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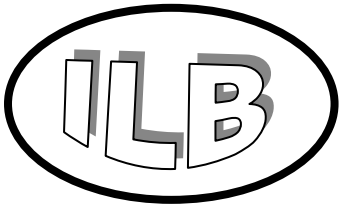

Modelling of the Demand Relations within the Commodity Chain: Application on the Wheat Commodity Chain in the Czech Republic

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Abstract

The paper is focused on formulation of demand relations in the commodity chain. Created model respects interdependence and interconnection of particular stages within the food commodity chain – it takes into account the fact that secondary demand function is formed not only by particular prices but also by level of demand on vertical previous market. The functions of primary consumer demand for final products and the functions of derived demands at the level of retail, processing and agricultural production are modeled. The wheat commodity chain in the Czech Republic is chosen for the application. Statistical verification of the model and derivation of standard characteristics of market subjects' behaviour (elasticities) are made. The model shows that demand of consequential vertical stage significantly takes a share in the size of particular secondary demand, consumer demand for basic bakery products is price and income inelastic and there are weak cross price elasticities among consumption of basic bakery products.

Key words: *Commodity chain, vertical demand system, demand interconnection, primary demand, secondary demand*

Introduction

One of the most typical features of contemporary world economic development is market interconnection and interdependence among different market levels within the horizontal and vertical linkages. New economic and social structures, their functions and processes are more and more organized on the basis of so-called nets, *Bečvářová (2006)*.
These changes are obvious also in the agrarian sector. Formation of the world food economy within the global nets is considered to be one of three decisive factors (together with new technologies and increasing consumer concern about food safety) determining development and future of the agrarian sector in European and world context. Changes in demographic structure, income and social position of consumers and changes of life style alter fundamentally nature of demand for food and other products of agricultural origin. Food is viewed as product of daily consumption with high value added that provides basic function of saturation, pleasure and health.
There are many factors affecting particular stages of agro-food chains, e.g. liberalisation of trade, changing consumer demand and increasing interest in food quality, animal welfare and environmental issues, increasing competition on the saturated agro-food markets, continuous concentration in the manufacturing industry and retail trade sector. Agribusiness[1] firms, in general, are confronted with rapidly changing markets and an almost world-wide competition. As a consequence, markets have become more dynamic and complex, *Lubbers, Koorevaar*

1. Agribusiness is conceptualized according to the Davis-Goldberg concept (1957).

(1999), Saxowsky, Duncan (1998), Boehlje, Akridge, Kalaitzandonakes (2002). These developments accentuate the degree of interdependence among different levels of food production in the agro-food chain.
Supply chain is now formed especially on the evaluation of supply and demand interactions on the segmented markets within the whole agribusiness, whereas food demand should be transformed into agricultural commodity demand through market signals, so that consumer demand for food determines the amount and structure of farm production, *Bečvářová (2006*). As success anticipation of all vertical subjects can be considered sophistication and ability to use information for immediate evaluation of the market situation, ability to anticipate demand in details and to respond to it in the supply.

Objectives and Methodology

The paper focuses on formulation of demand relations system in the framework of chosen commodity chain by means of economic-mathematical model. The approach is based on vertically recursion determination of secondary demand functions. It is supposed that primary consumer demand function is a basic function and other market (secondary) demand functions, that characterise demand on the first up to n-tuple stage of agricultural commodity processing, are linked to it. In addition to price influences, the demand of consequential vertical stage is always included in explanatory factors while constructing secondary demand functions. The model takes into account the fact that secondary demand function is formed not only by particular prices but also by level of demand on vertical previous market.
Source data are represented by time series, which is to be taken into account while modelling of demand relations, *Minařík (1998*). For this reason directly dynamized models are defined to quantify dependences in given demands. Designed models arise from linear form of relations, which appears sufficient regarding achieved determination indexes.
The wheat commodity chain is chosen for the application. The data published by The Czech Statistical Office and The Czech Ministry of Agriculture are used for modelling of subjects' behaviour on the particular markets within the wheat commodity chain. On the consumer market the demands for bread, rolls and flour are quantified (as primary demand functions) to find out the behaviour of demand subjects. Thereinafter the demand of bakeries for flour and the demand of mills for wheat (as secondary demand functions) are quantified. Regression analysis (OLS) is used for estimation of model parameters, *Gujarati (1988)*. Statistical verification of the constructed model and derivation of standard characteristics of behaviour (elasticities) are performed.

