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# DETERMINATION OF VARIABLES FOR SOFT SAWNWOOD DEMAND MODELS

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## ABSTRACT

The issue of input variables for demand modelling in the soft sawnwood market is addressed in the paper. The procedure is based on theoretical assumptions and possible effects of factors and on the analysis of conditions on wood and wood products market, between which there are certain links. An overview of the theoretical aspects of derived demand, the characteristics of demand on the wood and wood product markets is provided in the introductory part. It is also focused on the determination of market factors. The procedure and selection of input variables for classification into models, their quantification and methods of logical and statistical verification are defined. Basic data and variables for econometric models are captured and used to create models of domestic demand for soft sawnwood. The results represent the basic functional relationships between the factors that affect domestic demand. The benefits relate to the development of knowledge in the field of modelling of the market for wood products and represent a concretization of relevant factors of demand for soft sawnwood in the years 1990-2020 in the Slovak Republic. The basic factors that appear to be suitable for explaining the development of domestic demand for this commodity include gross domestic product, population size, number of completed dwellings, the value of construction production and the price of soft sawnwood.

**Key words:** derived demand, soft sawnwood, demand models, correlation coefficient

## INTRODUCTION

Modelling the relationships between market elements is a complex process which involves modelling the supply and demand side of the market and at the same time is the basis for further development of strategies at the national and corporate level (HATRÁK 2007). Demand and supply as the basic determinants of the market are interconnected and regulated by the market price and, retrospectively, the mutual relations between them affect this price (GOLDBERGER 1964). The theory of consumer demand assumes that the demand for a certain product comes from the consumer (satisfaction of needs) and is limited by his/her possibilities (disposable income) (HOLMAN 1999). The quantity demanded is a function of product price, consumer income, prices of substitute and complementary products and consumer preferences (SMRTNÍK 1996). Wood represents one of many inputs to the production process, so that together with other production factors they are transformed into a certain number of outputs (SOLBERG and MOISEYEV 1997). The demand for wood and wood products depends on the demand for final products and is proportional to the activity

of industries and final consumers or other producers who use wood and wood products as a source of production process to achieve the final production. In other words, the final demand on the wood market depends on the resulting demand for final wood products, where the final products are realized on the consumer market. (BAUDIN and BROOKS 1995; BUONGIORNO 1977; GOLDSTEIN and KHAN, 1985). In short, demand for wood products correlates with economic growth (BAUDIN and KANGAS 2003, BUONGIORNO 1978), growth of the construction sector (HURMEKOSKI 2015, BORZIKOWKSI 2017), prices of substitute products (ANYIRO 2013, BAUDIN and KANGAS 2003), with preferences in the use of products (BRÄNNLUND 1988, MICHINAKA 2011), demographic development (BAUDIN and BROOKS 1995, BUONGIORNO 1977) and exchange rate developments (HURMEKOSKI 2015, MICHINAKA 2011). In the broadest sense, demand is diverted from the development of the overall national economy (PALUŠ 2002, HURMEKOSKI 2015, BORZIKOWKSI 2017). In addition to traditional socio-economic factors, the formation of forestry and other related policies, which mainly affect trade, the market, sustainable development, the environment, etc., has an increasingly important influence on the development of the market and trade in wood and wood products (IHEKE 2012, ONOJA 2015, HURMEKOSKI 2013). The country's overall economic growth is the most important factor influencing demand at the wood market (BAUDIN and KANGAS 2003, BUONGIORNO 1978). The size of the economy's output, which can be expressed in terms of gross domestic product (GDP), depends on the development of economic growth. In other words, the growth of GDP is as important as its actual level (LISÝ *et al*. 2011). If the dependences between the development of the wood market and GDP are known, it is possible to determine the possible development of the wood market on the basis of forecasts of the future development of GDP growth (ESALA *et al.* 2012).

Developments in the construction sector, mainly fixed capital formation, have a direct impact on the market for mechanical wood processing products - sawnwood and wood based panels (O'CONNOR *et al.* 2004, ESALA *et al*. 2012). Activity in the construction sector is very sensitive to changes in economic growth of the country. At the same time, it is a sector where these changes occur as one of the first sectors of the national economy (BUONGIORNO 2009, CEI-BOIS 2004). The size of the disposable income of the population and interest rates has an impact on the construction decision of the population and the availability of investment funds (BAUDIN and KANGAS 2003, BUONGIORNO 1978). Rising prices of construction work and building land reduce construction activity (ESALA *et al.* 2012, IHEKE 2012). The country governments' program statements and housing policy objectives imply support for housing construction by the government by providing construction premiums, long-term loans from housing development funds, or by supporting the availability of mortgage loans (LUNDMARK 2010). In some countries, new construction (residential and non-residential) plays a key role (MAHAPATRA and GUSTAVSSON 2008), in others the repair and reconstruction sector make up the majority of construction output (O´CONNOR *et al*. 2004). The volume of wood used in each sector depends on the traditions and uses of the wood (ANYIRO 2013, BAUDIN and KANGAS 2003). Some other sectors that use a significant share of wood products include e.g., industrial production, automotive industry, shipbuilding industry, etc. (PALUŠ 2013). Consumption decisions are also influenced by the existence of alternative options - the availability and price of substitute products on the market. The availability of potential substitution products has an impact on demand elasticity, both in the short and long term. At this level, demand is almost perfectly inelastic. Market information in the field of substitute products or design influences the choice of products and services (EASTIN *et al.* 2001, MUTANEN 2006, SATHRE and O´CONNOR 2010).

