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EMPIRICAL MODELING OF LONG-TERM INTERRELATIONS AND SHORT-TERM DYNAMIC ADJUSTMENTS OF PRIVATE CONSUMPTION IN UKRAINE

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Oliskevych M. O. Empirical Modeling of Long-term Interrelations and Short-term Dynamic Adjustments of Private Consumption in Ukraine

In view of economic instability in Ukraine, it's getting more and more relevant to study macroeconomic interrelations that would not only be based on long-term equilibrium trends, but at the same time would also represent the dynamic response of variables to shocks affecting the economic environment. The paper is aimed at an empirical study of long-term interrelations and a short-term adjustment mechanism when making consumer decisions by households in Ukraine. The paper presents a statistical analysis of the dynamic properties of the series of consumption, income and inflation. The paper also defines the stochastic trend and stochastic seasonality, it tests the existence and direction of causality in the interrelations, as well as it substantiates and estimates the cointegrating long-term equilibrium interrelation. Basing on the detected cointegration of the studied series, we developed an econometric dynamic error correction model that includes economic equilibrium relations derived from macroeconomic theory and also allows to model short-term effects of various factors on the rate of consumption change, such as changes in the rate of growth of income, changes in savings rates over the previous year, seasonality and deviations from a long-term equilibrium resulting from unanticipated shocks in the economy. The developed ECM-model is well-suited to predict changes in the levels and dynamics of fluctuations of the actual values of consumption and also has practical application in assessing and predicting the response of consumption, and thus aggregate demand, in making political and economic decisions both in a long-term perspective and in short-term adjustments.

***Key words**: private consumption, econometric modeling, cointegration, error correction model, stochastic seasonality*

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Олискевич М. А. Эмпирическое моделирование долгосрочных взаимосвязей и краткосрочных динамических приспособлений частного потребления в Украине

Ввиду нестабильности экономических процессов в Украине, актуальность приобретает изучение макроэкономических взаимосвязей, которые учитывали бы не только долгосрочные равновесные тенденции, но в то же время описывали бы динамическую реакцию поведения переменных на шоки, которые влияют на экономическую среду. Целью статьи является эмпирическое исследование долгосрочных соотношений и механизма краткосрочного приспособления при принятии потребительских решений домохозяйствами в Украине. В статье проведен статистический анализ динамических свойств рядов потребления, дохода и инфляции, выявлены стохастический тренд и стохастическая сезонность, протестированы наличие и направление причинности в связях, обосновано и оценено коинтеграционное долгосрочное равновесное соотношение. На основе выявленной коинтеграции исследуемых рядов разработана эконометрическая динамическая модель корректировки ошибок, которая учитывает равновесные экономические взаимосвязи, вытекающие из макроэкономической теории, а также позволяет смоделировать краткосрочные эффекты влияния на темпы изменения потребления таких факторов, как изменения в темпах роста доходов, изменений нормы сбережений на протяжении предыдущего года, сезонности и отклонений от долгосрочного равновесия, возникающие вследствие непредвиденных шоков в экономике. Построенная ЕСМ-модель показывает хорошую способность прогнозировать изменения в уровнях и динамику колебаний фактических значений потребления и имеет практическое применение при оценке и прогнозировании реакции потребления, а значит, и совокупного спроса, при принятии политических и экономических решений как в долгосрочной перспективе, так и во время краткосрочных приспособлений.

***Ключевые слова**: частное потребление, эконометрическое моделирование, коинтеграция, модель корректировки ошибки, стохастическая сезонность*

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Оліскевич М. О. Емпіричне моделювання довгострокових взаємозв'язків і короткострокових динамічних пристосувань приватного споживання в Україні

Зважаючи на нестабільність економічних процесів в Україні, набуває актуальності вивчення макроекономічних взаємозв'язків, які враховували б не тільки довгострокові рівноважні тенденції, але й водночас описували б динамічну реакцію поведінки змінних на шоки, які збурюють економічне середовище. Метою статті є емпіричне дослідження довгострокових співвідношень і механізму короткострокового пристосування при прийнятті споживчих рішень домогосподарствами в Україні. У статті здійснено статистичний аналіз динамічних властивостей рядів споживання, доходу та інфляції, виявлено стохастичний тренд і стохастичну сезонність, протестовано наявність і напрям причинності у зв'язках, обґрунтовано й оцінено коінтеграційне довгострокове рівноважне співвідношення. Ґрунтуючись на виявленій коінтеграції досліджуваних рядів, розроблено економетричну динамічну модель корегування помилки, яка враховує рівноважні економічні зв'язки, що випливають з макроекономічної теорії, а також дає змогу змоделювати короткострокові ефекти впливу на темпи зміни споживання таких чинників, як зміни у темпах росту доходів, зміни норми заощаджень упродовж попереднього року, сезонності та відхилень від довгострокової рівноваги, що виникають унаслідок непередбачуваних шоків в економіці. Побудована ЕСМ-модель виявляє хорошу здатність прогнозувати зміни в рівнях і динаміку коливань фактичних значень споживання та має практичне застосування при оцінюванні та прогнозуванні реакції споживання, а відтак і сукупного попиту, при прийнятті політичних і економічних рішень як у довгостроковій перспективі, так і під час короткострокових пристосувань.

