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Productivity Growth Determinants of Differently Developed Countries: Comparative Capital Input Results

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Abstract

The article aims to apply the growth accounting methodology to the Baltic countries in order to obtain detailed productivity growth determinants in the aggregated market economy with a particular focus to capital input. To this end, a new database following the KLEMS methodology for tangible and intangible capital indicators is constructed. The paper analyses determinants' genesis and growth tendencies in the context of more developed countries and uncovers the productivity gains associated with different types of capital assets. First, an overview of the economies during the period researched is presented. Second, a methodology is developed to derive new intangibles and EU KLEMS data for the Baltic countries. Third, statistical data are constructed for all economies and the growth accounting method is applied in order to obtain comparable results. Finally, economic analysis is conducted to detect certain aspects of the growth determinants for differently developed and structured economies.

Keywords

Productivity growth, KLEMS methodology, growth accounting, tangible capital, intangible capital, national accounts

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INTRODUCTION

Productivity is the ratio of output to all inputs. Determinants of labour productivity growth appear to be at the centre of both the European Union's (EU) current research and the political agenda. Moreover, labour productivity has constituted a key variable for economic growth and development theories dating back to R. Solow (1957), as well as in contemporary approaches to sustainable development.

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The growth accounting method is one of the best-known approaches to determining the proximate sources of productivity growth. The EU KLEMS and WORLD KLEMS databases provide information for economic analyses of different developed and developing countries. However, the EU KLEMS and WORLD KLEMS projects lack detailed information for detailed capital input and research results regarding the application of the growth accounting method for some less developed EU countries (e.g. Lithuania, Latvia, Estonia). Hence, the preparation of growth and productivity accounts, is advised and listed among nine specific satellite accounts (in the European Parliament and Council Regulation (No. 549/2013, p. 506, 525). However, not all National Statistics Departments have done so.

The goal of this research paper is to apply the growth accounting methodology to the Baltic countries in order to obtain detailed productivity growth determinants in the aggregated market economy with a particular focus to capital input (as these countries are missing this information).

In summary, it is essential to draw back the curtains of the Baltic states (Lithuania, Estonia and Latvia) and construct a database for them following the initial KLEMS methodology in order to attain in-depth and internationally comparable results. Such information is already available for more developed countries, but the Baltic countries are missing complete results. This information will thus fill an important research gap. Moreover, it will facilitate comparative economic analysis for a set of more developed countries within the EU for which information is already available from the determinants of the productivity growth perspective.

Furthermore, new intangible assets are deemed important for productivity growth, as indicated by the research of many scientists today (Mas and Quesada, 2014; Corrado et al., 2017; Haskel, 2018), including in reports (e.g. World Intellectual Property Report, 2017) and forecasts (e.g. European Forecast, 2016). Nevertheless, many intangible assets have not been fully estimated owing to a lack of necessary data (Corrado et al., 2006). One of the more novel aspects of this particular research is the incorporation of new intangibles, which are yet to be accounted for by national statistics, in the traditional growth accounting model. The statistical data for more developed economies can be found in INTAN invest database, but data for the Baltic countries are currently absent. Hence, brand estimates for detailed new intangible assets for the Baltic countries will be derived here. This will enable the Baltic countries' platforms to be clarified and their performance in the context of others in this contemporary research topic to be comprehended.

The article is structured as follows: Overview of the economies; Methodology and practical implementation; Results; Conclusions.

1 OVERVIEW OF THE ECONOMIES

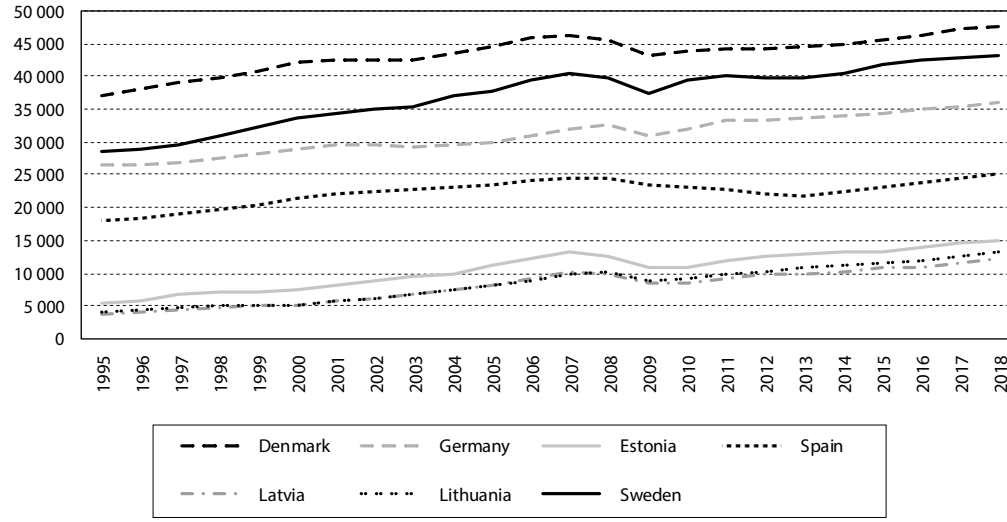
The selected countries are: Denmark, Germany, Spain, Sweden (hereinafter deemed more developed countries in terms of their gross domestic product, GDP), followed by the Baltic states of Estonia, Latvia and Lithuania.

Germany is the oldest EU member in the sample, having helped found it on 1 January 1958, followed by the accessions of Denmark (1 January 1973), Spain (1 January 1986) and Sweden (1 January 1995). In contrast, Lithuania, Latvia and Estonia all joined the EU on 1 May 2005. Moreover, not only are the Baltic states young members of the EU, but they previously belonged to the Soviet Union, only gaining their independence in 1991. The economies of the three Baltic countries are quite similar in terms of historical perspective, geography, size, economic structure, growth and development (Poissonnier, 2017).

Figure 1 provides the real GDP per capita for the seven countries during the period 1995–2018. Table 1 indicates the following sequence of countries in terms of GDP per capita in 1995 in nominal terms: Denmark, Germany, Sweden, Spain, Estonia, Latvia, Lithuania. In 2018 the following sequence could be distinguished: Denmark, Sweden, Germany, Spain, Estonia, Lithuania, Latvia. In terms of GDP

per capita real growth rates, the highest values were for the Baltic countries (from 3.9% to 4.1%). The annual growth rates of these countries are high compared with other countries, as is usually the case with so-called emerging economies. Indeed, their GDPs grew significantly from 1995 to 2018. These indicators highlight the importance of this research: to reveal the determinants of the growth of these emerging economies and to compare them in the context of more advanced counterparts.

Figure 1 GDP per capita at market prices, Euro, chain-linked volumes (2010) 1995–2018



Source: Own elaboration, upon the Eurostat data

Table 1 Gross domestic product, Euro per capita

Country	1995, current prices	2018, current prices	Real annual average growth rates
Estonia	2 000	19 500	4.0%
Latvia	1 700	15 300	3.9%
Lithuania	1 400	16 100	4.1%
Denmark	27 000	51 400	1.5%
Germany	24 400	40 800	1.4%
Spain	11 800	25 900	2.2%
Sweden	22 900	45 900	2.4%

Source: Own elaboration, upon the Eurostat data

From Table 2 it can be noticed that the agriculture, forestry and fishing (A) and manufacturing (C) (except Germany) industries shrunk in all of the economies. The consistent patterns of structural change explained by Todaro and Smith (2015) can be observed in that the economies are moving towards the expansion of service-based economies through the process of economic growth (Lankauskiene and Tvaronaviciene, 2012; Tvaronaviciene and Lankauskiene, 2013).

Table 2 Structure of nominal value added 1995–2015

	Estonia			Latvia			Lithuania			Denmark		
	1995	2017	Gr rate* %	1995	2017	Gr rate* %	1995	2017	Gr rate* %	1995	2017	Gr rate* %
Total**	100	100	4.6	100	100	4.4	100	100	4.6	100	100	1.6
A	8	4	4.7	12	5	2.1	13	5	0.9	5	1	0.3
B	3	2	3.7	0	1	10.5	0	0	3.1	1	2	–1.6
C	26	21	5.4	26	17	2.9	25	23	6.0	25	21	0.9
D, E	5	5	1.1	7	5	0.2	7	4	0.8	4	3	–0.5
F	9	9	4.1	6	9	4.9	9	9	4.7	8	8	1.0
G	17	16	4.1	12	20	6.4	20	23	5.4	19	20	2.1
H	11	10	2.5	18	13	3.8	10	14	4.2	9	9	1.5
I	2	2	4.5	1	3	5.8	2	2	2.9	2	2	–0.3
J	6	8	7.0	4	7	5.6	4	6	4.5	5	7	8.0
K	4	5	7.6	5	7	8.1	3	3	3.6	8	9	3.2
M, N	6	13	5.8	6	10	5.2	3	10	7.6	9	13	1.8
R, S	3	4	2.0	3	4	3.7	3	2	2.8	5	5	–0.3

	Germany			Spain			Sweden		
	1995	2017	Gr rate*%	1995	2017	Gr rate* %	1995	2017	Gr rate* %
Total**	100	100	1.4	100	100	1.8	100	100	3.3
A	1	1	–1.2	5	4	2.1	4	2	1.3
B	1	0	–4.3	1	0	–1.8	0	1	–1.9
C	32	33	1.8	23	21	1.4	33	22	2.9
D, E	4	4	0.5	4	5	2.3	5	4	1.0
F	9	6	–1.6	12	8	–1.1	8	9	1.4
G	14	14	1.9	16	17	2.6	15	15	3.9
H	6	6	1.9	7	7	1.2	9	7	1.5
I	2	2	–0.2	9	9	0.3	2	2	2.6
J	5	7	5.3	5	6	4.6	5	11	7.4
K	7	6	–0.9	7	6	3.1	6	7	3.7
M, N	13	16	1.7	7	12	3.3	9	16	4.2
R, S	5	5	0.3	4	4	3.2	4	4	1.8

Notes: * Real annual average growth rates 1995–2015.

** Total (Market economy), A – Agriculture, forestry and fishing, B – Mining and quarrying, C – Manufacturing, D-E – Electricity, gas and water supply, F – Construction, G – Wholesale and retail trade, repair of motor vehicles, H – Transportation and storage , I – Accommodation and food service activities, J – Information and communication, K – Financial and insurance activities, M-N – Professional, scientific, technical, administrative and support service activities, R-S – Arts, entertainment, recreation and other service activities.

Source: Own elaboration, upon the EU KLEMS data

In 2015, the transportation and storage (I) industry had comparatively higher shares in the total market economy in the Baltic states relative to other more developed economies. Financial and insurance (K) (except Latvia) and professional, scientific, technical, administrative and support service activities' (M, N) industrial shares in total value added of the market economy were lower for the Baltic states compared with other more developed economies (except Spain and Denmark).

Regarding the industrial real value-added growth rates, the highest growth rates were for the the Baltic countries. Moreover, these were positive for all industries, in contrast to the more developed economies. The highest industrial real value-added growth rates were for the information and communication industry (J) for all economies. Furthermore, high values were maintained in financial and insurance activities (K) (except Germany) and professional, scientific, technical, administrative and support service activities (M-N), and the highest values for these industries were in the Baltic countries. High industrial real value-added growth rates in the Baltic countries were also seen in the following industries: wholesale and retail trade, repair of motor vehicles and motorcycles (G); manufacturing (C); accommodation and food service activities (I); construction (F) and transportation and storage (H).

2 METHODOLOGY AND PRACTICAL IMPLEMENTATION

Numerous methods can be found in relevant scientific literature to account for productivity growth (Lankauskiene, 2014; Lankauskiene and Tvaronaviciene, 2014), but the best method is growth accounting for the research benefits it can provide (Lankauskiene, 2015; 2016). With roots in the work of Nobel Prize winner neoclassical economist Solow (1956), Jorgenson, Gollop and Fraumeni (1987) published their seminal study outlining the growth accounting approach based on the KLEMS methodology, which is today widely used by researchers (Timmer et al., 2007; Jäger, 2018).

Through the growth accounting method, value-added growth can be decompiled into contributions of hours worked and labour productivity inputs within a consistent framework (Timmer et al., 2010). Labour productivity inputs are composed of labour, capital and multi-factor productivity (MFP). MFP growth is measured as the difference between the volume growth of outputs and the volume growth of inputs. As such, it captures increases in the amount of value added that can be created by a given quantity of inputs. Stated another way, it captures the reduction in input costs to create a given amount of value added. Under strict neoclassical assumptions, MFP growth measures disembodied technological changes and innovation (Timmer et al., 2007; Inklaar and Timmer, 2008).

Hereinafter the traditional growth accounting method and EU KLEMS methodology are expanded through the incorporation of the new intangibles (Corrado et al., 2005; 2006; 2009).

Relevant information on practical implementation is provided in Tables 3, 4, 5 and 6.

Table 3 Research implementation details

Country coverage: Estonia, Latvia, Lithuania, Denmark, Germany, Spain, Sweden
* Research period: 1995–2015
Method: Growth accounting
Methodology: EU KLEMS supplemented by new intangibles
Data: Capital, labour, capital and labour compensation, value added
Capital data: Different types of capital assets (further detail in Table 5)
Labour data: Labour composition according to educational attainment
Databases: For capital data – EU KLEMS and INTAN Invest (for more developed economies); EU KLEMS, INTAN Invest, National statistics departments, WIOD, Eurostat (for the Baltic states), for labour data – EU KLEMS and WIOD

Note: * The research period refers to the latest period available in the statistical databases.
Source: Own elaboration

Table 4 Industrial aggregation

Industrial aggregation
Total Economy (A, B, C, D-E, F, G, H, I, J, K, L, M-N, O, P, Q, R-S) **Total Market economy (A, B, C, D-E, F, G, H, I, J, K, M-N, R-S)**
A – Agriculture, forestry and fishing
B – Mining and quarrying
C – Manufacturing
D-E – Electricity, gas and water supply
F – Construction
G – Wholesale and retail trade, repair of motor vehicles
H – Transportation and storage
I – Accommodation and food service activities
J – Information and communication
K – Financial and insurance activities
L – Real estate activities
M-N – Professional, scientific, technical, administrative and support service activities
O – Public administration and defence; compulsory social security
P – Education
Q – Health and social work
R-S – Arts, entertainment, recreation and other service activities

Source: Own elaboration

Table 5 Capital data

EU KLEMS data	• IT – Computing equipment • CT – Communications equipment • SoftwDB – Computer software and databases • TR – Transport equipment • OtherMash – Other machinery and equipment • NonResid – Non-residential equipment • Resid – Residential structures • Cult – Cultivated assets • RD – Research and development
INTAN Invest data – here referred as New Intangibles	• Minart – Entertainment artistic and literary originals + mineral explorations • Design – Design • Brand – Brand • OrgCap – Organisational capital • Train – Training • NPD – New product development in the financial sector

Source: Own elaboration

Table 6 Details on research novelty and author's contribution

Countries	Data availability in EU KLEMS database	Data availability in INTAN Invest database	Research contribution
More developed countries	YES	YES	• To the traditional EU KLEMS methodology (INTAN invest intangibles have been included).
Baltic countries	**Only for some indicators; major gaps**	NO	• New statistical EU KLEMS and INTAN Invest data created. • To the traditional EU KLEMS methodology (INTAN invest intangibles have been included).

Source: Own elaboration

Data for the Baltic and other selected countries were prepared following strict methodological rules and the growth accounting method applied (Timmer, 2007; Jäger, 2018). For the application of the growth accounting method, capital input files had to be constructed in order to obtain the capital volumes. Labour input files were constructed in order to derive labour services. To construct the productivity accounts' value added, labour compensation data were taken from the EU KLEMS database. Given that the traditional growth accounting method was expanded using the new intangibles, intangible capital components were added to the traditional growth accounting model. Hence, the following methodological steps were followed for the final estimation of productivity accounts: the nominal gross value added (GVA) was adjusted by adding the gross fixed capital formation (GFCF) nominal values of new intangible capital, and the capital compensation part was derived from subtracting the labour compensation from GVA adjusted to new intangible capital. These data were later used to derive the contributors of aggregated value added and productivity.

3 CAPITAL DATA: BALTIC COUNTRIES

3.1 Contribution to EU KLEMS database

The first available indicators were taken from the EU KLEMS database (Table 7), and in cases where the data were unavailable they were supplemented with data from the National Statistics departments or Eurostat databases. Once the real values of GFCF were obtained for each type of asset, the Harberger method (1978) was used to derive the initial 1995 capital stocks. Subsequently, using the perpetual inventory method (PIM) (Organisation for Economic Co-operation and Development – OECD, 2009), the capital stocks were constructed for the entire period (1995–2015) researched.

Table 7 Contribution to EU KLEMS database

Countries	Available indicators in EU KLEMS database, 2017 release	Unavailable indicators in EU KLEMS database, 2017 release
Estonia	SoftwDB, TR, OtherMash, NResid, Resid, RD, Minart, Cult	**IT, CT**
Latvia	IT, CT, SoftwDB, TR, OtherMash, NResid, Resid, Cult	**Minart, RD**
Lithuania	IT, CT, TR, OtherMash, NResid, Resid, Cult	**SoftwDB, RD, Minart**

Source: Own elaboration

Lithuania lacked indicators for the 2000–2015 year period, hence the backwards PIM was used to derive values from 1995 to 2000.

3.2 Contribution to INTAN Invest database

The new intangibles (Table 8) are not provided in the INTAN invest database for the Baltic countries. Consequently, new estimates were prepared using the methodology described by Corrado et al. (2012). The same sequence was applied for all of the Baltic countries.

Table 8 Contribution to INTAN Invest database

Countries	Data availability for new intangibles in INTAN Invest database
Estonia	**No**
Latvia	**No**
Lithuania	**No**
Other more developed economies	Yes

Source: Own elaboration

Organisational Capital (OrgCap)

Organisational capital was compiled from two parts: own account and purchased. For the former, the data indicators were taken from the Eurostat database: employment by occupation and economic activity (Nace Rev. 2) OC1 occupation – managers; total employment; annual earnings of managers; annual earnings total. For the data gaps, the interpolation method was used. Next, following Corrado et al. (2012), nominal GFCF was obtained. For the purchased component – using turnover data from Eurostat for industries M7022 (business and other management consultancy activities) and M70 (activities of head offices; management consultancy activities) – the output of M7022 was derived, and then with the assistance of USE tables in the WIOD database, the nominal GFCF of purchased component was attained (Corrado et al., 2012). The sum of the purchased and own account components was deemed the nominal GFCF of organisational capital (OrgCap).

Vocational training (Train)

Vocational training data were derived from Eurostat's Continuing Vocational Training Survey (CVTS). The variable was the cost of CVT courses as a percentage of total labour costs (all enterprises) for the years 2000, 2008 and 2012. For the information gaps, the interpolation method or backwards exponential function of the growth rates was used. This percentage was multiplied by the compensation of employees and was assumed to be 100 per cent of spending as GFCF. The values of apprenticeships were very low or were not provided at all, and so these values were not considered significant.

New product development costs in the financial services industry (Nfp)

The labour compensation of high-skilled workers in the financial services (K) industry was calculated. To this end, the share in total compensation of high-skilled workers in financial services (K) was multiplied by the total labour compensation in financial services (K), and a 0.08 coefficient for the derivation of nominal investment values was applied.

Design

Following methodological explanations by Corrado et al. (2012), turnover data from Eurostat M711 (architectural activities) and M71 (architectural and engineering activities; technical testing and analysis) were derived, followed by the output. The shares were applied for the approximated values of USE tables from WIOD. These calculated shares were considered as nominal GFCF.

Brand

This indicator consisted of two variables: advertising and market research. The industries of interest for their derivation comprised M731 (advertising), M732 (market research and public opinion polling) and M73 (advertising and market research). The shares of turnover and output were calculated. The proportions were applied for the intermediate consumption indicators from USE tables in the WIOD database. These shares were deemed nominal GFCF (Corrado et al., 2012; Mas and Quesada, 2014).

The above provided newly derived nominal GFCF intangible asset types, which were converted to real ones using the price levels for each type of asset. Once the real values of GFCF had been obtained for each asset type, the Harberger method was used to derive the initial capital stocks for the year 1995 (Berlemann et al., 2014). Once the initial real capital stocks for each type of capital had been derived, they were constructed using the PIM for the entire period 1995–2015.

3.3 Capital data: other selected countries

All EU KLEMS indicators of real stocks and price levels were taken from EU KLEMS databases for the selected countries regarding the following types of capital assets: IT, CT, SoftwDB, TR, OtherMash, NResid, Resid, RD, Minart, Cult namely. For the new intangibles (Minart, Design, Brand, OrgCap, Train, NPD), GFCF values were taken from the INTAN invest database, although they needed to be constructed to obtain the price levels and capital stocks required to accomplish growth accounting. In the INTAN Invest database, the GFCF nominal and GFCF chain-linked volumes are provided.

First, the price levels for certain types of capital assets for each of the selected countries were derived by dividing the GFCF nominal by the GFCF chain-linked volumes. Next the GFCF real values were derived by dividing the GFCF nominal dividing by price levels. Once the real values of GFCF had been obtained for each capital asset, the Harberger was used to derive initial capital stocks for the year 1995. Once the initial real capital stocks for each type of asset had been derived, they were constructed using PIM for the whole period 1995–2015.

Labour data for all of the countries were taken from EU KLEMS labour input files; where unavailable, they were supplemented from the WIOD database release 2016 Socio Economic accounts. The indicators were hours worked and compensation shares of high-, medium- and low-skilled workers.

4 RESULTS

First, industrial contributions to aggregated labour productivity growth were considered. The results are provided in Table 9 (the highest values are marked in bold). For the more developed economies, the highest industry contributors to aggregate labour productivity growth were: manufacturing; wholesale trade, hotels and restaurants; and information and communication or financial and insurance activities. While for the Baltic countries the first two positions remained the same, i.e. manufacturing and wholesale trade, hotels and restaurants, in third place was the transportation and storage industry.

Table 9 Industrial growth contributions to aggregate LP growth, percentage points, 1995–2015

	Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
Total industries	4.6	4.0	4.4	1.4	1.3	0.7	2.7
Agriculture, forestry and fishing	0.5	0.3	0.2	0.1	0.0	0.2	0.1
Mining and quarrying	0.2	0.0	0.0	–0.2	0.0	0.0	0.0
Manufacturing	**1.4**	**1.1**	**1.7**	**0.6**	**0.8**	**0.4**	**1.3**
Electricity, gas and water supply	0.2	0.0	0.2	0.0	0.1	0.0	0.0
Construction	0.2	0.4	0.3	0.0	0.0	0.0	0.0
Wholesale and retail trade; Repair of motor vehicles and motorcycles	**0.8**	**1.5**	**1.1**	**0.3**	**0.3**	**0.2**	**0.5**
Transportation and storage	**0.5**	**0.6**	**0.4**	0.1	0.1	0.0	0.1
Accommodation and food service activities	0.1	0.1	0.0	0.0	0.0	–0.2	0.0
Information and communication	0.1	0.0	0.1	**0.4**	**0.2**	0.1	**0.5**
Financial and insurance activities	0.3	0.5	0.1	0.2	0.0	**0.2**	0.2
Professional, scientific, technical, administrative and support service activities	0.3	0.0	0.0	–0.1	–0.2	–0.1	0.2
Arts, entertainment, recreation and other service activities	0.0	–0.4	0.2	0.0	0.0	0.0	0.0

Note: Highest rates are marked in bold.
Source: Own elaboration

Table 9 displays how the labour productivity growth rates and the contributions to labour productivity growth of manufacturing, wholesale, retail and repair of motor vehicles and motorcycles, transportation and storage and construction were much higher in the Baltic states than in the more advanced economies.

Table 10 presents the results of the contributors to aggregated labour productivity growth. The highest aggregated LP growth values were as follows: Estonia (5.0%), Latvia (4.9%), Lithuania (4.8%), Sweden (2.7%), Denmark and Germany (1.4%), Spain (0.6%). The reallocation effect was the highest for the Baltic countries – Lithuania (0.4%), Estonia (0.3%) and Latvia (0.1%) – positively contributing to their high values of aggregated labour productivity growth. The highest contributions of labour composition to aggregated LP growth were for Estonia and Germany (0.2%), followed by Sweden (0.1%), whilethe least negative values belonged to Latvia, Lithuania, Denmark and Spain (–0.1%).

Table 10 Contributions to annual average aggregated labour productivity growth (productivity total), percentage points, 1995–2015

			Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
AB = A + B	AB	Productivity total	5.0	4.9	4.8	1.4	1.4	0.6	2.7
	A	Productivity sectorial	4.6	4.0	4.4	1.4	1.3	0.7	2.7
	B	Reallocation effect	0.3	1.0	0.4	0.0	0.1	–0.1	–0.1
A = f + g + h	f	Contribution labour composition	0.2	–0.1	–0.1	–0.1	0.2	–0.1	0.1
	g	Capital contribution	2.7	1.3	2.4	0.7	0.7	1.0	1.2
	h	MFP	1.7	2.9	2.1	0.8	0.4	–0.3	1.4

Source: Own elaboration

Table 11 Capital contributions in detail, percentage points, 1995–2015

Capital contribution = 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12 + 13 + 14 + 15

		Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
	Capital contribution	**2.74**	**1.28**	**2.44**	**0.66**	**0.73**	**1.04**	**1.20**
1	IT	0.15	0.06	0.22	0.08	0.40	0.10	0.12
2	CT	0.20	0.02	0.15	0.02	0.01	0.09	0.10
3	TR	0.60	0.20	0.37	0.16	0.06	0.08	0.12
4	OtherMash	0.99	0.58	0.75	0.04	0.10	0.14	0.33
5	NonResid	0.41	0.07	0.47	0.02	–0.03	0.23	0.07
6	Resid	–0.09	0.05	0.00	0.00	0.00	0.16	–0.01
7	Cult	0.01	0.01	–0.02	0.04	0.00	0.03	–0.01
8	SoftwDB	0.08	0.07	0.15	0.15	0.06	0.07	0.09
9	Minart	–0.01	0.01	0.01	0.02	0.00	0.01	0.00
10	Design	0.09	0.04	0.07	–0.01	0.02	0.03	0.03
11	Nfp	0.02	0.04	0.00	0.01	0.00	0.01	0.01
12	RD	0.08	0.00	0.03	0.17	0.08	0.06	0.28
13	Brand	0.07	0.09	0.09	0.02	–0.01	0.02	–0.02
14	OrgCap	0.10	0.05	0.10	0.02	0.04	0.01	0.10
15	Train	0.04	0.03	0.03	–0.07	0.00	0.01	–0.02

Source: Own elaboration

Table 12 Ranked capital contributors to aggregated annual average labour productivity growth, 1995–2015

	Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
Capital contribution	**2.74**	**1.28**	**2.44**	**0.66**	**0.73**	**1.04**	**1.20**
IT*	5	6	4	4	4	4	3
CT*	4	12	6	9	5	5	6
TR*	2	2	3	2	0	6	4
OtherMash*	1	1	1	5	6	3	1
NonResid*	3	5	2	11	0	1	8
Resid*	0	7	0	0	0	2	0
Cult*	13	13	0	6	0	10	0
SoftwDB*	8	4	5	3	2	7	7
Minart*	0	14	12	8	0	15	11
Design*	7	9	9	0	7	9	9
Nfp*	12	10	13	12	8	13	10
RD*	9	0	11	1	1	8	2
Brand*	10	3	8	10	0	11	0
OrgCap*	6	8	7	7	3	12	5
Train*	11	11	10	0	0	14	0

Note: * The largest contributor value = 1; the least = 14. Accordingly, negative values were not considered to have any significant impact on growth, hence their contributions were not considered as significant and were not included.
Source: Own elaboration

The largest capital contributions to aggregated labour productivity growth were for the Baltic countries (Table 11: from 1.28 % to 2.74%). When capital contributors were ranked (Table 12), the following results could be observed. Hereinafter attention will be paid to the first five ranks of each country that most significantly contributed to aggregated market economy labour productivity growth. Estonia: OtherMash, TR, NonResid, CT, IT (two from five were intangible). Latvia: OtherMash, TR, Brand, SoftwDB, NResid (two from five were intangible). Lithuania: OtherMash, NResid, TR, IT, SoftwDB (two from five were intangible). In Denmark the results were as follows: RD, TR, SofwtDB, IT, OtherMash (three from five were intangible). Germany: RD, SoftwDB, OrgCap, IT, CT (all intangible). Spain: Nresid, Resid, OtherMash, IT, CT (two from five were intangible). Sweden: OtherMash, RD, IT, TR, OrgCap (three from five were intangible).

Table 13 Contributions of tangible and intangible capital to aggregated annual average labour productivity growth, 1995–2015

	Capital contribution	Share of tangible capital*	Share of intangible capital**
Estonia	2.74	2.25 (82%)	0.49 (18%)
Latvia	1.28	0.97 (76%)	0.31 (24%)
Lithuania	2.44	0.8 (80%)	1.64 (20%)
Denmark	0.66	0.36 (55%)	0.3 (45%)
Germany	0.73	0.53 (73%)	0.2 (27%)
Spain	1.04	0.82 (79%)	0.22 (21%)
Sweden	1.20	0.73 (61%)	0.47 (39%)

Notes: * = (refer to Table 11) 1 + 2 + 3 + 4 + 5 + 6 + 7.
** = (refer to Table 11) 8 + 9 + 10 + 11 + 12 + 13 + 14 + 15.
Source: Own elaboration

The highest shares of tangible capital in total (Table 13) corresponded to Estonia (82%), Lithuania (80%), Spain (79%) and Latvia (76%).

If we consider that all capital equals 100 (Table 14), from IT and CT capital the highest share was provided by Germany (55%). The highest shares of machinery-based capital (transport equipment and other machinery) were made by Latvia (61%), Estonia (58%) and Lithuania (46%). For buildings, the highest share was provided by Spain (37%), while for SofwDB (23%) and innovative property (28%) the leader was Denmark. In terms of economic competencies, the highest values were provided by Latvia (12%).

Table 14 Contributions of capital groups to aggregated annual average labour productivity growth, 1995–2015

For explanations 1, 2, 3 … etc. refer to Table 11		Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
SUM from I to VII = 100 %	**Capital contribution**	**2.74**	**1.28**	**2.44**	**0.66**	**0.73**	**1.04**	**1.20**
I = 1 + 2	ItandCT	13%	6%	15%	15%	55%	19%	19%
II = 3 + 4	Machinery-based	58%	61%	46%	31%	22%	20%	38%
III = 5 + 6	Buildings	12%	9%	19%	2%	–4%	37%	5%
IV = 8	SoftwDB	3%	5%	6%	23%	8%	6%	7%
V = 9 + 10 + 11 + 12	Innovative property	7%	6%	5%	28%	15%	11%	26%
VI = 13 + 14 + 15	Economic competencies	8%	12%	9%	–5%	4%	4%	5%
VII = 7	Cultivated assets	0%	1%	–1%	6%	0%	3%	–1%

Source: Own elaboration

Table 14 represents the capital structure, with a total of 100. Apparent are different structures of productivity determinants for the Baltic countries compared to their more developed counterparts: machinery-based capital dominates for the Baltic countries and economic competencies constitute a greater contribution of shares relative to more developed economies. Indeed, a far bigger part of IT and CT shares make up the capital contribution in Germany.

MFP (Table 10) accordingly presents the highest values: Latvia (2.9%), Lithuania (2.1%), Estonia (1.7%), Sweden (1.4%), Denmark (0.8%), Germany (0.4%), Spain (–0.3%). Table 15 presents the industries that contribute most to MFP growth. In more developed economies, these comprise manufacturing; wholesale and retail trade, repair of motor vehicles and motorcycles; information and communication for all of the countries; and financial and insurance activities (with the exception of Spain). For the Baltic countries, the first two positions are the same, but big contributions are also made by financial and insurance activities (except for in Lithuania), agriculture, forestry and fishing, transportation and storage (except for in Estonia) and construction (again, with the exception of Estonia).

Table 15 Industry contributions to aggregated MFP growth; percentage points, 1995–2015

	Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
Total, market economy*	1.70	2.85	2.11	0.85	0.42	–0.28	1.44
Agriculture, forestry and fishing	0.17	0.19	0.20	0.04	0.02	0.11	0.04
Mining and quarrying	0.02	0.02	0.01	–0.22	0.00	–0.01	–0.05

Table 15 (continuation)

	Estonia	Latvia	Lithuania	Denmark	Germany	Spain	Sweden
Manufacturing	0.67	0.54	1.09	0.35	0.50	0.24	0.70
Electricity, gas and water supply	0.02	–0.04	0.02	–0.04	0.02	–0.09	–0.05
Construction	0.00	0.32	0.20	0.08	–0.01	–0.20	–0.08
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.41	0.86	0.36	0.31	0.21	0.01	0.32
Transportation and storage	0.00	0.39	0.08	0.07	0.07	–0.03	–0.02
Accommodation and food service activities	0.06	0.08	–0.01	–0.03	–0.02	–0.24	0.01
Information and communication	–0.01	0.10	0.02	0.29	0.17	0.00	0.37
Financial and insurance activities	0.27	0.33	0.06	0.14	–0.08	0.10	0.12
Professional, scientific, technical, administrative and support service activities	0.02	0.02	0.00	–0.11	–0.41	–0.14	0.07
Arts, entertainment, recreation and other service activities	0.08	0.04	0.08	–0.04	–0.04	–0.04	0.02

Note: * All industrial MFP contributions summed to aggregate MFP.
Source: Own elaboration

CONCLUSIONS

During the process of economic growth, the agriculture, forestry, mining and manufacturing sectors shrink, while the service sector grows and expands. The industrial structure of the service sector changes accordingly, while ICT and intangible capital-intensive industries tend to grow and dominate.

All of the more developed economies examined here present a similar economic structure, with the exception of Germany. This economy has a larger manufacturing sector, and moreover this grew throughout the period researched.

The Baltic countries share a distinctive economic structure. The rate of growth of GDP per capita has been the highest, as is usually the case for emerging economies, manifesting a tendency to economic convergence. The transportation and storage industry's shares in value added are higher, but financial and insurance (except Latvia) and professional, scientific, technical, administrative and support service activities' industrial shares are lower relative to more developed economies.

In relation to industrial real value-added growth rates, the highest values are for the information and communication industry for all economies. All of the economies have also maintained high values in financial and insurance activities (except Germany) and professional, scientific, technical, administrative and support service activities. Nevertheless, the highest growth rates are for the the Baltic countries and, in contrast with the more developed economies, they are all positive.

The real growth rates of GDP and aggregated labour productivity are also higher for the Baltic countries compared with the more developed economies. Furthermore, the contributors to aggregated labour productivity, namely MFP, capital and reallocation, are higher for these economies as well. The highest contributions in terms of labour composition are for Estonia and Germany, while the least negative values belong to Latvia, Lithuania, Denmark and Spain.

Insights from the results of the industrial contributions to the aggregated labour productivity growth perspective. For more developed economies, the highest industry contributors to aggregate labour productivity growth are: manufacturing; wholesale trade and repair of motorvehicles; information and communication and financial and insurance activities. For the Baltic countries the first two positions remain the same, but the third position goes to the transportation and storage industry.

Insights from the results of the capital growth determinants perspective. For the Baltic states and Spain – which is the least developed of the four developed countries considered – the share of tangible capital is greater when compared with the more developed economies. Moreover, machinery-based (transport and other machinery) capital predominates in the Baltic countries. From this perspective, the Baltic economies are similar to Spain, in which NResid, Resid and OtherMachinery capital dominates. However, in terms of economic competencies (brand, organisational and training), the Baltic countries maintain strong positions, Latvia being foremost. From IT and CT capital the highest share by far is made by Germany, while the SofwtDB and innovative property leader is Denmark.

The ranked contributors uncovered the following consistency: the first contributors to aggregated labour productivity growth for more developed economies are in intangible capital, and RD tends to maintain the leading positions in more developed economies. In contrast in the Baltic countries, other machinery and transport capital assets make the major contributions to aggregated labour productivity growth, while RD does not take primary positions. Nevertheless, as already stated above, the industrial real value-added growth rates for industries (intangible, IT and CT and particularly R and D capital intensive), namely professional, scientific, technical, administrative and support service activities, information and communications and financial and insurance activities are for all of the Baltic economies especially high. This may be related to the notion that the Baltic economies are only at the stage of development when machinery-based capital predominates for necessary infrastructure creation, whereas later in the growth of their economic structure, both the industrial and main productivity growth determinants will change accordingly. Much greater significance should be acknowledged for intangible capital, particularly RD capital.