Results and Discussion

Interconnection among primary consumer demand and secondary (derived) demands in the wheat commodity chain can be seen in Figure 1, *Blažková (2002*). For simplification the possibility of wheat trade by middlemen was not included. There was also not distinguished retail and wholesale.

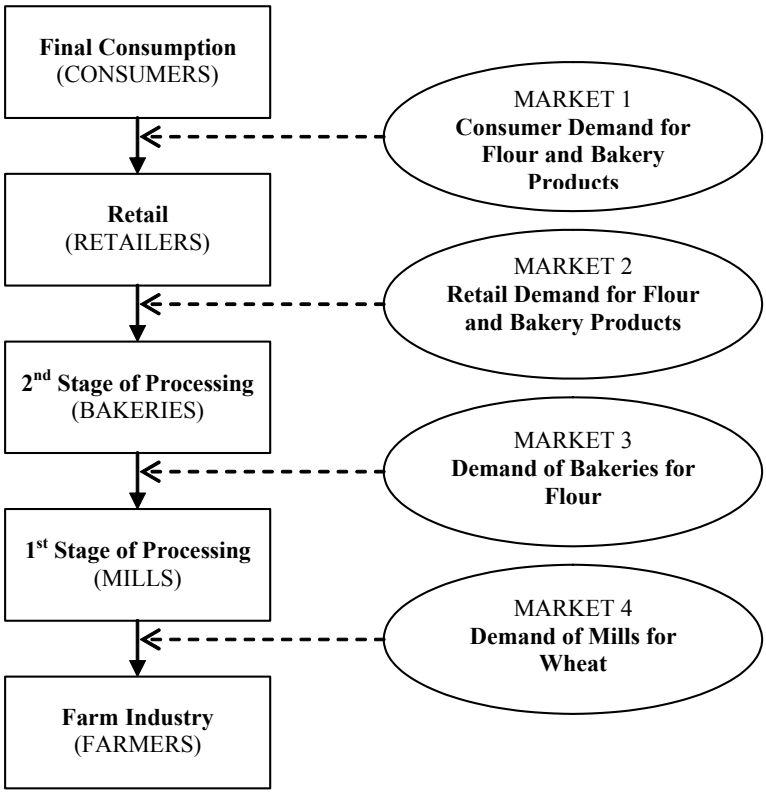

Figure 1. Wheat commodity chain

Consumer demand for flour and bakery products (see MARKET 1) can be in a simplified way formulated:

$$Q_{[1]a}=f_{[1]a}(p_{[1]1a}, p_{[1]2a}, \ldots, p_{[1]ka}, m) \quad (1)$$

respectively

$$Q_{[1]b}=f_{[1]b}(p_{[1]1b}, p_{[1]2b}, \ldots, p_{[1]lb}, m) \quad (2)$$

Retail demand for flour and bakery products is directly derived from consumer demand. Decision-making of subjects on a secondary level depends not only on consumer demand but also on other factors (e.g. financial funds of the subject, expectation of the subject, market size and others). For practical formulation there are considered only price influences. Demand function on the retail stage (MARKET 2) can be in a simplified way formulated:

$$Q_{[2]a} = f_{[2]a} (p_{[2]1a}, p_{[2]2a}, \ldots, p_{[2]na}, Q_{[1]a}) \quad (3)$$

respectively

$$Q_{[2]b} = f_{[2]b} (p_{[2]1b}, p_{[2]2b}, \ldots, p_{[2]ob}, Q_{[1]b}) \quad (4)$$

Demand of subjects at the 2nd stage of processing (demand of bakeries for flour) is a demand indirectly derived from consumer demand. It is derived by force of retail demand for bakery products. Formal notation of demand function on the 2nd stage of processing (MARKET 3) can be:

$$Q_{[3]} = f_{[3]} (p_{[3]1}, p_{[3]2}, \ldots, p_{[3]r}, Q_{[2]b}) \quad (5)$$

Demand of subjects at the 1st stage of processing (demand of mills for wheat) is also a demand indirectly derived from consumer demand. It is derived by force of bakeries and retail demand for flour. Demand function on the 1st stage of processing (MARKET 4) can be formulated:

$$Q_{[4]} = f_{[4]} (p_{[4]1}, p_{[4]2}, \ldots, p_{[4]s}, Q_{[3]}, Q_{[2]a}) \quad (6)$$

Clarification of graphic symbols used for formulation of demand functions (1)-(6) is itemised in Table 1.