***Ключові слова**: приватне споживання, економетричне моделювання, коінтеграція, модель корегування помилки, стохастична сезонність*

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In the changing and unstable environment of our country, it is essential to study macroeconomic relationships that would take into account not only long-term equilibrium trends, but at the same time would describe the dynamic response of the variables' behavior to the shocks that disturb the economic environment. The structure of the general macro econometric model of Ukraine, which is based on a new conceptual approach [1], enables us to investigate and enhance its separate components, taking into account the dynamic properties of the variables without violating the overall framework of the model. Considering that private household consumption is the most important measure of human well-being and an essential element of economic models as a whole, it therefore plays a significant role in the dynamics and speed of economic growth both in the long-term period and during short-term adjustments. It is important to work out the econometric consumption pattern that would deepen our analysis of the dynamic properties of the macro processes in the national economy and reinforce the conclusions of the block real sector integral model.

The importance of the formation and dynamics of consumer spending as an important element of the aggregate demand is noted in the works of both native and foreign economists. Scientific publications by D. Davidson, D. Henry, F. Srba, D. Romer, D. Campbell, W. Charemza, D. Dedman, J. Morley, A. Manitsaris, W. Mey, P. Brodin, I. Lukyanenko, G. Mohylyas, N. Horidko and others [1—6] reveal their interest in the quantitative modeling of various consumption aspects. The comprehensive study of consumer preferences and their dynamic properties is essential under the conditions of the current market transformation in Ukraine and it will help to improve the existing methodological aspects of the macro-econometric modeling of the national economy's dynamics.

The aim of this article is an empirical study of the long-term relationships and the short-term dynamic adjustment mechanism for making consumer decisions by Ukrainian households. The objective of this article is the development of an econometric dynamic model of error correction, its diagnostics, and the statistical and economic analysis of the effects of various factors and the substantiation of its use in forecasting.

The theoretical dynamic models that determine the behavior of consumption are based on maximizing the expected benefits for households [7]

$$\sum_{t=0}^{\infty}\sum_{s^t}\beta^t\cdot U\cdot(c_t(s^t),n_t(s^t))\cdot\pi_t(s^t),$$

where $U(\cdot)$ is a temporary utility function,

c_t – the level of consumption in period t,

n_t – the employment rate in period t, which depends on the previous history $s^t=\{s_t, s_{t-1}, ..., s_0\}$ of the realizations of random events s_t that occur before the period t and are determined by the availability in each of these periods of the system of preferences, income level, level of technology and information, which in their turn are stochastic processes. With the household budget constraint

$$\sum_{t=0}^{\infty}\{q_t\cdot(1+\tau_{ct})\cdot c_t-(1-\tau_{it})\cdot q_t\cdot[k_{t+1}-(1-\delta)k_t]\}\le$$

$$\le\sum_{t=0}^{\infty}\{r_t\cdot(1-\tau_{kt})\cdot k_t+w_t(1-\tau_{nt})\cdot n_t-q_t\tau_{ht}\}$$

and the government budget constraint

$$\sum_{t=0}^{\infty}q_t\cdot g_t\le\sum_{t=0}^{\infty}\{\tau_{ct}\cdot q_t\cdot c_t-\tau_{it}\cdot q_t\cdot[k_{t+1}-(1-\delta)k_t]+r_t\cdot\tau_{kt}\cdot k_t+,$$

$$+w_t\cdot\tau_{nt}\cdot n_t+q_t\tau_{ht}\},$$

where $\tau_{ct}, \tau_{it}, \tau_{kt}, \tau_{ht}$ denote different tax rates, and the equilibrium path of consumption is reduced to finding the solution of the differential equation

$$u'\cdot(c_t)=\beta\cdot u'\cdot(c_{t+1})\cdot(1+\tau_{ct})/(1+\tau_{ct+1})\cdot[(1-\tau_{it+1})(1-\delta)/(1-\tau_{it})+$$

$$+(1-\tau_{it+1})f'(k_{t+1})/(1-\tau_{it})].$$

Obviously the dynamic behavior of consumption is complex and determined by many factors, which undergo random disturbances in each period.

The development of an econometric model of consumption in Ukraine will be conducted on the basis of quarterly observations of the population's expenditures on the purchase of goods and services and their income during 2001–2013. The data has been obtained from statistical reports that are posted on the website of the State Statistics Service [8]. In particular, we make use of real indicators for an individual, taking into account the dynamics of the consumer price index and changes in population. Using the logarithms of variables in empirical modeling comes from the economic theory that attests to the concavity of theoretical economic relations [7] and by the statistical properties of the researched series. Testing for the presence of causality and its direction will be done with the help of the Granger causality checking procedure.

Having applied the Granger test, the results of which are shown in Table 1, we find that the amount of change in consumption is endogenous and the factors of change in incomes and the inflation rate are exogenous factors that determine the rate of change in consumer household expenditures. It should be noted that feedback effects don't have statistical significance.

Table 1

The Granger causality test results

VAR Granger Causality Tests			
Exogeneity: @seas(2), @seas(3), @seas(4)			
Dependent variable: Δ log(CONS)			
Excluded	Chi-sq	Df	Prob.
Δ log(INC)	10.77079	4	0.0293
INF	10.50611	4	0.0327
All	21.43643	8	0.0061

Correct application of the econometric approaches of the multivariate regression analysis requires carrying out a preliminary check of the time series for stationarity [9], since the use of non-stationary variables can lead to false regression that would not reflect the cause-effect relationships between variables. Graphic analysis of the behavior of consumption and income series shows that with the flow of time, the indicator values increase. Such behavior is usually caused by nonstationarity, the cause of which may be the presence of deterministic or stochastic trends, or both. The presence in the economic series of a stochastic trend is explained by the accumulation of random constant shocks, the average of which is zero, caused by the cycles of economic activity and the nonstationarity of the economic environment. Whereas not taking into account or dealing with the stochastic trend as a determinant of change is wrong and leads to the wrong conclusions, it is important in the process of developing an adequate econometric model of consumption to test the series for the single unit root, detection of which will be an indicator of a stochastic trend.