Given the similarities in economic structure and productivity growth determinants between the Baltic countries, more detailed analysis of productivity growth determinants in the particular industries that contribute most to aggregated labour productivity growth is required.

Moreover, as the significance of intangible capital during the process of economic growth might be clearly distinguished, investments to intangible capital should play a significant role. Therefore, further accounting research of yet-to-be-measured intangible capital components is necessary.

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Are Slovak Retail Gasoline and Diesel Price Reactions on Crude Oil Changes Asymmetric?

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Abstract

The paper explains why the Slovak retail gasoline and diesel prices rise more rapidly when the price of crude oil increases and fall slowly when the price of crude oil decreases. The weekly data of Slovak retail gasoline and diesel prices and European Brent oil prices since the first week of 2009 till the second week of 2019 are used. The error correction model with irreversible behaviour of explanatory variables is specified to test asymmetric response of retail gasoline and diesel prices on changes in crude oil prices. By our assumption of linked gasoline and diesel markets, we also adopt a common co-integration relationship. Consequently, the vector error correction model is included in the analysis. An expected asymmetry in the retail fuel price reactions on crude oil changes is rejected. Our results may be informative for the future research in Slovak business cycles and in market structure of retail gasoline and diesel sellers.

Keywords

Gasoline and diesel retail prices, crude oil prices, irreversible model, co-integration, asymmetries between the price of crude oil and the retail fuel

JEL code

C22, Q31

INTRODUCTION

This paper answers a question if the Slovak retail gasoline and diesel prices rise more rapidly when the price of crude oil increases and fall slowly when the price of crude oil decreases.[2]

Our motivation comes from following macroeconomic and microeconomic issues. Macroeconomic models of business cycles often lead to the assumption that firms adjust prices infrequently. In recent years, the increasing popularity of the New Keynesian research program has bolstered a line of inquiry into various empirical features of price stickiness. One possible explanation for price rigidity is the asymmetric reaction of output prices to input prices in production. Typical example is that, the fuel prices react more rapidly, when the crude oil price increases and fall slowly when the crude oil

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[2] A partial output of our study has been also published in Szomolányi et al. (2019).

price decreases (Douglas and Herrera, 2010). New Keynesian dynamic stochastic general equilibrium models have been increasingly used in the analysis of Slovak business cycles. In order to form the New Keynesian model correctly, we consider being it necessary to understand the origin of price rigidities. The price asymmetry can be caused by an imperfect market structure or an adjustment costs in production or inventory. Our result may be informative in research areas mentioned above.

A traditional approach to test asymmetric response of retail gasoline and diesel prices on changes in crude oil prices is the use of error correction models (ECM) and vector error correction models (VECM); e.g. Radchenko (2005), Grasso and Manera (2007), Honarvar (2009), Liu et al. (2010). In our paper we use this approach to test asymmetry between the price of BRENT crude oil and the Slovak retail gasoline and diesel price in the period 2009–2019. Our analysis uses weekly data. In addition to the commonly used single-equation error correction approach, it complements the multiple-equation error correction approach, as we assume that the gasoline and diesel markets in Slovakia are in the long-run interconnected and interact with each other. Therefore, we expect two co-integration relationships between the crude oil price and the retail fuel price for gasoline and for diesel. We confirm this assumption in our analysis. On the other hand, the asymmetric reactions of gasoline and diesel retail prices on changes in crude oil price are not supported in our analysis.

After the introduction in which we present motivation and brief methodology comment, the literature review follows. Section 2 presents the adopted methodology for both single-equation and multiple-equation approach. Section 3 describes the data set and it points to one significant tax change. Section 4 illustrates the results of our empirical analysis. The final section summarizes and provides conclusion.

1 LITERATURE REVIEW

There is a common belief that the retail gasoline prices rise more rapidly when the price of crude oil increases and fall slowly when the price of crude oil decreases. Borenstein et al. (1997) find the evidence of short-run asymmetry between the price of crude oil and the retail gasoline. Chen et al. (2005) find evidence of long-run and short-run asymmetries. Grasso and Manera (2007) find mixed evidence of long-run asymmetries following a crude oil shock for five European countries. Other studies indicating asymmetries between the price of crude oil and the retail gasoline are those by Radchenko (2005), Honarvar (2009), Meyler (2009), Liu et al. (2010), Rahman (2016), Sun et al. (2018), Bagnai et al. (2018), Bumpass et al. (2019).

Several explanations of the asymmetry have been proposed and tested. A short review is provided by Brown and Yücel (2000) and also Radchenko (2005). Borenstein et al. (1997) suggest three possible explanations for the asymmetric response of gasoline prices:

(i) the oligopolistic coordination theory,
(ii) the production and inventory cost of adjustment, and
(iii) the search theory.

When the crude oil price rises in an industry with a few dominant firms, each firm is quick to raise its selling price because it wishes to signal its competitors that it is adhering to the tacit agreement by not cutting its margin. When the crude oil price falls, each firm is slow to lower its selling price because doing so runs the risk of sending a signal to its competitors that it is cutting its margin and no longer adhering to the tacit agreement.

Borenstein and Shepard (2002) argue that the costs of adjustment of production and inventory cause the asymmetric response of gasoline prices. Since the adjusting levels of production and inventory is costly, firms spread the adjustment over time. A reduction in the price of crude oil, for example, will imply some long-run increase in the supply of gasoline. But if there are adjustment costs that increase with the absolute size of adjustment per period, firms will spread the adjustment over time, gradually achieving the full quantity increase implied by the decline in cost.

According to the search theory, an increase in the retail price of gasoline raises incentives to search for a lower priced retail outlet, while a decrease in the price lowers the incentive to search. Different search rules of consumers influence the elasticity of a retailer's demand and this leads to the asymmetric response of gasoline prices.

A broad descriptive approach was taken by Peltzman (2000). The author examines how the measures of imperfect competition, inventory cost, inflation-related asymmetric menu costs, and input price volatility influence the degree of asymmetry. In this study, Peltzman finds a negative correlation between the degree of asymmetry and input price volatility, but he finds no relationship between the degree of asymmetry and proxies for market power, inventory cost, and asymmetric menu costs.

While there is a lot of evidence suggesting asymmetry between the price of oil and retail gasoline, on the other hand, there are many papers with opposite results. Applying a threshold regression model, Godby et al. (2000) are unable to find evidence of the asymmetric adjustment in the Canadian gasoline market. Peltzman (2000) shows that the problem of an asymmetric response of output prices to changes in input prices is not specific to the gasoline market.

Bachmeier and Griffin (2003) report no evidence of asymmetry in the U.S. wholesale gasoline market for daily spot gasoline and crude oil price data, over the period 1985–1998. Bettendorf et al. (2003) study the retail price adjustment in the Dutch gasoline market. These authors argue that conclusions on the asymmetry are dependent on the choice of the day when the prices are observed.

Venditti (2010) also reports no systematic evidence of asymmetry for the U.S. as well as Euro areas over 1999–2009, using nonlinear impulse response functions with asymmetric price adjustment, as opposed to the traditional linear impulse response functions used in previous studies.

In recent papers Bagnai et al. (2018) indicate that the relationship between the U.S. prices of gasoline and crude oil has undergone a single structural break in the late 2008, and that after the break extreme observations have a non-negligible role in shaping asymmetry. Bumpass et al. (2019) fail to reject long-run symmetry at each stage of the retail gasoline supply chain in the U.S. market.

2 METHODOLOGY

We are interested in the question as to whether a positive unit change in the oil price has an identical influence on the fuel price as a negative unit change. The error correction model with irreversible behaviour of explanatory variables is considered to be the basic tool for the analysis of the asymmetric price reaction of fuel. The reason for this is clear: if non-stationary price variables are used as the first differences in this model, it is thus easy to separate positive and negative values in the explanatory variable.

A non-stationarity of variables is tested by unit root tests. We prefer the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981). The conventional unit root tests are biased when the data are trend stationary with a structural break. To avoid this problem, we also test variables using the Perron breakpoint unit root procedure (Perron, 1988).

2.1 The single-equation co-integration approach

The single-equation error correction model is essentially an auto-regressive distributed lag model with rearranged terms. We can show it by the auto-regressive distributed lag model of order one with three variables (ARDL(1,1,1)):

$$y_t = \beta_0 + \beta_1 y_{t-1} + \gamma_0 x_t + \gamma_1 x_{t-1} + \delta_0 z_t + \delta_1 z_{t-1} + u_t\,, \tag{1}$$

where y_t is regressand – an average weekly price of gasoline or diesel in time t; x_t is the key regressor – an average weekly price of oil in time t; z_t is another relevant regressor in time t (a diesel price

in the gasoline equation or a gasoline price in the diesel equation for example); u_t is a stochastic term in time t and β_0, β_1, γ_0, γ_1, δ_0 and δ_1 are unknown parameters of this regression model.

We can rewrite model (1) as the error correction (*ECM*) model (Engle and Granger, 1987):

$$\Delta y_t = \beta_0 + \gamma_0 \Delta x_t + \delta_0 \Delta z_t + (\beta_1 - 1)\left[y_{t-1} - \frac{(\gamma_0 + \gamma_1)}{1-\beta_1} x_{t-1} - \frac{(\delta_0 + \delta_1)}{1-\beta_1} z_{t-1} \right] + u_t , \tag{2}$$

which contains the original (one period lagged) variables in the levels and their first differences. This allows us to explore both the long-run equilibrium relationship and its adjustment along with the short-run dynamics. If a positive unit change of the regressor has an identical influence on the regressand as a negative unit change, we do not have to distinguish between them and we can estimate the overall response with one parameter for one regressor, as in the reversible model. But this is precisely a restriction. If this restriction is not valid, the estimation results can be improved by specifying increases ($\Delta^+ x_t$) and decreases ($\Delta^- x_t$) of the explanatory variable as separate variables and also by separating the positive and non-positive deviations from the long-run equilibrium relationship.

The asymmetric form of this irreversible error correction (*A-ECM*) model (Granger and Lee, 1989) is:

$$\Delta y_t = \beta_0 + \gamma_0^+ \Delta^+ x_t + \gamma_0^- \Delta^- x_t + \delta_0 \Delta z_t + \lambda^+ e_{t-1} \times D(e_{t-1} > 0) + \lambda^- e_{t-1} \times D(e_{t-1} \le 0) + u_t , \tag{3}$$

where: $e_{t-1} = y_{t-1} - \frac{(\gamma_0 + \gamma_1)}{1-\beta_1} x_{t-1} - \frac{(\delta_0 + \delta_1)}{1-\beta_1} z_{t-1}$ is one period lagged deviation from the long-run equilibrium relationship; $D(e_{t-1} > 0)$ is a dummy variable that equals 1 if $e_{t-1} > 0$ and equals 0 otherwise; $D(e_{t-1} \le 0)$ is a dummy variable that equals 1 if $e_{t-1} \le 0$ and equals 0 otherwise; λ^+ and λ^- are the corresponding adjustment parameters, β_0, γ_0^+, γ_0^- and δ_0 are also parameters of this regression.

Model (2) is obtained from model (3) using restrictions $\lambda^+ = \lambda^-$ and $\gamma_0^+ = \gamma_0^-$. This linear hypothesis in the linear model can be tested by the F test. In cases where model (1) has a more extensive dynamic structure, both models (2) and (3) will be also more extensive and the test hypothesis will additionally include parameter comparisons for further lags. Models (2) and (3) are some of the simplest types of error correction models, because their long-run equilibrium relationship does not contain any deterministic terms. When searching for the most appropriate specification of the model, it is necessary to analyse different versions of deterministic components as a constant and trend in both long-run relationship and short-run dynamic part of the equation. This brings us to the well-known five cases of the deterministic part of the model: no constant and no trend, restricted constant and no trend, unrestricted constant and no trend, unrestricted constant and restricted trend, unrestricted constant and unrestricted trend; among these we have to decide.

The single equation error correction models are usually estimated by means of a two-step Engle-Granger procedure (Engle and Granger, 1987) and the co-integration of variables is confirmed by an ADF test of residuals from the first step with the MacKinnon (1991) critical values adjusted for the number of variables. The estimates from the static long-run equation (the first step of the Engle-Granger procedure), although consistent, can be substantially biased in small samples, partly due to serial correlation in the residuals. In the first step of Engle-Granger procedure we use fully modified ordinary least squares (FMOLS) method proposed by Phillips and Hansen (1990). The FMOLS estimator employs a semi-parametric correction to eliminate problems caused by the long run correlation between the co-integrating equation and stochastic regressors' innovations. The FMOLS estimator is asymptotically unbiased and is efficient as other used methods e.g. dynamic ordinary least squares method.

The bias can be reduced by allowing for some dynamics in the long-run equation. In the first stage of Engle-Granger procedure we can estimate an autoregressive distributed lag (ARDL) model and solve for the long-run equation. Its residuals are a measure of disequilibrium and a test of co-integration is a test for the stationarity residuals. As an alternative to the two-step Engle and Granger procedure with the static long-run equation, the ECM model can be estimated just using the residuals from this ARDL model.

The co-integration of variables can be also verified by bounds testing. Pesaran et al. (2001) propose a test for co-integration that is robust with regard to the fact as to whether variables of interest are stationary or integrated of order one, or mutually co-integrated. They suggest a bounds test for co-integration as a test on parameter significance in the co-integrating relationship of the conditional error correction model. Once the test statistic is computed, it is compared to two asymptotic critical values corresponding to two opposite cases: in the first case, all variables are purely stationary, in the second one they are purely integrated of order one. When the test statistic is below the lower critical value, one fails to reject the null and concludes that co-integration is not possible. In contrast, when the test statistic is above the upper critical value, one rejects the null and concludes that co-integration is indeed possible. In either of these two cases, knowledge of the co-integrating rank is not necessary. Alternatively, if the test statistic is between the lower and upper critical values, testing is inconclusive, and knowledge of the co-integrating rank is required to proceed.

After the validation of co-integration, we form the asymmetric ECM and test the appropriate restrictions. In the asymmetric ECM, we do not re-estimate the co-integration relationship which is included in the variable representing the deviation from equilibrium.

2.2 The multiple-equation co-integration approach

We expect that there are co-integrating relationships between the crude oil price and one each for the retail fuel prices, for gasoline and for diesel, either individually or jointly; therefore, we are looking for a long-term equilibrium relationship between the price of oil and the retail price of fuel with the help of the vector error correction model (VECM).

Similarly, as the single-equation error correction model is an auto-regressive model, so the vector error correction model is a vector auto-regressive model. We can show it by the vector auto-regressive model of order two:

$$\mathbf{y}_t = \mathbf{\Phi D}_t + \mathbf{\Pi}_1 \mathbf{y}_{t-1} + \mathbf{\Pi}_2 \mathbf{y}_{t-2} + \mathbf{u}_t \,, \tag{4}$$

where: $\mathbf{y}_t$ is the vector of variables (gasoline price, diesel price and oil price) in time t; $\mathbf{D}_t$ is the matrix of deterministic terms (constant, trend, …) in time t; $\mathbf{u}_t$ is the vector of stochastic terms in time t and $\mathbf{\Phi}$, $\mathbf{\Pi}_1$ and $\mathbf{\Pi}_2$ are the matrices of unknown parameters of this model.

We can rewrite model (4) as the vector error correction (*VECM*) model of order one:

$$\Delta \mathbf{y}_t = \mathbf{\Phi D}_t + \boldsymbol{\alpha}\boldsymbol{\beta}^T \mathbf{y}_{t-1} + \mathbf{\Phi}_1 \Delta \mathbf{y}_{t-1} + \mathbf{u}_t \,, \tag{5}$$

where: $\boldsymbol{\alpha}\boldsymbol{\beta}^T = \left(\mathbf{\Pi}_1 + \mathbf{\Pi}_2 - \mathbf{I}\right)$ and $\mathbf{\Phi}_1 = -\mathbf{\Pi}_2$. Model (5) contains the original (one period lagged) variables in the levels and their first differences, and allows us to explore both the long-run equilibrium relationship and its adjustment along with short-run dynamics. Matrix $\boldsymbol{\beta}$ is called a co-integration matrix with co-integration vectors as columns and matrix $\boldsymbol{\alpha}$ is called a loading matrix. Again, it is necessary to analyse different versions of deterministic components $\mathbf{\Phi D}_t$ corresponding to five cases mentioned in part 2.1.

The asymmetric form of this irreversible vector error correction (A-VECM) model is:

$$\Delta \mathbf{y}_t = \mathbf{\Phi D}_t + \boldsymbol{\alpha}^+ \left[\boldsymbol{\beta}^T \mathbf{y}_{t-1} \times D\left(\boldsymbol{\beta}^T \mathbf{y}_{t-1} > \mathbf{0} \right) \right] + \boldsymbol{\alpha}^- \left[\boldsymbol{\beta}^T \mathbf{y}_{t-1} \times D\left(\boldsymbol{\beta}^T \mathbf{y}_{t-1} \leq \mathbf{0} \right) \right] + \mathbf{\Phi}_1^+ \Delta^+ \mathbf{y}_{t-1} + \mathbf{\Phi}_1^- \Delta^- \mathbf{y}_{t-1} + \mathbf{u}_t , \quad (6)$$

where: $\boldsymbol{\beta}^T \mathbf{y}_{t-1}$ is the vector of one period lagged deviations from the long-run equilibrium relationships; $D(\boldsymbol{\beta}^T \mathbf{y}_{t-1} > \mathbf{0})$ is the vector of a dummy variable; its element equals 1 if corresponding element of $\boldsymbol{\beta}^T \mathbf{y}_{t-1}$ is positive and equals 0 otherwise; similarly $D(\boldsymbol{\beta}^T \mathbf{y}_{t-1} \leq \mathbf{0})$ is the vector of a dummy variable; its element equals 1 if corresponding element of $\boldsymbol{\beta}^T \mathbf{y}_{t-1}$ is not positive and equals 0 otherwise; $\boldsymbol{\alpha}^+$ and $\boldsymbol{\alpha}^-$ are the loading matrices of corresponding adjustment parameters and $\mathbf{\Phi}_1^+$ and $\mathbf{\Phi}_1^-$ are also matrices with some pairs of the asymmetric parameters of this model. The multiplication operation in square brackets of model (6) does not represent the matrix product, but the product of elements in the same positions in corresponding vectors. Model (5) is obtained from model (6) using restrictions $\mathbf{\Phi}_1^+ = \mathbf{\Phi}_1^-$ and $\boldsymbol{\alpha}^+ = \boldsymbol{\alpha}^-$.

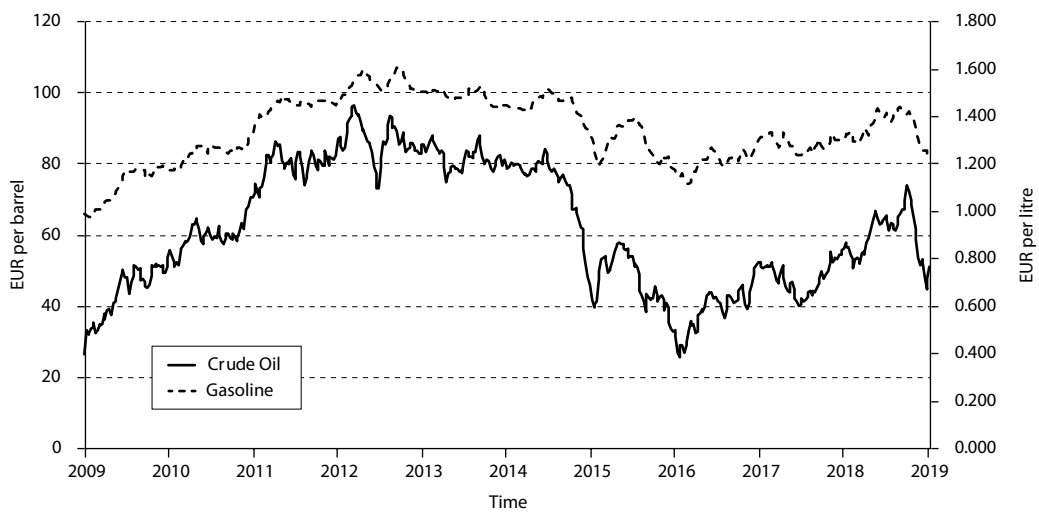
The test of co-integration in VECM is realized by Johansen's procedure (Johansen, 1988, 1991) by the lambda trace statistics depending on the specification of the deterministic components of model (5). After the validation of co-integration, we form the asymmetric VECM and test the appropriate restrictions. In the asymmetric VECM, we do not re-estimate co-integration relationships, which are included in the variables representing the deviations from the equilibrium.

3 DATA AND TAX LEGISLATION

Data of retail gasoline and diesel prices on Slovak market are gathered from the Statistical Office of the Slovak Republic. The spot prices for crude oil and petroleum products are gathered from the U.S. Energy Information Administration – the agency responsible for collecting, analysing, and disseminating energy information. Since we only have the weekly retail gasoline and diesel prices data, we can only use the weekly Europe Brent Spot Price FOB Dollars per Barrel for the analysis.

The weekly retail gasoline and diesel prices data are in euros, so we need to recalculate the crude oil prices from dollars to euros. We converted the daily oil prices in dollars by the euro exchange rate in dollars and then aggregated them into weekly averages. The daily reference exchange rate data series are gathered from the European Central Bank. All data pertains to the period from the first week

Figure 1 The Weekly Crude Oil Price and the Retail Gasoline Price (€)

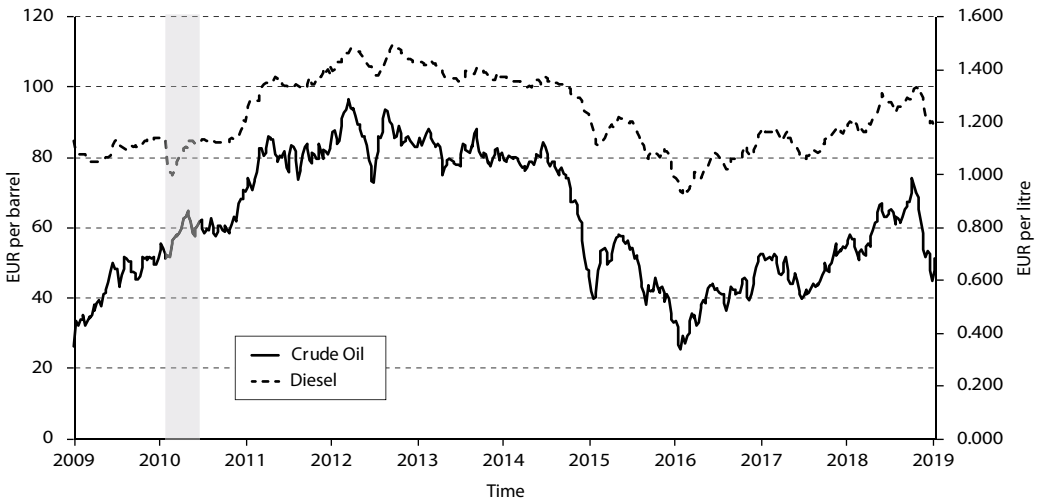


Source: The Statistical Office of the Slovak Republic and the U.S. Energy Information Administration

of 2009 till the second week of 2019, so we have 524 observations available. The graph of weekly crude oil price and the retail gasoline price is in Figure 1 and graph of weekly crude oil price and the retail diesel price is in Figure 2.

Liu et al. (2010) outline that taxes and levies make up a significant proportion of retail fuel prices and any changes in government taxes and levies can therefore have a significant impact on retail diesel and gasoline prices. During the period analysed, there was no significant change in consumption taxes, apart from February 2010, when almost a quarter of the consumption taxes on diesel decreased. In other cases, only the classification and categorization of fuels (due to biofuels), without significant intervention in tax rates (no more than 2%), occurred in legislative changes. The impact of the tax change on the consumption tax on diesel can be clearly seen also in the chart of the retail price for diesel. We have highlighted it by shading the graph area in Figure 2.

Figure 2 The Weekly Crude Oil Price and the Retail Diesel Price (€)



Source: The Statistical Office of the Slovak Republic and the U.S. Energy Information Administration

4 RESULTS

A non-stationarity of variables is tested by augmented Dickey-Fuller (ADF) test and also by Perron breakpoint unit root test procedure. The probability values representing the significance level at which we reject the null hypothesis are in Tables 1 and 2.

Table 1 The Probability Values for the Unit Root Tests (ADF Tests) of the Variables

Variable/ Test equation	Oil price	Gasoline price	Diesel price	Δ(Oil price)	Δ(Gasoline price)	Δ(Diesel price)
Const + Trend	0.3511	0.3518	0.7100	0.0000	0.0000	0.0000
Const	0.2943	0.0994	0.4519	0.0000	0.0000	0.0000
None	0.6288	0.7773	0.7053	0.0000	0.0000	0.0000

Note: The null hypothesis of ADF test is a unit root of a variable. We reject it only for the first differences.
Source: Own construction

Table 2 The Probability Values for the Breakpoint Unit Root Tests (Perron Procedure)

Variable/ Break specification	Oil price	Gasoline price	Diesel price	Δ(Oil price)	Δ(Gasoline price)	Δ(Diesel price)
Trend + Intercept	0.7013	0.8167	0.9670	<0.01	<0.01	<0.01
Trend	0.8933	0.7179	0.9035	<0.01	<0.01	<0.01
Intercept	0.2242	0.6018	0.7867	<0.01	<0.01	<0.01

Note: The null hypothesis of Perron procedure is a unit root of a variable. We reject it only for the first differences.
Source: Own construction

The unit root tests of the analysed time series confirmed the non-stationarity of all price variables. All used variables are integrated of order 1. As a result, the presence of co-integration can be considered among the price variables, since the conditions for using the Engle-Granger procedure are met.

4.1 The single-equation co-integration approach

In the Engle-Granger procedure we first estimate the long-run equation by FMOLS method and then we test the stationarity of its residuals by ADF test. The results of the Engle-Granger procedure with the static long-run equations for gasoline and diesel prices are in Tables 3 and 4. There are different specifications in the table: without the constant and trend (A), only with the constant (B), with the linear trend (C) and with the quadratic trend (D). We start with the oil price as only regressor and then we add the diesel price.

Table 3 The Results of Engle-Granger Procedure (Static Model) for Gasoline Prices

Exogenous: Oil price	Constant	Linear trend	Quadratic trend	Oil price	ADF τ stat [p-value]
A	–	–	–	0.0205 (0.0004)	–2.0835 [0.2063]
B	0.8965 (0.0201)	–	–	0.0072 (0.0003)	–3.8809 [0.0112]
C	0.7797 (0.0153)	0.0003 (0.00002)	–	0.0079 (0.0002)	–6.2863 [0.0000]
D	0.7716 (0.0124)	0.0008 (0.00008)	0.000001 (0.0000002)	0. 0072 (0.0002)	–7.3910 [0.0000]
Exogenous: Oil + Diesel price	**Constant**	**Linear trend**	**Quadratic trend**	**Oil price**	**ADF τ stat [p-value]**
A	–	–	–	–0.0016 (0.0005)	–5.0121 [0.0002]
B	0.4577 (0.0840)	–	–	0.0027 (0.0009)	–4.1931 [0.0148]
C	0.6537 (0.0591)	0.0003 (0.00002)	–	0.0065 (0.0007)	–5.0738 [0.0028]
D	0.6333 (0.0474)	0.0008 (0.00008)	0.000001 (0.0000002)	0. 0056 (0.0005)	–6.1232 [0.0002]

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for τ statistics of long-run equation residual ADF test are in the brackets.
Source: Own construction

Table 4 The Results of Engle-Granger Procedure (Static Model) for Diesel Prices

Exogenous: Oil price	Constant	Linear trend	Quadratic trend	Oil price	ADF τ stat [p-value]
A	–	–	–	0.0189 (0.0003)	–2.6352 [0.0684]
B	0.7541 (0.0151)	–	–	0.0076 (0.0002)	–5.0795 [0.0001]
C	0.7090 (0.0171)	0.0001 (0.00003)	–	0.0079 (0.0002)	–5.8968 [0.0000]
D	0.7063 (0.0172)	0.00007 (0.0001)	0.0000001 (0.0000002)	0. 0079 (0.0003)	–5.8929 [0.0001]
Exogenous: Oil + Gasoline price	**Constant**	**Linear trend**	**Quadratic trend**	**Oil price**	**ADF τ stat [p-value]**
A	–	–	–	0.0021 (0.0004)	–5.5634 [0.0000]
B	0.4688 (0.0583)	–	–	0.0054 (0.0005)	–4.7419 [0.0024]
C	0.5147 (0.0755)	0.00004 (0.00004)	–	0.0059 (0.0008)	–5.6171 [0.0003]
D	0.3766 (0.0873)	–0.0003 (0.0001)	0.0000005 (0.0000002)	0. 0049 (0.0008)	–5.3886 [0.0030]

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for τ statistics of long-run equation residual ADF test are in the brackets.
Source: Own construction

The results of all models (except the model without the constant and trend and without another regressor) confirm the justification for using co-integration equation for modelling the long run relationships between pairs of prices. Likewise, it seems to be appropriate to include the linear trend into the long run relationships for both prices (we should not use it only in the model for diesel prices with gasoline price as regressor).

All the estimates of static co-integration equations have auto-correlated residuals. We decided to avoid them with the help of dynamic ARDL models. The presented dynamic models were selected from a wide range of models to meet the no residual autocorrelation condition. We can see the results of Engle-Granger procedure with the dynamic long-run equations for the gasoline prices in Table 5 and for the diesel prices in Table 6.

Table 5 The Results of Engle-Granger Procedure (Dynamic Model) for Gasoline Prices

Exogenous: Oil + Diesel price	ADF τ stat [p-value]	Ljung-Box Q(1) [p-value]	Ljung-Box Q(2) [p-value]	Ljung-Box Q(3) [p-value]	Ljung-Box Q(4) [p-value]
ARDL(2,2,1) no trend	–23.2251 [0.0000]	0.7994 [0.371]	0.9042 [0.636]	0.9110 [0.823]	0.9110 [0.823]
ARDL(2,2,1) linear trend	–22.9940 [0.0000]	0.7681 [0.381]	0.8862 [0.642]	0.8863 [0.829]	0.8863 [0.829]

Note: The probability values for τ statistics of ADF test and Ljung-Box Q-statistics are in the brackets.
Source: Own construction

Table 6 The Results of Engle-Granger Procedure (Dynamic Model) for Diesel Prices

Exogenous: Oil + Gasoline price	ADF τ stat [p-value]	Ljung-Box Q(1) [p-value]	Ljung-Box Q(2) [p-value]	Ljung-Box Q(3) [p-value]	Ljung-Box Q(4) [p-value]
ARDL(1,4,1) no trend	–21.6932 [0.0000]	0.7219 [0.396]	1.4707 [0.479]	1.8625 [0.601]	2.5293 [0.639]
ARDL(2,2,1) linear trend	–23.5046 [0.0000]	1.5212 [0.217]	2.3250 [0.313]	2.9230 [0.404]	2.9230 [0.404]

Note: The probability values for τ statistics of ADF test and Ljung-Box Q-statistics are in the brackets.
Source: Own construction

The second alternative to deal with autocorrelation of residuals in the long-run equation is to replace two-step estimation of error correction models with one-step estimation (estimation of ARDL and rearranged) and then to use bounds testing of Pesaran et al.

Table 7 The Results of Estimation of ECM and Bounds Testing for Gasoline Prices

Exogenous: Oil price	Oil price	Linear trend	Adjustment parameter	F-Bounds test k	1% I(0) bound 1% I(1) bound
Case 1 ARDL(2,4)	0.0224 (0.0035)	_	–0.0023 (0.0017)	0.8966 1	4.81 6.02
Case 2 ARDL(2,4)	0.0075 (0.0007)	_	–0.0370 (0.0087)	5.9929 1	4.94 5.58
Case 3 ARDL(2,4)	0.0075 (0.0007)	_	–0.0370 (0.0087)	8.0707 1	6.84 7.84
Case 4 ARDL(2,4)	0.0079 (0.0004)	0.0002 (0.00004)	–0.0749 (0.0136)	10.010 1	6.10 6.73
Case 5 ARDL(2,4)	0.0079 (0.0004)	0.00002 (0.000005)	–0.0749 (0.0140)	14.231 1	8.74 9.63
Exogenous: Oil + Diesel price	**Oil price**	**Linear trend**	**Adjustment parameter**	**F-Bounds test k**	**1% I(0) bound 1% I(1) bound**
Case 1 ARDL(2,2,1)	–0.0014 (0.0016)	_	–0.0239 (0.0074)	3.5077 2	3.88 5.30
Case 2 ARDL(2,2,1)	0.0064 (0.0024)	_	–0.0365 (0.0087)	5.9820 2	4.13 5.00
Case 3 ARDL(2,2,1)	0.0064 (0.0024)	_	–0.0365 (0.0075)	7.8403 2	5.15 6.36
Case 4 ARDL(2,2,1)	0.0076 (0.0016)	0.0002 (0.00005)	–0.0587 (0.0106)	7.6517 2	4.99 5.85
Case 5 ARDL(2,2,1)	0.0076 (0.0016)	0.00001 (0.000004)	–0.0587 (0.0113)	8.6064 2	6.34 7.52

Note: The estimates of standard deviations of parameters are in the parentheses. In the last column the lower and upper critical value at 1% significance level of bounds test are shown. The adjustment parameter is $\beta_1 - 1$ in (2).
Source: Own construction

We analyse different versions of deterministic components in ECM as constant and trend in both the long-term equilibrium relationship as well as the short-run dynamic part of the equation. This will bring us to five cases: no constant and no trend (Case 1), restricted constant and no trend (Case 2), unrestricted constant and no trend (Case 3), unrestricted constant and restricted trend (Case 4), unrestricted constant and unrestricted trend (Case 5). For every case we choose the most appropriate ARDL model and make bounds testing at 1% significance level. The results are in Tables 7 and 8.

Table 8 The Results of Estimation of ECM and Bounds Testing for Diesel Prices

Exogenous: Oil price	Oil price	Linear trend	Adjustment parameter	F-Bounds test k	1% I(0) bound 1% I(1) bound
Case 1 ARDL(2,4)	0.0194 (0.0015)	–	–0.0047 (0.0022)	2.2687 1	4.81 6.02
Case 2 ARDL(2,4)	0.0084 (0.0005)	–	–0.0513 (0.0110)	7.2580 1	4.94 5.58
Case 3 ARDL(2,4)	0.0084 (0.0005)	–	–0.0513 (0.0110)	10.8866 1	6.84 7.84
Case 4 ARDL(2,4)	0.0086 (0.0004)	0.0002 (0.00005)	–0.0686 (0.0121)	10.765 1	6.10 6.73
Case 5 ARDL(2,4)	0.0086 (0.0004)	0.00001 (0.000003)	–0.0686 (0.0121)	16.019 1	8.74 9.63
Exogenous: Oil + Gasoline price	**Oil price**	**Linear trend**	**Adjustment parameter**	**F-Bounds test k**	**1% I(0) bound 1% I(1) bound**
Case 1 ARDL(1,4,1)	0.0030 (0.0008)	–	–0.0418 (0.0087)	7.6375 2	3.88 5.30
Case 2 ARDL(1,4,1)	0.0038 (0.0013)	–	–0.0467 (0.0096)	5.8559 2	4.13 5.00
Case 3 ARDL(1,4,1)	0.0038 (0.0013)	–	–0.0467 (0.0097)	7.7574 2	5.15 6.36
Case 4 ARDL(2,2,1)	0.0085 (0.0017)	0.00019 (0.00008)	–0.0564 (0.0097)	8.3695 2	4.99 5.85
Case 5 ARDL(2,2,1)	0.0085 (0.0020)	0.00001 (0.000003)	–0.0564 (0.0100)	10.631 2	6.34 7.52

Note: The estimates of standard deviations of parameters are in the parentheses. In the last column the lower and upper critical value at 1% significance level of bounds test are shown. The adjustment parameter is $\beta_1 - 1$ in (2).
Source: Own construction

The F-bounds test statistics is above the upper critical value for all cases except three models in Case 1, we can reject the null and conclude that co-integration is indeed possible. For three models of Case 1 (both gasoline price models and diesel price model with only one regressor), the F-bounds test statistics is below the lower critical value, one fails to reject the null and we conclude that co-integration is not possible. The results of almost all models (except for rarely used long-run specifications without deterministic terms) confirm the justification for using co-integration equation.