All markets are shaped by the general or individual preferences of end customers (BAUDIN 2003). This phenomenon is partly shaped by culture and partly influenced by the

level of information and knowledge about products and services (BUONGIORNO 2009). Communities use wood and wood products differently, depending on their preferences and traditions in the use of wood raw material (ESALA *et al.* 2012). The impact of demographic change on the wood market is reflected in increased population pressure on the use of natural resources (O'NEILL *et al*. 2010). The impact of changes in population structure is therefore important (HETEMÄKI 2011). The structure of the population aims to increase the share of the non-productive age group at the expense of productive people. In conditions of stable economic development, the demands of older people for social security, independent living, etc. will grow (BAUDIN 2003, BUONGIORNO 2009).

The main aim of this paper is determining a set of variables for demand modelling in the soft sawnwood market in Slovakia.

## MATERIAL AND METHODS

The selection of input data collection and processing was relatively difficult, especially due to the poor availability of data and their high variability when they were obtained from different sources. Where possible, data from official statistical sources (Statistical Office of the Slovak Republic) were preferred to estimate and recalculate. Input data were drawn from FAOSTAT databases (FAOSTAT 2022), Statistical Office of the Slovak Republic (ŠÚ SR 2022), from the data of the Ministry of Agriculture and Rural Development of the Slovak Republic (MPRV SR 2020) – the Report on Forestry in the Slovak Republic. Variables are expressed in absolute (physical and monetary) units. In order to eliminate the effect of inflation on the values of the input variables and the results obtained, all variables expressed in monetary units, such as GDP or the value of production in the sector are given in constant prices in 2015. Input data form two basic groups of variables – explanatory and dependent variables.

**Dependent variables**

In the demand models for soft sawnwood, the resulting demand is expressed as domestic consumption of the product *i* in the year *t*:

$$S_{it} = P_{it} + I_{it} - E_{it} \quad (1)$$

where:

$S_{it}$ - consumption of the product *i* in the year *t*,
$P_{it}$ - production of the product *i* in the year *t*,
$I_{it}$ - import of the product *i* in the year *t*,
$E_{it}$ - export of the product *i* in the year *t*.

Consumption calculated this way is called apparent consumption and does not take into account changes in stocks in a given year, which differ from actual consumption. Such an approach is not flawed unless the changes in stocks are large and are randomly distributed during the period considered. If annual inventory changes are significant, such an approach can cause large errors in the resulting consumption values and, consequently, errors in the estimated model parameters. If the prices of wood products are derived from the prices of finished products, it is likely that the size of stocks will be closely linked to the development of overall economic activity. For instance, if sales decrease during a period of low economic growth and recession, inventory will increase and the resulting consumption value calculated on the basis of (1) will be overestimated. Despite these complications, in the following analyses we considered data on apparent consumption to be the data on actual consumption. The development of consumption in the years 1990-2020 was analysed and the consumption of soft sawnwood was expressed in $m^3$.

**Explanatory variables**

Based on the theoretical assumptions about the development of demand for wood products, we gradually analysed the impact of the following explanatory variables on the size of demand:

- dwellings completed,
- GDP,
- GDP per capita,
- construction production,
- absolute prices of soft sawnwood.

***Non-price variables***

The number of completed dwellings expresses the total number of dwellings completed in a given year. The number is given in physical units. The development of the number of completed dwellings in the Slovak Republic during the years 1990-2020 is shown graphically in the results of this paper. GDP is an aggregate indicator that expresses the value of total output and services produced in a given country per year. For the purposes of quantification of models, we used the values of real gross domestic product, which is expressed in billion EUR at constant prices in 2015. GDP per capita is obtained as a share of real GDP and population size in a given year. The value of GDP per capita is expressed in EUR at constant prices in 2015. The absolute values of real GDP and GDP per capita are shown graphically in the results. Construction output includes construction, rebuilding, extension, renewal, repair and maintenance of buildings, including building assembly work and the value of built-in material, carried out by the contractor, own capacities or by subcontracting construction products from other building or non-building organizations for a given year. The value of construction output is expressed in billion EUR at constant prices of 2015. The absolute values of the construction output are shown graphically in the results.

***Price variables***

The process of obtaining and adjusting price data is limited by their unavailability and non-existent statistical sources on the price development of the main wood products in the Slovak Republic during the period under review. The analysis of the impact of prices on the size of demand requires data on the development of own prices of wood products, the prices of their main competing materials and the prices of final products in the end-use sectors of wood.

