parabolic trend stationarization was used for the depicting of this price transmission<sup>3</sup>.

The dynamics of the price transmission between the commodity market with the rye to consumer market with the bakery products and flour was expressed by the same way, i.e. model (7.2). Both observed price transmissions were also analysed on the basis of linear models with differential stationarization, see models (10.1) and (10.2). For modelling of the price transmissions according to (10.1), respectively (10.2), the first differences of relevant variables were used (9), which eliminate the linear trend in the used data. The computed values of the individual parameters of the regression models of the inter-market price transmissions together with their basic indicators of the statistical verification are showed in the following two tables – Table 3 and Table 4.

From the computed statistical characteristics illustrated in Table 3 and 4, it is obvious that from the view of the dynamic construction the linear models of the inter-market price transmission with the explicit

Table 3. Explicit-dynamic linear models of inter-market price transmission and their basic statistic characteristics

Linear model with parabolic trend stationarization for the price transmission from commodity market with food wheat to consumer market with bakery products and flour:		
$\left[ P_t^* \right]_0 = A1 + B1 \times [p1_t]_b + C1 \times t + D1 \times t^2 \quad (18.1)$		
$A1 = 15.3048$	$T A1  = 24.2995$	$\alpha(T A1 ) = 2.3210 \times 10^{-20}$
$B1 = 1.2106$	$T B1  = 5.2767$	$\alpha(T B1 ) = 5.3204 \times 10^{-7}$
$C1 = 0.6822$	$T C1  = 11.9476$	$\alpha(T C1 ) = 1.5655 \times 10^{-15}$
$D1 = -7.0957 \times 10^{-3}$	$T D1  = 5.2990$	$\alpha(T D1 ) = 6.0740 \times 10^{-6}$
$I1^2 = 0.9895$	$F(I1^2)_{3,28} = 880.2958$	$\alpha(F) = 8.4398 \times 10^{-28}$
Linear model with parabolic trend stationarization for price transmission from commodity market with rye to consumer market with bakery products and flour:		
$\left[ P_t^* \right]_0 = A2 + B2 \times [p2_t]_b + C2 \times t + D2 \times t^2 \quad (18.2)$		
$A2 = 16.4008$	$T A2  = 33.5305$	$\alpha(T A2 ) = 3.7825 \times 10^{-24}$
$B2 = 0.9151$	$T B2  = 6.3435$	$\alpha(T B2 ) = 7.2993 \times 10^{-7}$
$C2 = 0.7765$	$T C2  = 20.3874$	$\alpha(T C2 ) = 2.4512 \times 10^{-18}$
$D2 = -1.0367 \times 10^{-2}$	$T D2  = 9.3332$	$\alpha(T D2 ) = 4.3168 \times 10^{-10}$
$I2^2 = 0.9893$	$F(I2^2)_{3,28} = 860.8468$	$\alpha(F) = 1.1500 \times 10^{-27}$

<sup>3</sup>From the tested polynomial functions for depicting of the trend component  $\tau(t)$  in the explicit dynamic models, there was on the basis of the value of multiple corrected correlation index chosen as the most suitable second order polynomials.

Table 4. Implicit-dynamic linear models of inter-market price transmission and their basic statistic characteristics

Linear model with differential trend stationarization for price transmission from commodity market with food wheat to consumer market with bakery products and flour:		
$\left[ \Delta^1 (P_{t+1})^* \right]_0 = A1 + B1 \times \left[ \Delta^1 (p_{t+1}) \right]_b \quad (10.1)$		
$A1 = 0.4540$	$T A1  = 5.3526$	$\alpha (T A1 ) = 9.5215 \times 10^{-6}$
$B1 = 0.7642$	$T B1  = 2.1366$	$\alpha (T B1 ) = 4.1197 \times 10^{-2}$
$I1^2 = R1^2 = 0.1360$	$F(I1^2)_{1,29} = 4.5650$	$\alpha (F) = 4.1197 \times 10^{-2}$
Linear model with differential trend stationarization for price transmission from commodity market with rye to consumer market with bakery products and flour:		
$\left[ P_t^* \right]_0 = A2 + B2 \times [p2_t]_b + C2 \times t + D2 \times t^2 \quad (10.2)$		
$A2 = 0.4543$	$T A2  = 5.1036$	$\alpha (T A2 ) = 1.9018 \times 10^{-5}$
$B2 = 0.2331$	$T B2  = 1.2366$	$\alpha (T B2 ) = 0.2262$
$I2^2 = R2^2 = 0.0501$	$F(I2^2)_{1,29} = 1.5292$	$\alpha (F) = 0.2262$

expression of time component (models in Table 3) turned out to be better. For these dynamic models (18.1) and (18.2), correlation indices approached the value of 99%, which was also reflected into indicators of the statistical verification ( $F$ -tests and  $T$ -tests of individual parameters). On the contrary, linear models of the price transmission with indirect form of dynamization, in this case models with differential stationarization (see Table 4), gained very low values of correlation coefficients (13.6% a 5%). For the model of price transmission between commodity market with rye to consumer market with bakery products and flour, the significance level of  $T$ -tests did not even gain the 10% level (22%). This model cannot therefore be considered as statistically verified. From these reasons, exclusively linear models with parabolic trend stationarization (18.1) and (18.2) were used for subsequent quantification of elasticity of analysed inter-market price transmissions, although many researches in this field recommend models with differential stationarization (f. e. Mc Corrison, Morgan and Rayner 2001).