Finally, we construct the corresponding asymmetric error correction models and test the asymmetry. The error correction (ECM) model (2) is obtained from the asymmetric error correction (A-ECM) model (3) using restrictions $\lambda^+ = \lambda^-$ and $\gamma_0^+ = \gamma_0^-$. This joint linear hypothesis can be tested by the F test. The rejection of the joint hypothesis concludes that asymmetry is indeed possible. In the analysis we estimate two more specifications. First is A-ECM model with the restriction $\gamma_0^+ = \gamma_0^-$. The rejection of the hypothesis $\lambda^+ = \lambda^-$ concludes that long-run asymmetry (LR-A) is indeed possible. Second is A-ECM model with the restriction $\lambda^+ = \lambda^-$. The rejection of the hypothesis $\gamma_0^+ = \gamma_0^-$ concludes that short-run asymmetry (SR-A) is indeed possible. In both cases we consider more extensive short-run dynamic structure including lagged first differences of crude oil prices.

The results of testing of asymmetries in A-ECM for gasoline prices are in Table 9. We use all error correction models shown in Table 7 with the exception of those, where the bounds tests conclude no possibility of co-integration.

Table 9 The Results of Testing of Asymmetries in A-ECM for Gasoline Prices

Exogenous: Oil price	λ^+	λ^-	**Asymmetry test**	**LR-A test**	**SR-A test**
Case 2	–0.0614 (0.0188)	–0.0251 (0.0129)	0.8390 [0.5224]	1.7066 [0.1920]	0.5603 [0.6916]
Case 3	–0.0707 (0.0186)	–0.0117 (0.0115)	1.7427 [0.1232]	4.5341 [0.0337]	1.1093 [0.3513]
Case 4	–0.0502 (0.0223)	–0.1027 (0.0261)	1.0635 [0.3797]	1.1558 [0.2829]	0.8938 [0.4674]
Case 5	–0.0800 (0.0188)	–0.0636 (0.0224)	0.7737 [0.5690]	0.3232 [0.5700]	0.8931 [0.4678]
Exogenous: Oil + Diesel price	λ^+	λ^-	**Asymmetry test**	**LR-A test**	**SR-A test**
Case 2	–0.0500 (0.0168)	–0.0316 (0.0101)	0.4149 [0.7423]	0.7053 [0.4014]	0.2706 [0.7630]
Case 3	–0.0564 (0.0176)	–0.0248 (0.0124)	0.8079 [0.4899]	1.6317 [0.2020]	0.4551 [0.6347]
Case 4	–0.0390 (0.0184)	–0.0805 (0.0198)	0.7907 [0.4994]	1.3746 [0.2416]	0.3337 [0.7164]
Case 5	–0.0596 (0.0168)	–0.0571 (0.0174)	0.2256 [0.8786]	0.0239 [0.8772]	0.3337 [0.7164]

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for F statistics are in the brackets. LR-A test and SR-A test are realized on restricted A-ECM models.
Source: Own construction

The analogous selection procedure is carried out for the diesel prices in Table 10. We use all error correction models shown in Table 8 with the exception of those, where the bounds tests conclude the no possibility of co-integration.

Table 10 The Results of Testing of Asymmetries in A-ECM for Diesel Prices

Exogenous: Oil price	λ^+	λ^-	**Asymmetry test**	**LR-A test**	**SR-A test**
Case 2	–0.0858 (0.0234)	–0.0327 (0.0149)	2.2333 [0.0499]	1.1440 [0.2853]	2.0326 [0.0886]
Case 3	–0.0874 (0.0234)	–0.0306 (0.0153)	2.3090 [0.0432]	2.7551 [0.0976]	2.0444 [0.0870]
Case 4	–0.0574 (0.0192)	–0.0805 (0.0210)	1.7147 [0.1295]	0.7610 [0.3834]	2.0120 [0.0916]
Case 5	–0.0959 (0.0228)	–0.0514 (0.0169)	2.0370 [0.0721]	1.6474 [0.1999]	2.0081 [0.0921]
Exogenous: Oil + Gasoline price	λ^+	λ^-	**Asymmetry test**	**LR-A test**	**SR-A test**
Case 1	–0.0383 (0.0118)	–0.0533 (0.0244)	1.5742 [0.1656]	0.2865 [0.5927]	1.9096 [0.1075]
Case 2	–0.0466 (0.0136)	–0.0483 (0.0228)	1.5207 [0.1816]	0.0561 [0.8128]	1.9038 [0.1085]
Case 3	–0.0443 (0.0142)	–0.0535 (0.0124)	1.6087 [0.1560]	0.1616 [0.6878]	1.9919 [0.0945]
Case 4	–0.0432 (0.0147)	–0.0762 (0.0199)	1.8397 [0.1389]	1.5964 [0.2070]	2.0694 [0.1273]
Case 5	–0.0643 (0.0182)	–0.0497 (0.0149)	1.4813 [0.2187]	0.3222 [0.5705]	2.0660 [0.1277]

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for F statistics are in the brackets. LR-A test and SR-A test are realized on restricted A-ECM models.
Source: Own construction

The answer to the key issue of price asymmetry is negative in all cases at 1% significance level. The LR-A is possible at 5% significance level in the gasoline model with unrestricted constant and without trend (Case 3). Unspecified asymmetries are possible at 5% significance level in two diesel models: the first with restricted constant and without trend (Case 2), the second with unrestricted constant and without trend (Case 3).

In these entire estimates oil price alone is considered to be exogenous variable. If price of another retail fuel price (diesel for gasoline equation, gasoline for diesel equation) is endogenous than the multiple-equation specification shall be considered.

4.2 The multiple-equation co-integration approach

As the gasoline and diesel markets are linked, we have also used vector error correction models in our analysis. The first question to answer is whether we have one or two co-integration relations between three price variables. We use Johansen co-integration test and its trace statistics. The results of the analysis are in Table 11.

We consider 4 cases: no deterministic trend in the data, and no intercept or trend in the co-integrating equation (A), no deterministic trend in the data, and an intercept but no trend in the co-integrating equation (B), linear trend in the data, and an intercept but no trend in the co-integrating equation (C) and linear trend in the data, and both an intercept and a trend in the co-integrating equation (D); among which we have to decide. All reasonable models indicate two co-integration relations between three price variables.

Table 11 The Results of Johansen Co integration Test – Number of Co-integration Relations

Maximum lag	Scheme A	Scheme B	Scheme C	Scheme D
1	1	2	2	2**
2	1	2	2	2**
3	1	2	2	2**
4	1	2	2	2**

Note: Trace statistics select numbers at 5% significance level. Asterisks indicate the selection of scheme by AIC criteria for each lag.
Source: Own construction

The Johansen test with its lambda trace statistics indicates two co-integration equations, so we normalized model to create one co-integrating equation for gasoline and the other for diesel. According to the appropriate likelihood ratio test we did not reject the weak exogeneity of crude oil prices. The equilibrium relations for Slovak gasoline and diesel prices cannot influence the crude oil prices. The results of estimation of vector error correction models are in Table 12.

Table 12 The Results of Estimation of VECM with Restrictions – Different Maximum Lag

Max lag 1	β in co-integrating equations			Adjustment parameters α		Weak exogeneity
	Gasoline price	Diesel price		Gasoline price	Diesel price	
Oil price	0.0076 (0.0004)	0.0087 (0.0004)	Gasoline	–0.0752 (0.0120)	–0.0346 (0.0118)	1.1946 [0.5503]
Trend	0.0002 (0.00005)	0.0002 (0.00005)	Diesel	–0.0358 (0.0111)	–0.0729 (0.0109)	

Table 12 (continuation)

Max lag 2	β in co-integrating equations			Adjustment parameters α		Weak exogeneity
	Gasoline price	Diesel price		Gasoline price	Diesel price	
Oil price	0.0076 (0.0004)	0.0087 (0.0004)	Gasoline	–0.0746 (0.0126)	–0.0267 (0.0124)	2.7658 [0.2509]
Trend	0.0002 (0.00005)	0.0002 (0.00005)	Diesel	–0.0324 (0.0117)	–0.0674 (0.0115)	
Max lag 3	**Gasoline price**	**Diesel price**		**Gasoline price**	**Diesel price**	
Oil price	0.0076 (0.0004)	0.0087 (0.0004)	Gasoline	–0.0692 (0.0132)	–0.0159 (0.0129)	1.9499 [0.3772]
Trend	0.0002 (0.00005)	0.0002 (0.00005)	Diesel	–0.0286 (0.0121)	–0.0643 (0.0118)	
Max lag 4	**Gasoline price**	**Diesel price**		**Gasoline price**	**Diesel price**	
Oil price	0.0076 (0.0004)	0.0087 (0.0004)	Gasoline	–0.0670 (0.0139)	–0.0107 (0.0135)	2.2435 [0.3257]
Trend	0.0002 (0.00005)	0.0002 (0.00005)	Diesel	–0.0238 (0.0125)	–0.0631 (0.0123)	

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for χ^2 statistics are in the brackets.
Source: Own construction

The results of testing of asymmetries in A-VECM are in Table 13. We use all vector error correction models shown in Table 12 due to lag robustness of our analysis. We test the joint hypothesis of overall asymmetry, long-run asymmetry (LR-A) and also short-run asymmetry (SR-A) as we did in single-equation co-integration approach.

Table 13 The Results of Testing of Asymmetries in A-VECM

Max lag 1	Gasoline long-run		Diesel long-run		Asymmetry test	LR-A test	SR-A test
	α^+	α^-	α^+	α^-			
Gasoline eq.	–0.0532 (0.0230)	–0.1030 (0.0286)	–0.0430 (0.0211)	–0.0335 (0.0257)	6.2064 [0.5159]	2.8558 [0.5822]	3.2203 [0.3589]
Diesel eq.	–0.0353 (0.0227)	–0.0235 (0.0283)	–0.0528 (0.0208)	–0.1007 (0.0254)			
Max lag 2	**Gasoline long-run**		**Diesel long-run**		**Asymmetry test**	**LR-A test**	**SR-A test**
	α^+	α^-	α^+	α^-			
Gasoline eq.	–0.0536 (0.0235)	–0.1067 (0.0294)	–0.0430 (0.0219)	–0.0276 (0.0256)	12.3342 [0.2633]	3.3732 [0.4974]	9.5468 [0.1451]
Diesel eq.	–0.0346 (0.0230)	–0.0129 (0.0289)	–0.0480 (0.0215)	–0.0942 (0.0251)			
Max lag 3	**Gasoline long-run**		**Diesel long-run**		**Asymmetry test**	**LR-A test**	**SR-A test**
	α^+	α^-	α^+	α^-			
Gasoline eq.	–0.0437 (0.0241)	–0.1024 (0.0299)	–0.0365 (0.0224)	–0.0245 (0.0256)	14.9755 [0.3089]	3.5505 [0.4702]	11.8460 [0.2221]
Diesel eq.	–0.0218 (0.0235)	–0.0035 (0.0292)	–0.0441 (0.0218)	–0.0900 (0.0250)			

Table 13 (continuation)

Max lag 4	Gasoline long-run		Diesel long-run		Asymmetry test	LR-A test	SR-A test
	α^+	α^-	α^+	α^-			
Gasoline eq.	–0.0374 (0.0246)	–0.1045 (0.0306)	–0.0301 (0.0229)	–0.0215 (0.0255)	17.0085 [0.3850]	4.0920 [0.3937]	13.1857 [0.3557]
Diesel eq.	–0.0143 (0.0241)	–0.0024 (0.0300)	–0.0423 (0.0224)	–0.0891 (0.0250)			

Note: The estimates of standard deviations of parameters are in the parentheses. The probability values for χ2 statistics are in the brackets.
Source: Own construction

The asymmetry is not considered to be possible at 5% significance level in all cases. We state that Slovak retail fuel prices do not respond more quickly when crude oil price rises rather than when it decreases.

CONCLUSION

The aim of the paper was to answer the question if Slovak retail gasoline and diesel prices rise more rapidly when the price of crude oil increases and fall slowly when the price of crude oil decreases. To test asymmetric response of retail gasoline prices on changes in crude oil prices we used the error correction model with irreversible behaviour of explanatory variables.

Some asymmetries were possible at 5% significant level by the single-equation co-integration analysis. However, the oil price alone was considered to be exogenous variable in all these possibilities. By the endogeneity of another retail fuel price (diesel for gasoline equation, gasoline for diesel equation), the multi-equation co-integration analysis should be realized. The justness of this approach was supported by the Johansen's co-integration test stating that two co-integration relationships between crude oil price and both retail fuel prices were. By the multi-equation co-integration analysis, we did not reject symmetric responses of the Slovak gasoline and diesel prices on changes in crude oil price at 5% significant level in all cases.

Our results do not support asymmetric transmission of changes in the price of oil to the price of gasoline. This information may be useful for future research of Slovak business cycles based on the dynamic stochastic general equilibrium models. The price rigidities do not come from asymmetric reactions of output prices on changes in input prices. Another sources of price rigidities as menu costs or costs of processing information should be considered (Douglass and Herrera, 2010). Even if the Slovak market would be imperfect, according to our results it would have been not shown price asymmetry.

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CO_2 Emissions-Economic Growth Relationship Revisited: New Insights from the Time-Varying Cointegration Approach

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Abstract

One of the most discussed topics of Environmental economics is the choice of the appropriate functional form to examine the income-environmental impact relationship. Since the developing economies encounter different development stages, the use of relevant specification and technique gains special importance to reveal the country specific relationship. Considering the afore-mentioned points, this study employs the time-varying cointegration approach to investigate the CO_2 emissions-economic growth relationship in the case of developing country, Azerbaijan. Time-varying cointegration approach a) takes into account the varying nature of elasticity of emissions and b) does not require the functional specification to be a polynomial. The results document a long-run relationship between carbon emissions and income. The study also concludes that the EKC hypothesis does not hold in Azerbaijan. The positive and time-varying income elasticity of carbon emissions, slightly decreasing at the end of the time period, can be seen as an indication that the country has implemented a number of successful emission/pollution regulatory measures.[4]

Keywords

CO_2 emissions, time-varying cointegration approach, economic growth, EKC hypothesis, Azerbaijan

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C14, C32, Q01, Q43, Q52, Q53, Q56

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INTRODUCTION

The Environmental Kuznets Curve (EKC) framework illustrates the link between certain indicators of environmental degradation and income per capita. The main question that the EKC hypothesis places is whether the level of environmental degradation does increase or not during a country's economic growth stage. The discussion on the EKC hypothesis gained substantial momentum back in the early 1990's when Grossman and Krueger (1991) explored the potential impact of North American Free Trade Agreement (NAFTA) and the concepts of popularization in the 1992 World Bank Development Report (Stern, 2003). At the early stages of economic growth, environmental pollution rises along with a growth in national per capita income as people are more interested in jobs and income than clean air and water, which results in inadequate environmental regulation. However, at higher income levels, environmental degradation decreases as people increasingly value environmental quality along with regulation standards, implying an inverted U-shaped EKC curve. This framework can explain the path of Carbon-dioxide (CO_2) emissions using different order polynomial functions of income level. Many reasons can explain the spur of this relevant discussion, with the primary being the rapid climate change issue over the last few decades, as well as the problem of global warming. The EKC hypothesis has been investigated for a range of environmental indicators (see for example, Wang et al., 2013; inter alia). One of the hot topics in the environmental degradation-income literature is the choice of the appropriate functional form in relevance to the above link. The conventional form used is the polynomial function of the income variable, which has received certain criticism (Liddle and Messinis, 2016; Mikayilov et al., 2018b) in terms of representing the true response of environmental indicators to changes in the income variable. There are certain studies that have employed different methodological approaches, such as spline functions (Schmalensee, Stoker, Judson, 1998), non-linear-in-parameters specifications (Galeotti, Lanza, Pauli, 2006), Quantile Cointegration Regression approach (Apergis, 2016), a reduced form linear modeling approach (Liddle and Messinis, 2016) and a time-varying coefficient cointegration approach (Mikayilov et al., 2018b). In addition to the concerns discussed in Mikayilov et al. (2018b), the common feature of all the above-mentioned studies is that all have investigated the relationship in relevance to the case of developed countries. As it is well known, the EKC literature argues that the shape of the relationship between an environmental indicator (i.e., CO_2 emissions) and the income variable is mainly U-shaped in the case of developed countries, while for the developing country cases, it needs to be investigated for certain individual countries. Therefore, it is worth analyzing the relationship in the case of developing countries by employing one of the methods that explicitly considers the weaknesses of the previous studies.

Given the above discussion, the goal of this study is to empirically examine the rationality of the EKC hypothesis in the case of Azerbaijan, using time-varying cointegration methodology, for the first time, for a developing country case. This methodology provides certain advantages in the empirical analysis, such as considering the possibility that the coefficients can vary over time, taking into account the long-run relationship and testing for it. For country case, the current paper investigates that of Azerbaijan for a number of reasons: Firstly, to our knowledge, the time-varying coefficient approach has not been applied to the case of a developing economy; Azerbaijan has witnessed different economic phases, beginning with the post-Soviet period, which increases the likelihood of the drivers to respond to certain factors in a time-varying manner. Secondly, Azerbaijan is a resource-rich country with the empirical results potentially being set as an example for other resource-rich developing economies. Thirdly, there are a few studies on the CO_2 emissions-economic growth relationship in the case of Azerbaijan. Based on the above points, the current study investigates the CO_2 emissions-economic growth relationship in the Azerbaijani case by employing the time-varying coefficient cointegration approach, while investigating this relationship within the Environmental Kuznets Curve framework.

The contribution of the current study is twofold: Firstly, it employs a methodology (Park and Hahn, 1999), that addresses some limitations of previous research (for example, Liddle and Messinis, 2016;

Apergis, 2016; Moosa, 2017), to investigate the relation between environmental degradation and economic growth. Secondly, it employs the suggested methodology to the case of a developing economy, while all other studies in the relevant literature investigated the same relationship in the case of developed countries.

The structure of the paper is the following: a review of the related literature is given in Section 1. Section 2 provides the theoretical framework and methodology of the study. The employed data is described in Section 3. Sections 4 and 5 discuss empirical results and findings, respectively, while conclusion and policy implications are illustrated in the last chapter.

1 LITERATURE REVIEW

Table 1 summarizes both time series and panel studies in terms of sample period considered, functional forms selected, econometric methodologies employed, income elasticity and shape of the CO_2-income relationship found.

Only four studies are reviewed, since our main focus in this section is the time series studies for Azerbaijan. More specifically, Mikayilov et al. (2017a) explore the impact of urbanization, energy consumption and real Gross Domestic Product (GDP) on atmospheric pollution coming from automobile transportation in Azerbaijan within the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) framework, developed by Dietz and Rosa (1994, 1997). The study applies the Autoregressive Distributed Lags Bound Testing (ARDLBT) approach, proposed by Pesaran et al. (2001) and Pesaran and Shin (1999), spanning the period 1990–2014 and finds the presence of a long-run relationship among the variables. However, their analysis does not illustrate the trajectories of the variables to provide deep information on how their movement looks over time. Secondly, the study examines the impacts on pollution from automobile transportation, not on total CO_2. Mikayilov et al. (2017b) analyze the effects of energy consumption, real GDP and population on pollution stemming from the automobile transportation sector in Azerbaijan. Their study uses annual data, spanning the period 1990–2014 and utilizing the ARDLBT approach in the STIRPAT framework. Likewise, this study also investigates the impact of income on pollution from transport.

Mikayilov et al. (2018a) examine the CO_2 emissions effects of economic growth in Azerbaijan over the period 1992–2013. The paper finds positive impacts of income on carbon emissions in the long-run. This study employs the conventional polynomial specification and ends up with the linear form to be the best fit for the studied country case.

Finally, Shuai et al. (2017) conduct panel, as well as time series estimations for a sample of 164 countries (including Azerbaijan) within a quadratic functional form framework. The main drawback of this study is that it uses an Ordinary Least Squares (OLS) analysis, which yields biased estimation results when variables are cointegrated. The second concern is that the analysis makes use of a time span ranging from 1960–2011, while Azerbaijan gained its independence in 1991. This can potentially lead to a major problematic issue: if the analysis actually uses a data sample from 1960, then the estimations are potentially suffering from the measurement error problem, as the period 1960–1990 refers to the Soviet Union time, in which a centrally planned economic system was in effect. Additionally, the study suffers from the absence of any cross-sectional tests, as well as from any cross-sectional dependency test which generates biased panel unit root and cointegration tests.

In terms of the panel studies reported in Table 1, except that by Shuai et al. (2017), all the other studies present estimation results only for the entire panel under consideration and not for individual countries in the panel sample. Further, only the study by Perez-Suarez and Lopez-Menendez (2015) considers the cubic functional form, while the remaining studies restrict themselves to using either a quadratic or a linear functional form. All the panel studies, except that by Mitic et al. (2017), ignore the presence of any cross-sectional dependence across the data, although the countries included are linked to each other economically, financially and politically. Furthermore, certain studies, e.g. Erdogan and Ganiev (2016),

Table 1 Review of the CO_2 studies for Azerbaijan

Paper	Time Interval	Country (Group)	Specification	Estimation approach	Income elasticity	Relationship type
Apergis and Payne (2010)	1992–2004	CIS region*	QFF	FMOLS. Panel data	With Russia: 1.55–2.96 ln GDP; without Russia: 1.37–2.54 ln GDP	IUS
Tamazian and Rao (2010)	1993–2004	24 countries*	QLF	GMM. Panel data	0.04–1.22 ln GDP	IUS
Stolyarova (2013)	1960–2008	93 countries*	LLF	GMM. Panel data	Short-run elasticity: 0.3–0.79	Not reported
Brizga et al. (2013)	1990–2010	Former USSR*	LLF	Index decomposition analysis and OLS. Panel data	0.86	US (Azerbaijan)
Perez-Suarez and Lopez-Menendez (2015)	1860–2012	175 economies*	CLF	NLS. Time series data	Not reported	No specific pattern
Erdogan and Ganiev (2016)	1992–2013	8 Central Asian countries*	QFF	Fixed effect and random effect. Panel data	0.13	IUS
Al-Mulali et al. (2016)	1980–2010	107 economies*	QLF	DOLS. Panel data	4.75–0.18 ln GDP (panel with Azerbaijan)	IUS Panel with Azerbaijan
Ito (2017)	2002–2011	42 economies*	LLF	GMM and PMGE. Panel data	GMM: 0.13 PMG: 0.34	MI
Shuai et al. (2017)	1960–2011	164 countries*	QFF	OLS. Time series and panel data	0.04	US
Mitic et al. (2017)	1997–2014	17 countries*	LLF	DOLS and FMOLS. Panel data	0.35	MI
Mikayilov et al. (2017a)	1990–2014	Azerbaijan	LFF	ARDLBT. Time series data	0.13	MI
Mikayilov et al. (2017b)	1990–2014	Azerbaijan	LFF	ARDLBT. Time series data	0.13	MI
Mikayilov et al. (2018a)	1992–2013	Azerbaijan	CLF	VECM, ARDLBT, DOLS, FMOLS and CCR	0.70 to 0.82	MI

Abbreviations: CIS = Commonwealth of Independent States, QFF = quadratic functional form, QLF = Quadratic functional form in logarithms, IUS = Inverted U-shaped, FMOLS = Fully Modified Ordinary Least Squares, US = U-shaped, GMM = Generalized Method of Moments, LLF = Log-linear function, CLF = cubic functional form in logarithms, ARDLBT = Autoregressive Distributed Lags Bounds Testing, DOLS = Dynamic Ordinary Least Squares, OLS = Ordinary Least Squares, PMGE = Pooled Mean Group Estimator, VECM = Vector Error Correction Method, NLS = non-linear least squares method, EIR = Emission-Income Relationship, MI = Monotonically Increasing, MD = Monotonically Decreasing, LS = L-shaped, NS = N-shaped, USSR = Union of Soviet Socialist Republics.
Note: * The study included Azerbaijan.
Source: Adopted from Mikayilov et al. (2018a)

Perez-Suarez and Lopez-Menendez (2015), Brizga et al. (2013) and Tamazian and Rao (2010) do not account for any non-stationarity and cointegration properties in relevance to the variables used. By contrast, our study addresses all the above-mentioned shortcomings that the earlier studies faced.

2 THEORETICAL FRAMEWORK AND METHODOLOGY

A typical model relating CO_2 emissions and income is an equation (in a logged or level form) with CO_2 emission on the left-hand side and the powers of income on the right-hand side (Shafik and Bandyopadhyay, 1992). A general typical model can be expressed as below:

$$lnCO_2 = \alpha_0 + \alpha_1 lnY + \alpha_2 ln^2 Y + \alpha_3 ln^3 Y, \tag{1}$$

where CO_2 is CO_2 emissions per capita and Y denotes income per capita. $\alpha_i s$ are the coefficients to be estimated. For the given specification, the income elasticity of CO_2 emissions is defined as:

$$\eta = \frac{\partial \mathrm{CO}_2}{\partial Y} \frac{Y}{\mathrm{CO}_2} = \alpha_1 + 2\alpha_2 lnY + 3\alpha_3 ln^2 Y. \tag{2}$$

In the case that, the coefficient of the cubic term is insignificant and the analysis should drop it. Then, Formula (1) reduces to the quadratic functional form as follows:

$$lnCO_2 = \alpha_0 + \alpha_1 lnY + \alpha_2 ln^2 Y. \tag{3}$$

The income elasticity for specification (3) is defined as follows:

$$\eta = \frac{\partial \mathrm{CO}_2}{\partial Y} \frac{Y}{\mathrm{CO}_2} = \alpha_1 + 2\alpha_2 lnY. \tag{4}$$

Similarly, when the coefficient of the quadratic term is statistically insignificant then Formula (3) turns into:

$$lnCO_2 = \alpha_0 + \alpha_1 lnY. \tag{5}$$

In this case, the income elasticity of CO_2 emissions is the coefficient of the income variable in logarithmic form, namely α_1. Since the elasticities in Formulas (2) and (4) include certain variables to make them interpretable and to give an idea about their sign and magnitude, it is preferred to calculate them at their mean value of income level. Other functional forms and appropriate elasticities are also possible (Shafik and Bandyopadhyay, 1992; Lieb, 2003; inter alia). Although Formula (1) is the widely used functional form in the pollution-income literature, certain studies provide a negative criticism on that (Zhang, 2012; Moosa, 2017; Liddle and Messinis, 2016; Mikayilov et al., 2018b; inter alia). As Mikayilov et al. (2018b) argue, the income elasticity of emissions depends on the chosen functional specification. For example, in Baek (2015), both the linear and cubic specifications are found to be significant in the Canadian case, while both the linear and quadratic specifications are found to be significant in the US case. Similarly, Jaforullah and King (2017) end up with significant quadratic and cubic specifications in both Canada and Finland cases, and with significant linear and cubic specifications in Sweden case. If the analysis calculates elasticities based on different specifications, it will potentially find different results, as well as different types of the emissions-income relationship. Even the magnitudes

and the signs of these elasticities might be different (Jaforullah and King, 2017). Given the above discussion, it is concluded that the employment of the time-varying cointegration (TVC) approach is the appropriate method that avoids these above-mentioned shortcomings.

The use of the conventional functional approach described in Formulas (1)–(5) assumes that the elasticities are constant over time; however, certain studies (Haas and Schipper, 1998; Chang and Martinez-Chombo, 2003; Chang et al., 2014; Mikayilov et al., 2017c; inter alia) criticize the constant elasticity approach considering certain drivers, such as structural changes, shocks to an economy; different economic and political regimes. These studies reach the conclusion emphasizing that the conventional models are unstable to any potential structural deviations from the existing development path, generating estimates which lead to misrepresentative estimation results. In addition, according to Lucas (1976), under regime changes, the estimated parameters are likely unstable. To address this issue, Apergis (2016), Liddle and Messinis (2016), Moosa (2017), and Mikayilov et al. (2018b) study the CO_2 emissions-income relationship by employing different methods which consider the time-varying characteristic of income elasticity. Apergis (2016) and Moosa (2017) limit their study to the likelihood of changing the coefficients in the quadratic functional form, while the method employed by Liddle and Messinis (2016) requires the presence of a number of regimes (four of them in their case study). Moreover, all the above-mentioned studies focus on advanced economies. Mikayilov et al. (2018b) employ the Time-Varying Coefficient Cointegration (TVC) technique suggested by Park and Hahn (1999) for the case of advanced economies. This approach considers long-run elasticity as a function of a time. This function is approximated semiparametrically by polynomials and pairs of trigonometric functions. Assuming α_t to be varying elasticity over time, the model in (1) turns into a TVC model described as:

$$lnCO_{2\,t} = \alpha_0 + \alpha_t lnY_t + u_t\,, \tag{6}$$

where (u_t) is an error term. The coefficient is assumed to be a function of time. The methodology will not be described here as the space is limited. For further details of the methodology and related tests, interested readers can refer to Park and Hahn (1999), Chang et al. (2014).

Before implementing cointegration among the variables, the analysis tests the unit root properties of the variables through the Elliott-Rothenberg-Stock (1996), Phillips-Perron (PP, Phillips and Perron, 1988), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS, Kwiatkowski et al., 1992) tests.

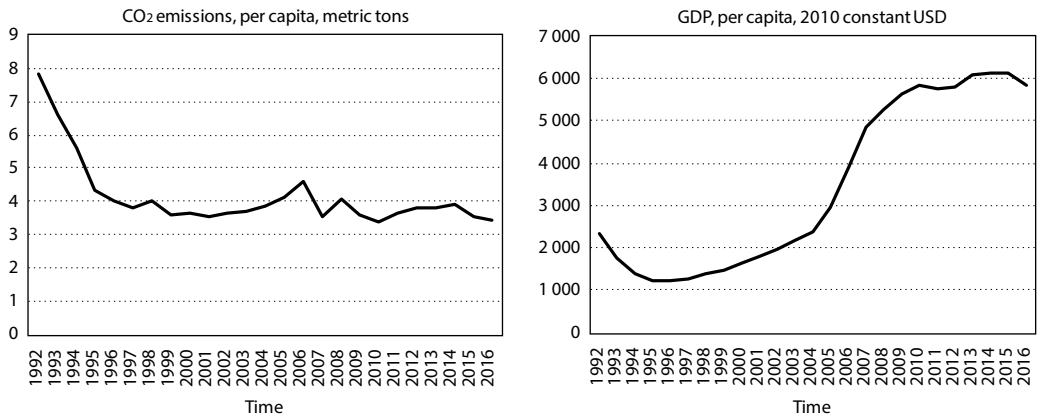
3 DATA

The available data ranging from 1992–2016 is used. CO_2 emissions (CO_2) are in metric tons of carbon dioxide and they are the dependent variable in the modeling approach. Data for 1992–2014 was taken from World Bank, 2015–2016 was taken from KNOEMA World Data Atlas. GDP per capita data in 2010 constant USD was obtained from the World Bank Development Indicators Database (WB, 2016). Figure 1 shows the time profile of per capita CO_2 and per capita GDP, over the period 1992–2016.

As it can be seen from Figure 1, GDP increases over time, while CO_2 emissions decreased up to 1996, then increased up to 2006, furthermore they demonstrated a volatile pattern since 2006. For the time period 1996–2016, CO_2 emissions in Azerbaijan increased with an annual growth rate of 3.8%, while GDP increased by 8.5% on an annual basis. The presence of a jump in 2006 might be explained by oil income coming from the completed oil projects for that time.

Descriptive statistics are given in Table 2. As it can be seen from Table 2, based on the coefficient of variation (25% for per capita CO_2 and 58% for per capita GDP) one can conclude that the volatility in CO_2 is relatively smaller and in GDP higher than 30%, which is taken in the literature as the benchmark level for a homogeneity check.

Figure 1 Plots of the variables



Source: WB (2016)

Table 2 Descriptive statistics

Country	CO_2 emissions per capita, metric tons					GDP per capita, constant 2010 US$				
	Min	Mean	Max	St Dev	CoV (%)	Min	Mean	Max	St Dev	CoV (%)
Azerbaijan	3.39	4.14	7.81	1.04	25	2 357	3 448	6 123	2 006	58

Notes: Min = sample minimum, Max = sample maximum, StDev = standard deviation, CoV = Coefficient of Variation.
Source: Authors' calculation based on WB (2016) data

The empirical analysis that follows makes use of the natural logarithm of both variables (both in per capita terms), which are denoted by small letters, i.e., co_2 and y.

4 EMPIRICAL RESULTS

4.1 Unit root tests' results

The results of the unit root tests are reported in Table 3. The overall findings illustrate that for co_2 emissions there is an evidence in favor of stationarity at first difference. For the case of the income variable, if only the intercept mode is considered, both the KPSS tests recommend the presence of a *I(1)* variable, while

Table 3 Unit root tests' results

Variable		The ERS test				The PP test		The KPSS test	
		Level	k	First difference	k	Level	First difference	Level	First difference
Intercept	co_2	−1.74*	0	−2.17**	1	−5.07***	−4.97***	0.42	0.34***
	y	−2.65**	1	−1.84*	1	−0.39*	−2.73*	0.63	0.23***
Intercept and trend	co_2	−2.56	0			−3.95**		0.14**	
	y	−3.00*	1			−3.11		0.11**	

Notes: ERS, PP and KPSS denote the Elliott-Rothenberg-Stock test, Phillips-Perron and Kwiatkowski-Phillips-Schmidt-Shin tests, respectively. Maximum lag order is set to two and optimal lag order (k) is selected based on Schwarz criterion in the ERS test; ***, ** and * indicate rejection of the null hypotheses at the 1%, 5% and 10% significance levels respectively; the critical values are taken from Elliott-Rothenberg-Stock (1996, Table 1), and Kwiatkowski-Phillips-Schmidt-Shin (1992) for the ERS, PP and KPSS tests, respectively.
Source: Estimation results

the ERS and PP tests are inconclusive. In the case of the intercept and trend model ERS and KPSS tests prefer income variable to be stationary at level, while PP rejects this conclusion. However, based on the graphical investigation of the variable and general theoretical sense regarding this variable it is concluded that the income variable is stationary in first difference. Therefore, the conclusion is that the used variables are integrated of the first order.

4.2 Estimation results

First, based on the Bayesian Information Criterion (BIC), the analysis relies on choosing the number of the polynomials (p) and trigonometric pairs (q) in the modeling approach. The chosen number of p and q is 1 and 2, respectively. Next, the analysis applies the Canonical Cointegration Regression (CCR) by Park (1992). Before reporting the results of the TVC approach, the presence of any cointegration relationship should be investigated. The Variable Addition Test (VAT) by Park (1990) is used to test whether there is a long-run relationship between the variables. The results are reported on the right side in Table 4. The null hypothesis of the VAT test states the presence of cointegration among the variables. The VAT test statistic (84.33) is found to be greater than its critical values, thus, rejecting the presence of a long-run relationship; however, this might be due to the small sample size, which is the case here. This is due to the fact that VAT test is asymptotically distributed by a Chi-square test, which requires a large sample size. In order to test the long-run relationship from a robustness perspective, the analysis also used the Pesaran's Bounds test for cointegration (Pesaran and Shin, 1999; Pesaran et al., 2001), as well as the Engle-Granger cointegration test; the results (given in Table 6) document the presence of a cointegration relationship between CO_2 emissions and GDP. Based on this result, the analysis proceeds to the next step, through testing the significance of the time-varying coefficient. For these exercises a Wald test suggested by the TVC methodology by Park and Hahn (1999) is employed. The test simply examines the joint significance of the coefficients of polynomials and trigonometric pairs. The null of this test states the insignificance of the time-varying coefficient. As described in Park and Hahn (1999) this test statistics is distributed as Chi-square test with $p + 2q$ degrees of freedom, where p is number of polynomials and q is number of trigonometric pairs. Since there are five λ's ($p = 1$, $q = 2$), the degree of freedom is 5. The null hypothesis of the test states the joint insignificance across the coefficients. These results are presented on the left side in Table 4. The test statistic (0.24) is very small; thus, accepting the null hypothesis at any significance level. Overall, the findings indicate that the income coefficient is not time-varying or, to put it differently, the change in the income elasticity is not noticeable.