The issue of lack of information on price development on the domestic market was solved by approximating domestic market prices of the main wood products using average unit prices of foreign trade, which are calculated from the value and volume of exports or imports of soft sawnwood. The average export and import prices do not represent the actual domestic price. The theoretical assumption about the export and import price is that the export price should be higher and the import price lower than the domestic market price. In terms of free international trade, it can also be assumed that the export price reflects the existing production conditions of the exporting country (input prices, wages, capital price, etc.) and the import price of the production conditions of the country of origin (SMRTNÍK 1992). International trade in wood products is in many cases limited by the passive and active autonomous measures of the state's foreign trade policy, which in turn has an impact on the level of the price. In addition to these barriers, the price in foreign trade is affected by the amount of transport costs, costs of handling goods, insurance of goods, etc. In case data on the price development of soft sawnwood on the domestic market is not available, export or import prices are often used as a substitute for domestic prices (BAUDIN and LUNDBERG 1984, BUONGIORNO 1977, 1978, SCHWARZBAUER 1990). If the volume of exports prevails over imports in a given country, the export price is preferred to the import price and *vice*

*versa*. The volume of exports significantly exceeded imports during the examined period. The unit export price therefore relates to a larger volume of soft sawnwood and was used as a substitute for the domestic price for demand analysis. On the other hand, we can assume that the export prices may not be the most appropriate variable to express price conditions on the domestic softwood market. The increase in soft sawnwood production during the period observed may be more strongly motivated by the existing price differences between the domestic and foreign price levels than by the growth in demand and impulses on the domestic market. The domestic price starts to adjust to the export price only with a certain time delay. Given these assumptions, it is possible that at a given point in time, the difference between the export and domestic price of soft sawnwood is higher than the difference between the import and domestic price, thus the import price can be considered a better approximation of domestic prices. Nevertheless, due to the fact that the import of soft sawnwood is approximately 3 to 4 times lower in terms of trade balance, we used the export prices of soft sawnwood.

Correlation analysis methods, graphical methods and other methods of statistical analysis were used to analyse the interdependence of the development of indicators. An initial examination of the relationships between the variables was performed using a scatter plot and a description of their relationship resulting from the graph. Extreme or typical values, possible form of dependencies were determined and the results of the analysis were compared and presented. After an initial graphical review, the phase of searching for exact statistics that confirms the estimates from the graphs has begun. Statistical correlation analysis tools were used for this purpose. It was determined whether there is a relationship between the variables and, if so, what its strength is. The evaluation of the dependence of two random variables is dealt by a simple correlation analysis, which emphasizes more on the intensity of the relationship than on the study of variables in the cause-effect direction (regression). The dependencies we examined were mainly linear, where correlation is a measure of a linear relationship. The important fact is that correlation is not causality. The task of correlation analysis is to identify, quantify and statistically test correlation.

A necessary part is a logical analysis of the problem, in terms of the significance of the correlation itself, which may be distorted or may not exist at all (HENDL 2004). Based on a theoretical review of the functioning of the wood products market, it is possible to define certain assumptions about the relationships between variables. In direct relation to the growing values of one variable, there is an increase in the values of other variable (e.g., the growth of demand has a positive effect on GDP growth). In an indirect relationship with the rising values of one variable, the values of the other variable decrease (e.g., the decline in demand is caused by rising prices). The relationship is uncorrelated if there is no direct or indirect linear relationship between the values of the two variables. In the case of non-price variables, the dependence is assumed to be positive, thus the correlation coefficient will acquire positive values (BAUDIN and BROOKS 1995, BUONGIORNO 1977, GOLDSTEIN and KHAN 1985, HURMEKOSKI 2015, BORZIKOWKSI 2017). As for the price of soft sawnwood, we assume that the dependence will be negative, thus the correlation coefficient will acquire negative values (BAUDIN and LUNDBERG 1984, BUONGIORNO 1977, 1978, SCHWARZBAUER 1990).

The correlation coefficient, like covariance, is a measure of the "mutual difference" of two measured quantities. Unlike covariance, the correlation coefficient is scaled, which means that its value does not depend on the units in which the two measured quantities are given. The value of each correlation coefficient must be from the interval (-1,+1). The analytical correlation tool was used to analyse each mutual combination of measured quantities, which is used to determine the dependence of two measured quantities, i.e., whether higher values of one quantity are related to higher values of the other quantity

(positive correlation), or whether lower values of one quantity are related to higher values of the other quantity (negative correlation), or whether the values of both quantities are independent (correlation close to zero).

The output of the analysis in the form of a table is a correlation matrix, in which the values of the correlation coefficient calculated using Excel 2019 were displayed. A graphical representation of the relationship between the explanatory and dependent variables is presented in *Fig. 1-6*.

## RESULTS AND DISCUSSION

Tab. 1 shows the development of selected production and trade indicators of soft sawnwood in the Slovak Republic in the period 1990-2020. Consumption of soft sawnwood is calculated as the production + import - export. Absolute prices are calculated as export prices in EUR, export quantities in $m^3$. GDP is calculated using the expenditure method at the reference year 2015. Production of sawnwood was the largest before the global crisis in 2008, namely 2,062,861 $m^3$. Consumption has increased by 301,245 $m^3$ and doubled since 1993, the year of the establishment of the Slovak Republic.