Moreover, the series of consumption, income and inflation over the defined period are characterized by seasonality, which is even more noticeable when the deterministic trend is deleted from the series. It should be noted that series to which seasonal variations are inherent, may contain deterministic seasonal components, be a stationary seasonal process or have detected stochastic seasonality [10]. Therefore for correct modeling of quarterly observations of economic indicators it is also essential to determine the type of its seasonality.

It is possible to verify the seasonal integrity of a number of consumption logarithms $log\,(CONS)_t$ on the basis of the DHF test (Dickey, Hasza, Fuller) [4; 10]. The test procedure starts with the estimation of the AR(m) specification for the seasonal differences series

$$\Delta_4 log(CONS_t) = \theta_1 \Delta_4 log(CONS)_{t-1} + \theta_2 \Delta_4 log(CONS)_{t-2} + \dots + \theta_m \Delta_4 log(CONS)_{t-m} + u_t \qquad (1)$$

and the use of obtained results $\theta\hat{}_1, \dots, \theta\hat{}_m$ as parameters for the construction of the series

$$z_t = log\,(CONS)_t - \theta\hat{}_1\, log\,(CONS)_{t-1} - \theta\hat{}_2\, log\,(CONS)_{t-2} - \dots - \theta\hat{}_m\, log\,(CONS)_{t-m}. \qquad (2)$$

Then we estimate the auto-regression of the n^{th} order where the additional exogenous variable is the lag value constructed according to (2) the quantity z_t, that is

$$\Delta_4 log\,(CONS)_t = \gamma z_{t-4} + a_1 \Delta_4 log\,(CONS)_{t-1} + \dots + a_n \Delta_4 log(CONS)_{t-n} + \xi_t. \qquad (3)$$

The DHF-test is based on an assessment of the parameter γ and its Studentized t-statistic. On the basis of the properties of the residue of auto-regression form (1) for different values of m we get *m=6 i* $\theta\hat{}_1 = 0.93$, $\theta\hat{}_2 = 0.09$, $\theta\hat{}_3 = 0.02$, $\theta\hat{}_4 = -0.22$, $\theta\hat{}_5 = 0.06$, $\theta\hat{}_6 = 0.02$. Then choosing *n=4* in the analysis of estimated specifications for different *n* we obtain $\gamma\hat{} = 0.018$, $s_\gamma\hat{} = 0.021$, $t_\gamma = 0.909$. Since the calculated value of the test statistic exceeds the critical value at significance level $\alpha = 0.01$, it can be argued that the logarithms of consumption are seasonally integrated, and therefore, its seasonal component is stochastic.

We can investigate in more detail the statistical properties of a number of $log(CONS)_t$ using HEGY methods (Hylleberg, Engle, Granger, Yoo) [10]. The idea is to study transience not only as a unit root, but in testing the possible presence of each of the four roots whose modulus is unity ($\varphi = 1$, $\varphi = -1$, $\varphi = i$, $\varphi = -i$). Note that since the seasonal difference can be written as

$$\Delta_4\, log\,(CONS)_t = log\,(CONS)_t - log\,(CONS)_{t-4} = (1-L^4)\, log\,(CONS)_t = (1-L)(1+L)(1+L^2)\, log(CONS)_t = = (1-L)(1+L)(1+iL)(1-iL)\, log(CONS)_t\,, \qquad (4)$$

where L – the lag operator is such that $L(log(CONS)_t) = log(CONS)_{t-1}$, $L^j(log(CONS)_t) = log(CONS)_{t-j}$, then the representation (4) implies that the seasonal differences cover the possibility of a difference of four different unit roots. The first root $\varphi=1$, which corresponds to component $(1-L)$, is a unit root, which characterizes the presence of a number of stochastic trends and corresponds to a zero frequency in the spectrum. Other roots $\varphi = -1$ and $\varphi = \pm i$, which we obtain in accordance with the factors $(1 + L)$ and $(1 + iL)(1 - iL)$, describe the seasonal structure of the series that is associated with stochastic cycles in accordance with the semi-annual and annual periodicity. Only when all components in (4) are statistically significantly different from zero, is the series stable, corresponding to $I(0)$. The procedure for checking the presence of the unit root with a different frequency in logarithms of consumption $log(CONS)_t$ under test HEGY, requires the creation of additional variables

$$Y1_t = (1+L)(1+L^2)log(CONS)_t = log(CONS)_t + log(CONS)_{t-1} + log(CONS)_{t-2} + log(CONS)_{t-3},$$

$$Y2_t = -(1-L)(1+L^2)log(CONS)_t = -log(CONS)_t + log(CONS)_{t-1} - log(CONS)_{t-2} + log(CONS)_{t-3},$$

$$Y3_t = -(1-L)(1+L)log(CONS)_t = -log(CONS)_t + log(CONS)_{t-2},$$

$$Y4_t = -L(1-L)(1+L)\, log(CONS)_t = -log(CONS)_{t-1} + log(CONS)_{t-3},$$

and estimation of the auxiliary regression

$$\Delta_4\, log\,(CONS)_t = \beta_1 Y1_{t-1} + \beta_2 Y2_{t-1} + \beta_3 Y3_{t-1} + \beta_4 Y4_{t-1} + \varepsilon_t. \qquad (5)$$