Table 4 TVC estimations and cointegration test results

TVC significance test				VAT			
Test statistics	**10% CV**	**5% CV**	**1% CV**	**Test statistics**	**10% CV**	**5% CV**	**1% CV**
0.24	9.24	11.07	15.09	84.33	7.78	9.49	13.18

Note: Null hypothesis for TVC significance test is: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$.
Source: Estimation results

Although the time-varying income elasticity is found to be insignificant, the estimation results are reported for further analysis and for future comparison purposes. The detailed results of the long-run estimations with time-varying coefficients are reported in Table 5, while the time-varying income coefficient/elasticity is illustrated in Figure 2.

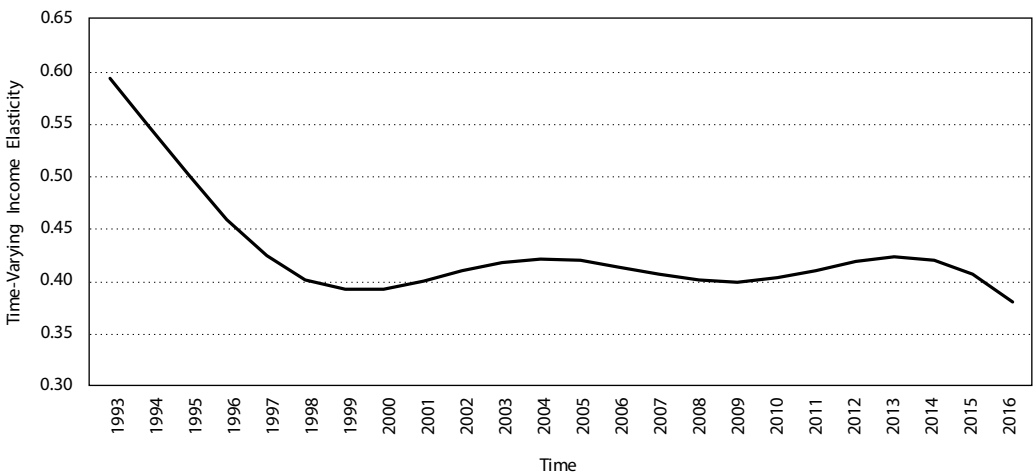
Table 5 Time-varying coefficient estimates

Coefficients/ τ(intercept)		Estimated Parameters					
		λ_0	λ_1: $\frac{t}{T}$	λ_2: $\cos(2\pi \frac{t}{T})$	λ_3: $\sin(2\pi \frac{t}{T})$	λ_4: $\cos(4\pi \frac{t}{T})$	λ_5: $\sin(4\pi \frac{t}{T})$
Estimates	0.70	0.58	–0.25	0.07	–0.03	0.02	0.02
P-values	0.71	0.53	0.64	0.64	0.63	0.64	0.66

Source: Estimation results

As depicted in Figure 2, the time-varying income elasticity/coefficient reveals negligible change, ranging from 0.38 to 0.59.

Figure 2 Time-varying income elasticity, against time

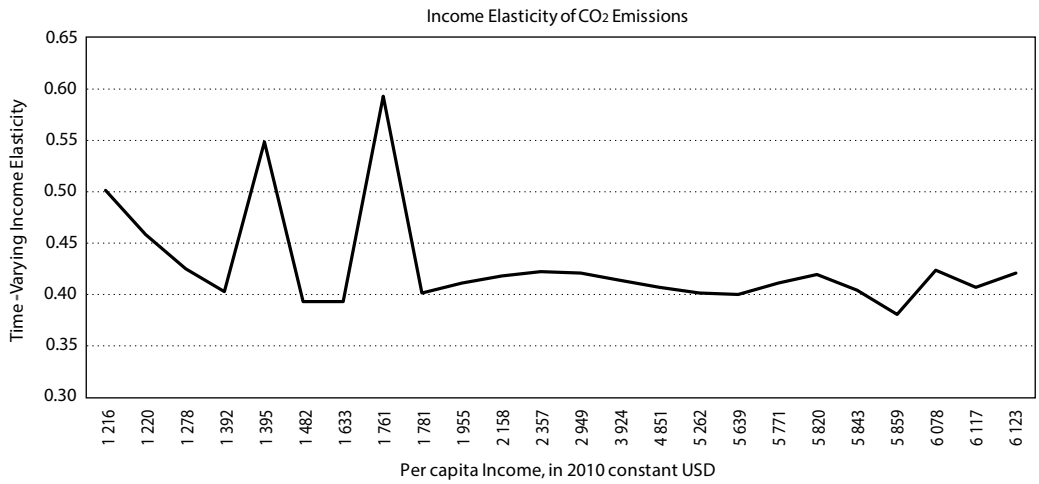


Source: Estimation results

The graph of the time-varying income elasticity of CO_2 emissions depicted in Figure 2 is not directly comparable with the conventional elasticities, since in the conventional one the graph of the elasticity is depicted against the per capita income level, while in Figure 2 the elasticity sketched against time. To make the finding comparable we matched the varying elasticity values with the appropriate per capita income levels and the values are given as Figure 3. As Figure 3 demonstrates the income elasticity is almost constant with few fluctuations corresponding to the per capita levels 1 216, 1 395 and 1 761 which correspond to three consecutive years, namely 1993, 1994 and 1995 (corresponding to the left side of the TVC in Figure 2), and this relatively high values can be most likely interpreted with inherited emissions level from the Soviet time. As known in the case of linear functional form, which is mainly the case for the developing countries, the income elasticity of emissions is a constant number and the income elasticity of CO_2 emissions in Figure 3 resembles this case. The rationale behind the monotonically increasing relationship in case of developing countries can be explained with the fact that, at initial stage of development path economic growth negatively affects environmental quality (see for example, Lieb, 2003; Cole 1999; inter alia) consuming resources and energy, consequently polluting the environment. After some threshold level of income countries can increase environmental quality using

some portion of income to address negative results of economic growth. One point to mention is that as demonstrated in Figure 2 the income elasticity is slightly evolving over time, but it is almost constant across the different values of per capita income, as the Figure 3 demonstrates. The finding of constant elasticity for Azerbaijani case can be explained by the lack of necessary socio-economic policies to deal with environmental, safety and lack of social awareness of the importance of environmental quality.

Figure 3 Varying income elasticity, against income



Source: Estimation results

Based on the almost constant income elasticity across income values, which means the elasticity is not a function of drivers evolving over time, it is concluded that the relationship between economic growth and CO_2 emissions is a linear relationship. In other words, the income elasticity is constant. Hence, having concluded the constancy of the income elasticity of carbon-dioxide emissions, the investigation is continued with the linear functional specification.

The existence of long-run relationship is tested by employing the Bounds test for cointegration (Pesaran and Shin, 1999; Pesaran et al., 2001) and Dynamic Ordinary Least Squares (DOLS, Saikkonen, 1992; Stock and Watson, 1993) estimation-based Engle-Granger test for cointegration. The results of cointegration tests are given in Table 6. Both tests concluded that the variables share a common trend.

Table 6 Results of cointegration tests

Bounds test		**Engle-Granger tests**
F-statistics		
11.45		Engle-Granger tau-statistics
Critical values		–4.02*
10%	4.49	Engle-Granger z-statistics
5%	5.15	–150.62***
1%	6.73	

Notes: Bounds test = Pesaran's Bounds test for cointegration; Engle-Granger tests based on the DOLS estimations. *, *** stand for rejection of no cointegration null hypothesis at 10% and 1% significances levels, respectively.
Source: Estimation results

As a next step we used the ARDLBT (Pesaran and Shin, 1999; Pesaran et al., 2001) and DOLS methods to estimate the long-run relationship, and the estimation results are given in Table 7. In the specification, we also added the time trend to consider the impact of technology and innovations on CO_2 emissions.

Table 7 Long-run estimation results

Variables/methods	ARDLBT	DOLS
Income, per capita	0.76***	0.63***
P-value	0.00	0.00
Time trend	–0.07***	–0.06***
P-value	0.00	0.00

Note: *** stand for rejection of null hypothesis at 1% significance level.
Source: Estimation results

As given in Table 7, both methods give quite close results, and the coefficients are statistically significant, having the signs in line with the theoretical expectations.

5 DISCUSSION

Based on the above findings, the relationship between environmental degradation and economic growth needs to be investigated starting with a proper functional form, i.e., the income elasticity of CO_2 emissions might be time-varying which is caused by different drivers changing over time. The response of the environmental indicator to economic growth in the case of developing country might differ depending on the developmental stage of the country. In other words, the magnitude and the direction of the response might be changing over time, while it is assumed to be constant in the conventional linear functional form approach. The conclusion of the linear relationship (or any other) should be decided based on the detailed investigation of the relationship.

Employing a battery of time series unit root tests, the study concluded that per capita emissions and per capita GDP are integrated of order one. The variables are stationary at first differenced form, hence then the presence of a long-run relationship between them is checked for. Although, the VAT cointegration test rejects the presence of such a long-run relationship, most likely due to the small sample size, the Bounds and Engle-Granger cointegration tests confirm the validity of a cointegration relationship between the variables. The time-varying coefficient was tested for significance using the Wald test, with the results confirming its insignificance. Hence, the response of CO_2 emissions to income levels is not time-varying i.e. it is almost constant. Although, the time-varying income elasticity is found to be insignificant, this finding can be interpreted as the change being very small. Moreover, the coefficient itself suggests an interpretable story about the development path of the economy. The Azerbaijani economy witnessed recession during the period 1991–1995, a stable economic growth path in the period 1996–2003, rapid economic growth during 2004–2010, and a recovery period after 2010 (Mikayilov et al., 2017c). As it can be seen from Figure 2, the time-varying income elasticity of CO_2 emissions almost 'replicates' the developmental path of the economy. The decrease in emission levels during the recession period can be explained by the collapse of the industrial sector, following the collapse of the Soviet regime; that is, it is not a gain coming from environmental concerns, rather it is the result of the downfall of the whole economy. The slight increase of emission levels after 1998 is the result of the reinvigoration of the economy, focusing first on the necessary needs and unconsciously 'ignoring' the need for environmental quality, which is a case across all countries in a similar growth stage. The fact that the time-varying income elasticity of CO_2 emissions is fluctuating over time is not the result only of this study; Liddle and Messinis (2016)

for Belgium, Spain, New Zealand, Norway, Switzerland and US, and Mikayilov et al., (2018 b) for Finland, Germany and Sweden provided similar results. The current study documented that the time-varying income elasticity of CO_2 emissions was positive. Liddle and Messinis (2016) also found a positive income elasticity of CO_2 emissions for the cases of Australia, Canada, Spain, Ireland, Italy, the Netherlands, New Zealand, Norway, and US. Moreover, Mikayilov et al. (2018b) found a positive income elasticity of emissions in twelve advanced economies.

With respect to the magnitude of income elasticity, it also worth noting that our findings are very close to those of other studies. More specifically, our results, ranging from 0.38 to 0.59, with the time-varying coefficient, and 0.63 to 0.76 in the case of the constant elasticity model are very close to those provided by Brizga et al. (2013) and by Mikayilov et al. (2018a). Brizga et al. (2013) found that the income elasticity of CO_2 emissions was 0.86, while using different methods, Mikayilov et al. (2018a) estimated it ranging from 0.70 to 0.82.

The sign of time trend, being negative, also confirms the belief in technological changes mitigating the environmental degradation.

Considering the time-varying behavior of income elasticity, one can conclude that the need for environmental quality turns out to be the priority issue when other necessary needs are satisfied, while it becomes secondary when basic necessities are unfulfilled. This conclusion is in line with the behavior of the economy and the society as a whole. Given that income elasticity is always positive, it can be concluded that the EKC hypothesis does not hold in the case of Azerbaijan, which is in line with the findings of the studies like Brizga et al. (2013), Narayan et al. (2016), Mikayilov et al. (2017a, 2017b, 2018a), Ito (2017), and Mitic et al. (2017). Although this study managed to test different functional specifications, it considers the shortcomings of the earlier papers, such as: the constant responses of emissions to income over time, the limitations of the functional forms to the cubic or smaller cases, and the omitted variable issue.

CONCLUSION AND POLICY IMPLICATIONS

The relationship between CO_2 emissions, and the magnitude and behavior of the response of CO_2 emissions level to increases in income, is one of the main concerns of our world. All countries strive to mitigate the negative impact of the uncontrolled and unsustainable economic growth on the environmental degradation/pollution issue. In this regard, both the Kyoto protocol and the Paris Agreement, as well as similar institutional pacts, put certain requirements in front of both developed and emerging countries. The conventional approaches modeling the relationship between CO_2 emissions and economic growth are faced with substantial debates, as new approaches are needed to confront their shortcomings. In this regard, the time-varying coefficient cointegration approach could be one of the alternative methods, which considers the likelihood the income elasticity that changes over time, since the response of CO_2 emissions to changes in income levels might not be constant over time. In addition, this method also addresses the contradicting findings resulting from the application of different polynomials of different orders. This method does not use the different powers of a variable (say income proxy) integrated in the first order, which is debatable from a theoretical point of view (Müller-Fürstenberger and Wagner, 2007).

The emissions-economic growth relationship gains special importance in the case of developing countries with higher growth targets and expectations, since these countries show an important (and increasing) share of global pollution levels. In this regard, the current study which contributed to the relevant literature is twofold. Firstly, by combining the use of a new approach in the case of a developing economy, i.e. Azerbaijan. Secondly, the study employed the time-varying coefficient cointegration approach using data spanning the period 1992–2016.

The results showed that the use of the time-varying coefficient cointegration approach was more relevant to investigate the environmental degradation-economic growth relationship, since it captures

the different responses of ecological indicators to the different stages of economic growth. The use of this methodology and its associated results indicates that income elasticity of CO_2 emissions was slightly varying over time, while the trajectory of the relationship mainly kept the same direction.

These findings indicated that the EKC hypothesis did not hold in the case of Azerbaijan. In recessionary periods, environmental quality is deemed unimportant requirement for society. However, it becomes the concern when the main necessities are satisfied.

The results of the study also pinpointed one of the main targets of sustainable development goals, i.e. using current resources while considering the needs of the future. The economy might have to cope with the lack of necessary goods and services, based on the increase of the emissions response to economic growth, close to the end of the varying elasticity (Figure 2). Although, the country gained a significant improvement in emissions' mitigation, the results highlighted that as a developing country, Azerbaijan still should take significant measures in relevance to the reduction of emission levels, such as the employment of energy efficient technologies, increasing the infrastructure associated with the transmissions and distribution quality, which in turn minimize the losses of energy use. Taxes on carbon-emissions intensive activities and programs targeted to increase social awareness regarding negative and unsolvable problems caused by unnecessary use of natural resources might also help to mitigate the increase of those emission levels. The results of the study enable to conclude that in order to make proper decisions, policymakers should explicitly take into account the varying feature of the response of the environmental indicators to changes in the growth at different stages of the economy. In other words, as the time-varying trajectory of the income elasticity in Figure 2 demonstrates, if the developing economy is facing recession or stagnation periods the fall in the level of CO_2 emissions (or other environmental indicator) is not necessarily reflected by the current economic policies followed by that country. Instead, it might be caused by considerable decrease in overall production level, or by the decrease of the size of the emission intensive imported goods, and in order to keep the sustainable development path, environmentally friendly policies should be continued. On the other hand, the increasing path of the income elasticity might not imply the environmental degradation if the country is following the sustainable development strategy, but the policies causing the dramatic changes in income level should be considered with caution.

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ANNEX – Abbreviations used in the text

EKC = Environmental Kuznets Curve; NAFTA = North American Free Trade Agreement; CO_2 emissions = Carbon-dioxide emissions; CIS = Commonwealth of Independent States; QFF = Quadratic functional form; QLF = Quadratic functional form in logarithms; IUS = Inverted U-shaped; FMOLS = Fully Modified Ordinary Least Squares; US = U-shaped; GMM = Generalized Method of Moments; LLF = Log-linear function; CLF = Cubic Functional form in Logarithms; ARDLBT = Autoregressive Distributed Lags Bounds Testing; DOLS = Dynamic Ordinary Least Squares; OLS = Ordinary Least Squares; PMGE = Pooled Mean Group Estimator; VECM = Vector Error Correction Method; NLS = Non-linear Least Squares Method; EIR = Emission-Income Relationship; MI = Monotonically Increasing; MD = Monotonically Decreasing; LS = L-shaped; NS = N-shaped; USSR = Union of Soviet Socialist Republics; STIRPAT = Stochastic Impacts by Regression on Population, Affluence and Technology; GDP = Gross Domestic Product; TVC = Time-Varying Coefficient Cointegration; ERS = Elliott-Rothenberg-Stock test; PP = Phillips and Perron test; KPSS = Kwiatkowski-Phillips-Schmidt-Shin test; StDev = Standard Deviation; CoV = Coefficient of Variation; VAT = Variable Addition Test; CV = Critical Value.

Analysis of Price Changes in Socially Important Food Products: Example of Azerbaijan

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Abstract

The aim of the research is to keep the price formation process of socially important food products under control and facilitate timely disclosure of tendencies that are contrary to market relations.

In this paper, some 19 socially important food products have been selected and tried to identify the share/contribution of the factors affecting their price changes in the example of Azerbaijan economy.

Econometric estimation methods are used in the paper. Database of the analysis is based on the official figures of the State Statistical Committee (SSC) of the Republic of Azerbaijan, covering the period from January 2016 to December 2017.

As a result, the methods for determining the contribution of factors in price fluctuations of socially important food products are presented, and the empirical results are interpreted as an example of the Azerbaijani economy.

Keywords

Regression analysis, price volatility, social foods, food prices, food prices determinants

JEL code

C32, C51, C88, Q11

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INTRODUCTION

At the current level of economic development in a globalized world, research on food consumption and nutrition is still relevant. Differences at the level of food supply for the world's population in different countries, as well as the deepening food security problem, increase the relevance of these studies. On the other hand, recent changes in the value of currencies as a result of sharp volatility of hydrocarbon prices in the world market have a significant impact on changes in production costs and import prices.

The fight against poverty and providing people with quality food were the focus of attention not only of countries, but also of influential international organizations. Millennium Development Goals (MDG) have also historically been considered the most successful global challenges against poverty. The second of 17 goals is to end hunger, ensure food security and better nutrition, and promote sustainable agriculture.

By countries, the minimum wage and the cost of living are calculated on the basis of the consumer basket. In the consumer basket there is also a number of products that are considered socially significant food products.

Socially significant food products support the improvement of the population living standards, as well as the implementation of the Sustainable Development Goals. The main characteristics specifying the study is the fact that it considers the pricing process of only socially significant food products, rather than the basket used to calculate the consumer price index. It also serves to improve the living standards of the poor and those of the population whose calorie level is below the minimum, by studying factors that affect the standard of living of this population. The choice of socially significant food products may vary depending on the direction of research. As a factor in the selection of socially significant food products, there are products that play an important role in the daily nutrition of all segments of the population, while maintaining a high level of self-sufficiency, in relation to the minimum consumer basket, and so on.

Taking into consideration the above mentioned, the world market for hydrocarbon prices has changed dramatically, so has the analysis of socially significant food prices from the point of view of non-oil production, including import substitution, support for domestic production and food security, as well as the development of the non-oil sector and econometric assessment is an important area of research.

To this end, the article identifies factors affecting the pricing of social food products and summarizes the methodology for assessing the impact of these factors on price changes by econometric methods.

At the same time, an analysis of socially significant food products in the Azerbaijani economy was carried out and factors affecting price changes were selected and, based on this, the effects were evaluated by econometric methods.

The article was prepared in accordance with the "Methodological Guide to the Rules for the Analysis of Factors of Changes in the Food Market", approved by the Scientific Council of the Institute for Scientific Research on Economic Reforms of the Ministry of Economy of the Republic of Azerbaijan on June 30, 2017 and based on a study conducted by a working group created for this purpose. The results obtained during the study were presented to the Ministry of Economy of the Republic of Azerbaijan in the form of a report.

1 LITERATURE REVIEW

Researchers at the FAO Agricultural Development Economics Division, G. Pierre G., C. Morales-Opazo and M. Demeke, considering that many countries continue to suffer from high food price volatility, studied the three main food products in developing countries (rice, wheat and corn). Thus, using FAO's retail and wholesale databases for 36 developing countries, they measured price volatility using econometric methods. At the same time, they tried to explain price fluctuations between these countries, adding

a few explanatory variables related to economic processes and terms of trade. As a result, they concluded that the poor are net consumers of food and that high price volatility has a significant impact on their purchasing power, which in turn affects the quantity of food consumed and its quality (Pierre, Morales-Opazo, Demeke, 2014).

Erokhin, an employee of the School of Economics and Management at Harbin Engineering University, in his article applied an approach to assessing the sustainability of food supplies in Russia. The purpose of the article is to identify factors affecting sustainability of food supplies and food security. To determine the impact of socio-economic variables on food security at the macroeconomic level, a regression model was evaluated, and on this basis impacts were determined (Erokhin, 2017).

In another article, researchers examined the determinants of price volatility for 6 key foods from January 2001 to March 2013. The main drivers of price volatility were indicators of real economic activity, biofuel production, oil prices and financial markets. The relationship between these macroeconomic and financial factors and products was identified and analyzed in the framework of the Bias multidimensional structure. Further, the impact of each factor in recent years on food volatility has been evaluated. The results show that the last two increases in food prices did not significantly change the dynamics of these prices (Sujithan, Avouyi-Dovi, Koliai, 2014).

Researchers from the Asian Development Bank (ADB) investigated the source of food price fluctuations in 11 developing countries in Asia. The research model is classified by block vector autoregression (VAR) and 10 variables, 3 blocks of the world, region and country depending on origin and nature. Empirical evidence shows that regional shock plays a very important role in explaining changes in local food prices, especially in the medium and long term. The shock of world food prices has no such effect on the dynamics of local food prices in developing Asia. The results show that Asian food markets are more integrated than regional markets. Short-term fluctuations in local food prices are largely due to the shock of the country itself (Huh and Park, 2013).

Apergis and Rezitis on the example of Greece, investigated fluctuations in food prices and their impact on short-term deviations between food prices and macroeconomic factors. The methodology included the use of the GARCH and GARCH-X models, and the results showed a positive effect on relationship between deviations and deviations in food prices (Apergis and Rezitis, 2011).

Researchers at the Pakistan Institute for Economic Development (PIDE) noted that prices are important to macroeconomic policy makers and analyzed the impact of food supply and demand factors on the Pakistani economy. Based on data from the 1970s and 2010s, they determined long-term dependence using an autoregressive model (autoregressive distributed lag model). The results show that cash flow has a significant impact on food prices in the long and short term, but the effect of subsidies is very small. On the other hand, rising world prices will create domestic inflation through imports and, as a result, market forces play a key role in creating long-term equilibrium (Ahsan, Iftikhar, Kemal, 2012).

C. Baumeister, member of the International Economic Analysis Department Bank of Canada, and L. Kilian, researcher at the Department of Economics University of Michigan, Department of Economics, analyzed in their study the impact of rising oil prices of US economy on food prices. The increase in real prices for corn, soybeans, wheat and rice purchased by American farmers was even more significant and allowed for a more detailed analysis and evaluation, partly because they could be associated with higher oil prices (Baumeister and Kilian, 2013).

F. Taghizadeh-Hesary, E. Rasoulinezhad and N. Yoshino examined in their articles the interconnection between energy and food prices in eight countries of Asia using the Panel-VAR model for 2000–2016. Energy prices here are mainly based on oil prices. As a result, they found that oil prices had a significant impact on food prices. At the same time, oil price inflation posed a threat to the food sector and emphasized the need for optimal use of renewable and non-renewable energy resources, emphasizing food security concern (Taghizadeh-Hesary, Rasoulinezhad, Yoshino, 2019).

A 2011 FAO study analyzed current trends in world food prices in terms of costs and benefits. Channels and parties that influence price volatility are also summarized with examples (FAO, 2011).

Summing up the reviewed literature, we can note that the study of fluctuations in food prices was adequately developed on the example of different countries and different researchers. Research in this area is mainly based on time series using econometric methods that help to obtain more reliable results. The main difficulty in conducting time series research is the monthly collection of data for each product. Another problem is that such studies are more often carried out by international organizations or official bodies of countries. This is reasoned by access to information and the introduction of a theory on the control of food markets at the state level.

2 TASK STATEMENT

In hydrocarbon-rich countries, the major part of the economy is concentrated on the oil and gas sector. Since the end of the 2014, the sharp decline in hydrocarbon prices in the global markets have resulted in serious consequences in oil-rich economies. Devaluation of local currencies against dollar and expensive imports of the goods can be shown as the main examples of these effects.

Food market in such economies is the main market where negative consequences of these processes are explicitly observed. Dependency of domestic consumption on import as well as dependency of local production on imported raw materials have led to a significant increase in food prices because of the devaluation. In the meantime, it can also lead to an artificial price increase, which is not directly related to the devaluation.

Considering this, the paper focuses on the analysis of the prices of the socially important goods in the food market of Azerbaijan through performing econometric evaluation methods and tools.

The major part of the goods export in Azerbaijan is crude oil. In this regard, oil revenues have higher share in the foreign trade turnover of Azerbaijan. At the peak of the oil prices, the national currency was stronger, and one unit of local currency was worth more than one US dollar. However, the sharp fall in hydrocarbon prices after 2014 had a devastating effect on the economy of Azerbaijan through import-export channels and led to the devaluation of the national currency twice.

On the other hand, the dependence on imports and the formation of the raw material base of the food production mainly due to imports has led to an increase in food prices to some extent.

In this regard, the analysis of fluctuations in food prices and the estimation of contributed factors are relevant in terms of taking the necessary steps towards market management and regulation.

3 DESIGN AND METHODOLOGY

Short-term and long-term economic problems are emerging in the market of the socially important food products. This is the same for almost every particular country. However, depending on the stage of development they are manifested in various forms. These problems have been well studied and justified in theory.

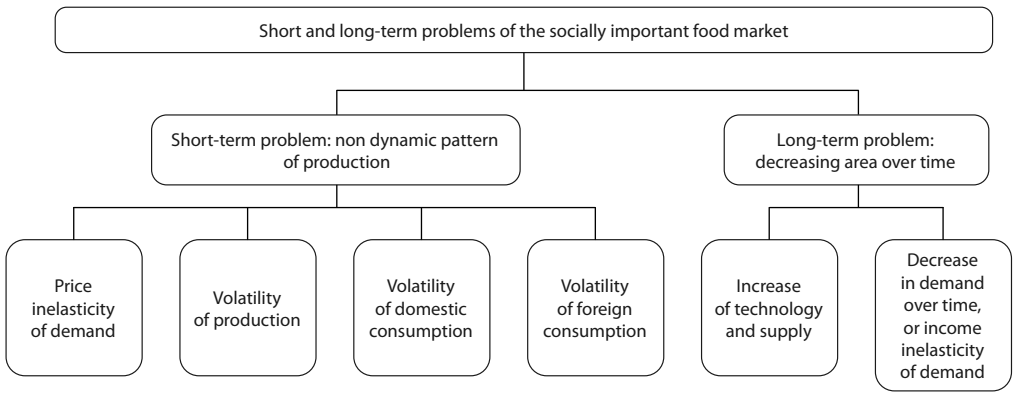
Generally, in economic theory the characteristics of this market for the short-and long-term are grouped as in Figure 1.

Based on the abovementioned information, it is possible to summarize the dependent and explanatory variables in the assessment of socially important food products as follows:

- Dependent variable – Retail price index;
- Explanatory variables – Production price, food expenditures of households, exchange rate, retail price of substitute products (if applicable), import prices, prices of raw materials, prices of utilities such as water, gas and electricity.

As the Azerbaijan's food market is analyzed in the paper, the methodologies have been adapted to the extent of the broadness of the database. In this regard, January 2016 was considered as the beginning

Figure 1 Short- and long-term problems of the socially important food market



Source: Developed by the authors based on McConnell and Brue (2001)

of the time series, and in order to get adequate results of the assessments all values of series were expressed at the price of January 2016 (base year). This ensures comparison of the performance of the dependent and explanatory variables with the single comparable benchmark, base year price.

The assessments were conducted in two ways: (i) a logarithmic valuation model, which allows an assessment of the impact of factors on retail price changes and (ii) a model with standardized time series, which allows assessing the individual contribution of factors to retail price changes.

(i) The coefficients found based on the logarithmic valuation model show a percentage change in the retail price index of the socially important food products due to a single percentage change in explanatory variables.

(ii) The coefficients found based on the standardized time series model allow to estimate the contribution of explanatory variables to the change of the retail price index of socially important food products.

The contribution of the explanatory variables in the change of the retail price index is found based on the construction of an econometric model, whereas time series is normalized through the following mathematical transformations.

Assuming that time series is given as following:

$$P_{2016Jan}, P_{2016Feb}, P_{2016Mar}, \ldots, P_{2017Nov}, P_{2017Dec}. \quad (1)$$

Then, the series is expressed at the price of base year (January 2016):

$$1, \frac{P_{2016Feb}}{P_{2016Jan}}, \frac{P_{2016Mar}}{P_{2016Jan}}, \ldots, \frac{P_{2017Nov}}{P_{2016Jan}}, \frac{P_{2017Dec}}{P_{2016Jan}}. \quad (2)$$

In order to find the contribution of the explanatory factors to the change in the index, the series were first normalized using the standard deviation and the mean.

Assuming that, is the series expressed at the base year price. In this case:

$$\text{Mean}\left(\overline{X}\right) = \frac{\sum_{i=2016Jan}^{2017Dec} X_i}{n}, \quad (3)$$

$$\text{Standard deviation}\left(\sigma\right) = \frac{\sum_{i=2016Jan}^{2017\ Dec} \left(X_i - \overline{X}\right)^2}{n}. \quad (4)$$

When normalizing the series by using mean and standard deviations, the time series used in the model becomes as follows:

$$\frac{X_{2016Jan}-\overline{X}}{\sigma}, \frac{X_{2016Feb}-\overline{X}}{\sigma}, \frac{X_{2016Mar}-\overline{X}}{\sigma},\ldots, \frac{X_{2017Nov}-\overline{X}}{\sigma}, \frac{X_{2017Dec}-\overline{X}}{\sigma}. \quad (5)$$

Thus, all-time series of the dependent and explanatory variables are normalized and standardized. Regression models will be constructed based on these series, and contribution of the factors in the changes of the retail prices index will be estimated.

In general, regression equation can be expressed in the form of the following indefinite function:

retail price = F (exchange rate, import price, export price, utility prices, food expenditures of households, raw material price).

For specific type of the goods, this equation may vary due to both the availability and appropriateness of the certain explanatory variables. For example, there are some products whose production and sale are formed only at the expense of domestic factors, and external factors such as import prices and exchange rates are irrelevant. From this point of view, the above-mentioned function is of a general nature.

Let us assume that the regression equation of any goods is obtained as follows:

$$y = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6X_6 . \quad (6)$$

The approach shows that, the sum of the regression coefficients obtained will be equal to the one if selected explanatory variables fully explain the dependent variable. However, it is impossible to reach this conclusion with full accuracy. The reason is that the multicollinearity of the selected explanatory variables is not fully met, and that not all the explanatory variables are taken into account. In fact, it is practically impossible to take into account all the explanatory variables in the model. At the same time, prices for some goods are influenced by factors that cannot be quantified. From this point of view, we can assume the sum of the coefficients obtained equals 1 with a certain error. In this case:

$$C = \sum C_i \approx 1 . \quad (7)$$

Effects of the explanatory variables:

$$\alpha_i = {C_i}/{C}, \qquad i = \overline{1,n} . \quad (8)$$

Thus, the coefficients represent the contribution of each factor in the change of retail prices over the respective period. If the retail price index of the product y has changed during the period under review by A%, then the share of the i-th factor on this change would be $\alpha_i \times A$.

4 ANALYSIS OF THE CURRENT SITUATION ON SOCIALLY SIGNIFICANT FOOD PRODUCTS IN THE ECONOMY OF AZERBAIJAN

The study analyzed various economic approaches to food pricing, their significance is given separately. Our goal is not to solve theoretical issues related to these problems, but to study these issues using the example of Azerbaijan as a specific country.

The specifics of these problems for Azerbaijan was studied, and it was found that the relative growth rate of food consumption does not exceed the growth rate of food production.

Studied are the mechanisms of supporting food production based on international experience in pricing of socially significant consumer goods. In international practice, the main task of state regulation of the development of the agro-industrial complex is to ensure the profitability of food producers taking into account extensive reproduction (this is the whole economic policy). This is due to the fact that in some developed countries financial support for agricultural production exceeds the cost of production by 1.5–2 times.

In international practice, the agro-industrial complex is directly or indirectly subsidized by the state: direct subsidies are provided for each hectare of arable land or for each unit of production; indirect subsidies include payment of a number of expenses related to rural development.

An analysis of the current situation in the field of agricultural subsidies and policy recommendations to improve this process were made taking into account international best practices.

As the socially significant food in the economy of Azerbaijan are: rice, wheat flour, wheat bread of best quality, pasta, beef meat with bones (minced), lamb with bones, chicken meat, raw milk with cream, brynza, chicken eggs, butterfat, olive oil, sunflower oil, corn oil, onions, potatoes, sugar, granulated sugar, black and green tea.

Rice production is low enough to meet demand in Azerbaijan. In this regard, the amount of rice imported is large. Self-sufficiency in rice is 10%. Thus, the dependence on imports is 90%. In 2016, the main share of rice imports was from India and accounted for 53.9% of total imports. The second major share is in the Russian Federation, which accounts for 29.5% of total imports. Imports from other countries account for 16.6% of total imports.

The level of self-sufficiency in all types of flour in the country is set at 95%, and the dependence on imports is 5%. In 2016, the volume of all flour reserves in the country amounted to 2.1 million tons. 74% of these stocks are produced, and 3.1% is imported. 1.2% of flour is used for livestock and poultry, 41.5% for industrial needs, 32.8% for food and only 0.1% for export. According to the State Statistics Committee, in 2016, 3 658.4 tons of flour or in the amount of 1 226.6 thousand dollars were imported to Azerbaijan. 97% of imported products accounted for the Russian Federation, which is mainly due to lower prices for imported flour from the country.

Self-sufficiency for flour (all types) and fresh bread without syrup, eggs, cheese or fruit is about 99.99%. Flour is considered the most important ingredient in the production of bread, it accounts for 50% of the cost of the product. The product is not imported due to its low shelf life.

The situation with pasta self-sufficiency indicates that this indicator fell to 51% in recent years, while Azerbaijan provided it by 70% only in 2012. The highest level of dependence on imports was recorded in 2013 (65.0%), and in 2016 compared to 2013 it decreased by 12.2%. In 2016, about 8 600 tons of pasta from different countries were imported to Azerbaijan. More than 90% of pasta imported into the country this year falls on Russia and Turkey, as well as the rest of Europe.

In 2016, beef self-sufficiency was 93%. The main share of imports of cattle beef belongs to Ukraine (87% of total imports). The share of other countries is 13%, including India, Brazil, the Republic of Moldova and so on.

Based on the food balance, the production of sheep and goat meat in 2016 amounted to 75 254 tons, which is 6.1% more than in the previous year. The self-sufficiency of domestic consumption of sheep and goat meat has always been high (98.4% on average over the past 5 years). Dependence on imports, such as beef and lamb, is very low in the price of this product, minimizing the risk of external price factors and exchange rate shock.

The second distinctive feature of chicken production in Azerbaijan is that it is produced by specialized enterprises. Thus, according to the statistics committee, only 1% of the production of beef, lamb and goat is accounted for by agricultural enterprises, which is 57% in poultry farming. The level of self-sufficiency in poultry farming peaked since 2013, but in 2016 it amounted to 79.1%.

Milk is not only a socially significant product, but also a raw material for the production of many important products. Since socially important products, such as butter, cheese, are included in the production process, the milk used in the study was used in the models in terms of the influence of milk prices and the price changes of these products. According to the State Statistics Committee, the level of self-sufficiency in Azerbaijan for milk with a fat content of 1–6% and 6% and above is quite high. In 2016, this indicator amounted to 99.5% and 95.4%, respectively. It can also be noted that 17.5% of the total amount of milk and dairy products is used for the production of cheese and 24.2% for butter.

