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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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 вражує
вали в не тільки довгострокові рівноважні тенденції, але й водночас описували в динамічну реакцію поведінки змінних на шоки, які збу
юють економічне середовище. Метою статті є емпіричне дослідження довгострокових співвідношень і механізму короткострокового при
стосування при прийнятті споживчих рішень домогосподарствами в Україні. У статті відзінено статистичний аналіз динамічних влас
твостей рядів споживання, доходів та інфляції, встановлено статистичну трендову і сезонну зміну, протестовано наявність і напрям
причинності у зв’язках, обґрунтовано її оцінено коінтеграційне довгострокове рівноважне соотношення. На основі виявлених коінтеграцій
рівень дослідження коеконометрична модель корекційної помилки, яка враховує рівноважні економічні відносини, здатна
предсказати краткосрочні ефективи впливу на темп
зміни потребення таких факторів, як зміна в темпах росту доходів, зміни норми сбережень на протяжені преды
дущого року, сезонності і відхилення від довгострокового рівноважного, викликає несподівані непередбачувані шоки в економіці. Поспі
лаєна ECM-модель показує хорошу спроможність прогнозувати зміни в урохах і динаміку коливань фактичних значень по
требення і має практичне призначення при оцінці та прогнозуванні реакції потребення, а також, і визначеної співвідношення, при
прийнятті політичних і економічних рішень через досягнення перспектив
так і під час короткострокових пристосувань.

Ключові слова: частотне потребення, економетричне моделювання, коінтеграція, модель корекційної помилки, статистична 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. Mohylas, 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]

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

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 \( s^t = [s_0, s_1, ..., s_t] \) 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

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

and the government budget constraint

\[
\sum_{t=0}^{\infty} q_t \cdot g_t \leq \sum_{t=0}^{\infty} \{\tau_{ct} \cdot q_t \cdot c_t - \tau_{ct} \cdot q_t \cdot (k_{t+1} - (1-\delta)k_t) + n_t \cdot \tau_{nt} \cdot k_t + w_t \cdot \tau_{nt} \cdot n_t + q_t \cdot \tau_{nt}\},
\]

where \( \tau_{ct}, \tau_{nt}, \tau_{nt}, \tau_{nt} \) denote different tax rates, and the equilibrium path of consumption is reduced to finding the solution of the differential equation

\[
u^t(\{c_t(s^t), n_t(s^t)\}) = \beta \cdot v^t(\{c_{t+1}(s^t)\} + (1 + \tau_{ct}) - [1 + (1-\delta)/(1-\theta)] + [1 - \tau_{nt}]f^t(k_{t+1})/(1 - \mu).
\]

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

<table>
<thead>
<tr>
<th>VAR Granger Causality Tests</th>
<th>Exogeneity: @seas(2), @seas(3), @seas(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: Δ log(CONS)</td>
<td></td>
</tr>
<tr>
<td>Excluded Chi-sq</td>
<td>Df</td>
</tr>
<tr>
<td>Δ log(INC)</td>
<td>10.77079</td>
</tr>
<tr>
<td>INF</td>
<td>10.50611</td>
</tr>
<tr>
<td>All</td>
<td>21.43643</td>
</tr>
</tbody>
</table>

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
tendencies decrease. Such behavior is usually caused by nonstation-
arity, the cause of which may be the presence of deterministic
or stochastic trends, or both. The presence in the economic se-
ries 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
dealing with the stochastic trend as a determinant of change
or seasonal integration 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 determin-
ist 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 \( \log(\text{CONS}) \), 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

\[
\Delta \log(\text{CONS})_t = \theta_1 \Delta \log(\text{CONS})_{t-1} + \theta_2 \Delta \log(\text{CONS})_{t-2} + \ldots + \theta_m \Delta \log(\text{CONS})_{t-m} + u_t, \quad (1)
\]

and the use of obtained results \( \theta_1, \ldots, \theta_m \) as pa-
rameters for the construction of the series

\[
z_t = \log(\text{CONS})_t - \theta_1 \log(\text{CONS})_{t-1} - \theta_2 \log(\text{CONS})_{t-2} - \ldots - \theta_m \log(\text{CONS})_{t-m}, \quad (2)
\]