The series is seasonally integrated if all the coefficients β_1, β_2, β_3, β_4 are not significantly different from zero and are stationary, if not all zero. If β_1 is significantly negative, then there are no off-season non-stationary stochastic components. If β_2 is significantly negative, then the series contains a six-month stochastic cycle. Coefficients β_3 and β_4 are responsible for the annual stochastic cycle and should be tested together using the Lagrange multipliers test. For testing the conclusion *t*-statistics of parameter β_j are compared with critical values from the corresponding tables that are derived based on the implementation of a large number of Monte Carlo experiments [10]. In the case where the residuals of model (5) are correlated, then regression testing is expanded by including the delay endogenous variable. Research has shown that testing for the seasonal unit root in the series $log(CONS)_t$, the correct input specification is

$$\Delta_4 log(CONS)_t = c + a_1 \Delta_4 log(CONS)_{t-1} + a_2 \Delta_4 log(CONS)_{t-2} + \ldots + a_4 \Delta_4 log(CONS)_{t-4} + b_1 Y1_{t-1} + b_2 Y2_{t-1} + b_3 Y3_{t-1} + b_4 Y4_{t-1} + u_t .$$

Estimating this regression, we obtain the following estimates of the parameters $b_1 = 0.01$, $b_2 = -0.12$, $b_3 = 0.04$, $b_4 = 0.03$ and the corresponding value of the test statistic $t_{b1} = 1.12$, $t_{b2} = -2.11$, $t_{b3} = -0.71$, $t_{b4} = -0.73$. As the importance of statistics for all parameters significantly exceed the critical value, it can be argued that the series of logarithms of consumption has a unit root of all types, in particular characterized by a stochastic trend and stochastic cycles of semi-annual and annual intervals, which can jointly describe the stochastic seasonal component. Note that since for small values of $(x_t - x_{t-4})/x_{t-4}$ for an arbitrary number of $\Delta_4 log(x_t) = log(x_t) - log(x_{t-4}) = log(x_t/x_{t-4}) = log(1+(x_t - x_{t-4})/x_{t-4}) \approx (x_t - x_{t-4})/x_{t-4}$, the seasonal difference of the logarithm series approximates its annual growth rate .

Therefore, studies based on DHF and HEGY techniques motivates us during the simulation to use the fourth-order seasonal difference of the logarithm series of consumption $\Delta_4 log(CONS)_t$, which describe the growth rate of real consumption per capita in Ukraine . We will also do a statistical study of the properties of this series. Specifically, to test the presence of the unit root in the seasonal differences of logarithms of consumption and the series of first differences on the basis of the extended Dickey- Fuller test. ADF test results are shown in Table 2.

Table 2

The results of the extended Dickey-Fuller test for a series of annual growth rates of consumption

Null Hypothesis: $\Delta_4 log\ (CONS)_t$ **has a unit root**			
Lag Length: 4			
Exogenous: Constant		t-Statistic	MacKinnon p-values
Augm. Dickey-Fuller test statistic		**-1,653536**	0,4468
Test critical values:	1% level	-3,600987	
	5% level	-2,935001	
	10% level	-2,605836	
Null Hypothesis: $\Delta\Delta_4 log\ (CONS)_t$ has a unit root			
Exogenous: None		t-Statistic	MacKinnon p-values
Augm. Dickey-Fuller test statistic		**-4,744607**	0,0000
Test critical values:	1% level	-2,624057	
	5% level	-1,949319	

The value of the ADF statistics indicate the presence of a unit root in the series $\Delta_4 log(CONS)_t$ and its lack in the series $\Delta\Delta_4 log(CONS)_t$.Therefore, test results show that changes in the annual rate of growth of consumption $\Delta\Delta_4 log(CONS)_t$ is stationary, and therefore it is advisable to build an econometric model based on its use.

Since the joint modeling of non-stationary series is not valid [9], we will conduct an analogous study for the series of income logarithms $log(INC)_t$ and inflation INF_t, which we measures as $\Delta_4 log(P)_t$. The results of DHF, HEGY and ADF tests for these series are shown in Table. 3, where the values of the statistics that are significantly negative with a *p-value=0.01* are marked **.

The analysis of the test shows that the dynamics of consumption and income series are characterized by stochastic components with similar properties. In particular, the series of logarithms of consumption and income are seasonally integrated, and their first differences of seasonal differences are stationary. Thus both series $log(CONS)_t$ and $log(INC)_t$ contain a stochastic trend and stochastic cycles characterized by semi-annual and annual frequencies. HEGY test results for inflation in Ukraine show that it is not stationary and is not associated with stochastic cycles, but all the tests indicate the presence of a unit root, which describes a stochastic trend and the dynamics of its behavior.

Therefore, on the basis of the analysis, it can be argued that

$$log\ (CONS)_t \sim IS_4(1,1), \quad log\ (INC)_t \sim IS_4(1,1), \quad INF_t \sim I(1),$$

and therefore to build proper consumption patterns we need to use the transformation $\Delta\Delta_4 log(CONS)_t$, $\Delta\Delta_4 log(INC)_t$, ΔINF_t, that measures short-term fluctuations in the rate of change of consumption, income and inflation.