In 2016, the self-sufficiency level for all types of cheese was 88.3%, and the dependence on imports was 11.7%. Looking back on previous years, it becomes clear that these percentages are not accompanied by significant changes. The fact that the production of all types of cheese has been growing since 2012 indicates a growing trend. In 2016, the largest share in the import of cheese and cottage cheese to Azerbaijan was made by cheese exporters, such as Germany (26.4%), the Russian Federation (25.8%) and Denmark (11.8%).

Eggs in the country are provided from 99 to 100% of eggs in all years of the country's population due to domestic production. Some of the imported eggs belong to some breeds of domesticated poultry. But in general, it is obvious that egg production has completely covered the domestic market. In addition, it should be noted that egg production was carried out by both households and farmers.

The highest level of butter production over the past 6 years was recorded in 2016 (25 604 tons). Domestic production is the basis for the consumption of butter in the country. According to the Statistics Committee, the level of self-sufficiency in the consumption of butter in domestic production in 2016 amounted to 75.6%, which is 6.4% more than in the previous year. In general, New Zealand is the world's largest producer and exporter of butter, accounting for 21% of world butter exports. In 2016, $ 28.4 million worth of butter was imported to Azerbaijan from various countries. New Zealand has the highest concentration of butter in the import structure. This year, New Zealand accounted for 74% of butter (6 210 tons, or $ 20.5 million).

From the food balance of vegetable oils it is clear that imports are quite high. The level of self-sufficiency in vegetable oils in 2016 amounted to 36.9%. This figure has fallen sharply compared to previous years. The level of dependence on imports is 68.9%. From the table of vegetable oils and consumption it can be seen that in 2016, stocks amounted to 254 300 tons, more than half of which was formed through imports. However, vegetable oil exports have fallen sharply compared to previous years.

Statistical data on the use and consumption of dried onions in the country in 2012–2016 is presented. As can be seen from the table, in 2016 the production of dry onions increased by 7.2% compared to 2012 and by 0.5% compared to 2015. Despite the decline in production, imports grew 4.2 times. On the whole, onion stocks have decreased since 2014 to 210 800 tons. It should be noted that in 2016 there was a decrease in onion cultivation compared to the previous year (2015 – 12 065 ha, 2016 – 11 953 ha).

Despite an increase in potato production in 2016, the dependence on potato imports among the country's population was 18.1% (3.1 percentage points more than in 2015), and the level of self-sufficiency was 85.5% (3.6 percentage points less than in 2015) due to an increase in domestic consumption. The natural climate and geographical conditions of Azerbaijan allow growing potatoes in many regions of the country. In 2016, about 183 thousand tons of potatoes were imported from different countries to Azerbaijan. More than 90% of the potatoes imported into the country this year are from neighboring countries and this is mainly due to the price of potatoes imported from these countries is more than two times lower than the prices of potatoes imported from other countries, and close to the distance.

The world produces 94–97 million tons of sugar (raw sugar), of which 56–60 million tons of sugar cane and 36–38 million tons of sugar beets. According to the Statistics Committee, sugar self-sufficiency is 114.4%, and dependence on imports is 15.3%. At the same time, the self-sufficiency of stocks of raw materials for sugar production is 5.9%, and the dependence on imports is 94.1%. High demand for raw

materials in the production process is one of the factors affecting sugar prices. Although the level of self-sufficiency in sugar production is high, the food balance for the production of raw sugar suggests that sugar used in sugar production is quite high. The import of raw sugar and sugar in 2016 was mainly from Brazil (92.5%). Compared to other countries, importing raw sugar and sugar from Brazil is cheaper.

According to the Statistics Committee, tea self-sufficiency in 2016 is 44.9%, and dependence on imports is 60.6%. According to the tea balance, we can say that the amount of imported tea is quite large. Import volume decreased by 6.6% in 2016 compared to 2015, which can be explained by changes in the manat rate. Tea imports in 2016 were mainly from Sri Lanka (91.5%). The average cost of one kilogram of tea imported from Sri Lanka is $ 3.47, which is lower than the prices in other imported countries. Other countries with sufficient imports are the Russian Federation (2.1%) and India (1.9%).

Changes in price indices for socially significant food products in January–December 2017 compared to the corresponding period of the previous year based on an analysis of the current situation and data of the Statistics Committee are presented in Table 1.

Table 1 Change in price indices of socially significant food products in January–December 2017 compared to the same period last year

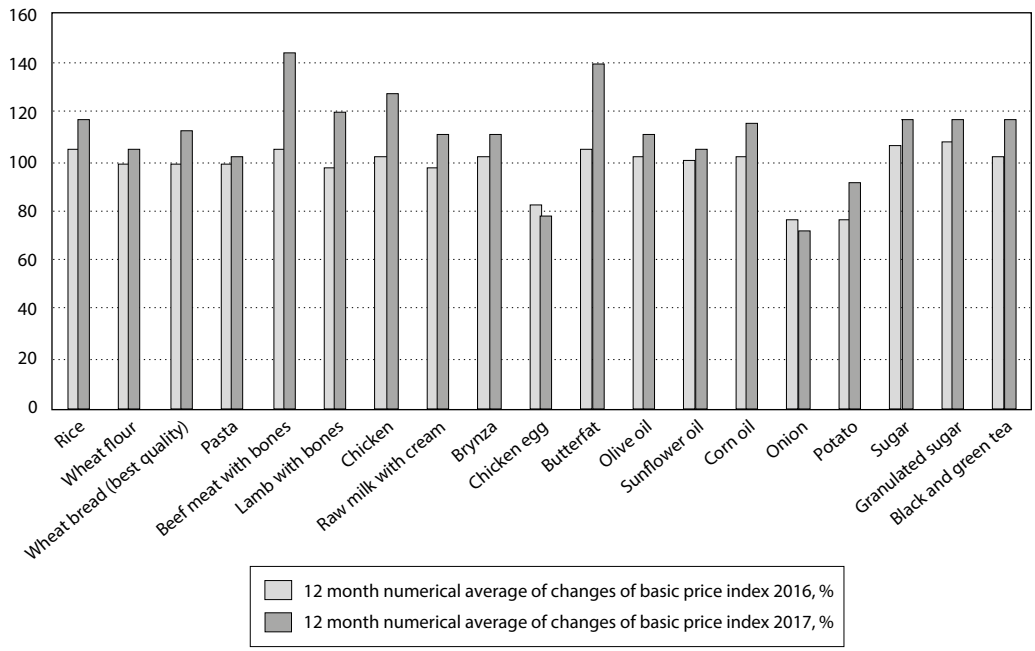
Name of socially significant products	12 month numerical average of changes of basic price index, %	12 month numerical average of changes of basic price index, %	Change (+) increase (–) decrease, %
	2016	2017	
Rice	105.61	117.77	11.51
Wheat flour	99.63	106.51	6.90
Wheat bread (best quality)	100.11	113.76	13.64
Pasta	100.12	103.25	3.12
Beef meat with bones	106.29	145.66	37.04
Lamb with bones	99.08	121.98	23.11
Chicken	102.56	128.42	25.21
Raw milk with cream	98.94	111.63	12.83
Brynza	103.02	113.04	9.72
Chicken egg	83.58	78.60	–5.96
Butterfat	105.96	140.52	32.62
Olive oil	103.10	111.91	8.54
Sunflower oil	102.25	106.96	4.60
Corn oil	103.72	116.55	12.38
Onion	77.43	73.59	–4.96
Potato	77.84	92.46	18.78
Sugar	107.21	118.76	10.76
Granulated sugar	109.53	118.96	8.61
Black and green tea	102.79	119.03	15.79

Source: The State Statistical Committee (SSC) of the Republic of Azerbaijan

As can be seen from Table 1, in the products under consideration there were significant price fluctuations. To this end, the econometric regression equations were established based on factors selected in the EViews statistical software according to the methodology.

Changes in the 2016–2017 retail price index for 19 socially significant food products selected for the Azerbaijani economy are presented graphically in Figure 2. As you can see, retail prices for all products except chicken eggs (–5.96%) and onions (–4.96%) rose.

Figure 2 Comparison of changes in the price index for socially significant food products (January 2016 = 100%)



Source: The State Statistical Committee (SSC) of the Republic of Azerbaijan

5 DATA ANALYSIS

Researches on food consumption and nutrition are always used as the primary source of information for determining the cost of goods and services necessary for the population, consumption structure, ratio of food and non-food products, and quantitative and qualitative indicators of living standards. The SSC regularly maintains statistics and researches on food consumption and consumption expenditures, which must meet the following requirements.

Researches must cover:

1. Different groups of food products;
2. Origin of food products;
3. Cost of the food products;
4. Food consumption tradition;
5. Households, its inhabitants and different groups of the population;
6. Nutrition value of food products;
7. Level of calories in nutrition;
8. Food loss;
9. The study of anthropometric indicators.

Information on items numbering from one to five is studied during food consumption surveys, and an expert determines the information on number 6. Based on this data, food balances are compiled, and per capita daily food consumption is calculated by using these balances through national, geographical and regional units. After determining food consumption by individual regions, the country average is calculated.

The database of the research was formed based on the official data of the SSC and the Central Bank of the Republic of Azerbaijan (CBAR) on a monthly basis, covering the period from January 2012 to December 2017. The sampling period was selected from January 2016 to December 2017. The data used is derived from the following sources, and some of the information is adapted based on official figures as well:

- Average Producer Prices – form 1-SQ of the SSC (Producer prices of industrial products, prices of industry-related services and raw materials used for the production of industrial products) is used;
- Food Price Index – prices and price indices bulletins were used in Price Statistics of the SSC;
- Import prices and import volumes – the bulletins of the foreign trade relations of Azerbaijan were used in the Trade Statistics of the SSC. Since the prices of imported products are expressed in US dollars, the official exchange rate of the CBAR has been used to convert them into manat;
- Production volume – form 1-Production report of SSC (Production and distribution of goods and delivery of services), and production of agricultural livestock products report were used;
- Household consumption expenditures – data were derived from consumer expenditure section in the household budget statistics of the SSC;
- Exchange Rate – exchange rate information is available on the official website of the CBAR on a monthly basis.

6 RESULTS

Estimates on socially important food products in the Azerbaijani economy were made using econometric models based on monthly historical data, starting from January 2016 to December 2017.

Table 2 describes the indicators used for each product's evaluation in the EViews model. Note that, in the model, if the variable has the notion "USD", it is the price expressed in US dollar.

Table 2 Name and description of indicators in EViews software package

İQ_USD_MƏHSULUN ADI	Import price of goods in USD
İSTQ_MƏHSULUN ADI	Average producer price of goods
XQİY_ MƏHSULUN ADI	Price of raw materials
BİNDEX_ MƏHSULUN ADI	Retail price index of goods
TECHİZAT_ELEKTRİK	Electricity price
TECHİZAT_QAZ	Natural gas price
EV_TES_İSTXERC	Food expenditures of households
MEZENNE	USD/AZN exchange rate

Source: Own construction

The results of the regression equations performed are given in the Appendix. Based on these results, the calculations were made on the basis of the abovementioned methodological approach. Thus, the contribution of factors affecting changes in the price indexes of socially important food products in 12 months of 2017 compared to the same period of the previous year is presented in Table 3.

Table 3 Contribution of factors affecting retail price indices of 19 socially important food products

No.	Socially important food products	12-month retail price change,%	Contribution of factors						
			Exchange rate	*Food expenditures of households*	*Utility costs*	*Import price*	*Export price*	*Producer price*	*Price of raw materials*
1	Long rice	11.51	5.72	4.83					0.96
2	Wheat flour	6.90	3.34	0.74	0.47	0.76			1.60
3	Bread	13.64	7.07	4.38	2.89				–0.71
4	Macaroni	3.12	1.23	0.01	0.16	–0.44			2.16
5	Beef	37.04	6.55	3.64		1.43		25.42	0.00
6	Mutton	23.11	2.30	–0.71				21.52	0.00
7	Chicken	25.21	1.74	13.86	3.70	9.74		–3.83	
8	Unpasteurized milk	12.83	3.26	–0.77					10.33
9	Bryndza cheese	9.72	1.58	1.36	0.04	1.24			5.50
10	Chicken egg	–5.96							
11	Butter	32.62	4.36	2.63	0.46	10.48			14.69
12	Olive oil	8.54	1.29	1.07	0.18		4.37		1.62
13	Sunflower oil	4.60	2.54	1.75				0.20	0.10
14	Corn oil	12.38	4.67	3.44	1.00	0.03	1.41		1.82
15	Onion	–4.96					–2.44	–0.91	–1.61
16	Potato	18.78	10.29	–0.49		–1.49	2.50		7.97
17	Sugar	10.76	3.43	2.78	3.41	–2.87			4.02
18	Castor sugar	8.61	3.39	4.88	0.06	–1.32			1.60
19	Black and green tea	15.79	3.21	–0.82		2.16	1.52		9.73

Source: Constructed by the authors based on the results of the research

According to Table 3, the increase in retail prices was mainly due to the exchange rate. This might be explained by the double devaluation of the national currency in the period under review. At the same time, changes in import prices have also led to an increase in retail prices, as more products are imported. The presence of import prices in dollars takes into account the processes occurring in countries of origin, that is, the increase in production prices. For example, major contribution of the some 32.62% price increase in butter came from the increase in import prices (+10.48%).

Among 19 socially important food products, price change of chicken egg was also assessed, however, the results were inadequate. The reason for this may be official regulation of prices for chicken eggs, as well as other products. At the same time, the capacity of chicken eggs to be traded by individual households also hindered the natural pricing process. From this point of view, evaluations on chicken eggs have not produced adequate results.

Table 4 Share of factors affecting retail price indices of 19 socially important food products based on the model with monthly observations in 2016–2017 (in %)

No.	Socially important food products	Share of factors, in %							Sum
		Exchange rate	*Food expenditures of households*	*Utility costs*	*Import price*	*Export price*	*Producer price*	*Price of raw materials*	
1	Long rice	49.71%	41.93%					8.36%	100%
2	Wheat flour	48.39%	10.72%	6.74%	11.02%			23.13%	100%
3	Bread	51.86%	32.10%	21.22%				–5.18%	100%
4	Macaroni	39.39%	0.26%	5.19%	–14.07%			69.23%	100%
5	Beef	17.69%	9.82%		3.87%		68.63%		100%
6	Mutton	9.97%	–3.06%				93.09%		100%
7	Chicken	6.89%	54.99%	14.69%	38.63%		–15.19%		100%
8	Unpasteurized milk	25.44%	–5.97%					80.53%	100%
9	Bryndza cheese	16.26%	13.95%	0.39%	12.79%			56.61%	100%
10	Chicken egg								
11	Butter	13.37%	8.05%	1.42%	32.14%			45.02%	100%
12	Olive oil	15.16%	12.58%	2.16%		51.17%		18.93%	100%
13	Sunflower oil	55.23%	38.10%				4.46%	2.21%	100%
14	Corn oil	37.74%	27.78%	8.08%	0.27%	11.39%		14.74%	100%
15	Onion					49.24%	18.35%	32.40%	100%
16	Potato	54.81%	–2.61%		–7.95%	13.31%		42.44%	100%
17	Sugar	31.83%	25.81%	31.70%	–26.65%			37.31%	100%
18	Castor sugar	39.41%	56.75%	0.67%	–15.38%			18.56%	100%
19	Black and green tea	20.31%	–5.20%		13.66%	9.65%		61.58%	100%

Source: Constructed by the authors based on the results of the research

CONCLUSION

In recent years, along with the change in hydrocarbon prices in the world market, certain economic problems occurred in countries whose economy is largely dependent on the oil and gas sector. Following the drop in oil prices, the volume of foreign currency inflow decreased in oil-exporting countries, and the value of the local currencies started to fall, resulting in their devaluation. The devaluation

of the local currencies led to the rise in import prices as well. Retail prices increased for imported products and/or local products that indirectly depends on import. This resulted in high inflation rate, especially in countries whose export widely consists of hydrocarbon resources and domestic food market is vulnerable to the import prices.

As an oil exporting country, the sharp drop in oil prices had a serious negative impact on the economy of Azerbaijan as well. The depreciation of the national currency (AZN) and the increase in import prices led to an increase in prices in both wholesale and retail food market. Under these conditions, the analysis of the retail price fluctuations and determination of the main contributors of the inflation rate in food products have become an essential task for both academic community and policymakers in Azerbaijan. Therefore, the main purpose of the research in this paper is to find the determinants of the price increases in foods especially after the two times devaluation of AZN in 2015 following the double drop in oil prices. Despite some stabilization in oil prices, psychological pressure to the AZN after devaluations kept momentum and gradual depreciation continued in 2016 and 2017 as well, where headline inflation rates reached 12.4% and 12.9%, respectively. Therefore, we take specifically the data from 2016 to 2017 to capture the price changes and their determinants in this period specifically.

Identification and assessment of the factors has been carried out empirically based on the given methodology. Thus, 19 types of food products that are of the highest socially importance were selected, and the effect of the exogenous factors on the retail prices of these products was evaluated econometrically. As a result, it was concluded that, price increases in food products analyzed were largely due to the increase in import prices, and this relationship is statistically significant as well. This has shown itself in both the devaluation of local currency and the rise in selling prices of imported products in country of origin. Since import prices are modeled in foreign currency, this factor only reflects the effects of the changes in country of origin of import products.

Analyzing and evaluating price increases is important also from the point of view of pursuing economic policy. The results of the study were formally submitted to the Ministry of Economy of the Republic of Azerbaijan. At the same time, the results can play an important role in future economic policy decisions aimed at reducing the dependence of certain products on import and maintaining the exchange rate stability of the national currency.

Further improvement of the research, that is, inclusion of the prices of wider range of raw materials to the model, will help to explain the results more profoundly. In addition, further expansion of the time-series is important for controlling food price fluctuations in general, not just analyzing them for specific period.

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APPENDIX

Dependent Variable: BINDEX_DUYU
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
XQIY_XAMDUYU_USD	0.083198	0.116084	0.716702	0.4815
EV_TES_ISTXERC	0.417308	0.158618	2.630910	0.0156
MEZENNE	0.494702	0.153327	3.226451	0.0040
R-squared	0.742874	Mean dependent var		3.86E-15
Adjusted R-squared	0.718385	S.D. dependent var		1.000000
S.E. of regression	0.530674	Akaike info criterion		1.687130
Sum squared resid	5.913905	Schwarz criterion		1.834386
Log likelihood	–17.24556	Hannan-Quinn criter		1.726197
Durbin-Watson stat	0.350698			

Dependent Variable: BINDEX_BUGDAUNU
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_BUGDAUNU	0.132123	0.116500	1.134101	0.2716
XQIY_BUGDAYUMSAQ_USD	0.071479	0.101960	0.701056	0.4922
XQIY_YUMSAQBUGDA_AZN	0.205766	0.148233	1.388130	0.1820
DUMMY	0.080793	0.142134	0.568426	0.5768
EV_TES_ISTXERC	0.128543	0.173576	0.740557	0.4685
MEZENNE	0.580180	0.134510	4.313268	0.0004
R-squared	0.862890	Mean dependent var		6.15E-16
Adjusted R-squared	0.824804	S.D. dependent var		1.000000
S.E. of regression	0.418565	Akaike info criterion		1.308347
Sum squared resid	3.153535	Schwarz criterion		1.602861
Log likelihood	–9.700167	Hannan-Quinn criter		1.386482
Durbin-Watson stat	0.937053			

Dependent Variable: BINDEX_COREK
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISTQ_BUGDAUNU_ELANOV	–0.128445	0.094046	–1.365762	0.1880
XQIY_MAYA	0.071888	0.094524	0.760519	0.4563
TECHIZAT_QAZ	0.231508	0.081398	2.844156	0.0104
EV_TES_ISTXERC	0.350183	0.117324	2.984740	0.0076
MEZENNE	0.565753	0.102391	5.525400	0.0000
R-squared	0.912527	Mean dependent var		–1.02E-16
Adjusted R-squared	0.894111	S.D. dependent var		1.000000
S.E. of regression	0.325406	Akaike info criterion		0.775564
Sum squared resid	2.011888	Schwarz criterion		1.020992
Log likelihood	–4.306764	Hannan-Quinn criter		0.840676
Durbin-Watson stat	1.126075			

Dependent Variable: BINDEX_MAKARON
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_MAKARON	–0.140392	0.115551	–1.214979	0.2410
XQIY_BUGDA_AZN	0.281810	0.177443	1.588176	0.1307
ISTQ_SUD	0.168897	0.149324	1.131078	0.2737
ISTQ_YUMURTA	0.239855	0.145331	1.650404	0.1172
DUMMY	0.051799	0.166910	0.310340	0.7601
EV_TES_ISTXERC	0.002592	0.166079	0.015608	0.9877
MEZENNE	0.392913	0.179782	2.185501	0.0431
R-squared	0.821877	Mean dependent var		2.73E-16
Adjusted R-squared	0.759011	S.D. dependent var		1.000000
S.E. of regression	0.490907	Akaike info criterion		1.653367
Sum squared resid	4.096818	Schwarz criterion		1.996966
Log likelihood	–12.84041	Hannan-Quinn criter		1.744524
Durbin-Watson stat	0.940168			

Dependent Variable: BINDEX_MAL
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_MAL	0.041992	0.049504	0.848264	0.4063
ISTQ_MAL	0.745600	0.058620	12.71925	0.0000
EV_TES_ISTXERC	0.106659	0.039746	2.683507	0.0143
MEZENNE	0.192194	0.043600	4.408154	0.0003
R-squared	0.984391	Mean dependent var		6.29E-16
Adjusted R-squared	0.982050	S.D. dependent var		1.000000
S.E. of regression	0.133977	Akaike info criterion		–1.031287
Sum squared resid	0.358996	Schwarz criterion		–0.834944
Log likelihood	16.37544	Hannan-Quinn criter		–0.979197
Durbin-Watson stat	1.602695			

Dependent Variable: BINDEX_QOYUN
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISTQ_QOYUN	0.932575	0.050109	18.61089	0.0000
EV_TES_ISTXERC	–0.030703	0.048295	–0.635742	0.5318
MEZENNE	0.099887	0.055355	1.804482	0.0855
R-squared	0.975456	Mean dependent var		–5.55E-17
Adjusted R-squared	0.973118	S.D. dependent var		1.000000
S.E. of regression	0.163957	Akaike info criterion		–0.661961
Sum squared resid	0.564517	Schwarz criterion		–0.514704
Log likelihood	10.94353	Hannan-Quinn criter		–0.622894
Durbin-Watson stat	1.195291			

Dependent Variable: BINDEX_TOYUQ
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_TOYUQ	0.374480	0.144685	2.588250	0.0180
ISTQ_TOYUQ	–0.147255	0.130982	–1.124243	0.2749
DUMMY	0.142372	0.189080	0.752972	0.4607
EV_TES_ISTXERC	0.533117	0.171754	3.103947	0.0058
MEZENNE	0.066781	0.191474	0.348771	0.7311
R-squared	0.735311	Mean dependent var		–3.24E-16
Adjusted R-squared	0.679588	S.D. dependent var		1.000000
S.E. of regression	0.566050	Akaike info criterion		1.882783
Sum squared resid	6.087836	Schwarz criterion		2.128210
Log likelihood	–17.59339	Hannan-Quinn criter		1.947895
Durbin-Watson stat	0.826507			

Dependent Variable: BINDEX_SUD
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
XQIY_BUGDAKEP	0.774400	0.122620	6.315461	0.0000
EV_TES_ISTXERC	–0.057364	0.109880	–0.522056	0.6071
MEZENNE	0.244628	0.130220	1.878576	0.0743
R-squared	0.874974	Mean dependent var		4.81E-16
Adjusted R-squared	0.863067	S.D. dependent var		1.000000
S.E. of regression	0.370045	Akaike info criterion		0.966084
Sum squared resid	2.875599	Schwarz criterion		1.113341
Log likelihood	–8.593011	Hannan-Quinn criter		1.005151
Durbin-Watson stat	0.751663			

Dependent Variable: BINDEX_BRINZA
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_BRINZA	0.144594	0.052882	2.734270	0.0132
ISTQ_SUD	0.639769	0.065043	9.836124	0.0000
DUMMY	0.004379	0.043553	0.100533	0.9210
EV_TES_ISTXERC	0.157625	0.038325	4.112882	0.0006
MEZENNE	0.183806	0.045630	4.028222	0.0007
R-squared	0.986379	Mean dependent var		1.74E-15
Adjusted R-squared	0.983512	S.D. dependent var		1.000000
S.E. of regression	0.128406	Akaike info criterion		–1.084180
Sum squared resid	0.313276	Schwarz criterion		–0.838752
Log likelihood	18.01016	Hannan-Quinn criter		–1.019068
Durbin-Watson stat	1.665517			

Dependent Variable: BINDEX_YUMURTA
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
XQIY_BUGDAKEP	–0.428908	0.299120	–1.433902	0.1679
XQIY_BUGDADENI	–0.453735	0.194411	–2.333894	0.0307
DUMMY	–0.021886	0.281185	–0.077835	0.9388
EV_TES_ISTXERC	–0.030584	0.249809	–0.122428	0.9038
MEZENNE	0.728386	0.299963	2.428251	0.0253
R-squared	0.437019	Mean dependent var		–1.39E-15
Adjusted R-squared	0.318496	S.D. dependent var		1.000000
S.E. of regression	0.825532	Akaike info criterion		2.637475
Sum squared resid	12.94857	Schwarz criterion		2.882903
Log likelihood	–26.64970	Hannan-Quinn criter		2.702587
Durbin-Watson stat	0.845166			

Dependent Variable: BINDEX_KEREYAGI
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_KEREYAGI	0.360930	0.058455	6.174535	0.0000
ISTQ_SUD	0.505631	0.068974	7.330773	0.0000
TECHIZAT_ELEKTRIK	0.015979	0.100795	0.158530	0.8757
EV_TES_ISTXERC	0.090440	0.047462	1.905512	0.0720
MEZENNE	0.150146	0.065603	2.288707	0.0337
R-squared	0.987349	Mean dependent var		–1.94E-15
Adjusted R-squared	0.984685	S.D. dependent var		1.000000
S.E. of regression	0.123753	Akaike info criterion		–1.158013
Sum squared resid	0.290979	Schwarz criterion		–0.912586
Log likelihood	18.89616	Hannan-Quinn criter		–1.092901
Durbin-Watson stat	1.422975			

Dependent Variable: BINDEX_ZEYTUNYAGI
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IXRAC_USD_ZEYTUNYAGI	0.596478	0.115551	5.162021	0.0001
XQIY_ZEYTUN_EMALSIZ_USD	0.220682	0.107847	2.046256	0.0548
DUMMY	0.025170	0.157819	0.159488	0.8750
EV_TES_ISTXERC	0.146586	0.138335	1.059650	0.3026
MEZENNE	0.176765	0.147682	1.196927	0.2461
R-squared	0.818548	Mean dependent var		–1.70E-15
Adjusted R-squared	0.780348	S.D. dependent var		1.000000
S.E. of regression	0.468671	Akaike info criterion		1.505220
Sum squared resid	4.173397	Schwarz criterion		1.750648
Log likelihood	–13.06264	Hannan-Quinn criter		1.570332
Durbin-Watson stat	1.677640			

Dependent Variable: BINDEX_GUNEBAXANYAGI
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISTQ_GUNEBAXANYAGI	0.048497	0.089540	0.541619	0.5941
XQIY_XAMGUNYAGI_USD	0.024050	0.085413	0.281574	0.7812
EV_TES_ISTXERC	0.414696	0.106846	3.881249	0.0009
MEZENNE	0.601116	0.101522	5.921023	0.0000
R-squared	0.902437	Mean dependent var		–8.99E-16
Adjusted R-squared	0.887802	S.D. dependent var		1.000000
S.E. of regression	0.334959	Akaike info criterion		0.801397
Sum squared resid	2.243956	Schwarz criterion		0.997739
Log likelihood	–5.616761	Hannan-Quinn criter		0.853486
Durbin-Watson stat	1.086155			

Dependent Variable: BINDEX_QARGIDALIYAGI
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_QARGIDALIYAGI	0.003340	0.101572	0.032883	0.9742
IXRAC_USD_QARGIDALIYAGI	0.138571	0.108148	1.281308	0.2173
XQIY_XAMQARGYAGI_USD	0.192203	0.098150	1.958252	0.0668
XQIY_SODA_KAUSTIK_USD	–0.012855	0.095271	–0.134935	0.8942
DUMMY	0.098288	0.136552	0.719783	0.4814
EV_TES_ISTXERC	0.338122	0.133414	2.534385	0.0214
MEZENNE	0.459302	0.146424	3.136790	0.0060
R-squared	0.877709	Mean dependent var		–1.07E-15
Adjusted R-squared	0.834548	S.D. dependent var		1.000000
S.E. of regression	0.406758	Akaike info criterion		1.277298
Sum squared resid	2.812689	Schwarz criterion		1.620897
Log likelihood	–8.327571	Hannan-Quinn criter		1.368454
Durbin-Watson stat	0.936959			

Dependent Variable: BINDEX_SOGAN
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IXRAC_USD_SOGAN	0.484341	0.217128	2.230666	0.0367
ISTQ_SOGAN	0.180533	0.215469	0.837859	0.4115
XQIY_AZOT_USD	0.318699	0.183386	1.737856	0.0969
R-squared	0.311163	Mean dependent var		1.24E-15
Adjusted R-squared	0.245560	S.D. dependent var		1.000000
S.E. of regression	0.868585	Akaike info criterion		2.672567
Sum squared resid	15.84325	Schwarz criterion		2.819823
Log likelihood	–29.07080	Hannan-Quinn criter		2.711634
Durbin-Watson stat	0.886533			

Dependent Variable: BINDEX_KARTOF
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_KARTOF	–0.070698	0.203673	–0.347113	0.7323
IXRAC_USD_KARTOF	0.118347	0.196951	0.600893	0.5550
XQIY_KARTOFTOX_USD	0.377279	0.206859	1.823843	0.0839
EV_TES_ISTXERC	–0.023207	0.256685	–0.090408	0.9289
MEZENNE	0.487188	0.255437	1.907276	0.0717
R-squared	0.366789	Mean dependent var		1.90E-16
Adjusted R-squared	0.233481	S.D. dependent var		1.000000
S.E. of regression	0.875510	Akaike info criterion		2.755033
Sum squared resid	14.56385	Schwarz criterion		3.000460
Log likelihood	–28.06039	Hannan-Quinn criter		2.820145
Durbin-Watson stat	0.634546			

Dependent Variable: BINDEX_SEKER
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_SEKER	–0.222347	0.176667	–1.258559	0.2252
XQIY_QAMISCUG_QIY	0.175983	0.133279	1.320413	0.2042
XQIY_XAMSEKER_USD	0.135325	0.094048	1.438889	0.1683
TECHIZAT_QAZ	0.057178	0.111800	0.511428	0.6156
TECHIZAT_ELEKTRIK	0.207266	0.297958	0.695622	0.4961
EV_TES_ISTXERC	0.215329	0.196691	1.094758	0.2889
MEZENNE	0.265567	0.220082	1.206672	0.2441
R-squared	0.920058	Mean dependent var		–2.22E-15
Adjusted R-squared	0.891843	S.D. dependent var		1.000000
S.E. of regression	0.328872	Akaike info criterion		0.852194
Sum squared resid	1.838661	Schwarz criterion		1.195793
Log likelihood	–3.226329	Hannan-Quinn criter		0.943351
Durbin-Watson stat	1.079757			

Dependent Variable: BINDEX_SEKERTOZU
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_SEKERTOZU	–0.130105	0.181522	–0.716744	0.4823
XQIY_XAMSEKER_USD	0.156948	0.136960	1.145940	0.2660
TECHIZAT_ELEKTRIK	0.005641	0.344930	0.016355	0.9871
EV_TES_ISTXERC	0.479896	0.212396	2.259443	0.0358
MEZENNE	0.333323	0.314087	1.061245	0.3019
R-squared	0.794127	Mean dependent var		1.21E-15
Adjusted R-squared	0.750786	S.D. dependent var		1.000000
S.E. of regression	0.499214	Akaike info criterion		1.631486
Sum squared resid	4.735070	Schwarz criterion		1.876914
Log likelihood	–14.57784	Hannan-Quinn criter		1.696598
Durbin-Watson stat	0.636087			

Dependent Variable: BINDEX_CAY
Method: Least Squares
Sample: 2016M01 2017M12
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IQ_USD_CAY	0.129767	0.142927	0.907931	0.3753
IXRAC_USD_CAY	0.098048	0.120507	0.813625	0.4259
XQIY_CAY_QABSIZ	0.773242	0.211089	3.663107	0.0017
EV_TES_ISTXERC	–0.067085	0.181224	–0.370178	0.7153
MEZENNE	0.047883	0.174033	0.275141	0.7862
R-squared	0.806622	Mean dependent var		–2.55E-15
Adjusted R-squared	0.765911	S.D. dependent var		1.000000
S.E. of regression	0.483827	Akaike info criterion		1.568873
Sum squared resid	4.447684	Schwarz criterion		1.814301
Log likelihood	–13.82648	Hannan-Quinn criter		1.633985
Durbin-Watson stat	0.777361			

Spatial Variations in the Educational Performance in Slovak Districts

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Abstract

This paper deals with the spatial analysis of the educational performance measured by the average percentage Maths scores achieved in individual districts of Slovakia in Testing 9 during the school year 2018/2019. Besides identification of the spatial patterns in test scores achievements, the paper tries to investigate the impact of selected socio-economic variables (average nominal monthly wage and unemployment rate) onto the test scores achievements. Since we suppose the significant impact of the socially disadvantaged background onto the test results, corresponding dummy variable was taken into consideration as well. The ordinary least squares (OLS) estimation of the global linear regression model was followed by the local spatial approach using the geographically weighted regression (GWR) to capture the geographical variability of estimated parameters. Spatial variations in the relationship among the educational performance and the selected socio-economic variables were confirmed.

Keywords

Educational performance, geographically weighted regression, spatial variations, Slovak districts

JEL code

C21, I21

INTRODUCTION

The issue of educational performance is very attractive from the political, economic as well as from the social point of view. Improvement of the educational quality, identification of the strengths and weaknesses of the educational process as well as revealing of the disparities in educational performance are crucial factors incorporated in majority of the national development strategies. Disparities in educational performance can be connected with many factors including the pupil's home and family background, various teacher characteristics and school characteristics (see e.g. Qiu and Wu, 2011). As pointed out e.g., by Fotheringham, Charlton and Brunsdon (2001), Naidoo, van Eeden and Munch (2014), and Vidyattama, Li and Miranti (2019), by analysing the educational performance inequalities it is important to investigate the socio-economic characteristics of the analysed region.

There have been published various studies dealing with the educational performance testing the impact of different socio-economic variables (family income, unemployment rate, families with a single parent,

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parents' education etc.).[2] However, the degree to which socio-economic factors matter differs across individual countries (Haahr et al., 2005). Some researchers (Fotheringham, Charlton and Brunsdon, 2001; Naidoo, van Eeden and Munch, 2014; Gutiérrez, Sánchez, and Giorguli, 2011; Qiu and Wu, 2011; Chocholatá, 2019) accent that the spatial variations in the educational performance can be masked by estimating only a classic global model, i.e. that some socio-economic variables can have a significant effect in some regions while in other regions their effect may be insignificant. The geographically weighted regression (GWR) approach developed by Brunsdon, Charlton and Fotheringham (see e.g., Fotheringham, Brunsdon and Charlton, 2002) enables to reveal the spatial variations in modelled relationships.

Educational performance both at the international and national level is usually measured by the test scores achieved by pupils or students. Slovakia is involved in various international test measurements, e.g. PISA (OECD's Programme for International Student Assessment), TIMSS (Trends in International Mathematics and Science Study), PIRLS (Progress in International Reading Literacy Study), TALIS (Teaching and Learning International Survey), ICILS (The International Computer and Information Literacy Study).[3] Monitoring and assessment of the quality of educational process at the national level, is measured by the external testing of the primary school pupils (Testing 5, Testing 9) and the secondary school students (external part of secondary school graduation exam). The test achievement scores also enable to have the detailed view on the pupils' and students' knowledge as well as to identify the strengths and weaknesses of the educational process.