Then we estimate the auto-regression of the \( n \)th order
where the additional exogenous variable is the lag value con-
structed according to (2) the quantity \( z_t \), that is

\[
\Delta \log(\text{CONS})_t = \gamma z_{t-4} + \alpha_1 \Delta \log(\text{CONS})_{t-1} + \ldots + \alpha_4 \Delta \log(\text{CONS})_{t-4} + \varepsilon_t, \quad (3)
\]

The DHF-test is based on an assessment of the param-
eter \( \gamma \) 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 \( m=6 \) \( \theta_1=0.93, \theta_2=0.09, \theta_3=0.02, \theta_4=-0.22, \theta_5=0.06, \theta_6=0.02 \). Then choosing \( n=4 \) in the
analysis of estimated specifications for different \( n \) we obtain
\( \gamma=0.018, s^2=0.021, t=9.099 \). 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 compo-
nent is stochastic.

We can investigate in more detail the statistical proper-
ties of a number of \( \log(\text{CONS}) \), using HEGY methods (Hylle-
berg, 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 writ-
ten as

\[
\Delta_n \log(\text{CONS})_t = \log(\text{CONS})_t - \log(\text{CONS})_{t-n} = (1-L)^n \log(\text{CONS})_t = (1-L)(1+L)(1+L^2) \log(\text{CONS})_t = \Delta_n \log(\text{CONS})_t, \quad (4)
\]

where \( L \) — the lag operator is such that \( L \log(\text{CONS})_t = \log(\text{CONS})_{t-L} \), \( L(\log(\text{CONS})_t) = \log(\text{CONS})_{t-L} \), then the represen-
tation (4) implies that the seasonal differences cover the pos-
tibility 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 \( \varphi = -1, \varphi = \pm i \), which we obtain in accordance
with the factors \( (1 + L) \) and \( (1 + IL) \) — 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 \( l(0) \).
The procedure for checking the presence of the unit root with a
different frequency in logarithms of consumption \( \log(\text{CONS}) \),
under test HEGY, requires the creation of additional variables

\[
Y_1 = (1+L)(1+L^2) \log(\text{CONS})_t = -\log(\text{CONS})_t + \log(\text{CONS})_{t-L} + \log(\text{CONS})_{t-2L} + \log(\text{CONS})_{t-4L},
\]

\[
Y_2 = -(1-L)(1+L^2) \log(\text{CONS})_t = -\log(\text{CONS})_t + \log(\text{CONS})_{t-L} - \log(\text{CONS})_{t-2L} + \log(\text{CONS})_{t-4L},
\]

\[
Y_3 = -(1-L)(1+L) \log(\text{CONS})_t = -\log(\text{CONS})_t + \log(\text{CONS})_{t-L} - \log(\text{CONS})_{t-2L} - \log(\text{CONS})_{t-4L},
\]

\[
Y_4 = -L(1-L)(1+L) \log(\text{CONS})_t = -\log(\text{CONS})_t + \log(\text{CONS})_{t-L} + \log(\text{CONS})_{t-2L} + \log(\text{CONS})_{t-4L},
\]

and estimation of the auxiliary regression

\[
\Delta_n \log(\text{CONS})_t = \beta_1 Y_1 + \beta_2 Y_2 + \beta_3 Y_3 + \beta_4 Y_4 + e_t, \quad (5)
\]
seasonal unit root in the series $\log(\text{CONS})$, the correct input specification is

$$\Delta_4 \log(\text{CONS}) = c + a_1 \Delta_4 \log(\text{CONS})_{t-1} + a_2 \Delta_4 \log(\text{CONS})_{t-2} + \ldots + a_4 \Delta_4 \log(\text{CONS})_{t-4} + b_1 Y_1 + b_2 Y_2 + b_3 Y_3 + b_4 Y_4 + u_t.$$ 

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 $t_b = 1.12$, $t_{b_2} = -2.11$, $t_{b_3} = -0.71$, $t_{b_4} = -0.73$. 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 $\Delta \log(x_t) = \log(x_t) - \log(x_{t-4}) = \log(1 + (x_t - x_{t-4})/x_{t-4}) \approx (x_t - x_{t-4})/x_{t-4}$, 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 $\Delta_4 \log(\text{CONS})$, 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.