**Tab. 1 Development of selected production and trade indicators of soft sawnwood and selected variables for creating models in the Slovak Republic in the years 1990-2020.**

| Selected indicators of soft sawnwood in the Slovak Republic in the period 1990-2020 | | | | | |
|---|---|---|---|---|---|
| **Year** | **Production** | **Import** | **Export** | **Consumption** | **Absolute prices** |
| | m³ | m³ | m³ | m³ | €/m³ |
| 1990[a] | 879000 | 26641 | 165495 | 740146 | 16 |
| 1991[b] | 641000 | 12200 | 150864 | 502336 | 26 |
| 1992[b] | 336000 | 26400 | 165921 | 196479 | 35 |
| 1993 | 345000 | 2573 | 73226 | 274347 | 227 |
| 1994 | 400000 | 9600 | 300000 | 109600 | 132 |
| 1995 | 427000 | 11000 | 270625 | 167375 | 116 |
| 1996 | 426000 | 10400 | 241250 | 195150 | 161 |
| 1997 | 501000 | 16500 | 260700 | 256800 | 136 |
| 1998 | 845000 | 22600 | 734800 | 132800 | 389 |
| 1999 | 845000 | 18000 | 681000 | 182000 | 367 |
| 2000 | 845000 | 32000 | 683000 | 194000 | 628 |
| 2001 | 845000 | 40000 | 751000 | 134000 | 799 |
| 2002 | 845000 | 34000 | 649000 | 230000 | 605 |
| 2003 | 1150000 | 36000 | 645000 | 541000 | 457 |
| 2004 | 1251000 | 24000 | 663000 | 612000 | 581 |
| 2005 | 1984000 | 23000 | 681000 | 1326000 | 360 |
| 2006 | 1760000 | 56000 | 608634 | 1207366 | 266 |
| 2007 | 1872000 | 218000 | 536268 | 1553733 | 182 |
| 2008 | 2062861 | 131709 | 391535 | 1803035 | 124 |
| 2009 | 1605395 | 183854 | 354320 | 1434929 | 194 |
| 2010 | 1778780 | 235998 | 537005 | 1477773 | 218 |
| 2011 | 1460000 | 143066 | 511723 | 1091343 | 179 |
| 2012 | 1110000 | 149605 | 486441 | 773164 | 247 |
| 2013 | 990000 | 204926 | 501936 | 692990 | 233 |
| 2014 | 1190000 | 295870 | 695680 | 790190 | 295 |
| 2015 | 1150000 | 358000 | 629164 | 878836 | 441 |

| | | | | | |
|---|---|---|---|---|---|
| 2016 | 1200000 | 302101 | 810377 | 691724 | 501 |
| 2017 | 1305500 | 234517 | 667182 | 872835 | 388 |
| 2018 | 1300000 | 302690 | 794408 | 808282 | 354 |
| 2019 | 1263000 | 292392 | 847443 | 707949 | 447 |
| 2020 | 1182000 | 352490 | 958898 | 575592 | 518 |

*Source: Faostat 2022, own calculations*

*a – Tunák (1995)*
*b – data calculated from date for Czechoslovakia*

The values of the correlation coefficients between the explanatory and dependent variables are given in *Tab. 2*. Graphs of the correlation between the explanatory and dependent variables are shown in *Fig. 1-6*.

**Tab. 2 Values of the correlation coefficient between the explanatory and dependent variables.**

| Dependent variables | Consumption of soft sawnwood |
|---|---|
| Population | 0.38 |
| GDP per capita | 0.58 |
| GDP | 0.58 |
| Number of completed dwellings | 0.52 |
| Value of construction output | 0.31 |
| Price of soft sawnwood | -0.22 |

*Fig. 1* describes the relationships between soft sawnwood consumption and population, where a positive relationship can be observed. The results confirm the theoretical assumption that population has a positive impact on the consumption of soft sawnwood. The consumption of soft sawnwood is correlated with population (r = 0.38). Such dependencies are also pointed out by O'NEILL *et al.* (2010), HETEMÄKI (2011), BAUDIN (2003), BUONGIORNO (2009).