Table 1. Graphic symbol meaning

$p_{[1]1a}$, $p_{[1]2a}$, …, $p_{[1]ka}$	consumer prices of mill products and other products with substitution or complementary relation
$p_{[1]1b}$, $p_{[1]2b}$, …, $p_{[1]lb}$	consumer prices of bakery products and other products with substitution or complementary relation
$p_{[2]1a}$, $p_{[2]2a}$, …, $p_{[2]ma}$	processor prices of mill products offered by mills and other prices that influence decisions of retailers about purchases of foodstuffs
$p_{[2]1b}$, $p_{[2]2b}$, …, $p_{[2]ob}$	processor prices of bakery products offered by bakeries and other prices that influence decisions of retailers about purchases of foodstuffs
$p_{[3]1}$, $p_{[3]2}$, …, $p_{[3]r}$	processor prices of flour offered by mills and other prices that influence decisions of bakeries about production
$p_{[4]1}$, $p_{[4]2}$, …, $p_{[4]s}$	farm prices of wheat offered by farms and other prices that influence decisions of mills about production
a	index symbolizes various kinds of mill products (e.g. smooth flour, whole-meal flour)
b	index symbolizes various kinds of bakery products (e.g. bread, rolls, buns and so on)
m	consumer income
$Q_{[1]a}$	purchases of mill products realised by consumers
$Q_{[1]b}$	purchases of bakery products realised by consumers
$Q_{[2]a}$	purchases of mill products realised by retailers
$Q_{[2]b}$	purchases of bakery products realised by retailers
$Q_{[3]}$	purchases of flour realised by bakeries
$Q_{[4]}$	purchases of wheat realised by mills

On the basis of available data the model of demand functions was framed (Table 2). By reason of unavailability of necessary data for modelling of the secondary demand at the retail stage it was thought of retail demand (MARKET 2) as identical with consumer demand (MARKET 1).

Table 2. Model of demand relations within the wheat commodity chain

Consumer market for flour, bread and rolls – MARKET 1
Demand of the average Czech consumer for flour (1.1):
$Q'_{[1]1t} = 13.1883 + 0.0648\ p_{[1]1t} + 0.00004\ m_t - 0.4446\ t$
Demand of the average Czech consumer for bread (2.1):
$Q'_{[1]2t} = 66.3570 - 0.0848\ p_{[1]2t} - 0.1590\ p_{[1]3t} - 0.00003\ m_t - 0.2725\ t$
Demand of the average Czech consumer for rolls (2.2):
$Q'_{[1]3t} = 47.1995 + 0.6433\ p_{[1]2t} - 0.9793\ p_{[1]3t} + 0.00008\ m_t + 1.4901\ t$
Processor market for flour – MARKET 3
Demand of bakeries for flour (5.1):
$Q'_{[3]t} = 459806 + 13.3839\ p_{[3]t} + 394.8794\ Q_{[1](2+3)t} + 3629.403\ t$
Commodity market for wheat – MARKET 4
Demand of mills for wheat (6.1):
$Q'_{[4]t} = -1526990 - 62.5404\ p_{[4]t} + 2.1926\ Q_{[3]t} + 108422.1\ Q_{[1]1t} + 3739.873\ t$

Multiple determination coefficient (R^2) and multiple correlation coefficient (R) were used for statistical model verification. General statistical demonstrativeness of the model was evaluated by means of F-test. Standard characteristics of behaviour of demand subjects – elasticieties - were derived and are listed in Table 3. Statistical model verification is listed in Table 4.

