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MONEY DEMAND IN ROMANIAN ECONOMY, USING MULTIPLE REGRESSION METHOD AND UNRESTRICTED VAR MODEL

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Abstract: The paper describes the money demand in Romanian economy using two econometrics models. The first model consist in a multiple regression between demand money, monthly inflation rate, Industrial production Index and the foreign exchange rate RON/Euro. The second model (Unrestricted Vector AutoRegressive model) is applied for the same variables used in the first model. Identifying a statistically strong model, capable of stable estimations for the money demand function in Romania's economy constitutes a prerequisite to the application of an efficient monetary policy.

Key words: money demand; unrestricted VAR model; Romania

Multiple regression estimation of Romanian money demand function

The theory underlying money demand function is based on the classical macroeconomic model of Hicks & Hansen IS-LM, specifically LM curve. The theoretical hypothesis (assumptions) of the dual equilibrium model for the money market in an open economy are: the perfect mobility of capital, uncovered interest rate parity principle, monetary policy conducted by the central bank are using the short term interest rate variable as the operational one without affecting the stability of the exchange rate of the national currency.

The LM curve is defined by the all possible combinations of interest rate and income levels for which the demand of money is equal with money supply (Figure 1.).

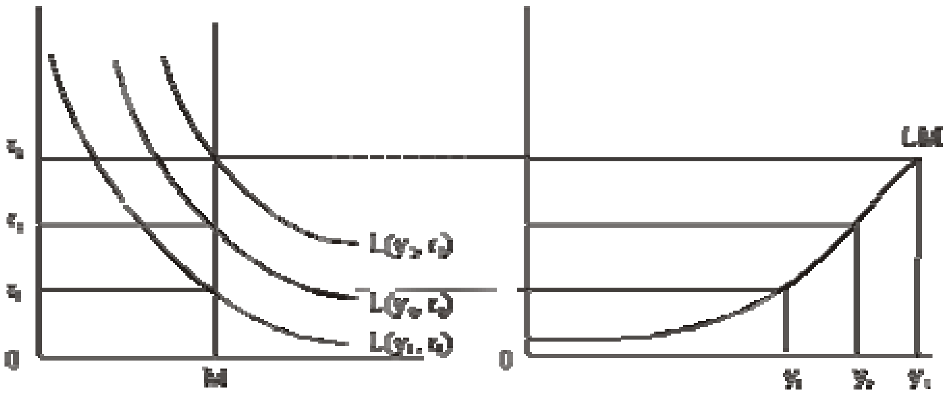


Figure 1. LM curve

The money demand function is a synthetic way of measuring the dependence between, on the one side, the monetary aggregates - as the money issued by the monetary financial institutions: credit institutions and money market funds, and used as financial resource by the non-banking entities: non-issuing money institutions, and, on the other side, the money consumers in the economy.

The classic model [3;4][1] estimates this correlation by the degree of explanation of the endogenous variable "monetary aggregate" by the following exogenous variables: monthly price growth rate, value of the economic output (GDP, industrial production value), average passive interest rate practiced by the credit institutions as an expression of the "price of money" and other variables expressing the cost of opportunity for possessing the currency - like exchange rate, the dynamics of the domestic capital index or a foreign capital index related to the analyzed economy. Taking into account changes in the international oil markets as an indicator of foreign restrictions could be useful in explaining the money demand pattern.

The specific choice of variables used to estimate the demand of money depends on the working hypotheses, on the availability of data with adequate frequency, as well as on conclusions of previous studies and research works regarding the significance of correlations that point to one indicator being more reliable than others in approximating the variable.

In order to express the monetary aggregate in the Romanian economy, the choice has been made for the broad money indicator M2 (known as broad money up to 2007, after which M3 was introduced, M2 becoming the intermediary monetary aggregate). The explanation of the use of M2 resides in the higher degree of coverness of the financial instruments by this indicator. Narrow money M1 is almost designed to be a proxy measure of the exchange transaction incentives of money only, while broad money M2 is designed to quantify also the accumulation of value purpose of holding money.