Statistically verified models (18.1) and (18.2) were also consecutively tested from the position of diminishing demand mechanism, that in connection with the estimations of the direct price elasticity of the selected secondary demand functions constructed according to (2) unambiguously defines coincident orientation of the selected inter-market transmissions. Positive level of the intensity of analysed inter-market price transmissions also seems to be logical from the point of view of the direction of the carried-out

analysis (the price transmission from the commodity market to the consumer market). From this point of view, both constructed models of inter-market price transmission (18.1) and (18.2) were considered to be economically adequate, because their parameters  $B1$ , respectively  $B2$  were positive, thus the relationship (11.1) or (11.2) is valid.

After finishing statistical and economic verification of the price transmission models with explicitly defined trend component (18.1) a (18.2), it was proceeded with their application. Coefficients of the price transmission elasticity between the commodity market with the food wheat to the consumer market with the bakery products and flour were computed in accordance with the relationship (12.1). According to the analogical relationship (12.2), the coefficients of elasticity of the price transmission between the commodity market with rye to the consumer market with bakery products and flour were determined. The achieved coefficients of the elasticity  $[EPT1_t]_{b0}$  and  $[EPT2_t]_{b0}$  within observed time period (1995–2002) are ranked according to individual quarters in Table 5.

From the computed values of the elasticity of the first type  $[EPT1_t]_{b0}$ , it is obvious that in the observed time period 1995–2002 the elasticity of price transmission between the commodity market with food wheat to the consumer market with bakery products and flour ranged from 0.1162 to 0.2138. An average value<sup>4</sup> of the price transmission elasticity according to linear model with parabolic trend stationarization (18.1) reached in the observed time

<sup>4</sup>The average value was determined by means of simple arithmetic average.



period the value of 0.1602. Accordingly 1% change of price on the commodity market with food wheat was vertically transmitted on the consumer market with bakery products and flour in the form of the average increase in the price level on this final market by 0.1602%.

The coefficients of the second type, i.e. coefficients of the price transmission between the commodity market with rye to the consumer market with bakery products and flour  $[EPT2_t]_{b0}$ , showed in the same period (1995–2002) noticeably lower values. Minimum value of the inter-market price transmission was in this case equal to +0.0689% and maximum value reached only +0.1409%. The average level of the price transmission elasticity between the selected market reached according to the linear model (18.2) in this time period the level of +0.1067%, which means that 1% change in price on the commodity market with rye was in observed time period transmitted to the

consumer market with bakery products and flour in the form of the price level increase on these market in average by 0.1067%. Based upon the found out coefficients, it is possible to label both analysed inter-market price transmission as strongly inelastic.

After the determination price transmission elasticity between selected markets, i.e. determining of the coefficients  $[EPT1_t]_{b0}$ , respectively  $[EPT2_t]_{b0}$ , the analysis proceeded with the estimations of the own price elasticity of the commodity demand for food wheat (16.1) and commodity demand for rye (16.2). For this purpose, the coefficients of direct price elasticity of consumer demand for bakery products and flour  $[e_t]_0$  were used on one side (see Table 2), and on the other side, coefficients of the price transmission elasticity  $[EPT1_t]_{b0}$ ,  $[EPT2_t]_{b0}$ , that are depicted in Table 5. The estimations of the own price elasticity of the commodity demand for food wheat  $[e1_t]_b$  and own price elasticity of commodity demand for rye

Table 5. Coefficients of elasticity of price transmission between commodity market with food wheat to consumer market with bakery products and flour:

Year	I Q		II Q		III Q		IV Q	
	$[EPT1_t]_{b0}$	$[EPT2_t]_{b0}$	$[EPT1_t]_{b0}$	$[EPT2_t]_{b0}$	$[EPT1_t]_{b0}$	$[EPT2_t]_{b0}$	$[EPT1_t]_{b0}$	$[EPT2_t]_{b0}$
1995	0.1834	0.1225	0.1797	0.1211	0.1622	0.1058	0.1679	0.1029
1996	0.1798	0.1078	0.1886	0.1182	0.1999	0.1314	0.2009	0.1382
1997	0.2097	0.1409	0.2139	0.1376	0.1941	0.1248	0.1896	0.1273
1998	0.1863	0.1298	0.1784	0.1269	0.1673	0.1121	0.1636	0.1055
1999	0.1583	0.1013	0.1505	0.0975	0.1343	0.0825	0.1259	0.0748
2000	0.1247	0.0727	0.1267	0.0727	0.1328	0.0792	0.1436	0.0937
2001	0.1491	0.1028	0.1517	0.1090	0.1393	0.0689	0.1345	0.1050
2002	0.1334	0.1078	0.1224	0.1067	0.1177	0.0915	0.1162	0.0943