This paper examines the average percentage Maths scores achieved in individual districts of Slovakia in Testing 9 (T9)[4] during the school year 2018/2019 in order to assess some spatial patterns in test scores achievements as well as to identify the impact of selected socio-economic variables (average nominal monthly wage and unemployment rate) and that of a socially disadvantaged background onto the test scores achievements. Besides the classic global linear regression approach, the instruments of spatial analysis and GWR are used as well.

The paper is organized as follows: the introduction is followed by the section devoted to GWR methodology issues, the second section comprises the data, the third section deals with the empirical results of analysis and the last section concludes the paper.

1 GEOGRAPHICALLY WEIGHTED REGRESSION – METHODOLOGICAL ISSUES

To assess the impact of selected socio-economic variables onto the educational performance, the first step is usually to estimate the parameters of the global linear regression model using the ordinary least squares (OLS) approach. Taking into account the spatial character of modelled data, the application of the OLS on such data is usually connected with the violation of statistical assumption of independent residuals and quite often also with the violation of the assumption of residual constant variance (Qiu and Wu, 2011). Concerning the spatial data analysis, two types of the spatial effects can be distinguished, the spatial autocorrelation and the spatial heterogeneity. While the significant tendency towards clustering of similar (dissimilar) values in space is known as positive (negative) spatial autocorrelation, the presence of spatial heterogeneity indicates that parameters can vary across regions depending on their location (Chocholatá, 2018a, 2018b; Furková, 2018; Qiu and Wu, 2011). As pointed out e.g., by Abreu, De Groot and Florax

[2] For a survey, see e.g. Chocholatá and Furková (2017).

[3] For more information see: <*https://www.nucem.sk/sk/merania*>.

[4] Testing 9, i.e. external testing (in national language and Mathematics) of pupils of the 9th year of primary schools as well as those of the 4th year of grammar schools/sport schools with an eight-year educational program, is performed by the National Institute for Certified Educational Measurements (Národný ústav certifikovaných meraní vzdelávania „NÚCEM") in order to monitor pupils' level of knowledge and skills and to obtain relevant information about their performance at the end of lower secondary education.

(2005), and Anselin (2001), using the cross-sectional models, it is quite problematic to distinguish between these two spatial effects since these often come together. Fotheringham (2009) asserts that in some cases the spatial autocorrelation among residuals can be caused by the spatial heterogeneity and in such cases it is a good solution to use the local approach.[5] The local approach, i.e., the GWR approach, can be used to alleviate problems from both spatial effects in a global linear regression model (Qui and Wu, 2011).

The GWR approach enables to estimate local parameter values for each region in the data set and thus let us see the spatial heterogeneity of the analysed relationships. The corresponding model can be written as follows (Wheeler and Páez, 2010):

$$y_i = \beta_{i0} + \sum_{k=1}^{p-1} \beta_{ik} x_{ik} + \varepsilon_i \,, \tag{1}$$

where index $i = 1, \ldots, n$, denotes the i-th region, y_i is the value of dependent variable at region i, x_{ik} denotes the values of the k-th independent variable at region i, β_{i0} is the intercept, β_{ik} is the regression parameter for the k-th independent variable, p is the number of regression terms, and ε_i denotes the error term at region i.

The GWR model expressed in matrix notation is as follows (Wheeler and Páez, 2010; Furková, 2018):

$$y_i = \boldsymbol{x_i \beta_i} + \boldsymbol{\varepsilon_i} \,, \tag{2}$$

where $\mathbf{x}_i$ is a row vector of independent variables and $\boldsymbol{\beta}_i$ is a column vector of regression parameters at region i. The local regression parameters are functions of region i and can be estimated by the weighted least squares:

$$\widehat{\boldsymbol{\beta}_i} = \left(\boldsymbol{X}^T \boldsymbol{W}_i \boldsymbol{X} \right)^{-1} \boldsymbol{X}^T \boldsymbol{W}_i \boldsymbol{y} \,, \tag{3}$$

where $\boldsymbol{\beta}_i$ is the vector of p local regression parameters at region i, $\boldsymbol{y}$ denotes the $n \times 1$ vector of dependent variables, $\boldsymbol{X}$ is the $n \times k$ matrix of independent variables (including a column of ones for the intercept) and $\boldsymbol{W}_i = diag\,(W_{i1}, W_{i2}, \ldots, W_{in})$ is the $n \times n$ diagonal weight matrix at region i (Wheeler and Páez, 2010).

The weights are linked to the proximity of the region i to all the other regions. Regions closer to the region i have a higher weight in local regression in comparison to regions more distant in space (Fotheringham, Brunsdon and Charlton, 2002). The calculation of weights is based on the spatial kernel function (in general we can distinguish adaptive and fixed spatial kernel functions) and specification of its bandwidth. The optimal value of bandwidth can be calculated e.g., by minimising a cross validation score – CV or by the corrected Akaike Information Criterion – AICc (see e.g., Fotheringham, Brunsdon and Charlton, 2002; Nakaya, 2016). The difference between the adaptive and fixed spatial kernel function is as follows: since the adaptive spatial kernel function is based on the use of the same number of regions in each local kernel, the fixed spatial kernel function uses the same spatial range in each local kernel (for more information see e.g., Wheeler and Páez, 2010). GWR results in estimation of n vectors of local parameters, i.e. one for each region. Analysts often map the estimated local parameters to uncover something which is hidden in the global linear regression model and try to assess the spatial pattern of the estimated parameters (Fotheringham, Charlton and Brunsdon, 2001; Wheeler and Páez, 2010). To test whether the local GWR model describes the data significantly better than a global linear regression model, the GWR ANOVA test can be used. For the further testing procedures dealing e.g. with the spatial variation of the estimated local regression parameters see Leung, Mei and Zhang (2000), and Nakaya (2016).

[5] See e.g., Mur, López and Angulo (2008), Qiu and Wu (2011) for issues regarding the links between the spatial dependence and spatial heterogeneity.

2 DATA

The empirical part of the paper is based on the data set which comprises the regional data for the 79 districts of Slovakia. The dependent variable is the T9 average percentage Maths scores for the 79 Slovak districts retrieved from the website of NÚCEM[6] for the school year 2018/2019. The shape file of the Slovak districts was downloaded from the website Freemap Slovakia.[7] To assess the impact of socio-economic variables on the districts' school performance (measured by T9 average percentage Maths scores), the independent variables – average nominal monthly wage (in Euro) and unemployment rate (in %) in a district (for the year 2018) were downloaded from the DATAcube database of the Statistical Office of the Slovak Republic.[8] One more independent variable, a dummy (0/1) variable, indicating districts with more than 5% pupils with the socially disadvantaged background was retrieved from the above mentioned NÚCEM website. The whole analysis was performed in the free downloadable softwares GeoDa and GWR4.

Testing 9 from Mathematics in the school year 2018/2019 was performed at April 3, 2019 by 40 452 pupils with the Slovak average percentage Maths scores' achievement of 63.1%. Box plots and descriptive statistics for the T9 average percentage Maths scores (denoted as *mat*),[9] average nominal monthly wage (*w18*) and unemployment rate (*un18*) are depicted in Figure 1.

Figure 1 Box plots of the average percentage T9 test scores in Maths (*MAT*), average nominal monthly wage in Euro (*w18*) and unemployment rate in % (*un18*)

Note: Figure available in the online version of Statistika: Statistics and Economy Journal No. 2/2020.
Source: Author's calculations in GeoDa

Besides the mean values of analysed indicators (calculated as the average of the district values) there is possible to identify various upper outliers and one lower outlier. As for the dependent variable, the average percentage Maths scores, the upper outlier was the district of Bratislava I and lower outliers were the districts of Revúca and Gelnica. Extremely high average nominal monthly wages – upper outliers – were detected in the districts of Bratislava I, Bratislava II, Bratislava III and Bratislava IV. Upper outliers with regard to the high unemployment rates were identified for the districts of Rimavská Sobota, Kežmarok, Rožňava and Revúca. Minimum and maximum values further confirm the that there are huge differences across analysed districts concerning the average percentage Maths scores with minimum of 44.7% (Gelnica) and maximum of 78.8% (Bratislava I). The average nominal monthly wages of 726 Euro in Bardejov district and of 1 696 Euro in Bratislava II district, illustrate the enormous difference between the minimum and the maximum values. Regarding the unemployment rates, the difference of almost 14.5 percentage points between the lowest 1.68% unemployment rate (Hlohovec) and 16.15% (Rimavská Sobota) clearly indicates the existence of the substantial regional differences, as well.

Figure 2 illustrates the box maps[10] for the analysed variables (T9 average percentage Maths scores – *mat*, average nominal monthly wage – *w18* and unemployment rate – *un18*) in order to visualise the unequally distribution of analysed variables over space and to detect possible clusters of similar or dissimilar values. Figure 2 incorporates the unique values map indicating localization of the 11 districts with more than 5% pupils with the socially disadvantaged background (*szp*) as well.

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[6] <*https://www.nucem.sk/dl/4422/S_T9_2019_Priloha_4.1.pdf*>.
[7] <*http://wiki.freemap.sk/HraniceAdministrativnychUzemi*>.
[8] <*http://datacube.statistics.sk/*>.
[9] Descriptive statistics are calculated based on district values of the Maths test scores.
[10] Box map consists of six categories and it is a special form of a quartile map. However it is worth mentioning, that the first and the last quartile no longer correspond to exactly one fourth of the observations, since the lower and upper outliers, respectively, are depicted as extra categories (Anselin, Kim and Syabri, 2010).

Figure 2 Box maps of the average percentage T9 test scores in Maths (*MAT*), average nominal monthly wage in Euro (*w18*), unemployment rate in % (*un18*) and unique values map indicating 11 districts with more than 5% pupils with the socially disadvantaged background (*szp*)

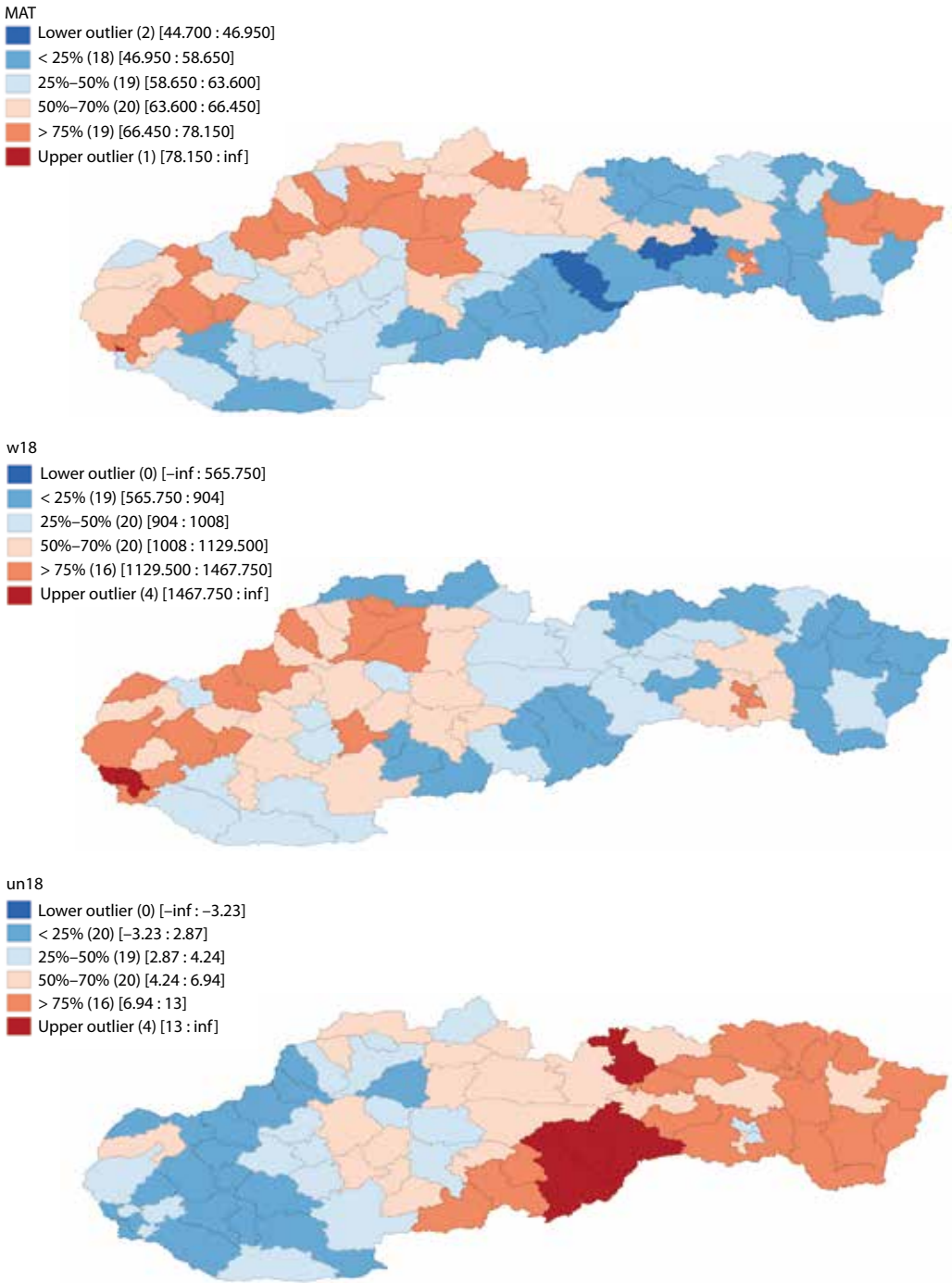


Figure 2 (continuation)

Source: Author's calculations in GeoDa

Regarding the dependent variable, average percentage Maths scores, the best results were detected in region Bratislava I followed by other 19 districts located in western, middle and eastern part of Slovakia. Districts with the worst results were Gelnica and Revúca. Low test scores achievements were detected also in districts located mostly in southern and eastern part of Slovakia.[11] Significant polarisation between western and eastern districts in also visible in case of both independent variables – average nominal monthly wage and unemployment rate. The unique values map indicates 11 districts with more than 5% pupils with the socially disadvantaged background located in the southern part of middle Slovakia and eastern part of Slovakia. Based on the above-mentioned results of the spatial analysis indicating the presence of the huge spatial heterogeneity, it could be hardly supposed that the same relationship can hold across all the regions in the data set under investigation (Chocholatá, 2018b).

3 EMPIRICAL RESULTS

As the first step, the global linear regression model was estimated using the classic OLS technique:

$$mat_i = \beta_0 + \beta_1 w18_i + \beta_2 un18_i + \beta_3 szp_i + \varepsilon_i , \tag{4}$$

where the dependent variable (*mat* – average percentage T9 test scores in Maths) is a function of independent variables (*w18* – average nominal monthly wage in 2018, *un18* – unemployment rate in 2018 and *szp* – dummy variable indicating districts with more than 5% pupils with the socially disadvantaged background), β_0, β_1, β_2 and β_3 are unknown parameters and ε_i represents an error term. Estimates of individual global parameters (i.e. without regional differentiation) are in Table 1 (column: Linear model). The estimated parameters corresponding to the average nominal monthly wage and unemployment rate were statistically significant at the 1 percent level of significance indicating the positive impact of average nominal monthly wages and negative impact of the unemployment rate on the analysed average percentage Maths scores. The negative impact of the socially disadvantaged background was confirmed at the 10 percent level of significance.

[11] With regard to the test results of previous five years, i.e. 2014–2018, districts of Gelnica, Rožňava and Rimavská Sobota belong to the five districts with the worst Maths scores, on the other hand, only the district of Bratislava I belongs to the top five districts with the best Math scores achievements during this five years' period.

Table 1 Estimation results of OLS regression and of GWR

Model	Linear model OLS	GWR				
		Minimum	Lower Quartile	Median	Upper Quartile	Maximum
β_0	54.6945***	45.8446	50.5667	52.5663	63.3869	68.9600
β_1 (*w18*)	0.0117***	0.0018	0.0061	0.0142	0.0150	0.0201
β_2 (*un18*)	–0.8056***	–1.2958	–1.1706	–1.0132	–0.9153	–0.8537
β_3 (*szp*)	–3.1972*	–2.5232				
AICc	461.313	453.578				
Adjusted R^2	0.5794	0.6332				

Notes: Symbols ***, * indicate the rejection of H_0 hypotheses at 1% and 10% level of significance, respectively.
Source: Author's calculations in GeoDa and GWR4

Since we deal with the spatial data, the regression residuals were further tested for the presence of the spatial autocorrelation by calculation of the spatial diagnostic test statistics – the Moran's *I* (the formula for calculation see e.g., Getis, 2010). Corresponding Moran's scatterplot with the estimated Moran's *I*[12] of 0.1298 indicating the presence of the statistically significant positive spatial autocorrelation is in Figure 3.[13]

Figure 3 Moran's scatterplot of the OLS residuals

Note: Figure available in the online version of Statistika: Statistics and Economy Journal No. 2/2020.
Source: Author's calculations in GeoDa

To capture the spatial heterogeneity across analysed regions, the global analysis based on model (4) was followed by the local spatial analysis based on model (5). Model (5) is an extension of the GWR model (1) with the mixture of globally fixed and locally varying parameters. It was supposed that while the variables of average nominal monthly wage and unemployment rate have the locally varying impact (with the corresponding geographically varying, i.e. local parameters β_{i1} *and* β_{i2}), the variable of *szp* is expected to be the global variable[14] (with the fixed, i.e. global parameter β_3):

$$mat_i = \beta_{i0} + \beta_{i1} w18_i + \beta_{i2} un18_i + \beta_3 szp_i + \varepsilon_i \,. \tag{5}$$

Parameters of model (5) were estimated based on GWR technique using the adaptive bi-square kernel with 61 nearest neighbours (Nakaya, 2016). The GWR estimation results (minimum, lower quartile, median, upper quartile, maximum) are gathered in Table 1 (columns: GWR). The estimated parameters confirmed the positive impact of average nominal monthly wages and negative impact of both the unemployment rate and socially disadvantaged background on the analysed average percentage Maths scores. Figure 4

[12] The Moran's *I* values were calculated based on the queen contiguity matrix of the first order.
[13] Randomization with 999 permutations was used to prove the statistical significance of results.
[14] Testing geographical variability of local parameters proved the global character of the szp variable. Results are available from the author upon request.

illustrates the spatial variation of local coefficients of determination R_i^2 and those of estimated local parameters from the GWR fit, respectively. The values of local R_i^2 spanning from moderate 0.549 (Bytča) to good 0.735 (Lučenec) indicate an acceptable goodness-of-fit and clearly confirm the different model performance across individual regions. The impact of the average nominal monthly wage on the Maths test scores was positive across all the Slovak districts however having the different intensity in eastern regions and regions located in the south of western and middle part of Slovakia. Considerable spatial variation (especially between districts located in western and eastern part of Slovakia) is visible for the parameter values of the second local variable, the unemployment rate, confirming its overall negative effect.

Figure 4 Local coefficients of determination R_i^2 (*localR2*) and local parameters of average nominal monthly wage (est_*w18*) and unemployment rate (est_*un18*) from the GWR fit

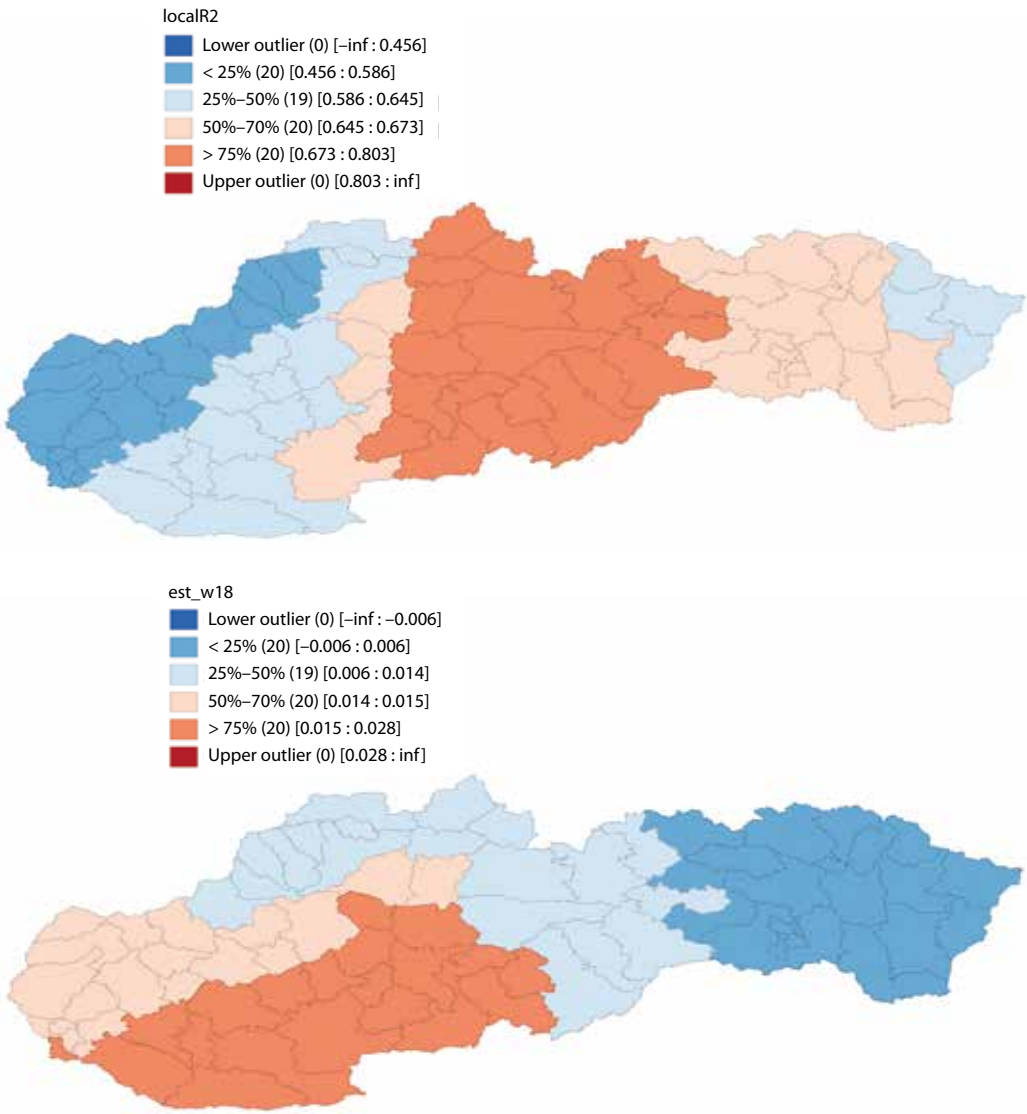
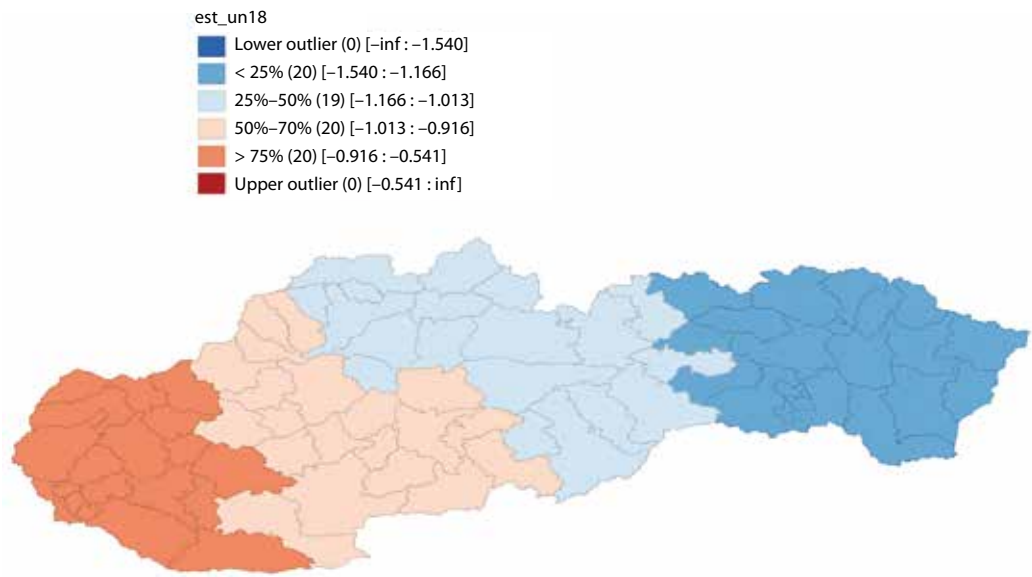


Figure 4 (continuation)



Source: Author's calculations in GWR4 and GeoDa

Comparing the estimation results of the global model (4) and those of the local model (5) based on values of *adjusted* R^2 0.5794 and 0.6332, respectively (Table 1), indicates some improvement in the model performance. Taking into account the AICc values of 461.313 and 453.578 for the OLS and GWR fit, respectively (Table 1), suggests some considerable improvement in the GWR model fit as well (for more information see e.g. Burnham and Anderson, 2002). Standardised residuals from the GWR fit, as documented in Figure 5, did not show a particular spatial pattern (Gutiérrez, Sánchez, and Giorguli, 2011). Moran's *I* values of –0.005 clearly confirm no evidence of the statistically significant spatial autocorrelation. The statistically significant improvement in the GWR model performance over the global OLS model was confirmed by the GWR ANOVA test with the test statistic F = 3.305.

Figure 5 Moran's scatterplot of the standardised residuals from the GWR fit

Note: Figure available in the online version of Statistika: Statistics and Economy Journal No. 2/2020.
Source: Author's calculations in GeoDa

4 DISCUSSION

The empirical results of this paper are in accordance with those of following studies confirming the significant spatial variation of the regression parameters by analysing of the educational performance. Fotheringham, Charlton and Brunsdon (2001) examined the relationship between the school performance in Britain (measured by Maths scores in 1997) and the socio-economic indicators of school catchment areas revealing some spatial variations in the results, i.e. that "some attributes of school catchment areas have an effect on school performance in some areas and not in others and such variations are masked in global results" (Fotheringham, Charlton and Brunsdon, 2001, p. 2). Spatial heterogeneity in educational outcomes in Mexico in 2000, based on the GWR technique, was confirmed by the study presented by Gutiérrez, Sánchez, and Giorguli (2011). The paper of Qiu and Wu (2011) deals with the geographic variations in the impact of various student characteristics, teacher characteristics

and school characteristics onto the American College Test scores for the 447 public high schools in Missouri. Their GWR analysis showed "that some local areas have weak variable relationships or even opposite variable effects from their corresponding global effects at certain local regression neighbourhoods" (Qiu and Wu, 2011, p. 81). The study of Naidoo, van Eeden and Munch (2014) was aimed at identification of spatial patterns among the 2010 matric pass rates of secondary schools in Cape Town as well as at investigation of spatial relationships between matric pass rates and selected socio-economic variables. Regarding the GWR results, the significant spatial variation in the spatial distribution of all parameters was confirmed. Chocholatá (2019) analysed the spatial variation in the relationship between the Slovak districts' school performance and various socio-economic variables. The local GWR approach enabled to confirm the statistically significant spatial variation in the modelled relationship and to reveal quite a high amount of districts with locally different impacts of analysed socio-economic indicators.

CONCLUSION

This paper deals with the spatial relationship among the educational performance and the selected socio-economic indicators at the district level. The results of the spatial analysis revealed the huge differences in educational performance (measured as Testing 9 average percentage Maths scores) as well as in values of both the socio-economic variables (average nominal monthly wage and unemployment rate) across analysed districts depending on their location. One more variable, the dummy 0/1 variable, indicating the impact of the socially disadvantaged background, was also taken into account. The global relationship among the average percentage Maths scores, the socio-economic variables and a dummy variable implies the positive impact of the average nominal monthly wage and the negative impact of the unemployment rate and socially disadvantaged background onto the test results. In order to consider that the location does matter in the analysis of the educational performance and to capture the considerable spatial heterogeneity, the local spatial approach based on the GWR was used as well. Although the corresponding global and local parameter estimates have the same signs, there is a significant spatial variation in the analysed relationship. Furthermore, mapping of the local parameter estimates enables to provide a more detailed view of the modelled relationship in each district.

ACKNOWLEDGMENT

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Using a Mediation Test to Determine the Causes and Effects of Vietnamese City-Based Consumer Patriotism

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Abstract

This study developed the measurement model of consumer patriotism, proposed by Ngoc and Trong (2018), in the context of Vietnamese city-based consumers. In addition to testing the stability of the measurement model for consumer patriotism, the study focused on investigating the role of cause and effect in consumer patriotism, using the mediation test process of Frazier et al. (2004). The study was conducted in a consumer product context. A random sample of 300 households in Hanoi, the capital of Vietnam, was chosen for collecting data. The results show that patriotism is the cause of consumer patriotism, and consumer patriotism has positive effects on consumer ethnocentrism and consumer domestic product buying behavior. The study results can help improve the effectiveness of campaigns to promote consumption of domestic product.

Keywords

Consumer patriotism, consumer ethnocentrism, domestic consumption, mediation test

JEL code

Z13, F52, M00

INTRODUCTION

Marketers and policymakers of many countries have used people's affection to promote domestic consumption because it does not involve a tariff barrier, so it does not violate any trade agreement. In Singapore, for example, an incentive program for domestic consumption was introduced by the Singapore government in 1956 and is still actively promoting domestic consumption (2014).[2]

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Another example is the campaign "Vietnamese people give priority to using Vietnamese goods", which was first launched nationwide by the Vietnam Politburo in 2009. Therefore, researchers are very interested in investigating the emotional bias of consumers for domestic production. In Vietnam, there have been several studies that have focused on this topic: Le, Thi Nguyen and Van Nguyen (2013); Ngoc and Trong (2018); Nguyen, Nguyen and Barrett (2008). The most recent study discovered that patriotism was a factor affecting Vietnamese consumers' patriotism (Ngoc and Trong, 2018). These two authors redefined the construct of consumer patriotism and developed a measurement model of this construct in the context of a developing country (Vietnam). This measurement model of the construct consumer patriotism was successfully tested by Ngoc and Trong (2018) through two studies; the first used convenience sampling of consumers and the second used random sampling of consumers in Ho Chi Minh city, the most populous city in Vietnam. Ngoc and Trong (2018) also suggested that future studies should increase the practicality of the measurement model of consumer patriotism by adding buying behaviors so that practitioners could gain a better understanding of the role of consumer patriotism. Therefore, in the work presented here, the measurement model of the construct of consumer patriotism of Ngoc and Trong (2018) has been developed in the context of consumer domestic product buying behavior. The domestic product selected for this research was packets of cookies. The authors chose this product because it is a cheap fast-moving consumer good with low value, so it does not require consumers to engage in much consideration when buying it. Also, there is now no significant difference in quality, form, and price between domestic and foreign packets of cookies in the market in Vietnam. Consequently, this limits the effects of unwanted external factors in the consumer purchase decision process.

1 LITERATURE SURVEY

1.1 Consumer patriotism

All the studies of consumer patriotism (Han, 1988; MacGreg and Wilkinson, 2012; Ngoc and Trong, 2018; Tsai, 2010) have considered consumer patriotism as the belief of consumers that it is the duty of a patriot to buy domestic goods to protect the domestic economy and workers. A different scale of consumer patriotism was developed by Ngoc and Trong (2018). This alternative approach exploited the emotional aspect arising from the consumers' affection with their mother country and things related to that country.

A term closely related to consumer patriotism is "economic patriotism". Clift and Woll (2012a, p. 308) defined economic patriotism as "economic choices which seek to discriminate in favor of particular social groups, firms or sectors understood by the decision-makers as insiders because of their territorial status. Economic patriotism entails a form of economic partiality: a desire to shape market outcomes to privilege the position of certain actors". According to Clift and Woll (2012b), in each field, the actors who have privileges are diverse: they may be countries, domestic companies, workers, or domestic consumers. The makers of decisions about economic choices in this definition also vary; they may be consumers, producers, workers, politicians, or policy makers. When Clift and Woll (2012a) defined the construct of economic patriotism as an economic choice to favor certain groups chosen by the choice makers, they placed this construct within theory of social identity.

According to theory of social identity, people's self-image includes two parts: personal identity and social identity. Social identity is defined as "part of an individual's self-concept which derives from his knowledge of his membership of a social group (or groups) together with the emotional significance attached to that membership" (Tajfel, 1974, p. 69). The main point of theory of social identity is that in a society, individuals categorize themselves into groups, then these groups identify themselves through things associated with their own group identity, and which can be distinguished from other groups. The in-group people share the same views, and behaviors toward out-groups through an attitude of cooperation, conflict, prejudice or discrimination in a process called social comparison (Tajfel, 1982).

In a country setting, the mother country is the in-group of a person, while other countries represent out-groups (Shankarmahesh, 2006; Verlegh, 2007). This classification helps create a sense of attachment within the group but also leads to a contrast between the in-group and the out-group, which can lead to barriers and conflicts between the two groups.

This study used the main idea of the definition of consumer patriotism from the empirical studies of Han (1988); MacGregor and Wilkinson (2012); Ngoc and Trong (2018); Tsai (2010) and concretized the nature of social identity in the definition of economic patriotism proposed by Clift and Woll (2012a) to form the improved definition of consumer patriotism: *"consumer patriotism is the consumer biased choices made to support the domestic economy by buying domestic goods to help domestic businesses and workers, and the emotional reasons for that biased choices".*

1.2 Patriotism

Patriotism is often perceived as a love of one's country and devotion to it, but it can be taken in many forms (Schatz, Staub, Lavine, 1999). Patriotism is not only love but also an individual's concern about the country and a connection to their homeland and its symbols (Berns, 1997).

In theory of social identity, many researchers often use nationalism and patriotism interchangeably. However, these are two concepts that should be separated. Nationalism is people's awareness of national supremacy, a domineering national direction, and low appreciation of other countries. Patriotism refers to a positive feeling for one's own country (Kosterman and Feshbach, 1989).

1.3 Consumer ethnocentrism

Shimp and Sharma (1987) defined consumer ethnocentrism as a unique economic form of ethnocentrism that captures the beliefs of consumers about the appropriateness and morality of purchasing foreign products. Consumers having an ethnocentric attitude consider that the products produced in their own country are good and consider the purchasing of foreign products as wrong because they can adversely affect workers' jobs, restrain the development of domestic businesses, and endanger the economy.

1.4 The relationship of patriotism, consumer patriotism, and consumer ethnocentrism

In theory of social identity, the origin of both consumer ethnocentrism and patriotism arises from the attachment of individuals to their in-group, which in this case is their mother country (Zeugner-Roth et al., 2015). In terms of direction, patriotism is concerned with bias that favors the in-group, but consumer ethnocentrism is a bias against out-groups (Zeugner-Roth et al., 2015). A similar classification is also used for the construct of consumer patriotism. Consumer patriotism is the economically positive bias that is based on an individual's attachment to his/her in-group. Consumer patriotism is only directed toward the relationship with the in-group and not directed toward the out-group, as in consumer ethnocentrism.

From these ideas, the authors of current study would identify the potential relationships between the three constructs of patriotism, consumer patriotism, and consumer ethnocentrism. Although Ngoc and Trong (2018) demonstrated the existence of a causal relationship between these three factors, in the current work, theory of social identity was used for theoretical arguments about the relationship between these three constructs. This was necessary because Frazier et al. (2004) suggested that in the mediation effect test, the relationship between variables should be demonstrated on theoretical grounds.

1.4.1 The relationship within two pairs of constructs: patriotism/consumer ethnocentrism and patriotism/consumer patriotism

According to Johnson (1965), the national identity increases the common identity of the own national people as well as sense of belonging to of people which are in-group (the citizens of this country).

So, the national identity increases both positive bias with people in-group and negative bias with people out-groups (foreigners). In marketing literature, national identity has been discussed using the concept of patriotism (Kim, Yim, Ko, 2013, p. 77) because patriotism is one of the main sources of national identity (Petya and Marco, 2014). Therefore, it can be believed that patriotism is a strong predictor of xenophobic attitude in consumption which is represented by consumer ethnocentrism, and domestic economical bias which is represented by the consumer patriotism. A series of marketing studies related to the consumer ethnocentrism model has demonstrated the existence of a positive relationship between patriotism and consumer ethnocentrism (Auruskeviciene, Vianelli, Reardon, 2012; Dmitrovic, Vida, Reardon 2009; Erdoğan and Burucuoğlu, 2016; Fernández-Ferrín et al., 2015; Ishii, 2009; Ngoc and Trong, 2018; Pentz et al., 2017; Rybina, Reardon, Humphrey, 2010; Shankarmahesh, 2006). The positive relationship between patriotism and consumer patriotism also summarized by the work of Ngoc and Trong (2018) as follows: people who are more patriotic will be more biased towards domestic economic support.