Although, the exogenous variables have to be restricted to the most significant ones, thus avoiding multicollinearity. Out of purely practical reasons, the industrial production index has been selected to measure the economic output, whereas for the cost of money we considered significant the average interest rate for one month as a liability of monetary financial institutions. For medium and long term maturity we used the interest rate of the one year government bonds. Longer maturities have been left out because of the discontinuity in issuance, in relation to the investor lack of preference for medium and long term maturities.

As an indicator of price increases, we used the monthly Consumer Price growth rate, as the GDP deflator is available, at best, quarterly, starting with 1998.

Our study has been compensating for the inflationary component by studying the dependence between the deflated monetary aggregate and the real money demand factors.

For the following regressors the 't' statistic significance of the coefficients of the money demand function has been confirmed: industrial production index, real money balances as the log level recorded three months ago, monthly inflation rate and the foreign exchange rate (leu/Euro). The money demand elasticity in respect of interest rate (as the average cost of monetary financial institutions for the borrowed resources and, implicitely, as the rate of return of deposits made by non-banking entities with the banks) was not being confirmed at the 10% level of significance. Thus, the conclusions of some previous work papers that the interest rate channel is not efficiently working in the romanian economy are confirmed by the statistical data [1]. The weak sensitivity of the real variables block could be explained by the rigidity of the economy to the monetary impulses due to the specific structural changes in our emerging economy. On the other side, the National Bank of Romania'monetary policy was focused on the monetary aggregates (base money) as the operational target, the exogenity of interest rate being a practical issue in the nominal variables block.

Thus, we have estimated the equation of the money demand for the Romanian economy using the following specific version:

$$m_t = a_0 + a_1 m_{t-1} + a_2 prodind_{t-3} - a_3 r\inf l_t + a_4 curs\_eur_t + \varepsilon_t$$

where:

m is the real monetary aggregate, deflated using the CPI (real M2) and seasonally adjusted, decimal logarithm values being considered; seasonally adjustment has been performed using the Census X11 method, considering the multiplicative method. The need to isolate and detach the seasonal component from the series of the monetary aggregate was imposed by the known peak effect during summer and holidays. Introducing unadjusted series would have led to rejection of the coefficients, the statistical significance being infirmed with a probability of 90%.

rinfl is the monthly CPI rate, logarithm values;

prodind is the Industrial Production Index, logarithm vales

curs_eur is the foreign exchange rate RON/Euro, logarithm values.

Table 1 presents the estimators of the regression coefficients, obtained using Eviews 4 software, for the time horizon for January 1992-December 2005, statistical series having monthly frequency.

Table 1. Estimators of the regression coefficients

Dependent Variable: LOG(M2_SA/p)
Method: Least Squares
Date: 02/27/08 Time: 15:22
Sample(adjusted): 1992:04 2005:12
Included observations: 165 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.192377	0.031722	6.064535	0.0000
LOG(m2_SA(-1)/p(-1))	0.951809	0.008594	110.7478	0.0000
LOG(rinfl)	-0.012963	0.002819	-4.599288	0.0000
LOG(PROD_IND(-3))	0.054574	0.027316	1.997866	0.0474
LOG(CURS_EUR)	0.048924	0.011085	4.413621	0.0000

R-squared	0.999853	Mean dependent var	4.075405
Adjusted R-squared	0.999850	S.D. dependent var	1.911885
S.E. of regression	0.023439	Akaike info criterion	-4.639032
Sum squared resid	0.087899	Schwarz criterion	-4.544912
Log likelihood	387.7201	F-statistic	272760.0
Durbin-Watson stat	1.789483	Prob(F-statistic)	0.000000

A powerful influence of the autoregressive component upon the deflated broad money has been detected (the estimated coefficient being 0.95); the value of the industrial production as an approximate value of the real aggregate supply, is positively correlated with monetary aggregate, but transmission of this influence is produced with a time lag of 3 months. Thus, the changes in real variables is reflected in values of the nominal variables after 3 months, but the influence is not strong (estimated elasticity is 0.05: at a change in the industrial production index with 1%, the reaction of the broad money over 3 months is of size 0.05%). Estimation of simultaneous correlation of this link has been infirmed by the "t" test, at a probability level of 90%.