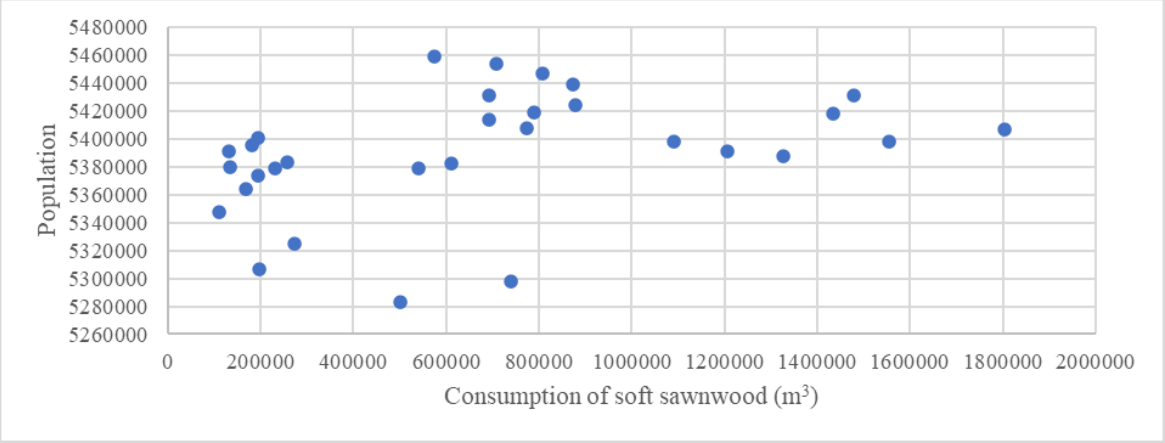


**Fig. 1 Relationship between soft sawnwood consumption and population.**

*Fig. 2* and *Fig.* 3 describe the relationships between soft sawnwood consumption and GDP per capita (*Fig. 2*) and GDP (*Fig. 3*), where a positive relationship can be observed. The theoretical assumption that economic growth has an impact on the consumption of soft sawnwood can be therefore confirmed. PALUŠ (2002), HURMEKOSKI (2015) and BORZIKOWKSI (2017) also point to such conclusions. The correlation coefficient for GDP and GDP per capita has the same value (0.58). There is a presumption that a multicollinearity

will arise when classifying variables into GDP and GDP per capita models. Such an issue is solved by choosing an indicator that has better statistical parameters for modelling purposes.