Research on the series $\Delta_4 log(CONS)_t$, $\Delta_4 log(INC)_t$, INF_t showed the same order of their integration, which allows us to carry out research on the co-integration which is the basis for modern econometric models. In general, a linear combination of non-stationary series are non-stationary, but when their co-integration exists as a co-integration vector, their use will give a stationary value that satisfies the long-term connection between the studied parameters.

To establish a long-term equilibrium relation between consumption and its factors and finding the co-integrating vector, we will make use of the autoregressive distributed lag model, which contains the consumption and income delay to

Table 3

The results of testing the presence of stochastic seasonality component and the stochastic trend

Test Method	Consumption	Income	Inflation
	log (CONS)	log (INC)	INF
DHF test	0.0146	0.0161	—
HEGY test	3.8502	1.2016	-0.7097
	-0.7677	-0.8005	-4.6061**
	-0.8395	-1.0140	-4.5093**
	-0.9705	-0.1881	-4.2167**
ADF test	Δ_4 log (CONS)	Δ_4 log (CONS)	INF
	-0.7628	-1.5181	-1.2329
ADF test	$\Delta\Delta_4$ log (CONS)	$\Delta\Delta_4$ log (CONS)	Δ INF
	-4.2754**	-4.2701**	-5.0037**

the fifth order, as well as inflation lags and deterministic components. We will use *S1*, *S2*, *S3* to denote seasonal variables, which will be used to approximate the stochastic seasonality series.

Assessing the ADL (5, 5, 1) model

$$log(CONS)_t = a_0 + a_1 log(CONS)_{t-1} + a_2 log(CONS)_{t-2} + a_3 log(CONS)_{t-3} + a_4 log(CONS)_{t-4} + a_5 log(CONS)_{t-5} + b_0 log(INC)_t + b_1 log(INC)_{t-1} + b_2 log(INC)_{t-2} + b_3 log(INC)_{t-3} + b_4 log(INC)_{t-4} + b_5 log(INC)_{t-5} + c_0 INF_t + c_1 INF_{t-1} + d_1 S1_t + d_2 S2_t + d_3 S3_t + \varepsilon_t,$$

we find the coefficients of the equation of static long-term equilibrium

$$log(CONS)_t = a + b\, log(INC)_t + c\, INF_t + s_1 S1_t + s_2 S2_t + s_3 S3_t + u_t.$$

With the ADL model, we find that long-term consumption by income elasticity is estimated as $b\hat{} = (b_0+b_1+b_2+b_4+b_5)/(1-a_1-a_2-a_3-a_4-a_5)$. Similarly, we evaluate the long-term marginal impact on the consumption rate of inflation $c\hat{} = (c_0+c_1)/(1-a_1-a_2-a_3-a_4-a_5)$ and the long-term seasonal shift of consumption. The results of the calculations are presented in Table 4.

Table 4

The evaluation of the long-term co-integration relationship

Lag order	Short-term effects of distributed lags in the ADL model					
	Consumption	Income	Inflation	Seasonality		
0	—	0.7648	-0.0756	-0.018	-0.003	-0.059
1	0.5761	-0.3239	-0.0787	—	—	—
2	-0.1778	0.0354	—	—	—	—
3	0.2335	-0.0574	—	—	—	—
4	-0.0007	-0.0136	—	—	—	—
5	0.1502	-0.2009	—	—	—	—
Long-term effect						
Const		INC	INF	S1	S2	S3
0,4608		0.9372	-0.7077	-0.084	-0.016	-0.272

So, we get a long-term relationship between consumption, income and inflation

$$log\,(CONS)_t = 0.46 + 0.94\, log\,(INC)_t - 0.71\, INF_t + a\, D_t + u_t, \quad (6)$$

where D_t denotes the vector of the deterministic seasonality component . Note that the Student's statistic of the individual coefficients of the seasonal variables and LM statistics for aggregating their testing indicate that seasonal factors are not statistically significant, therefore the level of long-term relationships is not subject to significant seasonal shift.

Deviations from the long-term relationships is explained by fluctuations which are observed in the short-term and determined by the residue $u\hat{}_t$ of the model (6). Research on the use of the Ingle - Granger technique indicates stationary residuals, since the value of the test statistic is *IG=-3.0175* which is statistically significantly negative for significance *level α=0,01*. Отже, $u\hat{}_t \sim I(0)$, and therefore we can say that equation (6) defines the long-term co-integrating relationship . Note that the dynamics of the series $u^{\wedge}_t$, which is shown in Figure 1, is characterized by significant peaks in the third quarter of each year, indicating a significant short-term consumption deviation by Ukrainian consumers from the long-term equilibrium path from July to September of each year. This increase in consumer spending is associated with costs caused by the holidays, the beginning of the school year and preparations for autumn and winter and is spurred by the accumulation of funds in the previous quarter.

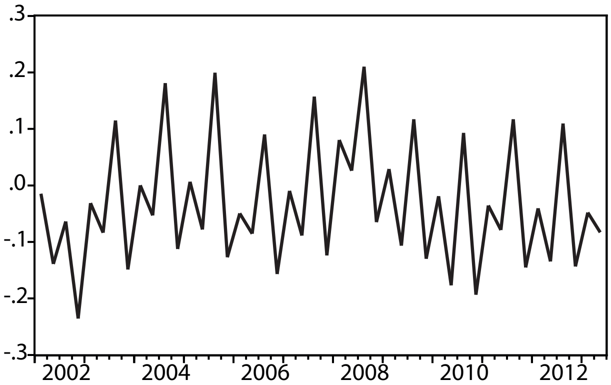

Fig. 1: Dynamics of consumption deviations from long-term equilibrium value

The resulting long-term co-integrating relationship (6) makes it possible to build an error correction model (ECM) based on the use of stationary rows and allows you to combine long-term equilibrium relationships and describe the short-term fluctuations arising from deviations from long-term trajectories and which are caused by different types of disturbances and shocks that in the short term contravene the fixed tendencies and structure of relationships between variables.