The opportunity cost of holding the money has been approximated by means of introducing the leu/Euro exchange rate: the equation confirms the positive correlation between the exchange rate and the real broad money. The national currency depreciation influences the growth of money demand in real terms, as a consequence of the considerable weight of the foreign currency denominated part of the monetary aggregate. The shifting from local currencies to USD/Euro, as a process of substitution of the national currency, is characteristic for emerging markets, marked by significant changes in economic structure, and for which the tax of holding the money (inflation rate) and inflationary expectations are high.

The inverse correlation between the inflation rate and the real broad money is statistically confirmed by the "t" test. Interesting to observe is the small influence of prices upon the real broad money.

Stationarity of the data has been verified with the ADF (Augumented Dicky-Fuller) test, for the case of a liniar trend, a constant and eight lags, corresponding to the timespan of january 1992-december 2005 (results are presented in table 2).

The degree of explanation brought by the exogenous variables in their entirety, contributes in proportion of 99% (adjusted R^2 coefficient) to the obtaining of values for the adjusted series of money demand, as is visible from figure 2.

The errors terms resulted from the regression, represented as a blue line has been tested for autocorrelation: the Durbin-Watson statistic confirms the rejection of the autocorrelation in the residual series; as a consequence, the regression parameters are relevant and statistically significant.

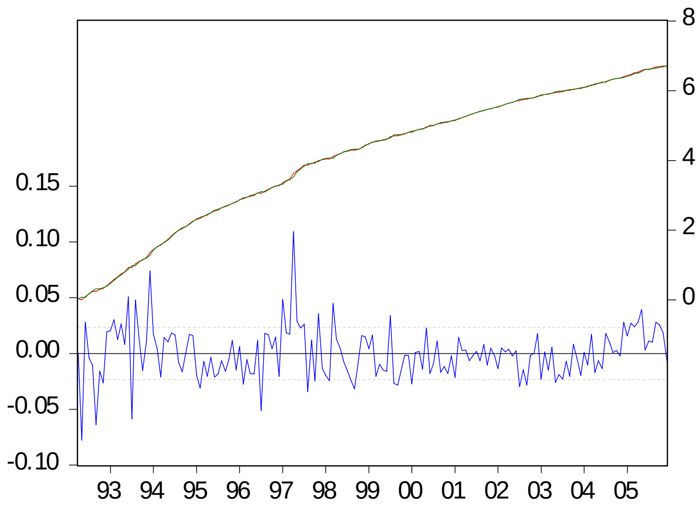


Figure 2. Adjusted versus real money demand

Tabel 2. Augumented Dicky-Fuller

Augmented Dickey-Fuller Test for real broad money M2/p

Sample(adjusted): 1992:06 2005:12

ADF Test Statistic	7.864602	1% Critical Value*	-3.4715
		5% Critical Value	-2.8792
		10% Critical Value	-2.5761

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test for industrial production index prod_ind

Sample(adjusted): 1992:06 2005:12

ADF Test Statistic	-7.769099	1% Critical Value*	-3.4715
		5% Critical Value	-2.8792
		10% Critical Value	-2.5761

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test for exchange rate leu/euro

Sample(adjusted): 1992:06 2005:12

ADF Test Statistic	-3.205847	1% Critical Value*	-3.4715
		5% Critical Value	-2.8792
		10% Critical Value	-2.5761

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test for inflation rate

Sample(adjusted): 1992:06 2005:12

ADF Test Statistic	-3.205847	1% Critical Value*	-3.4715
		5% Critical Value	-2.8792
		10% Critical Value	-2.5761

* MacKinnon critical values for rejection of hypothesis of a unit root.