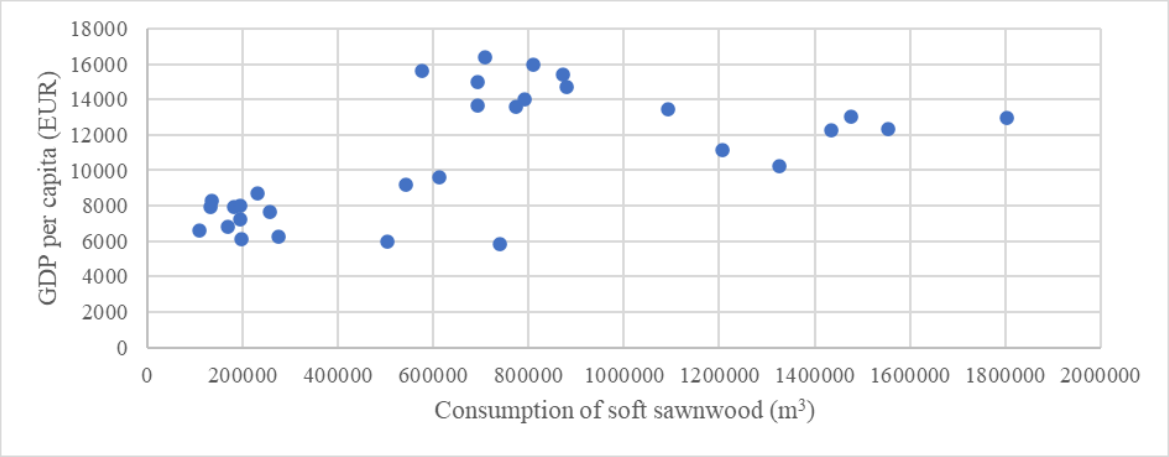


**Fig. 2 Relationship between soft sawnwood consumption and GDP per capita.**

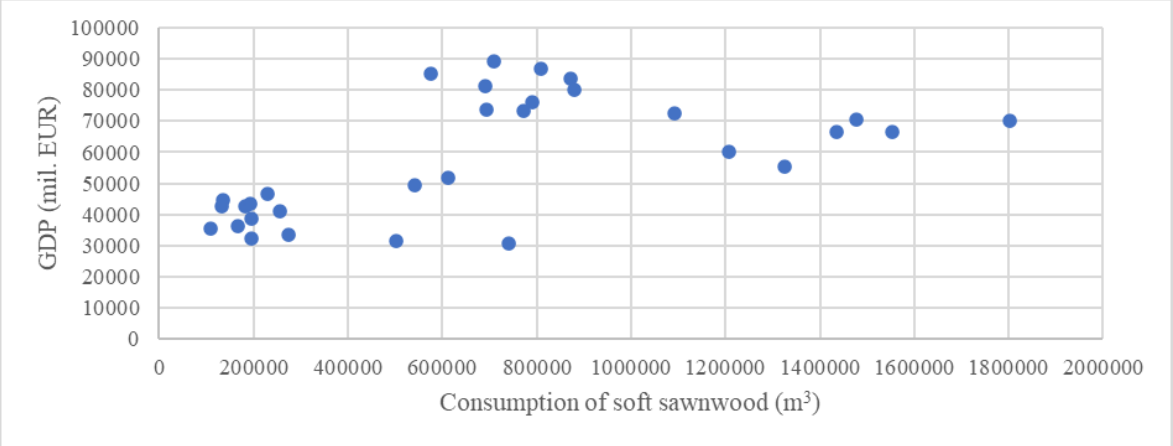


**Fig. 3 Relationship between soft sawnwood consumption and GDP.**

*Fig. 4* describes the relationship between the consumption of soft sawnwood and the number of completed dwellings, where a positive relationship can be observed. *Fig. 5* describes the relationships between the consumption of soft sawnwood and the value of construction output. The results confirm the theoretical assumption that construction has a positive impact on the consumption of soft sawnwood. The consumption of soft sawnwood is correlated with the activity of consumer industries – the value of construction output (r = 0.31) and the number of completed dwellings (r = 0.52). Such dependencies are also pointed out by O'CONNOR *et al.* (2004), ESALA *et al.* (2012), BAUDIN and KANGAS (2003), BUONGIORNO (1978), LUNDMARK (2010). Construction output and the number of completed dwellings are likely to be correlated when included in the models. In the USA, instead of the number of completed dwellings, the number of dwellings started is used, due to the significantly greater preference for the construction of wooden houses, which makes the consumption of soft sawnwood even higher. For example, number of completed dwellings are used by ADAMS and BLACKWELL (1973).

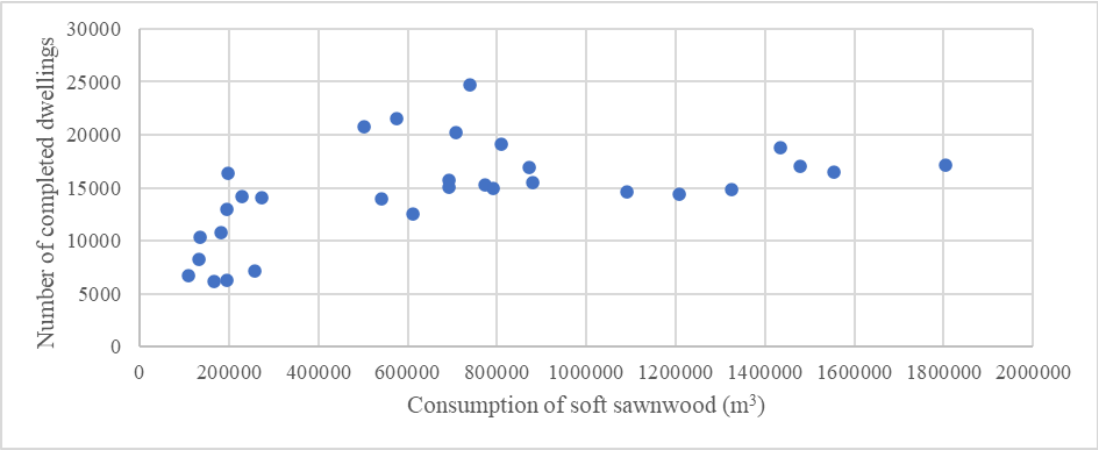


**Fig. 4 The relationship between the consumption of soft sawnwood and the number of completed dwellings.**

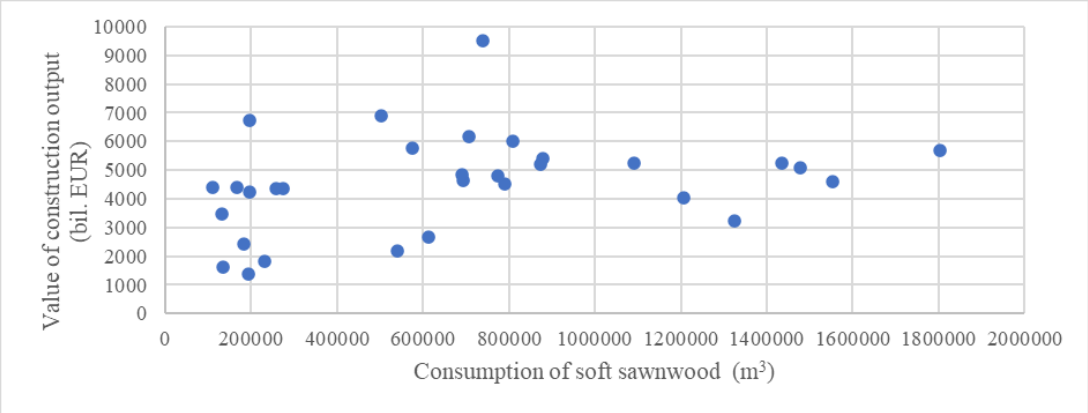


**Fig. 5 Relationship between soft sawnwood consumption and construction output value.**

*Fig. 6* describes the relationships between the consumption of soft sawnwood and its price, which have a negative effect. It confirms the theoretical assumption that the price has a negative effect on the consumption of soft sawnwood. EASTIN *et al*. (2001), MUTANEN (2006), SATHRE and O'CONNOR (2010) point to such conclusions as well.