The value of the ADF statistics indicate the presence of a unit root in the series $\Delta_4 \log(\text{CONS})$, and its lack in the series $\Delta \Delta_4 \log(\text{CONS})$. Therefore, test results show that changes in the annual rate of growth of consumption $\Delta \Delta_4 \log(\text{CONS})$ 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 $\log(\text{INC})$, and inflation $\log(\text{INF})$, which we measure as $\Delta \log(\text{P})$. 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 $\log(\text{CONS})$ and $\log(\text{INC})$ 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 $\log(\text{CONS}) \sim IS_4(1,1), \log(\text{INC}) \sim IS_4(1,1), \log(\text{INF}) \sim I(1)$, and therefore to build proper consumption patterns we need to use the transformation $\Delta \Delta_4 \log(\text{CONS}), \Delta \Delta_4 \log(\text{INC}), \Delta \log(\text{INF})$ that measures short-term fluctuations in the rate of change of consumption, income and inflation.

Research on the series $\Delta \Delta_4 \log(\text{CONS}), \Delta_4 \log(\text{INC}), \log(\text{INF})$ 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
we find the coefficients of the equation of static long-term equilibrium
\[ \log(\text{CONS})_t = a + b \log(\text{INC})_t + c \text{INF}_t + s_1 S1 + s_2 S2 + s_3 S3 + u_t. \]

With the ADL model, we find that long-term consumption by income elasticity is estimated as 
\[ b^* = \frac{b_0 + b_1 + b_2 + b_3}{1 - a_1 - a_2 - a_3 - a_4 - a_5}. \]

Similarly, we evaluate the long-term marginal impact on the consumption rate of inflation 
\[ c^* = \frac{c_0 + c_1}{1 - a_1 - a_2 - a_3 - a_4 - a_5} \]
and the long-term seasonal shift of consumption. The results of the calculations are presented in Table 4.

Table 3

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Consumption</th>
<th>Income</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHF test</td>
<td>0.0146</td>
<td>0.0161</td>
<td>—</td>
</tr>
<tr>
<td>HEGY test</td>
<td>3.8502</td>
<td>1.2016</td>
<td>-0.7097</td>
</tr>
<tr>
<td></td>
<td>-0.7677</td>
<td>-0.8005</td>
<td>-4.6061**</td>
</tr>
<tr>
<td></td>
<td>-0.8395</td>
<td>-1.0140</td>
<td>-4.5093**</td>
</tr>
<tr>
<td></td>
<td>-0.9705</td>
<td>-0.1881</td>
<td>-4.2167**</td>
</tr>
<tr>
<td>ADF test</td>
<td>Δ_1 \log(\text{CONS})</td>
<td>Δ_1 \log(\text{CONS})</td>
<td>\text{INF}</td>
</tr>
<tr>
<td></td>
<td>-0.7628</td>
<td>-1.5181</td>
<td>-1.2329</td>
</tr>
<tr>
<td>ADF test</td>
<td>ΔΔ_1 \log(\text{CONS})</td>
<td>ΔΔ_1 \log(\text{CONS})</td>
<td>Δ_{\text{INF}}</td>
</tr>
<tr>
<td></td>
<td>-4.2754**</td>
<td>-4.2701**</td>
<td>-5.0037**</td>
</tr>
</tbody>
</table>

Table 4

<table>
<thead>
<tr>
<th>Lag order</th>
<th>Short-term effects of distributed lags in the ADL model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consumption</td>
</tr>
<tr>
<td>0</td>
<td>0.7648</td>
</tr>
<tr>
<td>1</td>
<td>0.5761</td>
</tr>
<tr>
<td>2</td>
<td>-0.1778</td>
</tr>
<tr>
<td>3</td>
<td>0.2335</td>
</tr>
<tr>
<td>4</td>
<td>-0.0007</td>
</tr>
<tr>
<td>5</td>
<td>0.1502</td>
</tr>
<tr>
<td></td>
<td>Const</td>
</tr>
<tr>
<td>0.4608</td>
<td>0.9372</td>
</tr>
</tbody>
</table>

So, we get a long-term relationship between consumption, income and inflation
\[ \log(\text{CONS})_t = 0.46 + 0.94 \log(\text{INC})_t - 0.71 \text{INF}_t + a D_t + u_t, \quad (6) \]
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 \( u^* \) 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 \( \alpha = 0.01 \). Отже, \( u^* \sim \mathcal{I}(0) \), and therefore we can say that equation (6)
defines the long-term co-integrating relationship. Note that the dynamics of the series $u^t$, 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