Table 3. Elasticities

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**average**
$p_{[1]1}e_{[1]1}$	0.0396	0.0390	0.0368	0.0413	0.0453	0.0419	0.0374	0.0339	0.0382	0.0386	0.0389	0.0433	0.0379	0.0357	**0.0391**
$me_{[1]1}$	0.1279	0.1482	0.1858	0.2157	0.2252	0.2590	0.2789	0.2957	0.3207	0.3378	0.3607	0.3816	0.4112	0.4401	**0.2849**
$p_{[1]2}e_{[1]2}$	-0.0128	-0.0141	-0.0158	-0.0203	-0.0242	-0.0246	-0.0229	-0.0214	-0.0226	-0.0223	-0.0244	-0.0246	-0.0243	-0.0271	**-0.0215**
$p_{[1]3}e_{[1]2}$	-0.0493	-0.0539	-0.0593	-0.0768	-0.0896	-0.0882	-0.0785	-0.0719	-0.0766	-0.0743	-0.0787	-0.1038	-0.1003	-0.1202	**-0.0801**
$me_{[1]2}$	-0.0235	-0.0272	-0.0350	-0.0422	-0.0440	-0.0511	-0.0537	-0.0555	-0.0609	-0.0630	-0.0672	-0.0723	-0.0772	-0.0840	**-0.0541**
$p_{[1]3}e_{[1]3}$	-0.4659	-0.4899	-0.5108	-0.6635	-0.7731	-0.6969	-0.5656	-0.4836	-0.4962	-0.4583	-0.4662	-0.6627	-0.5994	-0.7314	**-0.5760**
$p_{[1]2}e_{[1]3}$	0.1491	0.1582	0.1671	0.2159	0.2577	0.2398	0.2030	0.1779	0.1808	0.1698	0.1778	0.1937	0.1791	0.2031	**0.1909**
$me_{[1]3}$	0.0885	0.0987	0.1202	0.1454	0.1514	0.1612	0.1544	0.1490	0.1574	0.1549	0.1587	0.1843	0.1841	0.2039	**0.1509**
$p_{[3]}e_{[3]}$	0.1297	0.1292	0.1161	0.1426	0.1661	0.1581	0.1377	0.1256	0.1345	0.1302	0.1270	0.1392	0.1239	0.1220	**0.1344**
$Q_{[1](2+3)}e_{(3)}$	0.0675	0.0683	0.0688	0.0667	0.0625	0.0620	0.0631	0.0725	0.0703	0.0694	0.0690	0.0664	0.0670	0.0624	**0.0669**
$p_{[4]}e_{[4]}$	-0.1761	-0.1569	-0.1383	-0.1918	-0.2243	-0.2021	-0.1689	-0.1870	-0.2146	-0.1775	-0.1889	-0.2033	-0.1457	-0.1657	**-0.1815**
$Q_{[3]}e_{(4)}$	1.0560	1.0552	1.0228	1.0620	1.1292	1.0960	1.0867	1.1392	1.1862	1.1554	1.2084	1.1854	1.1871	1.1503	**1.1228**
$Q_{[1]1}e_{(4)}$	1.4172	1.3800	1.3214	1.2952	1.3441	1.3299	1.3219	1.3361	1.3500	1.2796	1.2902	1.3067	1.2118	1.2557	**1.3171**

Table 4. Statistical verification of developed model

Demand function	R^2	*R*	*F*
(1.1)	0.9269	0.9627	99.99 %
(2.1)	0.9494	0.9743	99.99 %
(2.2)	0.8367	0.9147	99.86 %
(5.1)	0.7384	0.8593	99.71 %
(6.1)	0.3458	0.5880	62.13 %

Demand behaviour of subjects on the consumer market

Through the use of income elasticity coefficient it was found out that flour is a normal good for the average Czech consumer – increase in consumer income by 1 % led to increase in flour consumption by 0.2849 %. Positive own price elasticity reflects that the average Czech consumer reacted to increase in flour price by increase in its consumption (own price elasticity coefficient was 0.0391). It is theoretically possible to account for this behaviour e.g. by higher increase in real incomes in comparison with increase in flour price, when increase in purchases of consumers could be caused by relatively cheap products in regard of disposable income. Values of elasticity coefficients correspond to both price and income highly inelastic demand for flour.
Increase in income of average Czech consumer by 1 % resulted in decrease in bread consumption by 0.0541 %, which followed from income elasticity coefficient. Bread had a character of slightly inferior good for consumer in observed time period and its consumption could be substituted by other kinds of bakery products when income had increased. Even though bread is generally believed to be necessary good of normal character, *Koutsoyannis (1979), Blažková, Syrovátka (2008*), this result could be caused by including consumption only of basic kind of bread in the model – consumer income rapidly increased after 1990 and supply of bakery products' assortment scaled up, which could cause consumers to substitute basic bread kinds by other special kinds of more expensive bread and bakery products. The average Czech consumer reacted to increase in bread price by decrease in its consumption (own price elasticity coefficient was -0.0215). Cross price elasticity (-0.0801) indicated weak complementary relations between bread and rolls purchases. Generally the consumer demand for bread can be accounted as price inelastic, which corresponds to given kind of foodstuff.
Demand for rolls was proved to be income inelastic (0.1509) and rolls had character of normal goods. Increase in price of rolls by 1 % led to decrease in consumer consumption of rolls by 0.5760 %. Weak substitution relations were found between bread and rolls consumption (cross price elasticity was 0.1909).