Estimating the reaction of the broad money to shocks in real economy variables (VAR model for the money demand in the economy)

An estimation of the correlation between the real exogenous variables and money aggregates based on the UVAR (Unrestricted Vector AutoRegressive) with three lags has been applied for the same variable used in the multiple regression. The system of simultaneous equations comprises thus, the following variables: real broad money M2 (seasonally adjusted levels), IPI (Industrial production index), inflation rate, leu/Euro foreign exchange rate. Series are monthly and covers the years 1992-2005; ADF stationarity tests have shown the stationarity of the series of broad money, foreign exchange rate and inflation rate with a probability of 95%.

The model specification is as follows:

$$\log(M_2\_SA(t)/p(t)) = a_0 + \sum_{i=1}^{3} a_{1i} \log(M_{2\_}SA(t-i)/p(t-i)) +$$
$$+\sum_{i=1}^{3} a_{2i} \log(prod\_ind(t-i)) + \sum_{i=1}^{3} a_{3i} \log(curs(t-i)) + \sum_{i=1}^{3} a_{4i} \log(r\inf l(t-i)) + u_1(t)$$
$$\log(prod\_ind(t)) = b_0 + \sum_{i=1}^{3} b_{1i} \log(M_{2\_}SA(t-i)/p(t-i)) + \sum_{i=1}^{3} b_{2i} \log(prod\_ind(t-i)) +$$
$$+\sum_{i=1}^{3} b_{3i} \log(curs(t-i)) + \sum_{i=1}^{3} b_{4i} \log(r\inf l(t-i)) + u_2(t)$$
$$\log(curs(t)) = c_0 + \sum_{i=1}^{3} c_{1i} \log(M_{2\_}SA(t-i)/p(t-i)) + \sum_{i=1}^{3} c_{2i} \log(prod\_ind(t-i)) +$$
$$+\sum_{i=1}^{3} c_{3i} \log(curs(t-i)) + \sum_{i=1}^{3} c_{4i} \log(r\inf l(t-i)) + u_3(t)$$
$$\log(r\inf l(t)) = d_0 + \sum_{i=1}^{3} d_{1i} \log(M_{2\_}SA(t-i)/p(t-i)) + \sum_{i=1}^{3} d_{2i} \log(prod\_ind(t-i)) +$$
$$+\sum_{i=1}^{3} d_{3i} \log(curs(t-i)) + \sum_{i=1}^{3} d_{4i} \log(r\inf l(t-i)) + u_4(t)$$

where i=1,3.

u_j (j=1,4) are the regression residuals called innovations or shocks. The corresponding innovation is, thus, that part of the evolution of the variable that neither be explained by its past values (own history), nor by other variables of the model.

The VAR method concentrates mainly on studying the impact of every shock upon every variable of the system of equations; this analysis is being performed by impulse response functions, by factorial decomposition of variance.

Table 3. comprises estimated coefficient of the VAR model, obtained with Eviews 4 software.

The impulsion response functions graphically represent the evolution of these shocks in time across 10 months, identifying the maximum impact upon variables taken into account by the model; the sizing of these dependencies between innovations and model variables is expressed in relative terms, that is, standard deviations of the shocks.