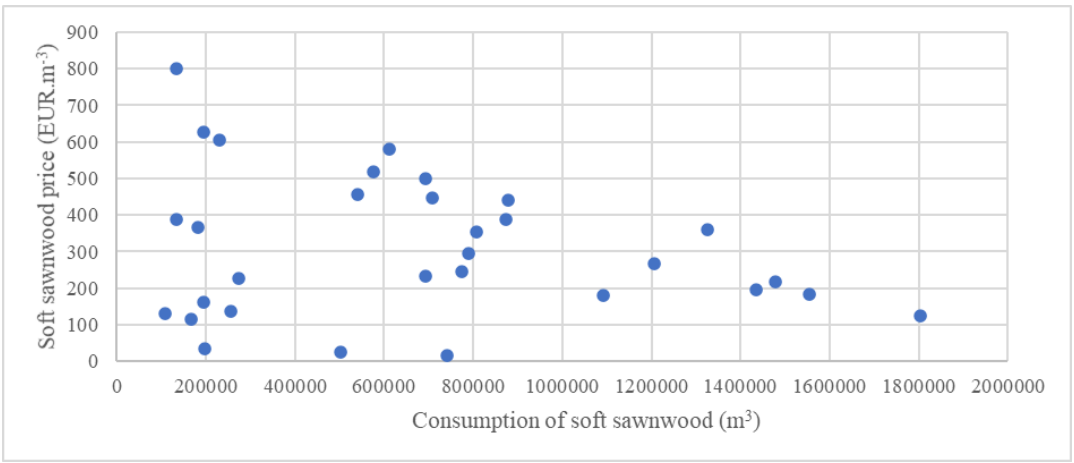


**Fig. 6 Relationship between soft sawnwood consumption and soft sawnwood price.**

The variables were selected based on the available literature. The theoretical assumption of impact was confirmed for all variables examined. The correlation coefficient between soft sawnwood consumption and its prices is r = - 0.22. The most significant

strength of dependence on the consumption of soft sawnwood can be observed between the change in GDP (r = 0.58) and the change in GDP per capita (r = 0.58). The signs of the values of the correlation coefficients meet the assumptions defined by the theory, i.e., that with the growth of GDP and GDP per capita, the consumption of soft sawnwood will increase (BAUDIN and KANGAS 2003, BUONGIORNO 1978). The variable of price of a wood product was represented by the variable of export price, expressed at constant 2015 prices in EUR.$m^{-3}$, given that the export of soft sawnwood in the Slovak Republic exceeds the import of soft sawnwood.

## CONCLUSIONS

The issue of theoretical aspects of demand models and the basis of their creation was analysed in the paper. Based on the theoretical background, the main factors relevant for the demand for soft sawnwood and their possible impact on the development of demand were defined. Different approaches to econometric modelling and their application in previous research are presented using an overview of published domestic and foreign resources. A separate part of the theoretical aspect is the analysis of wood and wood products market conditions. The main benefit of the analysis is the provision of information and the basis for demand modelling.

For modelling purposes, demand is expressed as the domestic consumption of a given product, which is calculated on the basis of the volume of production and foreign trade in a given year. For soft sawnwood, the basic explanatory variables that can be considered when creating demand models are population, GDP, GDP per capita, number of completed dwellings, value of construction output and the absolute prices of soft sawnwood. Based on these results, the factors which variables may be significant in the models of demand for soft sawnwood were determined.

### REFERENCES


ADAMS, F. G., BLACKWELL, J. 1973. An econometric model of the United States forest products industry. In Forest Science 19(2), p. 82-96.

ANYIRO, C.O., EZEH, C.I., OSONDU, C.K., NDUKA, G.A. 2013. Economic analysis of household energy use: A rural urban case study of Abia State, Nigeria. In Journal of Agriculture and Allied Sciences.

BAUDIN, A. and BROOKS, D. 1995. Projections of forest products demand, supply and trade. In ETTS V. UNECE/ FAO Timber and Forest Discussion Papers, ETTS V Working Paper, ECE/TIM/DP/6.

BAUDIN, A., BROOKS, D. 1995. Projections of forest products demand, supply and trade. In ETTS V. UN-ECE/FAO. Timber and Forest Discussion Papers. p. 41.

BAUDIN, A., KANGAS, K. 2003. Modelling and projections of forest products demand, supply and trade. In Geneva Timber and Forest Discussion Paper.

BORZYKOWSKI, N. 2017. The Swiss market for construction wood: estimating elasticities with time series simultaneous equations. Crag.

BRÄNNLUND, R. 1989. The social loss from imperfect competition: the case of the Swedish pulpwood market. In: The Scandinavian journal of economics. - Oxford: Wiley, ISSN 0347-0520, ZDB-ID 8170-X. - Vol. 91.1989, 4, p. 689-704.

BROOKS, D., SCHWARZBAUNER, P., BAUDIN, A. 1995. Modelling Forest Products Demand, Supply and Trade. United Nations, Geneva, Switzerland. p. 36.

BUONGIORNO, J. 1977. Long-term forecasting of major forest products consumption in developed and developing economies. In Forest Science 23. p. 13-25.

BUONGIORNO, J. 1978. Income and price elasticities in the world demand for paper and paperboard. In Forest Science. 24(2). p. 231-246.