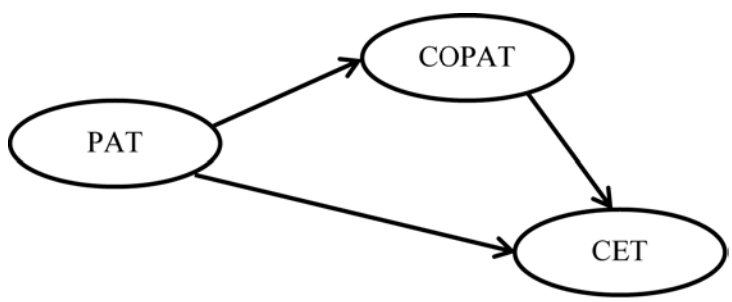
1.4.2 Relationship between consumer patriotism and consumer ethnocentrism

Consumer ethnocentrism is an out-group bias against foreign countries (Zeugner-Roth et al., 2015), but consumer patriotism is the individual's positive bias for his/her in-group. Therefore, there is potential for these two factors to be positively correlated. In their research on Vietnamese consumers, Ngoc and Trong (2018) demonstrated empirically that consumer patriotism increases the attitude of consumer ethnocentrism.

1.4.3 The simultaneous relationship of patriotism/consumer patriotism/consumer ethnocentrism

From the arguments above, the authors concluded about the relationship between patriotism (PAT), consumer patriotism (COPAT), and consumer ethnocentrism (CET) that if a person has stronger patriotism, he/she will develop more consumer patriotism, and as a result, his/her consumer ethnocentrism increases. His/her patriotism also directly increases his/her consumer ethnocentrism. These three factors (PAT/COPAT/CET) form a triangular model as shown in Figure 1. In this model, patriotism was the independent variable, consumer patriotism was the mediator variable and ethnocentrism was the dependent variable.

Figure 1 The triangular model of patriotism /consumer patriotism /consumer ethnocentrism



Source: Own formulation

1.5 Domestic consumption

Ngoc and Trong (2018) proposed that future studies should increase the practicality of the measurement model for consumer patriotism by establishing a research context with buying behavior for specific products. So, in this study, the authors have introduced the construct of domestic consumption (DC) into

the triangular model of the relationships between patriotism/consumer patriotism/consumer ethnocentrism. In this newly developed model, patriotism, consumer patriotism and consumer ethnocentrism are three factors that increase domestic consumption. The reason for establishing this relationship is explained as follows:

Domestic consumption is "conceptualized as activities that buyers perform to deliberately identify and select domestic products and brand" (Vida and Reardon, 2008, p. 36). Verlegh (2007) demonstrated that in the country setting, if the consumer had a high score for national identity, he/she was biased in assessing domestic products and willing to buy domestic products. This means the more patriotic consumers are, the more eager they are to consume domestic goods.

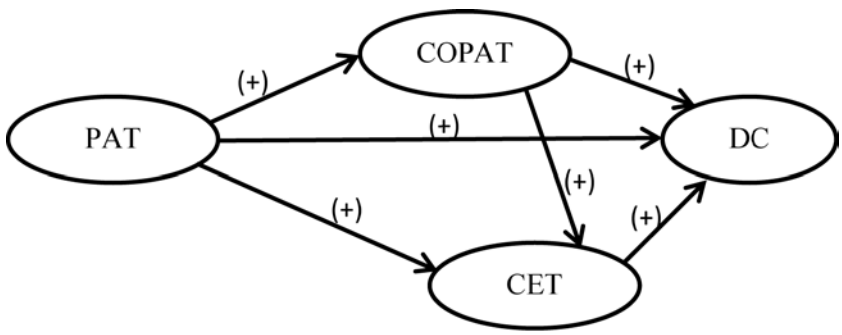
Ethnocentric consumers tend to have a higher appreciation of things that belong to their groups, and a lower appreciation of the things that do not belong to their groups. This leads to a biased evaluation of domestic products and increases their intention to purchase domestic products (Shimp and Sharma, 1987). This means that consumer ethnocentrism and domestic consumption have a positive relationship.

In terms of social identity theory, consumer patriotism increases a person's tendency to identify domestic people as members of their group, so they become sensitive to the suffering of workers who lose their jobs, or business owners that become bankrupt. This motivates them to protect these victims by consuming domestic goods (Tsai, 2010). Thus, in the current study, the relationship between consumer patriotism and domestic consumption was assumed to be positive.

1.6 Study framework and study hypotheses

Based on the arguments above, the conceptual framework shown in Figure 2 was formulated.

Figure 2 Conceptual framework



Source: Own formulation

If these relationships exist, this conceptual framework is a combination of four relationships of the type predictor/mediator/outcome variables. This leads to four hypotheses*:*

H_1: Consumer ethnocentrism plays a mediating role in the relationship between consumer patriotism and domestic consumption.

H_2: Consumer patriotism plays a mediating role in the relationship between patriotism and consumer ethnocentrism.

H_3: Consumer patriotism plays a mediating role in the relationship between patriotism and domestic consumption.

H_4: Consumer ethnocentrism plays a mediating role in the relationship between patriotism and domestic consumption.

2 METHODS

2.1 Measurement

In this study, there are four constructs need to be measured: patriotism, consumer patriotism, consumer ethnocentrism and domestic consumption. Measuring the first three constructs was based on the work of Ngoc and Trong (2018). Consumer patriotism and consumer ethnocentrism, each was measured with six statements, patriotism was measured with four statements. Domestic consumption was measured with four statement adapted from Vida and Reardon (2008). These statements were revised with results from a focus group with twelve researchers from the Southern Institute of Social Sciences of Vietnam. Five-point Likert-type scale was used and anchored from strongly disagree to strongly agree. Draft questionnaire was pretested with a convenience sample of 100 consumers. The draft questionnaire that passed this trial survey became the final questionnaire.

2.2 Sampling

Sampling unit is household. Two-stage sampling was utilized. The sample design used sampling frame from the Vietnam Population Change and Family Planning Survey 2017 of General Statistics Office of Vietnam. Firstly, the list of enumeration areas of the Vietnam Population Change and Family Planning Survey 2017 corresponding to urban districts of Hanoi city was used to randomly select enumeration areas. Secondly, the household list of each chosen enumeration area was used to randomly select a number of households. As a result, a list of 300 households were created. Households were approached for an interview in the evening or at weekends. If no one was at home, the household located next door, on the right, was invited to interview instead. At the end of the survey, 300 completed questionnaires were gathered. Seven questionnaire have more than 15% of the questions left blank. Hair et al. (2014) considered these situations as no answer cases, so these seven questionnaires were discarded leaving 293 complete responses.

2.3 Sample size

The authors used the empirical rule of Bollen (1989) for the relationship between sample size and model parameters. This rule states that the relationship of the sample size to the number of parameters must be at least a 5:1 ratio, when using a maximum likelihood estimation of the Structural equation model (SEM). In this study, the research model had 46 parameters (calculation of the parameters of the SEM model is shown in the Annex) and a sample size of 293 cases, giving a ratio of 6.3:1, which complied with the rule of Bollen (1989).

2.4 Statistical procedure for testing mediator effects

The authors used statistical test of the mediation effect to test the four research hypotheses. Acording to Frazier et al. (2004), the mediation test procedure includes four basic steps:

Step 1: Discussing the relation between causal and result factors. This relation has to be based on previous studies.

Step 2: Choosing mediator variable. The connection between the causal and mediation factor needs to be discussed at the conceptual level.

Step 3: Establishing causation. The mediator variable is assumed to be caused by the causal variable and to cause the result variable. Therefore, the conditions for establishing the causation chain need to be considered in the study design.

Step 4: Implementing mediator test. The null hypothesis of test is stated that the mediation factor does not have a mediation role. Mediational analyses can be performed with either multiple regression or structure equation models (SEM) because both methods have the same logic.

The first three steps of the mediation test procedure were discussed in section Literature review. The fourth step would be presented in next section Results. Wood et al. (2007) advised that when the mediation test is applied to complex models, such as models that include many mediation effects, multiple causal and result factors, or multiple relationships, SEM should be used if the sample size is large enough. Because the sample size for this study was satisfactory as in the above – mentioned sample size section, SEM (with the maximum likelihood estimation, bias corrected boostrap method) was utilized.

3 RESULTS

3.1 Sample profile

The sample comprised 31.1% men ($n_1 = 91$) and 68.9% women ($n_2 = 202$). A total of 58.7% ($n_1 = 172$) of respondents had undergraduate education, 19.5% ($n_2 = 57$) of respondents had graduate-level education or above, and 17.1% ($n_3 = 50$) of respondents had completed high school. The other respondents had a lower education level. A total of 19.1% of the sample ($n_1 = 56$) were 24 years of age or younger, nearly 53.2% ($n_2 = 156$) were aged from 25 to 40, and approximately 24.6% of respondents ($n_3 = 72$) were 41 or over. There were 9 missing values because the respondents refused to give their age.

3.2 Estimating the SEM to evaluate the measurement model and test the hypotheses

A number of researchers use Cronbach's Alpha coefficient and exploratory factor analysis (EFA) for the preliminary assessment of the measurement model of constructs before implementing the SEM. However, Kline (2005, pp. 204–205) argued that it is not entirely appropriate to implement an SEM based on the results of a prior EFA procedure because there is some evidence that the factor structures identified in EFA may become a poor fit when re-evaluated with the confirmatory factor analysis (CFA) procedure of SEM, with the same data.

Henson and Roberts (2006) proposed that when the researcher had a strong priori theory related to the data structure, CFA should be considered as an alternative solution to EFA. Therefore, the authors skipped EFA in this study. Cronbach's Alpha was calculated to consider whether or not to remove items that contributed poorly to the internal consistency of the four- measurement model of constructs. The value of Cronbach's Alpha ≥ 0.7 showed that all items used to measure the constructs were valid (Hair et al., 2010). In addition, Nunnally and Bernstein (1994) proposed that an item with an item-total correlation value > 0.3 can be retained in the scale because it contributes to the internal consistency of the scale. Based on these criteria, it can be seen in Table 1 that all the items that have been designed for each scale of the construct were satisfactory for SEM analysis. The SEM diagram of the research was shown in Figure 3.

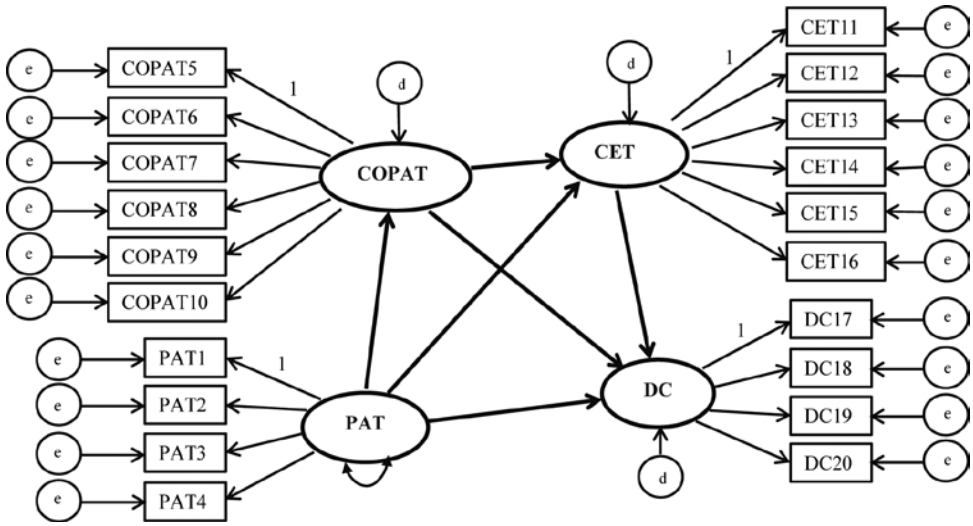
The analysis of SEM was conducted using the AMOS 20 software package. The results of this first analysis were used to evaluate the standardized factor loading of the CFA model. Kline (2011, p. 231) said that it is ideal if the researcher has standardized loading factor (FL) with values ≥ 0.7. Table 1 shows that only two indicators of the construct Consumer ethnocentrism had FL < 0.7 (0.642 and 0.615, respectively), but they both had very small p-values, indicating that they explained significantly the latent factor Consumer ethnocentrism. Consequently, the authors decided to maintain all the items of the consumer ethnocentrism scale to protect the content validity of the measurement model of consumer ethnocentrism.

Table 1 Item – total correlation, Cronbach's Alpha, factor loading and significance of items for constructs

Id	Factor	Content of item	Item – total correlation	Alpha if item deleted	Factor loading (FL)	*p-value*
1	Patriotism	Being a Vietnamese citizen means a lot to me	0.776	0.911	0.804	
2		I am proud to be a Vietnamese citizen	0.855	0.884	0.904	***
3		When a foreign person praises Vietnam, I feel like they praise me	0.813	0.899	0.857	***
4		I feel strong ties with Vietnam	0.830	0.894	0.879	***
		Cronbach's Alpha = 0.921; CR = 0.80; AVE = 0.74				
5	Consumer Patriotism	I buy Vietnamese goods to express the beauty of Vietnamese consumption	0.757	0.922	0.805	
6		I buy Vietnamese goods because I am Vietnamese	0.850	0.910	0.880	***
7		I feel ethnic pride every time I use Vietnamese goods	0.825	0.913	0.866	***
8		I will buy Vietnamese goods to express my patriotism	0.837	0.912	0.872	***
9		I buy Vietnamese goods to help domestic enterprises increase their competitiveness	0.800	0.916	0.822	***
10		I buy Vietnamese goods to contribute to creating jobs and generating income for the local labor	0.715	0.927	0.727	***
		Cronbach's Alpha = 0.930; CR = 0.86; AVE = 0.69				
11	Consumer ethnocentrism	Buying imported products causes Vietnamese people to lose their jobs	0.763	0.891	0.826	
12		Buying imported products helps foreign nations get rich	0.824	0.882	0.903	***
13		Buying imported products damages local businesses	0.828	0.881	0.897	***
14		Buying imported products is not a correct activity for the Vietnamese	0.781	0.888	0.807	***
15		We should buy imported products only when those products cannot be obtained within our country	0.659	0.905	0.642	***
16		True Vietnamese people should buy domestic products	0.637	0.909	0.615	***
		Cronbach's Alpha = 0.909; CR = 0.85; AVE = 0.62				
17	Domestic Consumption	Mostly I try to buy brands of domestic packets of cookies	0.719	0.803	0.797	
18		Whenever possible, I take time to look at labels in order to intentionally buy brands of domestic packets of cookies	0.674	0.821	0.766	***
19		I shop first at retail outlets that offer a variety of domestic packets of cookies	0.752	0.788	0.810	***
20		I shop first at retail outlets that offer many brands of domestic packets of cookies	0.634	0.838	0.706	***
		Cronbach's Alpha = 0.853; CR = 0.80; AVE = 0.59				

Note: *** p-value <0.001; AVE = Average Variance Extracted; CR = Composite Reliability.
Source: Own construction from surveyed data

Figure 3 The SEM diagram of the research



Source: Own construction

3.2.1 Testing the research hypotheses

Although values of indices indicated the goodness of fit of the SEM model (see Table 2), examining the statistical significance of the path coefficients in the model showed a p-value = 0.696 for the path between the PAT and DC (see Table 3). So, this path was removed, and the SEM was re-estimated. According to argument of Frazier et al. (2004), when the path coefficient between PAT and DC is unavailable, COPAT acts as a full mediator variable in the relationship PAT/COPAT/DC. Consequently, it was concluded for hypothesis H_3 that COPAT was a full mediator in the relationship between PAT and DC.

Table 2 The recommended and actual values of fit indices

	Fit indices	The first estimation	The second estimation	The third estimation (final)
1	χ^2_M/df_M	2.41	2.397	2.438
	The recommended value	χ^2_M/df_M <3 (Hair et al., 2010)		
	Conclusion	Satisfied	Satisfied	Satisfied
2	RMSEA	0.07	0.069	0.07
	The recommended value	0.06 ≤ RMSEA ≤ 0.07 (Hooper et al., 2008)		
	Conclusion	Satisfied	Satisfied	Satisfied
3	TLI	0.937	0.937	0.936
	CFI	0.945	0.946	0.944
	The recommended value	TLI and CFI > 0.9 (Hair et al., 2010)		
	Conclusion	Satisfied	Satisfied	Satisfied

Note: χ^2_M /df is the ratio between Chi-square and degrees of freedom; CFI = the Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; TLI =Tucker Lewis index.
Source: Own construction from surveyed data

Table 3 Path coefficients and their significance

Causal variable		Effect variable	The first estimation		The second estimation		The third estimation (final)	
			Path coefficients	*p-value*	Path coefficients	*p-value*	Path coefficients	*p-value*
PAT	→	COPAT	0.708	***	0.708	***	0.705	***
COPAT	→	CET	0.793	***	0.793	***	0.533	***
PAT	→	CET	–0.386	0.003	–0.386	0.003		
CET	→	DC	0.205	***	0.210	***	0.212	***
PAT	→	DC	–0.038	0.696				
COPAT	→	DC	0.363	***	0.335	***	0.333	***

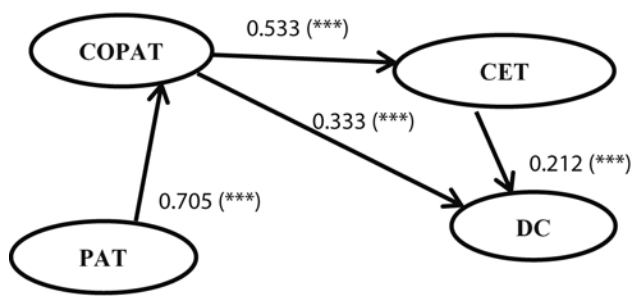
Note: *** p-value <0.001.
Source: Own construction

The second estimation showed that the SEM model met the goodness of fit criteria (see Table 2). The significance tests for the path coefficients showed that all the paths were significant (see Table 3). Although the path of PAT and CET was statistically significant, the coefficient was negative. This contrasted with the findings of the literature survey and the correlation coefficient between these two variables ($r = 0.116$, see Table 6), which all confirmed that this relationship was positive. Hair et al. (2014) stated that when the sign of the path coefficient between the predictor variable and the outcome variable is reversed it is the result of the "suppression effect". This situation shows the existence of a full mediator variable in the cause-effect relationship. Consequently, for hypothesis H_2, it was concluded that COPAT was a full mediator in the relationship between PAT and CET.

When COPAT was a full mediator variable between PAT and CET, it was necessary to remove the path from PAT to CET from the SEM model, even though this path was statistically significant. This was because trying to maintain the path between PAT and CET, based on the p-value of the significance test, resulted in the model suffering multicollinearity. Consequently, the path between PAT and CET was removed for the third implementation of the SEM model.

The indices of the goodness of fit of the model were shown in Table 2, and the significance test results of the path coefficients were shown in Table 3. This final SEM model had a good fit, and all the path coefficients were significant.

Figure 4 The relationship paths between constructs, with the values and statistical significances of the path coefficients on the arrows.



Note: *** p-value <0.001.
Source: Own construction

With regard to hypothesis H4, it can be seen (in Figure 4) that the paths between PAT and DC and between PAT and CET were unavailable. So, it was concluded that CET did not play a mediator role in the relationship between PAT and DC because there was no direct effect or indirect effect to allow the mediator variable to work. This meant that the H_4 hypothesis was rejected.

The validity of hypothesis H_1 was determined from the statistical evidence of direct and indirect mediation effects in the bias-corrected bootstrap method of SEM. Table 4 shows that both direct and indirect effects had 95% confidence intervals were different from zero, so it was concluded that CET was a partial mediator in the relationship between COPAT and DC.

Table 4 Testing the mediation effect of CET on the relationship between COPAT and DC, using the bias-corrected bootstrap method of SEM

95% confidence interval	Indirect effect		Direct effect	
	Value	Conclusion	Value	Conclusion
Lower	0.053	Different from 0	0.148	Different from 0
Upper	0.199		0.463	
Final conclusion	Mediator variable		Partial	

Source: Own construction

A summary of the conclusions about the four research hypotheses is shown in Table 5.

Table 5 Summary of the results of hypothesis tests

Id	Hypothesis	Paths	Supported or not	The role of the mediator variable
1	H_1	COPAT/CET/DC	Yes	Partial
2	H_2	PAT/COPAT/CET	Yes	Full
3	H_3	PAT/COPAT/ DC	Yes	Partial
4	H_4	PAT/CET/DC	No	

Source: Own construction

3.2.2 Evaluating the measurement model

Using the final estimation results from the SEM procedure, the measurement model of the research constructs was evaluated according to the following criteria.

3.2.2.1 Unidimensionality

The test for unidimensionality requires that each scale of the latent factor should consist of items loading highly on only this single factor (Hair et al., 2010). Because all the items showed proper FL values, it was concluded that the measurement model was unidimensional (see Table 1).

3.2.2.2 Reliability

Average Variance Extracted (AVE) values of all four constructs were > 0.5, and Composite Reliability (CR) values exceeded the 0.6 threshold (see Table 1). Therefore, it was concluded that the scales of the constructs PAT, COPAT, CET, and DC were reliable (Bagozzi and Yi, 1988).

3.2.2.3 Convergent validity

Hair et al. (2010) proposed that the condition for convergent validity of scales is FLs ≥ 0.5. It is assumed that a set of items having high reliability also has good convergent validity (Steenkamp and Van Trijp, 1991; Hair et al., 2010). Table 1 shows that there were no FLs < 0.5, so the authors concluded that all of the scales achieved good convergent validity.

3.2.2.4 Discriminant validity

Two criteria were used to assess the discriminant value of the scale: (1) all population correlation values among constructs were ≠ 1 (see Table 6); (2) the AVE of any construct was higher than the highest squared correlation between this construct and other constructs (see Table 7). As a result, the scales of the constructs met the discriminant validity criteria (Fornell and Larcker, 1981).

Table 6 Hypothesis test for the population correlation coefficient

Construct		Construct	Correlation coefficients	*p-value*
COPAT	↔	CET	0.379	0.000
COPAT	↔	PAT	0.672	0.000
COPAT	↔	DC	0.421	0.000
CET	↔	PAT	0.116	0.000
CET	↔	DC	0.401	0.000
PAT	↔	DC	0.226	0.000

Source: Own construction

Table 7 The AVEs (shown on the diagonal) and squared correlation coefficients between constructs

	COPAT	CET	PAT	DC
COPAT	0.690	0.144	0.452	0.177
CET		0.620	0.013	0.161
PAT			0.740	0.051
DC				0.590

Source: Own calculation

3.2.2.5 Monological validity

Steenkamp and Van Trijp (1991, p. 294) noted that the monological validity of the measurement model of a construct is assessed by verifying the relationship between a construct and other constructs in the theoretical system that is being studied. In our study, the relationship between constructs (see Figure 4) can be explained as follows: patriotism increasing consumer patriotism, and when the consumer patriotism was active it led to two positive results. The first was increasing consumer ethnocentrism, and the second was encouraging domestic consumption behavior. Consumer patriotism affected consumer ethnocentrism directly, but it affected domestic consumption behavior through two paths: the first is the direct path, the second is the indirect path through the mediator factor of consumer ethnocentrism.

4 DISCUSSION

The most important finding of this work is that Vietnamese patriotism does not automatically lead to consumer ethnocentrism and domestic consumption, but its effect takes place through the mediator of consumer patriotism. This explained why marketing campaigns in Vietnam which use slogans with a general content saying that buying domestic goods is patriotic action have been ineffective for a long time. Instead, there should be slogans emphasizing the responsibility of Vietnamese patriots to protect domestic production, keep jobs for Vietnamese workers and support domestic businesses. The marketing campaigns also need to be cleverly designed to evoke not only Vietnamese consumer patriotism but also to help people realize the wrongdoing of buying imported goods. By recognizing this, Vietnamese consumers will be more eager to engage in domestic consumption. It can be said that this research finding can help increase the effectiveness of campaign "Vietnamese people give priority to using Vietnamese goods".

CONCLUSION

This study provided evidence for the stability of the measurement model of consumer patriotism when the measurement model was developed in another city of Vietnam. This study also confirmed that consumer patriotism was a positively correlated outcome of patriotism (Ngoc and Trong, 2018). The relationship between these two factors is quite strong ($r = 0.672$, see Table 6), so further studies of the emotional bias of consumers including patriotism and consumer patriotism in the model as two predictive variables should be cautious about the multicollinearity phenomenon. The study also confirmed that consumer patriotism results in consumer ethnocentrism (Ngoc and Trong, 2018). A new point, compared with the work of Ngoc and Trong (2018), is that the domestic consumption of Vietnamese consumers was confirmed as a result of consumer patriotism. Consumer patriotism had both direct and indirect effects on domestic consumption. The direct effect is stronger than indirect effect (values of path coefficients 0.333 versus $0.533 \times 0.212 = 0.113$, see Figure 4). This study was carried out in the context of packets of cookies, which are a type of fast-moving consumer good with a low value so that consumers can buy these goods more from emotion than from cognition. Therefore, the results of this study need to be developed further in the context of long-term consumer goods and high-value goods to generalize the relationship rule. These future researchers should include in their model the cognitive variables that can influence domestic consumption such as assessment of the quality of domestic goods and the perceived value of foreign goods.

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Annex

Table A1 Calculation of the number of parameters for the SEM model in Figure 2

Id	Name	Subtotal
1	Variances of measurement errors	23
2	Variances of exogenous factors	1
3	Factor loadings	16
4	Path coefficients	6
Total		46

Source: Own calculation based on the SEM diagram of the research

Does Changes in Characteristics of a Fixed Exchange Rate Regime Impact Conditional Volatility? Evidence from the Case of Morocco

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Abstract

This article aims to exhibit and study the impacts that changing characteristics of a fixed exchange rate regime has on conditional volatility. To do so, using the U.S. dollar dirham (USDMAD) daily closing rates over 23 years, we compare the GARCH model results of four segmented sub-periods to each other and then to the global period of the study to detect disparities. The main result is that changes in exchange rate regime characteristics do impact the conditional volatility. Therefore, we recommend that the study of conditional volatility should use periods with no changes in the characteristics of the exchange rate regime to avoid bias. Otherwise, the use of segmented sub-periods should be adopted to take account of these changes. Finally, we present some key results about the impacts of these changes in Morocco's exchange rate regime on the conditional volatility.

Keywords

Exchange rate, conditional volatility, fluctuation bands

JEL code

F31, C58

INTRODUCTION

The volatility analysis of emerging countries' currencies has gained interest in the work of academics lately due to its importance in the domestic economic growth, the competitiveness, and the attraction of foreign investments for these countries. Most of these studies include a panel involving several countries and uses a continuous time series without taking into account changes in the exchange rate regime as they

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considered that the global fixed exchange regime did not change. However, we have reasons to believe that this methodology may be biased because it doesn't take into account the impact of changes in exchange rate regime parameters such as peg compositions and the size of fluctuation bands.

To address this problem, we will study the impact of these changes in the exchange rate regime on conditional volatility using the case of Morocco's fixed exchange rate regime. Morocco is the third biggest partner of the European Union in Africa[3] and one of the most essential non-oil countries in the MENA region. Its close location to Europe, its climate, and its affordable workforce made him an important hub of offshoring services and industries since the early '90s. Due to its growing importance in the MENA and the Mediterranean region, many researchers have conducted studies about the conditional volatility of Moroccan dirham (MAD) to assess its impact on trade and growth. However, all of them used a continuous-time series ignoring the fact that the country has undergone structural changes in its exchange rate regime over the years. This behavior makes the use of its case suitable for our study.

Our article will start with a literature review in Section 1 that will be followed by a presentation of the data used and the theoretical framework in Section 2. We will then give in Section 3 a brief presentation of the Moroccan's exchange rate regime and the evolutions that it undergoes. After that, we will present our empirical findings in Section 4 before ending with conclusion and some recommendations in the last section.

1 LITERATURE REVIEW

Since the early '90s, studies based on the works of Engle (1982), and Bollerslev (1986) start to be more and more present in the literature, most of them focusing on conditional volatility of economic aggregates such as inflation, trade flows or foreign exchange rates. The data used in these studies is usually continued and contains a significant number of observations to ensure the convergence and the positivity constraint of GARCH models (Hwang and Pereira, 2006).

In the case of exchange rates, the majority of the literature confirms the critical relationship between the exchange rate regime and exchange rate volatility. We cite as an example of studies demonstrating this relationship the works of Baxter and Stockman (1989), Aizenman (1992), Flood and Rose (1995), Hasan and Wallace (1996), Bayoumi and Eichengreen (1998), Bleaney and Fielding (2002), Levy-Yeyati and Sturzenegger (2005), Schnabl (2008), Katusiime, Agbola, Shamsuddin (2015), Alagidede and Ibrahim (2016), Calderon and Kubota (2017), and Phiri (2018). Therefore, the study on conditional volatility over a period containing different exchange rate regimes may have introduced biased results and failed to capture the volatility patterns.

As an example, one of the rare studies using a fragmented period accordingly with changes in exchange rate regime is the one of Rose (1996), the main results are that the widening of EMS's[4] fluctuation bands in 1993 resulted in a higher exchange rate volatility. Meanwhile, if we look at studies like Kearney and Patton (2000), which use data from 1979 to 1997, we find that it failed to capture the impact of this change on the conditional volatility and its transmission between the EMS's major currencies. Another example of studies using fragmented periods is Kocenda and Valachy (2006), who studied the transition from fixed to floating exchange rate regimes in the Visegrad countries. Their main results were that the switch to a floating regime tends to increase conditional volatility and that the width of fluctuation bands has a direct impact on exchange rate volatility.

That said, these articles only fragmented the periods of study into a fixed regime period and a floating one. Meanwhile, the fixed exchange rate period of Visegrad countries in the study of Kocenda and Valachy

[3] Source: European Commission, Eurostat (Comext, statistical regime 4).
[4] European Monetary System.

(2006) had also many changes in peg composition and into the size of fluctuation bands. However, the impacts of these changes remain unknown as the authors choose to consider the fixed regime period as one uniform continuous period. As of 2019, IMF (2019) finds that 66.6% of the world countries are still using a de facto fixed exchange rate regime, which makes these changes even more important as it's affecting the majority of the world's countries.

Thus, the original contribution of this article will be to exhibit and study the impacts of these changes on conditional volatility. To achieve our goal, we will use the case of Morocco, which is a country whose regime undergoes many changes since its independence. However, the central studies working on this country's conditional volatility, presented in Table 1, uses continuous times series, which make it a perfect benchmark for our study.

Table 1 Main studies using GARCH models to analyze Moroccan exchange rate volatility

	DATA Range	Country of study	Methods used
Rey (2006)	Quarterly data from 1970–2002	Algeria, Egypt, Tunisia, Israel, Morocco, and Turkey	GARCH, I-GARCH
Selmia, Bouoiyour, Ayachi (2012)	Quarterly data from 1972–2010	Morocco and Tunisia	GARCH, E-GARCH, T-GARCH, TS-GARJI, GJR-GARCH, GARCHK, P-GARCH
Abdalla (2012)	Daily data from 2000–2011	United Arab Emirates, Bahrain, Djibouti, Algeria, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Qatar, Saudi Arabia, Somali Syria, Tunisia, and Yemen	GARCH, EGARCH
Bouoiyour and Selmi (2014)	Quarterly data from 1996–2009	Morocco and Tunisia	GARCH, N-GARCH, T-GARCH, E-GARCH, GARCH-M
Abed, Amor, Nouira, Rault (2016)	Daily data from 2001–2015	Tunisia, Morocco, Egypt, Jordan, United Arab Emirate, Qatar and Saudi Arabia	GARCH, GJR-GARCH
Azzouzi and Bousselhami (2019)	Annual data from 1990–2017	Morocco and Turkey	GARCH-M, ARDL
Bahmani-Oskooee and Arize (2019)	Quarterly data from 1973–2015	Algeria, Cameroon, Ethiopia, Ghana, Kenya, Mauritius, Morocco, Nigeria, South Africa, Tanzania, Tunisia, Uganda, Zambia	GARCH-based Model

Source: Own construction

2 DATA AND METHODOLOGY

2.1 Data

Our first step was to choose a data set containing periods with a high number of observations to ensure both the convergence of the GRACH model and the integrity of our study. We chose to use the daily USDMAD official closing rates from June 3, 1996, to August 30, 2019, available on the website of the Central Bank of Morocco (Bank Al-Maghrib – BKAM).[5]

[5] *<http://www.bkam.ma/Marches/Principaux-indicateurs/Marche-des-changes/Cours-de-change/Cours-de-reference>.*

Table 2 Summary statistics of USDMAD rates and yields

	USDMAD Rates	USDMAD Yields
Mean	9.20715	6.93E-06
Median	9.16045	0.0
Maximum	12.0616	0.021079
Minimum	7.2088	–0.02157
Std. Dev.	0.967046	0.00211
Skewness	0.532087	–0.10255
Kurtosis	3.011696	9.255492
Jarque-Bera	284.9911	9 855.336
Probability	0.0	0.0
Sum	55 601.98	0.041852
Sum Sq. Dev.	5 646.604	0.02687
Observations	6 038.0	6 038.0

Source: Own construction

Table 2 shows that the USDMAD rates and yields are leptokurtic, which means the presence of more massive tails in the distribution. Regarding symmetry, the USDMAD yields are relatively symmetric, while the USDMAD rates are positively skewed, which means rates are more likely to be above average than below.

Figure 1 USDMAD official closing rates (Bank Al Maghrib)

Source: Own construction

The plotted series of USDMAD closing rates in Figure 1 shows the presence of volatility clusters over most of the studied period, which makes it a good fit for a GARCH's volatility model.

The second step was to determine the right segmentation of our time series to capture all the changes in the exchange rate regime. The segmentation selected is presented below with the main events delimiting its start and end:

- **Period 1**: this period starts from the opening of the Moroccan foreign exchange market in June 1996 and ends the day before the change of the basket composition on April 25th, 2001;
- **Period 2:** this period starts from the change in basket composition on April 25th, 2001, and ends in the day preceding the change in the basket weights on April 13th, 2015;
- **Period 3:** this period starts from the change of basket weights on April 13th, 2015, and ends the day before the widening of fluctuation bands on January 12th, 2018;
- **Period 4:** this period starts from the widening of fluctuation bands on January 15th, 2018, to August 30th, 2019.

In order the use GARCH models, the stationarity condition is required. To determine the stationarity of our data over every period, we will use the Augmented Dickey-Fuller test (ADF). We list the results of this test over all the study periods in Table 3.

Table 3 Results of Augmented Dickey-Fuller test of USDMAD closing rates in level and first difference

		Level data	1st difference	Stationarity
The global period 06/04/96–08/30/19	ADF test result	–1.661224	–83.66349	I(1)
	P-value	0.4511	0.0001	
1st period 06/04/96–04/24/01	ADF test result	–0.995442	–43.70107	I(1)
	P-value	0.7568	0.0001	
2nd period 04/25/01–04/10/15	ADF test result	–1.791138	–62.48813	I(1)
	P-value	0.3853	0.0001	
3rd period 04/13/15–01/12/18	ADF test result	–1.887809	–26.94473	I(1)
	P-value	0.3382	0.0000	
4th period 01/15/18–08/30/19	ADF test result	–1.763837	–19.23175	I(1)
	P-value	0.3983	0.0000	

Source: Own construction

The stationarity is present in the first difference. Therefore, we will use the USDMAD yields which we define as:

$$Y_t = R_t - R_{t-1}\,, \tag{1}$$

where: R_t is the USDMAD exchange rate of the date t.