Evaluating and comparing the different specifications obtained, we determine that the best adequate ECM model has the form

$$\Delta\Delta_4 \, log(CONS)_t = a_0 + a_1 \Delta\Delta_4 \, log(INC)_t + a_2 \Delta \, INF_t + a_3 \, Elong_{t-1} + a_4 \, Elong_{t-4} + a_5 \Delta S\_RATE_{t-1} + a_6 \Delta S\_RATE_{t-2} + a_7 \Delta S\_RATE_{t-3} + a_8 \Delta S\_RATE_{t-4} + a_9 \, S2_t + a_{10} \, SD\_2008Q1 + a_{11} \, D\_2010Q4 + \varepsilon_t,$$

where *ΔS_RATE* stands for the rate of savings, S2 – the seasonal dummy variable that takes the value 1 for the second quarter of each year, *Elong* – the deviation from the long-term relationshipship (6) and *SD_2008Q1* та *D_2010Q4* – the dummy variables that reflect the permanent and temporary displacement model. The resulsts from evaluating model (7) are given in the Table 5.

Statistical analysis of the model, which is based on the value of the adjusted coefficient of determination ($R^2=0.97$), the Durbin- Watson statistic ($DW=2.05$), the Fischer statistic ($F=135.8$), the Jarque - Bera statistic ($JB=0.21$) and test results of White and Breusch - Pagan on heteroscedasticity, confirm its adequacy. Fig. 2a, on the basis of the model (7), shows the

Table 5

The estimation results of the error-correction model

Dependent Variable: $\Delta\Delta_4$ log (CONS)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.0139	0.0053	-2.5897	0.0147
$\Delta\Delta_4$ log(INC)	0.9453	0.0450	20.9712	0.0000
ΔINF	-0.2688	0.1311	-2.0492	0.0493
Elong-1	-0.2193	0.0370	-5.9210	0.0000
Elong-4	-0.2600	0.0416	-6.2423	0.0000
Δ S_RATE-1	0.6883	0.1451	4.7410	0.0000
Δ S_RATE-2	0.8402	0.1247	6.7338	0.0000
Δ S_RATE-3	0.6432	0.1229	5.2307	0.0000
Δ S_RATE-4	1.4488	0.1013	14.301	0.0000
S2	-0.0284	0.0124	-2.2857	0.0295
S_2008Q1	0.0202	0.0063	3.1842	0.0034
P_D2010Q4	-0.0625	0.0149	-4.1910	0.0002

Statistics			
R-squared	0.9803	Mean dependent var	-0.0152
Adjusted R-squared	0.9730	Sum squared residue	0.0191
F-statistic	135.77	S.E. of regression	0.0109
Prob(F-statistic)	0.0000	Durbin-Watson stat	2.0576
Akaike info criterion	-4.8397	Schwarz criterion	-4.3432
Heteroskedasticity Test	1.1718	Jarque-Bera	0.2088

real and estimated short-term growth rate of consumption $\Delta\Delta_4 \, log(CONS)_t$, and in Fig. 2b, from the actual and calculated values of the model $\Delta\Delta_4 \, log(CONS)_t$, the value of $CONS_t$ - the real consumption per capita in Ukraine.

The average of the absolute relative errors between the actual and estimated values within the sample during 2001 – 2013 is 1.28 %. The inequality coefficient is 0.007 and is close to zero. Thus the ratio of the bias that measures the error estimation, which is related to the accuracy of the simulation variable is 0.0014, and the proportion of variance that measures the amplitude estimation error variable is 0.0048. The proportion of co-variance, equal to 0.9939, shows that the actual and calculated values based on the model are almost perfectly correlated. Thus, the accuracy of the indicators from the ECM model based on the values of consumption and actual data, and the ability of the model to reproduce the dynamics of oscillatory behavior of consumption in Ukraine, confirms the reliability and high quality of the modelling.