Table 6. The estimations of direct price elasticity of commodity demand for food wheat

Year	I Q		II Q		III Q		IV Q	
	$[e1_t]_b$	$[e2_t]_b$	$[e1_t]_b$	$[e2_t]_b$	$[e1_t]_b$	$[e2_t]_b$	$[e1_t]_b$	$[e2_t]_b$
1995	-0.0533	-0.0356	-0.0522	-0.0351	-0.0469	-0.0306	-0.0469	-0.0288
1996	-0.0558	-0.0335	-0.0633	-0.0397	-0.0715	-0.0470	-0.0705	-0.0485
1997	-0.0831	-0.0558	-0.0835	-0.0537	-0.0782	-0.0503	-0.0713	-0.0479
1998	-0.0792	-0.0551	-0.0762	-0.0542	-0.0720	-0.0483	-0.0643	-0.0415
1999	-0.0748	-0.0479	-0.0675	-0.0438	-0.0599	-0.0368	-0.0516	-0.0306
2000	-0.0610	-0.0356	-0.0581	-0.0333	-0.0622	-0.0371	-0.0636	-0.0415
2001	-0.0750	-0.0517	-0.0768	-0.0552	-0.0720	-0.0356	-0.0626	-0.0489
2002	-0.0716	-0.0579	-0.0644	-0.0561	-0.0622	-0.0483	-0.0568	-0.0460

$[e2_t]_b$  are according to the individual quarters summarized in Table 6.

From the above-mentioned Table 6, it is apparent that both commodity demand functions showed in the observed time period 1995–2002 very strongly inelastic price reactions. In case of the commodity demand for food wheat  $[e1_t]_b$ , the level of the direct price transmission elasticity ranged between  $-0.0469$  and  $-0.0835$ . The average coefficient of the price elasticity of this secondary demand function reached the value of  $-0.0657$ . On the basis of the average level of this coefficient, it can be stated that within the observed period 1% increase of the food wheat price caused decrease in demand in average by 0.0657% on the commodity market. By assessing of the direct price elasticity of commodity demand for rye  $[e2_t]_b$ , the price reactions were significantly weaker, i.e. this secondary demand is much more inelastic. The coefficients of the price elasticity of this secondary demand function were ranged between  $-0.0288$  and  $-0.0579$ . The average coefficient of the own price elasticity of the commodity demand for rye reached within 1995–2002 the value of  $-0.0441$ . Accordingly, in case of 1% increase in the price of rye the decrease of quantity demanded of this commodity in average by 0.0459% could be expected. With respect to the price reactions of the commodity demand for food wheat, lower level of the price elasticity of the commodity demand for rye is in accordance with the composition of these two agricultural commodities within the commodity chain of food grains.

## CONCLUSION

For the quantitative analysis of the price transmission elasticity between the commodity markets with food grains and the consumer markets with bakery products and flour (*EPT*), the regression linear models with dynamic construction were used. The definition of the dynamic structure of models was tested both in explicit and implicit expression. The explicit dynamization was done on the basis of the parabolic-trend stationarization, which was foregone by thorough verification of the seasonal component by means of the harmonic analysis (*G*-tests of extremes of periodgrams). The implicit dynamization of linear models was solved on the basis of first differences of relevant prices, respectively price levels. Finally, models with explicit dynamics were exclusively used for the quantification of price transmission elasticity, which unambiguously showed better values of statistical characteristics (correlation index, *F*-tests, *T*-tests). These models also entirely fulfilled the economic presumptions

in the sense of vertical price transmissions between observed market levels and law of declining demand for secondary demand functions. On the basis of the constructed linear models with parabolic-trend stationarization of the price transmission, it was found out that in the observed time period 1995–2002 the elasticity of price transmission between commodity market with food wheat and consumer market with bakery products and flour reached the average level of  $+0.1602\%$ . Within the same period, the elasticity of price transmission between commodity market with food wheat and consumer market with bakery products reached according to the analogical model the average value of  $+0.1067\%$ . Coefficients of elasticity of analysed price transmissions (*EPT*) were finally used together with coefficients of direct price elasticity of consumer demand for bakery products and flour ( $\epsilon$ ) for the estimations of own price elasticity of commodity demand for food wheat and rye ( $e$ ). In accordance with the construction of the estimations:  $e = \epsilon \times ETP$ , it was found out that the average level of direct price elasticity of commodity demand for food wheat is about  $-0.0659\%$  and the average level of direct price elasticity of commodity demand for rye is about  $-0.0441\%$ . Both observed secondary demand functions are therefore strongly inelastic with regard to the reaction to the direct price changes, while commodity demand for rye seems to be more inelastic.

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