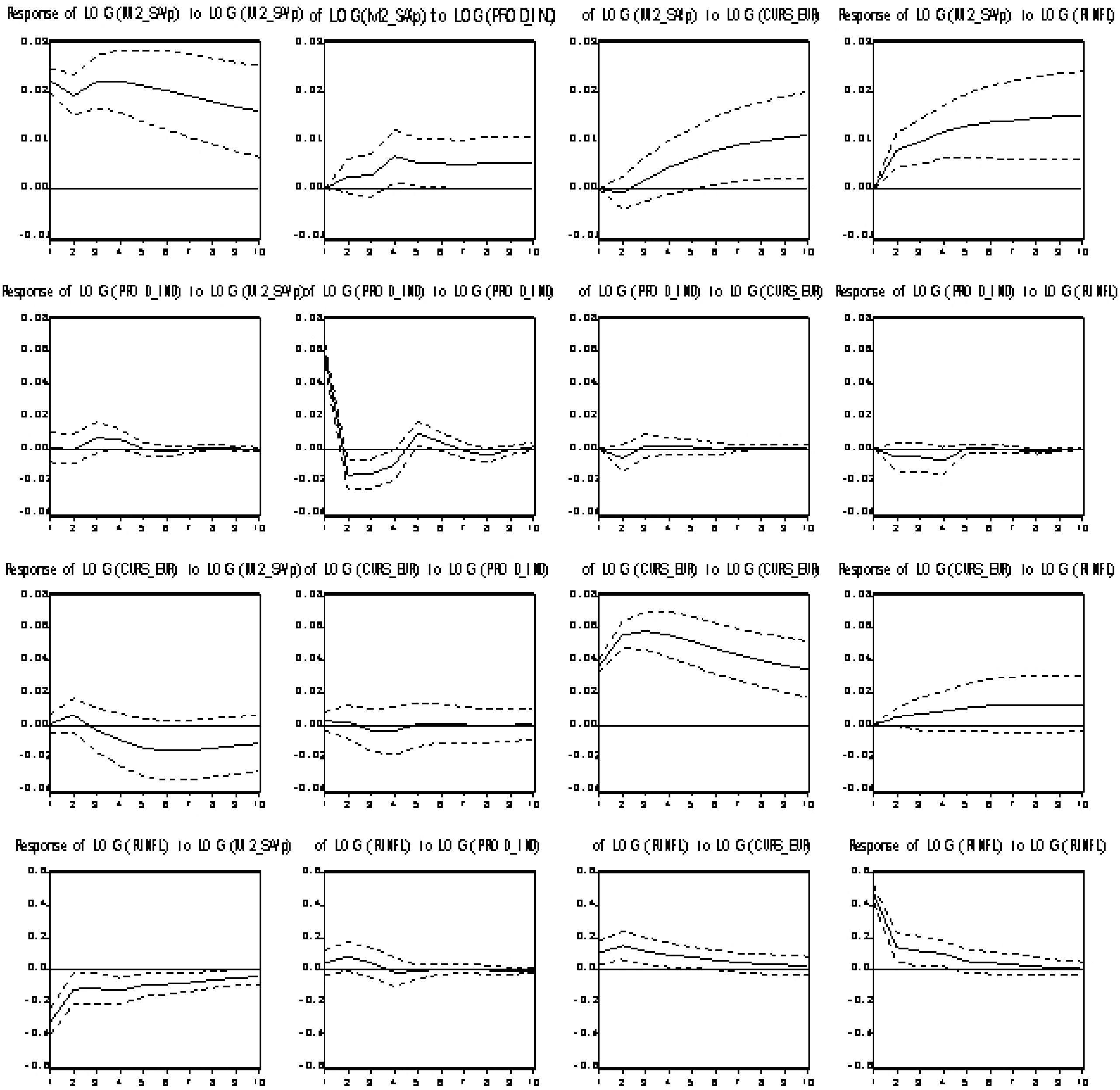
Tabel 3. The estimated coefficients of VAR model

Sample(adjusted): 1992:04 2005:12
Included observations: 165 after adjusting endpoints
Standard errors and t-statistic in brackets

	LOG(M2_SA/p)	LOG(PROD_IND)	LOG(CURS_EUR)	LOG(RINFL)
LOG(M2_SA(-1)/p(-1))	1.107870	-0.151211	0.376171	-1.267625
	(0.09407)	(0.24728)	(0.15506)	(2.45033)
	(11.7771)	(-0.61150)	(2.42604)	(-0.51733)
LOG(M2_SA(-2)/p(-2))	0.107563	0.322834	-0.960039	-1.195572
	(0.13958)	(0.36690)	(0.23006)	(3.63570)
	(0.77064)	(0.87989)	(-4.17291)	(-0.32884)
LOG(M2_SA(-3)/p(-3))	-0.215949	-0.246611	0.616877	2.005835
	(0.09335)	(0.24538)	(0.15387)	(2.43154)
	(-2.31338)	(-1.00501)	(4.00918)	(0.82492)
LOG(PROD_IND(-1))	0.034269	-0.261478	-0.040848	1.036583
	(0.02889)	(0.07593)	(0.04761)	(0.75244)
	(1.18632)	(-3.44352)	(-0.85791)	(1.37764)
LOG(PROD_IND(-2))	-0.017588	-0.315671	-0.105047	0.614014
	(0.02858)	(0.07512)	(0.04710)	(0.74434)