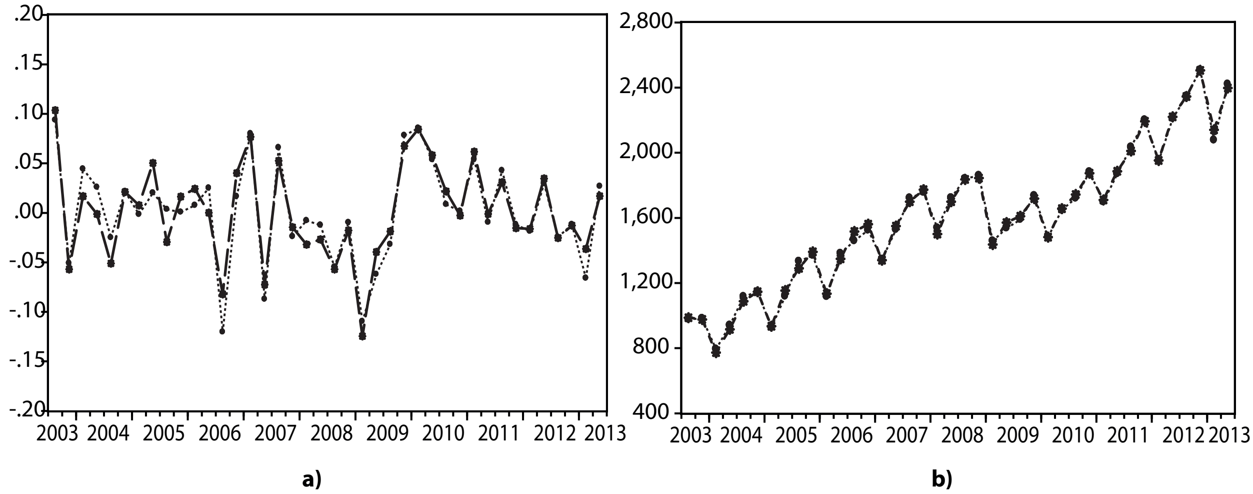

Fig.2: Real values and values obtained using ECM model

The model implies that short-term changes in consumption depend on short-term changes in income , and the elasticity of such changes is close to unity (equal to 0.95) and statistically significantly different from the marginal percentage propensity to consume in the long run (see Table 1). Inflation significantly and negatively affects the change in real consumption. In particular, short-term changes in seasonal consumption depends on changes in the rate of inflation, namely , the growth of the quarterly inflation rate leads to a decrease in real consumption.

Significant and negative values of the coefficients *a3* and *a4*, which determine the speed of adjustment to equilibrium, indicates that the model is dynamically stable. Consumption responds to past deviations from the long-term equilibrium path associated with unpredictable periodic shocks in the economy, and corrects the deviations within the next year. The coefficient a_3 is sensitive to deviations from the equilibrium of the previous quarter, and the coefficient a_4 is sensitive to deviations from equilibrium observed a year ago. Estimated values indicate that if there is a positive deviation of consumption from the long-term equilibrium relation (6) by 1%, then in the next quarter and the next year there is a deviation correction of 21% and 26 % respectively.

There is a significant effect on the change in consumption with changes in the rate of savings for each quarter of the previous year. Thus in each quarter there is a percent increase in consumption of approximately 70–80% of the increase in the savings rate of the previous three quarters, and full use of the corresponding increase that took place over the previous year. Note that the research models which contain more lags in the savings rate, indicate that changes in the rate of savings that occurred during earlier periods (5, 6, etc. quarters ago) do not have a statistically significant effect on the change in consumption, while the coefficients of other exogenous variables in the model remain stable. This result indicates that Ukrainian consumers on average spend their savings over the following year and are unable to accumulate them in the long run.

The negative and significant coefficient of the variable *S2*, which reflects the shift in short-term consumption in the second quarter of each year, indicates the reduction in this period, other things being equal, which is caused by the accumulation of funds for future cost increases in the third quarter, which indicates a relatively high value of deviations from the long-term level (see Fig. 1).

We explore the ability of the model (7) to predict the level of consumption in Ukraine. This estimate is based on the data covering a sample of observations from the 1st quarter of 2001 to the 2nd quarter of 2011. Then, using the estimated parameters, we calculate the predicted value for the next 8 periods (in the 3rd quarter of 2011 to the 2nd quarter of 2013) and compare them with the actual data for the period. The accuracy of the prediction is assessed on the basis of the root mean square error of prediction RMSE, the average absolute forecast error MAE, the mean absolute values of relative errors in percent MAPE, and the inequality coefficient Theil TIC [1; 11]. Table 6 shows the model's actual and the planned value of the levels of consumption and their absolute and relative error.

Therefore, the dynamics of consumption in Ukraine is completely determined by the dynamics of changes in income, inflation, changes in savings rates over the past year, as well as deviations from the estimated long-term equilibrium values that occurred during the previous year. The model makes

Table 6

Actual and predicted values of real consumption per capita in Ukraine on the basis of the developed error correction model

Period	Actual Consumption (Hryvnias)	Estimated Consumption (Hryvnias)	Absolute Error (Hryvnias)	Relative Error (%)
3rd Qtr 2011	2035.01	2012.71	22.30	0.0109
4th Qtr 2011	2200.67	2196.10	4.57	0.0021
1st Qtr 2012	1947.35	1966.31	-18.96	-0.0097
2nd Qtr. 2012	2209.43	2219.34	-9.91	-0.0045
3rd Qtr. 2012	2347.14	2347.92	-0.78	-0.0003
4th Qtr. 2012	2508.22	2508.79	-0.57	-0.0002
1st Qtr 2013	2077.74	2147.18	-69.44	-0.0334
2nd Qtr. 2013	2421.47	2396.47	25.00	0.0103

it possible to predict the long-term trend of the equilibrium levels of consumption in Ukraine, as well as the dynamics of its short-term fluctuations.

Conclusions. Static macroeconometric models, which are based on the use of classical simultaneous equations need to be improved and supplemented by more flexible econometric tools taking into account the short-term dynamics and adaptability of economic processes that are typical for the unstable economic development of our country. Since the improper use of econometric methods in cases of non-stationary data series, behavior of which is caused by the accumulation of random disturbances, can lead to false regression, a detailed analysis of the statistical properties of the variables used in the simulation is required. As a result of empirical research, we revealed stochastic trend and stochastic seasonality in the series of consumption, income and inflation, we tested the existence and direction of the causality in relations, and we justified and estimated the co-integrating long-term equilibrium relationship between them. The error correction model developed (7) takes into account the equilibrium of economic relations arising from the macroeconomic theory and also allows us to simulate the short-term effects on the rate of consumption's change of such factors as changes in the rate of income growth, changes in the rate of savings over the previous year, seasonality and deviations from the long-run equilibrium arising from unforeseen shocks to the economy. We found that Ukrainian households spend their savings over the course of the year and are unable to accumulate them in the long run. The calculated values of the coefficients, which measure the speed of adjustment to equilibrium, indicate that the model is dynamically stable, with 50% of the deviation from the long-term relation being adjusted during the year. The ECM model built shows a good ability to predict changes in the levels and dynamics of short-term fluctuations in the behavior of actual consumption values and it has practical application in assessing the average absolute value of the prediction relative error for a period of two years as being less than 1%. The developed model has practical application in evaluating and predicting the reaction of consumption and thus aggregate demand for political and economic decisions both in the long term, and during the short-term adaptations.