$$
\Delta \Delta_4 \log(CONS) = a_0 + a_1 \Delta \Delta_4 \log(INC) + a_2 \Delta \Delta_4 \log(INF) + a_3 \Delta \Delta_4 \log(Elong) + a_4 \Delta \Delta_4 \log(SP) + a_5 \Delta \Delta_4 \log(SP_{Q1}) + a_6 \Delta \Delta_4 \log(SP_{Q4}) + \varepsilon_t,
$$

where $\Delta S RATE$ stands for the rate of savings, $S_2$ – the seasonal dummy variable that takes the value 1 for the second quarter of each year, $Elong$ – the deviation from the long-term relationship (6) and $SP_{Q1}$ – the dummy variables that reflect the permanent and temporary displacement model. The results 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>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.0139</td>
<td>0.0053</td>
<td>-2.5897</td>
<td>0.0147</td>
</tr>
<tr>
<td>$\Delta \Delta_4 \log(INC)$</td>
<td>0.9453</td>
<td>0.0450</td>
<td>20.9712</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\Delta \Delta_4 \log(INF)$</td>
<td>-0.2688</td>
<td>0.1311</td>
<td>-2.0492</td>
<td>0.0493</td>
</tr>
<tr>
<td>Elong-1</td>
<td>-0.2193</td>
<td>0.0370</td>
<td>-5.9210</td>
<td>0.0000</td>
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<tr>
<td>Elong-4</td>
<td>-0.2600</td>
<td>0.0416</td>
<td>-6.2423</td>
<td>0.0000</td>
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<tr>
<td>$\Delta S RATE_1$</td>
<td>0.6883</td>
<td>0.1451</td>
<td>4.7410</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\Delta S RATE_2$</td>
<td>0.8402</td>
<td>0.1247</td>
<td>6.7338</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\Delta S RATE_3$</td>
<td>0.6432</td>
<td>0.1229</td>
<td>5.2307</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\Delta S RATE_4$</td>
<td>1.4488</td>
<td>0.1013</td>
<td>14.301</td>
<td>0.0000</td>
</tr>
<tr>
<td>S2</td>
<td>-0.0284</td>
<td>0.0124</td>
<td>-2.2857</td>
<td>0.0295</td>
</tr>
<tr>
<td>$S_{2008Q1}$</td>
<td>0.0202</td>
<td>0.0063</td>
<td>3.1842</td>
<td>0.0034</td>
</tr>
<tr>
<td>$P_{2010Q4}$</td>
<td>-0.0625</td>
<td>0.0149</td>
<td>-4.1910</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
</tr>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
</tr>
<tr>
<td>Akaike info criterion</td>
</tr>
<tr>
<td>Heteroskedasticity Test</td>
</tr>
</tbody>
</table>
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 depend 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 \(a3\) is sensitive to deviations from the equilibrium of the previous quarter, and the coefficient \(a4\) 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

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

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.
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 of co-integrating long-term equilibrium relationships 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


### Table 6

<table>
<thead>
<tr>
<th>Period</th>
<th>Actual Consumption (Hryvnias)</th>
<th>Estimated Consumption (Hryvnias)</th>
<th>Absolute Error (Hryvnias)</th>
<th>Relative Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd Qtr 2011</td>
<td>2035.01</td>
<td>2012.71</td>
<td>22.30</td>
<td>0.0109</td>
</tr>
<tr>
<td>4th Qtr 2011</td>
<td>2200.67</td>
<td>2196.10</td>
<td>4.57</td>
<td>0.0021</td>
</tr>
<tr>
<td>1st Qtr 2012</td>
<td>1947.35</td>
<td>1966.31</td>
<td>-18.96</td>
<td>-0.0097</td>
</tr>
<tr>
<td>2nd Qtr 2012</td>
<td>2209.43</td>
<td>2219.34</td>
<td>-9.91</td>
<td>-0.0045</td>
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<tr>
<td>3rd Qtr 2012</td>
<td>2347.14</td>
<td>2347.92</td>
<td>-0.78</td>
<td>-0.0003</td>
</tr>
<tr>
<td>4th Qtr 2012</td>
<td>2508.22</td>
<td>2508.79</td>
<td>-0.57</td>
<td>-0.0002</td>
</tr>
<tr>
<td>1st Qtr 2013</td>
<td>2077.74</td>
<td>2127.18</td>
<td>-69.44</td>
<td>-0.0334</td>
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<tr>
<td>2nd Qtr 2013</td>
<td>2421.47</td>
<td>2396.47</td>
<td>25.00</td>
<td>0.0103</td>
</tr>
</tbody>
</table>