	(-0.61547)	(-4.20240)	(-2.23021)	(0.82491)
LOG(PROD_IND(-3))	0.047984	-0.313506	0.018482	0.014463
	(0.02894)	(0.07608)	(0.04771)	(0.75393)
	(1.65781)	(-4.12050)	(0.38740)	(0.01918)
LOG(CURS_EUR(-1))	-0.073281	-0.128218	1.496446	3.231345
	(0.04646)	(0.12213)	(0.07658)	(1.21018)
	(-1.57730)	(-1.04987)	(19.5411)	(2.67013)
LOG(CURS_EUR(-2))	0.133757	0.263857	-0.706407	-3.294675
	(0.07548)	(0.19840)	(0.12441)	(1.96600)
	(1.77219)	(1.32991)	(-5.67820)	(-1.67583)
LOG(CURS_EUR(-3))	-0.061791	-0.050815	0.157700	0.493682
	(0.04544)	(0.11945)	(0.07490)	(1.18363)
	(-1.35983)	(-0.42542)	(2.10550)	(0.41709)
LOG(RINFL(-1))	0.016839	-0.010827	0.011044	0.295220
	(0.00376)	(0.00990)	(0.00621)	(0.09807)
	(4.47250)	(-1.09394)	(1.77960)	(3.01028)
LOG(RINFL(-2))	-0.001959	-0.006298	-0.011551	0.148286
	(0.00452)	(0.01189)	(0.00746)	(0.11784)
	(-0.43299)	(-0.52963)	(-1.54912)	(1.25840)
LOG(RINFL(-3))	-0.003161	-0.020569	0.011172	0.153754
	(0.00389)	(0.01023)	(0.00641)	(0.10132)
	(-0.81272)	(-2.01157)	(1.74250)	(1.51746)
C	0.073499	0.173660	-0.071412	0.423674
	(0.03838)	(0.10088)	(0.06326)	(0.99964)
	(1.91519)	(1.72144)	(-1.12892)	(0.42382)
R-squared	0.999864	0.237022	0.999321	0.668904
Adj. R-squared	0.999854	0.176787	0.999268	0.642765
Sum sq. resids	0.081358	0.562183	0.221043	55.20174
S.E. equation	0.023136	0.060816	0.038134	0.602635
Log likelihood	394.0993	234.6297	311.6410	-143.7914
Akaike AIC	394.2569	234.7872	311.7986	-143.6338
Schwarz SC	394.5016	235.0320	312.0433	-143.3891
Mean dependent	4.075405	-0.000154	-0.123119	-3.762357
S.D. dependent	1.911885	0.067029	1.409360	1.008271
Determinant Residual	Covariance	4.92E-10		
Log Likelihood		831.6832		
Akaike Information Criteria		832.3135		
Schwarz Criteria		833.2923		

The responses of the variables studied to a standard deviation of innovations (variation interval ± 2 standard deviations) are graphically represented, for a timespan of 10 monhs.



Conclusions

Identifying a statistically strong model, capable of stable estimations for the money demand function in Romania's economy constitutes a prerequisite to the application of an efficient monetary policy.

Obtaining by econometric means, the series of adjusted money demand, for which the statistical stability tests are confirmed, allows for the formalization of the link between the real-sector and monetary block, as well as the impact assessment of the levels of monetary variables upon the economy.

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