BUONGIORNO, J. 2009. International trends in forest products consumption: is there convergence? In Int. For. Rev. 11 (4), p. 490–500.
CEI-BOIS, 2004. Roadmap for the European Woodworking Industries. Executive Summary p. 34.
EASTIN, I.L., SHOOK, S.R., FLEISHMAN, S.J. 2001. Material substitution in the US residential construction industry, 1994 versus 1998. In Prod. J. 51 (9), p. 30–37.
ESALA, L.,HIETALA, J.,HUOVARI, J. 2012. Economic impacts of wood construction. PTT Reports 239 Helsinki, Finland.
FAOSTAT. 2022. https://www.fao.org/faostat/en/#data
GOLDBERGER, A. S. 1964. Econometric Theory. New York: John Wiley.
GOLDSTEIN, M., M. S. KHAN. 1985. Income and Price Effects in Foreign Trade. In Handbook of International Economics. p. 1041-1105.
HATRÁK, M. 2007. Ekonometria. Bratislava: IURA EDITION, 2007, Ekonómia. ISBN: 978-80-8078-150-7. p. 503.
HENDL, J. 2004. Přehled statistických metod zpracování dat: analýza a metaanalýza dat. Praha: Portál. ISBN: 8071788201. p. 583.
HETEMÄKI, L., NIINISTÖ, S., SEPPÄLÄ, R., UUSIVUORI, J. 2011. Murroksen jälkeen — metsien käytön tulevaisuus Suomessa (After the Transformation - The Future of Forest Utilization in Finland). Metsäkustannus, Hämeenlinna, p. 140.
HOLMAN, R. 1999. Ekonomie. Praha. ISBN: 978-80-7400-006-5. p. 691.
HURMEKOSKI, E. 2015. Factors affecting sawnwood consumption. In Europe Forest Policy and Economics, Elsevier, vol. 50, p. 236–248.
HURMEKOSKI, E., HATEMÄKI, L. 2013. Studying the future of the forest sector: Review and implications for long-term outlook studies.
IHEKE, O. R., OSUJI, J. 2015. Demand for fuel wood and its substitution possibilities in urban areas of Umuahia metropolis of Abia State, Nigeria.
LISÝ ET AL. 2011. Ekonómia. Bratislava: Iura Edition. ISBN 978-80-8078-406-5. p. 631.
LUNDMARK, R. 2010. European trade in forest products and fuels. In J. For. Econ. 16 (3), p. 235–251.
MAHAPATRA, K.,GUSTAVSSON, L. 2008. Multi-storey timber buildings: breaking industry path dependency. In Build. Res. Inf. 36 (6), p. 638–648.
MPRV SR. 2020. Správa o lesnom hospodárstve v Slovenskej Republike za rok 2019. Bratislava, MPRV SR, p. 70. https://www.mpsr.sk/zelena-sprava-2020/123---16162/
MICHINAKA, T., TACHIBANA, S., TURNER, J. A. 2011. Estimating price and income elasticities of demand for forest products: Cluster analysis used as a tool in grouping. In Forest Policy and Economics 13. p. 435-445.
Ministerstvo pôdohospodárstva a rozvoja vidieka Slovenskej Republiky. 2022. https://www.mpsr.sk/lesy-drevo-polovnictvo/47-37-1
MUTANEN, A., 2006. Estimating substitution in coniferous sawnwood imports into Germany. In J. For. Econ. 12 (1), p. 31–50.
Národná banka Slovenska. 2022. https://www.nbs.sk/sk/statisticke-udaje
O'CONNOR, J., KOZAK, R., GASTON, C., FELL, D. 2004. Wood use in nonresidential buildings: opportunities and barriers. For. In Prod. J. 54 (3), p. 19–28.
O'NEILL, B.C., DALTON,M., FUCHS, R., JIANG, L., PACHAURI, S., ZIGOVA, K. 2010. Global demographic trends and future carbon emissions. In Proc. Natl. Acad. Sci. U. S. A. 107 (41), p. 17521–17526.
ONOJA, A. O., IDOKO, O. 2012. Econometric analysis of factors influencing fuel wood demand in rural and peri urban farm houses of Kogi State. In The Journal of Sustainable Development.
PALUŠ, H. 2002. Modelovanie dopytu po výrobkoch z dreva na trhu v SR. Technická univerzita vo Zvolene. Zvolen. 1. vydanie. ISBN 80-228-1153-X. p. 49.
PALUŠ. H. 2013. Trh a obchod s drevom a výrobkami z dreva. Technická univerzita vo Zvolene. Zvolen. 1. vydanie. ISBN: 978-80-228-2587-0. p. 225.
SATHRE, R., O'CONNOR, J. 2010. Meta-analysis of greenhouse gas displacement factors of wood product substitution. In Environ. Sci. Pol. 13 (2), p. 104–114.
SMRTNÍK, J. 1996. Mikroekonómia. Zvolen. ISBN: 80-228-0554-8. p. 173.

SOLBERG, B., MOISEYEV, A. 1997. Demand and supply analyses of roundwood and forest products markets in Europe. Overview of present studies. EFI Proceedings No. 17. European Forest Institute, Finland.
ŠÚES. 2022. Štatistický úrad Európskych spoločenstiev. https://ec.europa.eu/eurostat/data/database
ŠÚSR. 2022. Štatistický úrad Slovenskej Republiky. http://datacube.statistics.sk/

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