REFERENCES

1. Лук'яненко І. Г. Динамічні макроекономічні моделі. Новий концептуальний підхід / І. Г. Лук'яненко. – К. : ВД «КМ Академія», 2003. – 52 с.

2. Лук'яненко І. Г. Емпірична оцінка функції приватного споживання для України / І. Г. Лук'яненко, Г. Є. Могиляс // Наукові записки НаУКМА. – К. : ВД «КМ Академія», 2003. – Т. 21. – С. 3 – 9.

3. Оліскевич М. О. Економетричне моделювання макроекономічних процесів: Сукупне споживання. Динамічні моделі з розподіленими лагами: навч.-метод. посібник / М. Оліскевич. – Львів : ВЦ ЛНУ імені Івана Франка, 2012. – 112 с.

4. Charemza W. W. New Directions in Econometric Practice / Wojciech W. Charemza, Derek F. Deadman, Edward Elgar. – Publishing Inc., USA. – 1997. – P. 344.

5. Manitsaris A. Estimating the European Union Consumption Function under the Permanent Income Hypothesis / Athanasios Manitsaris // International Research Journal of Finance and Economics. – 2006. – Issue 2. – P. 131 – 135.

6. Morley J. C. The Slow Adjustment of Aggregate Consumption to Permanent Income / J. C. Morley // Journal of Money, Credit and Banking. – 2007. – № 39 (2-3) March – April. – P. 615 – 638.

7. Ljungqvist L., Sargent T. J. Recursive Macroeconomic Theory / Lars Ljungqvist, Thomas J. Sargent. – The MIT Press Cambridge, 2004. – P. 1082.

8. Доходи та витрати населення [Електронний ресурс] / Державний комітет статистики України. – Режим доступу : http://www.ukrstat.gov.ua

9. Лук'яненко І. Г. Проблеми «хибної» регресії у економічних дослідженнях / І. Г. Лук'яненко // Наукові записки НаУКМА. – К. : ВД «КМ Академія», 2002. – Т. 20. – С. 422 – 424.

10. Hylleberg S. Seasonal Integration and Cointegration / S. Hylleberg, R. F. Engle, C. W. J. Granger, B. S. Yoo // Journal of Econometrics, North-Holland. – 1990. – № 44. – P. 215 – 238.

11. Холден К. Економічне прогнозування: Вступ / К. Холден, Д. А. Піл, Дж. Л. Томсон. – К. : Інформтехніка – ЕМЦ, 1996. – 216 с.

REFERENCES

Charemza, W. W., Deadman, D. F., and Elgar, E. New Directions in Econometric PracticeUSA: Publishing Inc., 1997.

"Dokhody ta vytraty naselennia" [Household income and expenditure]. Derzhavnyi komitet statystyky Ukrainy. http://www.ukrstat.gov.ua

Hylleberg, S., Engle, R. F., and J. Granger, C. W. "Seasonal Integration and Cointegration"Journal of Econometrics, North-Holland, no. 44 (1990): 215-238.

Kholden, K., Pil, D. A., and Tomson, Dzh. L. Ekonomichne prohnozuvannia [Economic forecasting]. Kyiv: Informtekhnika – EMTs, 1996.

Ljungqvist, L., and Sargent, T. J. Recursive Macroeconomic Theory: The MIT Press Cambridge, 2004.

Luk'ianenko, I. H., and Mohylias, H. IE. "Empirychna otsinka funktsii pryvatnoho spozhyvannia dlia Ukrainy" [Empirical evaluation function of private consumption in Ukraine]. Naukovi zapysky NaUKMA vol. 21 (2003): 3-9.

Luk'ianenko, I. H. "Problemy «khybnoi» rehresii u ekonomichnykh doslidzhenniakh" [The problem of "false" regression in economic research]. Naukovi zapysky NaUKMA vol. 20 (2002): 422-424.

Luk'ianenko, I. H. Dynamichni makroekonomichni modeli. Novyi kontseptualnyi pidkhid [The dynamic macroeconomic models. A new conceptual approach]. Kyiv: KM Akademiia, 2003.

Manitsaris, A. "Estimating the European Union Consumption Function under the Permanent Income Hypothesis"International Research Journal of Finance and Economics vol. 2 (2006): 131-135.

Morley, J. C. "The Slow Adjustment of Aggregate Consumption to Permanent Income"Journal of Money, Credit and Banking, no. 39 (2-3) (2007): 615-638.

Oliskevych, M. O. Ekonometrychne modeliuvannia makroekonomichnykh protsesiv: Sukupne spozhyvannia. Dynamichni modeli z rozpodilenymy lahamy [Econometric modeling of macroeconomic processes: total consumption. Dynamic models with distributed lags]. Lviv: VTs LNU imeni Ivana Franka, 2012.