2.2 ARCH and GARCH

Engle (1982) introduced as part of its analysis of the inflation variance in the United Kingdom, the heteroskedastic ARCH model (Autoregressive conditional heteroskedasticity), this model shows a conditional variance dependent on past observations. We formulate the ARCH model of order q in the following form:

$$r_t = \mu + y_t \; et \; y_t = \varepsilon_t \cdot \sigma_t ,$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, y_{t-i}^2 , \; \alpha_0 > 0 \text{ and } \alpha_i > 0 \text{ for evry } i \in \{1, \ldots, q\}, \tag{2}$$
$$y_t | \psi_{t-1} \sim N(0, \sigma_t^2),$$

where: y_t – the error terms of the mean equation,
r_t – logarithmic yields at the moment t,
μ – an average of the logarithmic yield,
ε_t – Gaussian process i.i.d such that $\varepsilon_t \sim N(0,1)$ (White noise),
σ_t – the volatility of the asset,
ψ_{t-1} – information available at t–1,
α_0 – can be considered as the minimum volatility since it is always strictly positive, the other parameters α_i represent shocks from prior periods.

Although the ARCH model is easy to estimate, it remains minimal due to the difficulties of determining the q order and the non-negativity constraint of the parameters. To address this problem Bollerslev (1986) introduces GARCH (Generalized Autoregressive conditional heteroskedasticity), which adopts a generalization similar to the extension of a model A.R. (p) to an ARMA (p, q). Conditional volatility materializes in the GARCH model materializes as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i y_{t-i}^2 + \sum_{j=1}^{p} \beta_i \sigma_{t-j}^2 , \tag{3}$$

p and q are positive integers, $\alpha_0 > 0$,

$$\alpha_i \geq 0 \; \forall \; i \in \{1, \ldots, q\}, \quad \beta_j \geq 0 \; \forall \; i \in \{1, \ldots, p\}.$$

This model is widely used in the study of the financial series because it incorporates the impact of past volatility through the autoregressive term. β_i.

3 MOROCCAN EXCHANGE RATE REGIME TIMELINE

Since independence in 1956, Morocco has adopted a fixed exchange rate regime with a hard peg to the French franc (FFR). After the collapse of Bretton Woods in the early '70s, Morocco switched its peg to a basket of currencies containing major world currencies. In 1996, the Moroccan authorities created a local foreign exchange market where banks are the main actors and where the capital movements are very restricted and controlled. Since 1997, the dollar raised sharply due to the Asian and Russian crisis, which pushed the Moroccan authorities in 2001 to operate a 5% devaluation of the local currency to preserve the country's competitiveness. This devaluation was materialized by a change in the composition of the peg basket to contain exclusively 80% EUR and 20% USD, dropping out significant currencies such as JPY and GBP. After the economic crisis in 2008, the U.S. and Europe experienced a contrasted recovery, which impacted the EURUSD exchange rate and, therefore, the USDMAD. In 2014, the dollar raised 23% again dirham in one year, urging the Moroccan authorities to change the weights of currencies composing the basket on April 13th, 2015. Since 2017, the Moroccan central bank (Bank Al-Maghrib) has communication about its intention of making the exchange rate regime more flexible. On January 15th, 2018, Morocco switched to the new exchange rate regime with fluctuation bands eight times larger moving them from ±0.3% to ±2.5%.

Table 4 Results of GARCH modelling of USDMAD yield over all periods

	1st period 06/04/96–04/24/01	2nd period 04/25/01–04/10/15	3rd period 04/13/15–01/12/18	4th period 01/15/18–08/30/19
$\alpha_0 10^6$	0.343303	0.018037	0.004508	0.029610
	0.1215	0.0560	0.6060	0.2802
α_1	0.081756	0.033899	0.012065	0.028068
	0.0173	0.00000	0.0464	0.0748
β_1	0.846255	0.962413	0.984976	0.949713
	0.00000	0.00000	0.00000	0.0000
$\alpha_1 + \beta_1$	0.92801	0.99631	0.99704	0.97778
Log-likelihood	6063.14	17318.9	3654.22	2134.85
Unconditional variance	4.76884	4.89041	1.52345	1.33269

Source: Own construction

Table 5 Results of USDMAD GARCH modelling in the literature and the global period of our study

	Rey (2006)	Selmia, Bouoiyour, Ayachi (2012)	Abdalla (2012)	Bouoiyour and Selmi (2014)	Abed, Amor, Nouira, & Rault (2016)	Azzouzi and Bousselhami (2019)	Bahmani-Oskooee and Arize (2019)	Our global period
$\alpha_0 10^6$	0.0002	0.00118	0.002149	0.00305	0.0074	0.00	0.004	**0.018133**
α_1	0.3540	0.0406	0.039420	0.01100	0.0494	–0.19	–0.05	**0.038852**
β_1	0.4378	0.4316	0.959707	0.98000	0.9034	0.86	1.03	**0.957930**
$\alpha_1 + \beta_1$	0.7918	0.4722	0.999127	0.99100	0.9528	0.67	0.98	**0.99678**
Log-likelihood	Quarterly data from 1970–2002	Quarterly data from 1972–2010	Daily data from 2000–2011	Quarterly data from 1996–2009	Daily data from 2001–2015	Annual data from 1990–2017	Quarterly data from 1973–2015	**Daily data from 1996–2019**

Source: Own construction

4 EMPIRICAL FINDING

The results of the GARCH model presented in Table 4 show a big difference in the GARCH model results for all the sub-periods. We believe these differences are due to the changes operated on the exchange rate regime in Morocco. To verify this supposition, we compute the GARCH model for the global period from 1996 to 2019 and present its results in Table 5 alongside with the ones of the studies presented earlier in the literature review as they are using GARCH model too in the case of Morocco.

By comparing the different results, we observe a vital contrast in GARCH parameters between the different studies. As an example, Trey (2006), and Selmia, Bouoiyour, Ayachi (2012) share 30 years of same frequency data but still have a very different parameters. The disparity is even bigger as we compare the results of Bahmani-Oskooee and Arize (2019), and Selmia, Bouoiyour, Ayachi (2012), all GARCH model results are contrasted even though they share the same frequency and more than 88% of the data set (37 years of data in stock). We observe the same phenomenon when we compare the results of Abdalla (2012), and Abed, Amor, Nouira, Rault (2016), who share more than 78% of their global data. These findings confirm our earlier supposition about the impacts of changes in characteristics of the exchange rate regime on the conditional volatility. Therefore, the study periods shouldn't be considered as continuous and should be segmented in sub-periods containing the same regime characteristics.

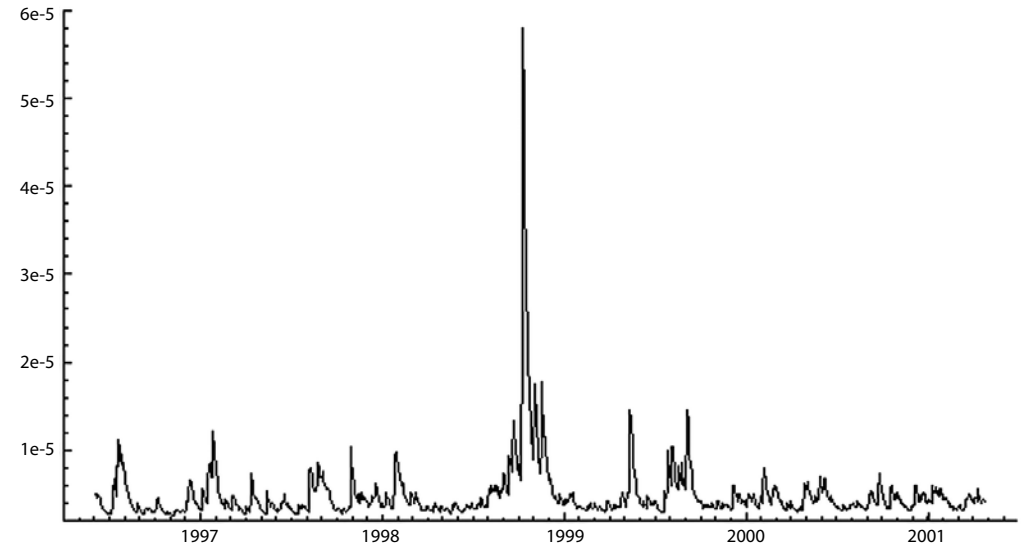
To test this assumption more in detail, we compare the results of our four sub-periods, presented in the DATA section, with the ones of our global period. We observe an important difference between the parameters of the global period and three of the sub-periods. Also, we notice that the 2nd sub-period, which is the largest among sub-periods, have approximately the same results as the global period. These observations confirm our assumption about the necessity of period fragmentation to avoid bias and capture the dynamics triggered by changes in the exchange rate regime's characteristics. To present examples of these dynamics, we will analyze the impact of these changes in the case of Morocco and show their importance in assessing the development of conditional volatility.

Going back to Table 4, we discern that the 1st sub-period is characterized by high minimal volatility due to the presence of major crises such as the Asian crisis and the internet bubble, which are identifiable in Figure 2 by their spikes. The minimal volatility tends to decrease after the devaluation of 2001 even though we observe some significant spikes in conditional volatility in Figure 3 linked primary to the financial crisis of 2009 and the Eurozone debt crisis in 2011–2012. We also observe that the impact of past volatilities, initially low in the first period, increase gradually after the change in peg composition. This change in is mainly caused by the peg composition as the presence of many interconnected major currencies offset the volatility effect.

On the other hand, a peg composed exclusively of EUR and USD is directly impacted by the EURUSD volatility as it's the case after 2001. However, this impact decreases significantly after the widening of fluctuation bands in 2018, as we can see in Figure 5. This decrease is caused by the domestic market, which becomes more active and got more leeway to face and absorb high volatility on the EURUSD parity. This last finding doesn't corroborate the results of Baxter and Stockman (1989), who consider that volatility is more important in a flexible regime than in a fixed one. It also contradicts the results of Rose (1996), and Kocenda and Valachy (2006), who suggests that more full fluctuation bands promote the volatility. We believe that the difference in capital movement policy may have a significant role in explaining these contradicted results. As a matter of fact, Edwards and Rigobon (2009) found in their study that strict control of capital movement, like the one in Morocco, could offset the external shocks and lower volatility.

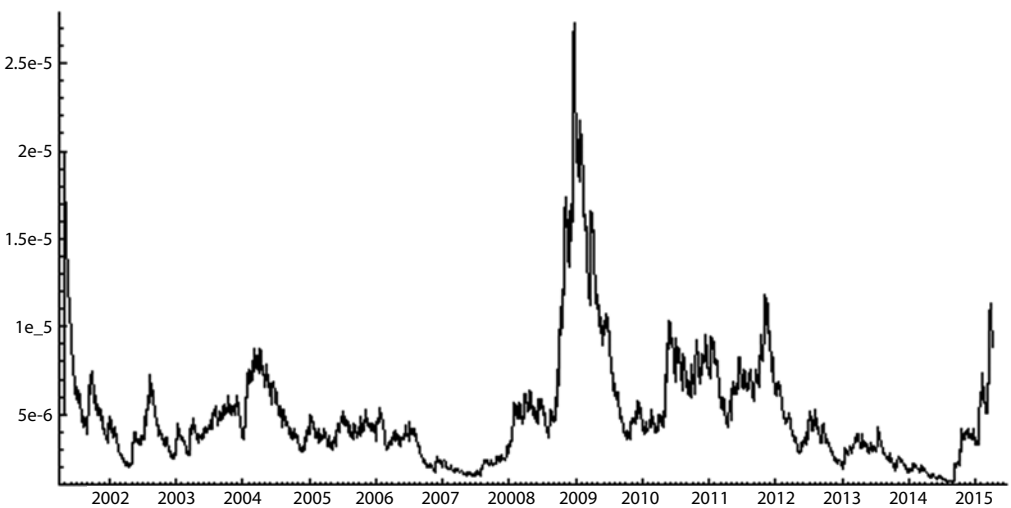
Our last observation is that the plot of conditional volatility in a global period makes it very hard to spot the spikes in periods with different degrees of volatility. As an example, the spikes in the first two sub-periods are easy to detect as they are corresponding to the global crisis in the financial market. However, it's a lot more challenging to spot the spikes of the 4th sub-periods in the global graph presented in Figure 6 as the volatility drops significantly. Presenting a segmented plot for every sub-period allows us to detect more efficiently the small crisis and, more importantly, the endogenous crisis as it's the case for this last sub-period.

Figure 2 Conditional volatility of USDMAD yields of the 1st period



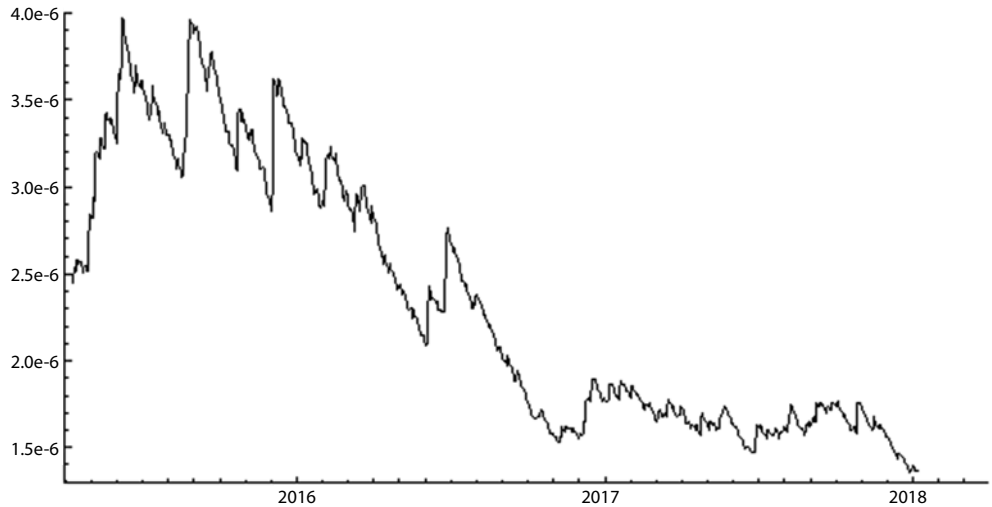
Source: Own construction

Figure 3 Conditional volatility of USDMAD yields of the 2nd period



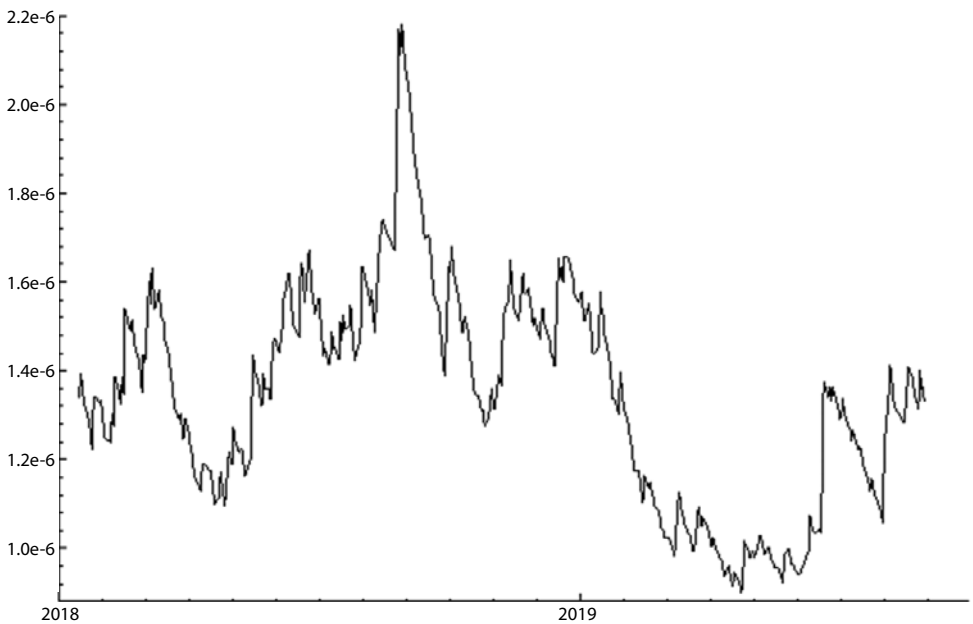
Source: Own construction

Figure 4 Conditional volatility of USDMAD yields of the 3rd period



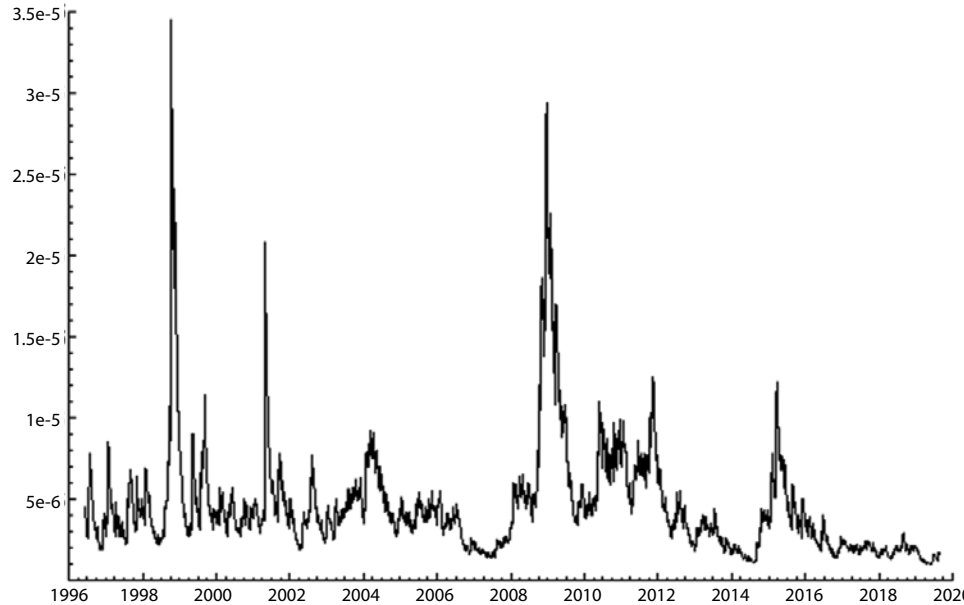
Source: Own construction

Figure 5 Conditional volatility of USDMAD yields of the 4th period



Source: Own construction

Figure 6 Conditional volatility of USDMAD yields of the global period



Source: Own construction

CONCLUSION AND RECOMMENDATIONS

In this study, we exploited the case of Morocco to exhibit and study the impacts of changes in the fixed exchange rate regime on conditional volatility. To achieve our goal, we proceeded to two-step analysis. In the first one, we compared the GARCH model results of the different articles presented in our literature review. This first step allowed us to exhibit significant dissimilarities between all the studies, even though most of them share essential common periods. The second step was meant to confirm the first finding and expose some of the benefits of using segmented sub-periods in conditional volatility study. To do so, we segment our time series of USDMAD yields into four sub-periods accordingly with the changes made in the exchange rate regime of the country. We then compared the GARCH model results of the four sub-periods to each other and then to the ones of the global period. This comparison yielded two majors results: the first one is a confirmation of our first finding concerning the significant difference between subperiods results and global ones. The second was that the changes in exchange rate characteristics have a significant effect on the evolution of conditional volatility. Therefore, to capture efficiently the dynamics caused by theses change, the period of study should be fragmented into sub-periods accordingly with the dates of the different changes in the fixed exchange rate regime.

Even though it wasn't the primary goal of our study, we come to some impressive results about the impacts of peg composition and the size of the fluctuation band on conditional volatility. We mainly found that a peg containing many major currencies amplifies the volatility but offset the impact of past volatilities. On the contrary, a peg composed exclusively of two currencies reduces the volatility but increases the impact of the past volatilities massively. The last results were that the widening of fluctuation bands reduced the volatility which contradicted the finding of Baxter and Stockman (1989), Rose (1996), and Kocenda and Valachy (2006). We attributed this contradiction to the difference in capital movement policies between the countries of the different studies, which is corroborated by the finding of Edwards and Rigobon (2009).

Based on our results, we strongly recommend that conditional volatility studies be made on periods with no changes in the exchange regime characteristics even though it is a fixed one. This segmentation will allow the researchers to avoid biased results and have a more detailed view of conditional volatility evolution. We also recommend, in the light of the results obtained, that further studies analyze the impact of peg compositions and the size of fluctuation bands to assess the exact effect of these characteristics on conditional volatilities. Finally, we believe that the use of structural breaks analysis as presented by Kocenda (2005), and the Markov Switching Model as used by Frömmel (2006), in the periods' fragmentation process can be an exciting extension of our study.

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A Territorial Model for Centralised Data Collection Implementation

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Abstract

The Italian National Statistical Institute (ISTAT) carries out the survey on the maritime transport of goods and passengers, as required by the Regulation (EU) No. 1090/2010 of the European Parliament and of the Council. The survey is a census as it refers to the final overall amount of the arrivals and departures recorded in Italian ports.

In order to improve the quality of data collection, within the new ISTAT organizational structure, introduced during 2016, the Central Directorate for data collection was created, specifically dedicated to the design, organization, implementation and integration of the data collection activities.

Then a specific project assigned to a selected number of ISTAT territorial offices the new role of conducting data collection activities on the territory.

The analysis is aimed at presenting the improvements both in terms of process efficiency and quality of the results expected from the new data collection approach.[4]

Keywords

Data collection, maritime transport, process efficiency

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INTRODUCTION

During 2016 the Italian National Statistical Institute (ISTAT) launched a wide modernization programme whose main objective was to increase the supply and the quality of the information produced by improving the effectiveness and efficiency of the statistical processes. The new organizational set-up was based on centralization of all the support services, which were clearly separated from statistical production processes, in order to increase overall effectiveness and efficiency. The new set-up introduced a Directorate dedicated specifically to the design, organization, implementation and integration of the data

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collection (DC) activities, called Central Directorate for data collection. The introduction of a specialist Data Collection, led also to the redesign of many of the management procedures adopted according to the Generic Statistical Business Process Model, already adopted with success by other statistical institutes. As the Central Directorate for data collection also the ISTAT's Territorial offices (UUTT) were located in the new *Department for data collection and development of methods and technologies for the production and dissemination of statistical information*, so establishing the foundations for closer cooperation. Then a specific project assigned to a selected number of these territorial offices the new role of conducting data collection activities on the territory.

The new organizational structure provides the following 8 offices located on the Italian national territory: – Piemonte, Valle D'Aosta and Liguria RMB; – Lombardia RMC; – Veneto and Friuli Venezia Giulia RMD; – Emilia Romagna, Toscana and Umbria RME; – Marche, Abruzzo and Puglia RMF; – Lazio, Molise and Calabria RMG; – Campania and Basilicata RMH; – Sicilia and Sardegna RMI. Each territorial office may include one or more regional offices.

In this framework, the new model introduces a more integrated management of the data collection process of the Survey on maritime transport conducted in Italy. It lays the foundations for a more complete review of the collection process, to be implemented in the next years, which involves the methods for preparing survey lists, the introduction of more efficient data acquisition and monitoring systems, the use of administrative sources that can reduce the weight of the direct survey. The solution outlined in this document is a first step in this direction.

1 THE ROLE ASSUMED BY THE TERRITORIAL OFFICES IN THE NEW ORGANIZATIONAL SETUP

In the above mentioned framework Istat started a new project that assigned to territorial offices a central role, in carrying out several cross-cutting data collection activities on the territory. In particular, ISTAT territorial offices were entrusted with several tasks typical of centralized Data Collection offices: checking and updating the lists of companies involved in the surveys, carrying out and monitoring data collection on the territory, providing support and assistance to users. The new model assigns a specific role to one leader territorial office that carries out a coordination of the data collection activities for all the offices in the territory. The same lead office also maintains relations with the structure dedicated to managing the implementation of data collection at central level (Division conducting data collection from direct surveys). The selection of the lead office is based on the experience accumulated in the specific subject area investigated. So, for the first time in Italy the activity of the Territorial offices in the field of data collection was not limited to the territory under its jurisdiction but is extended nationwide. During the start-up phase, the new management project for data collection on the territory is limited to a small number of activities: survey on Maritime transport, survey of Road accidents, Demographic statistics. At the conclusion of this opening phase, it is planned to extend it to other thematic sectors such as structural business statistics, tourism, environmental statistics.

In order to describe the new role of UUTT during the data collection phase, the case study of the Territorial Office for Marche, Abruzzo and Puglia (RMF) will be presented in the next paragraph. Starting from the survey edition 2018, it co-ordinates the activities of data collection on Maritime Transport statistics, in collaboration with the ISTAT Division for the implementation of data collection from direct surveys in the Central Directorate for Data Collection. During the start-up phase of the project, all the data collection activities taken over by the central structure were transferred to the territorial office through videoconferences and face-to-face meetings held at the headquarters in Rome. In particular, the transfer concerned the use of the tools applied for data capturing (named "Tramar"), for monitoring the DC, for the management of reminders, for assistance and support to respondents. Then, they were entrusted with the main activities typical of the centralized data collection such as the task of updating the lists of respondents, carrying out and monitoring data collection on the territory, providing technical support

for the correct filling out of the survey questionnaires, ensuring the consistency of the data acquired. In fact, the Territorial offices also carry out an activity of first level checking the information reported in the ISTAT Tramar questionnaires, filled out by the Maritime Agents, Forwarders, Recipients.

As it is foreseen, for the purpose of the survey, reminders for the transmission of monthly data will be sent periodically to respondents who will be contacted by relevant Istat Territorial Offices in order to collect updated contact information (i.e, phone and/or email addresses). This information is useful to reach people authorized to carry out the operations of declaration of boarding and landing of goods and passengers. Lastly, ISTAT's territorial offices make a consistency check with the administrative data available at the Ministry of Infrastructures and Transport (named PMIS system – Port Management Information System), also with a view to activating the desired interoperability between the PMIS system and the ISTAT system for the automatic exchange of data of statistical interest.

2 A CASE STUDY OF PROCESS INNOVATION: THE ROLE OF MARCHE, ABRUZZO AND PUGLIA (RMF) TERRITORIAL OFFICE IN DC IMPLEMENTATION FOR MARITIME TRANSPORT SURVEY

The reorganization of the data collection for maritime transport survey, that entrusted a coordination role to the Territorial office Marche, Abruzzo and Puglia, has determined the redesign of the flow of interventions to support respondents and of the checks of coverage and quality on information collected. Firstly, the redesign requested the revision of methods for monitoring the data collection trend by redefining the reports deducible from the dedicated web application (named "Tramarint" see Section 3), that is both an application for monitoring the survey trend, and a collaboration tool between Territorial Offices and Maritime Agencies. It offers facilities to manage the exchanges of information between ISTAT and the Maritime Agencies, in particular for the requests of password for accreditation to the data capturing system, for the modifications of the delegation powers, for restoring questionnaires to be modified. This last functionality allows, by operating on Tramarint back-office system, to support respondents for changes and restoration of previously entered questionnaires and which must be made accessible again to the Agency's completion. Tramarint is currently accessible only by the Territorial Office, to which it returns the views on the summaries of the inserted questionnaires and a summary of the compilation of the relevant questionnaire sections in relation to the specific characteristics of the ships surveyed, the goods moved, the passengers transported.

The Tramarint monitoring system, when its management was taken over by the Marche, Abruzzo and Puglia Territorial office, presented only partial reports. It was therefore necessary to expand the contents of the reports and to design and implement a new layout in order to rebuild the entire survey year for every single movement of ships arriving or departing. With the new display, the information refers to the whole registry of the marine agency and ship's marine data and in particular the ship code IMO (International Maritime Organization), a unique code assigned to the vessel when the keel was laid by the IHS Fairplay,[5] ex-Lloyd's Register – Fairplay.

The monitoring activity is carried out on the basis of two archives: the first is TRAMAR, the ISTAT website which collects the flow of the data of the survey with ISTAT ownership, according to Regulation (EU) No. 1090/2010 prescriptions. The second is the ADES (Arrivals Departures Enhanced Statistics) archive, which is fed by the flow deriving from the mandatory administrative records, for each arrival and departure of ships from/to any Italian port by the Shipper. The Recipient is the legal figure assuming

[5] Persons performing ship recommendation activities, assisting the master in respect of local authorities or third parties, receiving or delivering goods, embarking and disembarking passengers, acquiring freight, concluding transport contracts for goods and passengers with release of the relative documents, as well as any other activity for the protection of the interests assigned to him.

all the responsibilities related to the various aspects of port security and tax declarations on goods and passengers transported, with an additional requirement for cruise ships to communicate the list of passengers to the Ministry of the Interior for national security purposes. The Statistical Archive ADES is transmitted to ISTAT by the Statistical Office of the Ministry, that acquires the micro data (single trip of each ship identified by a code that is called visit_id) in possession of the Port Authorities and available for large and medium-sized Italian ports through the PMIS Portal.

Currently, the ADES file is acquired by the Division for integration of administrative sources and registers of the Central Directorate of Data Collection, and integration of the registers is carried out monthly. The file is transferred to the production Division that carries out the linkage with the data recorded in the ISTAT data capturing system in order to verify the exact correspondence between the data contained in the two databases that should not differ in anything except the fact that ISTAT, on the basis of what is prescribed by Eurostat to all Member States, requires a set of variables that is wider than those required for the PMIS system. Therefore, the comparison between the two archives should return an empty file in case of exact correspondence between the arrival/departure communications sent to the Port authorities and the TRAMAR forms. The condition is rarely verified, although the respondents are the same maritime agencies that feed both flows. The complexity associated with the identification of ships and agencies to be subject to reminder or quality control mainly concerns the enucleation of the following cases: alleged duplication, compilation of only one of the two types of travel (arrival only or departure only), excess of declarations of empty vessels in cabotage movements for which it is presumed that the ship is unlikely to arrive or depart effectively empty. It follows the need for a continuous exchange between the National Coordination Office and all the local offices, concerning the issue of the various territorial completeness checks of ships operating between the same ports of origin and destination. In such situations, very frequently it is necessary to determine both the correspondence of the number of trips and the correspondence in the definition of the type of ships and, as previously mentioned, the truthful correspondence of the indication of "empty ship". For this reason, in order to support information exchanges the Marche, Abruzzo and Puglia Territorial Office deemed it essential to activate a specific collaboration web area using the opportunity offered by the ISTAT Intranet. In addition to the need for frequent exchanges between the various territorial offices of the files monitored and the results, it allows to discuss any changes found by ISTAT territorial referents before requesting the Maritime Agency to formally communicate the changes. Only after the opportune exchanges of information between the territorial offices and the ISTAT lead office of Marche, Abruzzo and Puglia, the formal communication channel is activated. The collaboration area is also used to share the survey administrative documentation among all the involed actors on the territory in all the phases of the survey, notably between ISTAT and the maritime agencies. Example of this documentation are the informative letter to start the survey, the monthly alerts and the quarterly and annual reminders. The collaboration area also has the function of interchanging external source documents such as ministerial circulars, initiatives by trade associations such as "Federagenti" and "Assoporti", as well as lists and possible modifications of the territorial articulation of the Port Authorities and of the Port System Authorities, introduced by a recent legislation on port services in Italy.

Figure 1 Sharing information area among Territorial offices

Note: Figure available in the online version of Statistika: Statistics and Economy Journal No. 2/2020.
Source: ISTAT – Italian National Statistical Institute

3 DATA COLLECTION PROCEDURE OF THE ISTAT SURVEY ON MARITIME TRANSPORT

The data collection procedure is accessible by connecting to the secure site: <*https://indata.istat.it/tramar*> (and registering on first access). To receive the login credentials (username and password) to the Tramar

service it is necessary to fill in a form containing the information related to the subject to be granted and to the possible third party that he delegates to send the data. The user is in fact associated with the maritime agency, which can delegate a third party (for example a forwarder) to sending data through Tramar service. In the event that there is a person performing this task for several shipping agencies, the form must be completed for each agency; this subject will therefore be in possession of as many users as there are agencies that he represents in the use of the Tramar service.

3.1 Use of the web procedure

In occasion of first access the respondent has to connect to the website: <*https://indata.istat.it/tramar*> (the site is protected with SSL protocol that guarantees its authenticity and the protection of transmitted data). In the registration procedure the respondent is required to: 1) enter the user code and initial password contained in the e-mail sent by ISTAT; 2) enter the personal password; 3) press the Confirm key. The personal password, known only by the respondent, replaces the temporary one (not valid for the procedure). On the Web page the following functions are also available: 1) Survey: a brief illustration of the Survey; 2) Instructions: guide to completing the questionnaire with any updates; 3) Contacts: contains the e-mail address and telephone numbers for contacts with the toll-free number and the contact person for the survey and data collection. These functions can be accessed independently of the registration procedure. Once the registration procedure is completed, the respondent is enabled and can immediately proceed with the filling in using the Questionnaire button.

3.2 Web questionnaire

The home page of the Questionnaire displays first part containing the personal data related to the user, previously provided to ISTAT. These are not directly editable, except for the field relative to the email address to which the respondent wants to receive the return receipt of the electronic form. To insert a new declaration, the user must enter by typing or using the appropriate calendar key, the date of arrival/departure of the ship subject to the declaration. The user cannot enter a date later than the day the form was filled. Alternatively, if the user wants to upload a file without inserting individual declarations, he/she can proceed with uploading via 'Upload templates' from files that can be found on the right side of the calendar. The files to be accepted by the system must comply with the specifications, available in the 'Instructions and communications section'. The third part of the initial screen relates to the summaries of the inserted declarations or uploaded files.

Figure 2 Home page of the web questionnaire

Note: Figure available in the online version of Statistika: Statistics and Economy Journal No. 2/2020.
Source: ISTAT – Italian National Statistical Institute

From January 2018, it is requested to insert the Visit_ID issued by the Port Authorities in place of the field "name Shipowner". The Visit_ID is a "unique national ship stop code" consisting of 13 characters: a) the first 5 characters identify the port according to the UNECE code; b) the following 2 identify the year; c) the remaining 6 represent a progressive number corresponding to the ship stop. In case an incorrect Visit_ID is inserted, which does not respect these characteristics, a warning window will open a guide for solving the error. Typing the IMO (International Maritime Organization) number the user will automatically obtain all the characteristics related to the ship. In the event that only some of the characteristics of the ship are different, the important thing is that the type of ship, the net tonnage and the gross tonnage are correct. Once completed the compilation of the electronic questionnaire, the user will proceed with the next phase of checking and sending, through the appropriate screen. The checks carried out in this way are not to be considered exhaustive, since they mainly concern checks

on the quantities of goods by port of origin/destination. Once the checks have been completed, the user must proceed by verifying, and possibly modifying, the e-mail address to which he/she wishes to receive a return receipt stating that the declaration has been sent correctly. This will only happen if the user authorizes the sending by the appropriate check box. After making the final dispatch, it will no longer be possible for the user to modify the declaration of arrival/departure entered. It will instead be possible to save a copy of the form in PDF format on the user's computer.

CONCLUSION – RESULTS AND FINAL CONSIDERATIONS

The case study concerning the involvement of the Marche, Abruzzo and Puglia Territorial Office in the DC implementation introduces an innovative way of managing data collection, that is characterized by a distributed throughout the territory approach, opposed to the standard model which provides for a centralized approach. The new mode has the main objective of streamlining the investigation procedures by adopting a standardized approach to data collection, in order to increase the overall efficiency of the process. The case study of the Marche, Abruzzo and Puglia Territorial office also demonstrated the active role of the UUTT in the DC activities as a national reference, not limited to the sphere of the single office. In fact the first results point out the capacity of a Territorial office to assume the role of leadership in the management of the DC activities, of coordinating the activities of other offices/territorial entities as well as the role of reference to the central structures that deal with the management of the collection.

A first phase involves critical issues related to the consistent use of resources of the Central Data Collection Directorate, due to the rigidity of the existing data capturing and survey management systems; the difficulty of extending the harmonization and rationalization objectives typical of data collection

Figure 3 SWOT Analysis

Source: ISTAT – Italian National Statistical Institute

on the territory and the tendency to "mix" thematic and non-thematic topics. In the experience of maritime transport survey, the Marche, Abruzzo and Puglia office also demonstrated the ability to manage links with any intermediate bodies involved (other than ISTAT). The first results obtained showed a strong rationalization of the collection process with deep revisions of the modalities of relations with the agencies involved in the survey, in the roles of the external and internal actors involved and in the checks on the data made during the DC phase.

The process innovations introduced represent an example of solutions oriented to the standardization and harmonization of data collection management processes. In particular the procedures guarantee quality and harmonization of the survey lists, in order to avoid problems of poor updating and undercovering of the Registers and the possibility of reaching all the units involved in the samples.

The following SWOT analysis points out schematically strengths, weaknesses, opportunities and threats of the proposed approach.

The case study considered, moreover, represents a prototype model that can be of reference for the application in other research contexts and it may also be extended to other statistical surveys in the future.

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