Demand behaviour of subjects on the processor market

The model showed that in studied time period bakeries reacted positively to increase in processor price of flour offered by mills – such unusual behaviour of producer could be the cause of, for example, relative price depreciation of other production inputs that are not included in the model, low impact of flour price on bakery production in relation to other factors (e.g. production factors or consumer demand), time lag of bakery reactions to price changes. Quantified demand function showed positive dependence between consumer consumption of bakery products and production of these bakery products in bakeries. Related elasticity coefficient was 0.0669. It was confirmed that bakeries derive their production from primary demand.
On the market for wheat it was found out price inelastic demand of mills for wheat – increase in wheat price by 1 % led to decrease in wheat demanded by 0.1815 %. Analysis of relations between wheat demanded by mills and flour demanded by bakeries and consumers showed that

wheat demanded by mills increases both when flour demanded by bakeries increases (1.1228) and flour demanded by consumers increases (1.3171).

Conclusions

Created model of demand relations within the wheat commodity chain demonstrated interrelations among particular vertical stages and interconnection of particular demand functions within the commodity chain. As primary demand, at what secondary demands are dependent, final consumer demand for basic bakery products was considered. Consumer demand for mill and bakery products turned out to be both price and income inelastic, weak cross price elasticities among consumption of basic bakery products were detected. In the model it was validated dependence of processor demands on demands of subsequent vertical stages, it means positive dependence between flour purchases realised by bakeries and consumption of bakery products realised by consumers, and positive dependence between wheat purchases realised by mills and flour purchases realised by bakeries and consumers. As resulted from the model, while constructing secondary demand functions it is useful to include the demand of consequential vertical stage in explanatory factors, because the demand of consequential vertical stage significantly takes a share in the size of particular secondary demand.

In the created model it would be appropriate to analyse potential lag between particular stages of given vertical. Determination of suitable lag length, respectively distribution of its influence in time *t*, is however rather multivalent matter and requires individual additional analysis, *Hušek (1999)*. Inclusion of vertically previous demand impact in secondary demand functions points out additional possibilities of economic analysis, e.g. evaluation of dynamic price elasticity and recursion elasticity of secondary demand functions.

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References

Bečvářová, V. (2006) *Agribusiness has changed the criteria for success of agricultural enterprises*. Annals of the Polish Association of Agricultural and Agribusiness Economists. Vol. VIII, No. 6, p. 1-11. ISSN 1508-3535.

Blažková, I. (2002) *Úloha zpracovatele při formování poptávky po zemědělském produktu*. Doctoral dissertation thesis. PEF MZLU Brno. 124 p.

Blažková, I., Syrovátka, P. (2003) *Analýza cenových a příjmových vztahů ve spotřebitelské poptávce po pekárenských výrobcích*. Acta Mendelovy zemědělské a lesnické univerzity v Brně, Vol. 51, No. 2, p. 71-82. ISSN 1211-8516.

Boehlje, M.d., Akridge, J.t., Kalaitzandonakes, N.G. (2002) *Preparing for Success in the Agribusiness Market Place*. Journal of Agribusiness, 20 (1).

Davis, J. H., Goldberg, R. A. (1957) *A Concept of Agribusiness*. Boston Mass: Research Division, Harvard Business School.

Gujarati, D.N. (1988) *Basic Econometrics*. Second Edition, McGraw-Hill, Inc., 705 p. ISBN 0-07-025188-6.

Hušek, R. (1999) *Ekonometrická analýza*. . vyd. Praha: Ekopress. 303 s. ISBN 80-86119-19-X.

Koutsoyiannis, A. (1979) *Modern Microeconomics.* Second Edition, McMillan Press. 581 p. ISBN 0-333-25349-3.

Lubbers, R., Koorevaar, J. (1999) *Primary Globalisation, Secondary Globalisation, and the sustainable Development paradigm – Opposing Forces in the 21st Century*. In: Century Social Dynamics: Towards the Creative Society, OECD Forum for the Future, Berlin.

Minařík, B. (1998) *Statistika III*., PEF MZLU, Brno. p.154. ISBN 80-7157-189-X.

Saxowsky, D.M., Duncan, M.R. (1998) *Understanding Agriculture´s Transition into the 21st Century*. NDSU, Fargo ND 58105-5636, 31 pp.

Syrovátka, P., Bečvářová, V., Vinohradský, K., Lechanová, I. (2004) *Analýza elasticity poptávkových vztahů ve výrobkové vertikále obilí v podmínkách transformace českého agrárního sektoru*. (Research Study). PEF MZLU, Brno, 46 p.

Statistická ročenka České republiky. Czech Statistical Office. Available from <http://www.czso.cz>

Situační a výhledová zpráva Obiloviny. The Czech Ministry of Agriculture. Available from <http://www.mze.cz>