

## Macroeconomic model of national economy development (extended)

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### Abstract

The macroeconomic model offered in this paper describes complex functioning of national economy and can be used for forecasting of possible directions of its development depending on various economic policies. It is the extension of [2] and adoption of [3]. With the purpose of determination of state policies influence in the field of taxes and exchange rate national economy is considered within the framework of three sectors: government, private and external world.

The model is described by system of equations, including on behavioral ones. It lets to obtain the solution for Balance of Payments, National Accounts, Public Sector Finances and External Debt. In the model last letter of each identifier designates, that appropriate variable is designed or in the current prices (L – in national currency, D – in dollars), or in the base year prices (R).

As a base for account of behavioral functions serve real values of variables. Transition from real parameters to nominal is carried out by means of appropriate indexes of the prices, and from parameters, determined in dollars, to the corresponding parameters in local currency — through the exchange rate.

### Balance of Payments

#### Export

The export of goods and services (XGNFSD) is fined as a sum of export of goods ( XMRCHD) and export of services (XGFSRD).

Real export of goods (XMRCHR) is determined by behavioral function, which depends on real world gross domestic product (FGDPR) and temporal variable (t):

$$XMRCHR = f1(FGDPR, t).$$

The nominal export of goods is determined by the following dependence:

$$XMRCHD = XMRCHR * XMRCHDP,$$

where XMRCHDP is the index of world prices for export of goods is behavioral function, dependent on the world prices (TMUVPD):

$$XMRCHDP = f2(TMUVPD).$$

The export of goods in the current prices (XMRCHL) is received from export of goods in dollar expression (XMRCHD), multiplied to the exchange rate:

$$XMRCHL = XMRCHD * REXCHL.$$

The export of goods and services (XGNFSD) is obtained by addition to export of goods (XMRCHD), the export of services (XGF SRD) which is set exogenously:

$$XGNFSD = XMRCHD + XGF SRD.$$

Transition from export of goods and services in dollar expression (XGNFSD) to local currency expression (XGNFSL) is carried out by multiplication by the exchange rate REXCHL:

$$XGNFSL = XGNFSD * REXCHL.$$

### **Import**

Volume of import of goods and services (MGNFSD) is subdivided into import of goods (MMRCHD) and import of services (MGFSRD). The import of goods includes of import of power resources (MOILD) and import of other goods (MOTH D).

Volume of import depends on real GDP and relative prices for import. The real import of power resources is represented by behavioral function, dependent on real GDP (NGDPR) and relative prices for import of power resources ( $MOILD/(GDPLP/REXCHL)$ ).

$$MOILR = f_3(NGDPR, MOILD/(GDPLP/REXCHL)).$$

The real import of other goods is also represented by behavioral function, dependent on real GDP (NGDPR) and relative prices for import of other goods ( $MOTHDP/(GDPLP/REXCHL)$ ):

$$MOTHR = f_4(NGDPR, MOTHDP/(GDPLP/REXCHL)).$$

Total volume of real import of goods is determined by a sum of import of power resources and other goods:

$$MMRCHR = MOILR + MOTHR.$$

Indices of prices for import are determined for power resources ( $MOILD$ ), and for other goods ( $MOTHDP$ ). The index of world prices for import of power resources is determined by behavioral function, dependent on a general level of world prices ( $TMUVPD$ ):

$$MOILD = f_5(TMUVPD).$$

Index of world prices for import of other goods is similarly defined:

$$MOTHDP = f_6(TMUVPD).$$

The formula of recalculation of all the components of import from nominal prices in dollars expression are shown below:

$$\begin{aligned} MOILD &= MOILR * MOILD, \\ MOTHD &= MOTHR * MOTHDP, \\ MMRCHD &= MOILD + MOTHD. \end{aligned}$$

The general price index of the import of goods ( $MMRCHDP$ ) is determined by the ratio of import in nominal prices ( $MMRCHD$ ) and import in real prices ( $MMRCHR$ ):

$$MMRCHDP = MMRCHD/MMRCHR.$$

Total nominal import of goods and services (MGNFSD) is determined as a sum of import of goods (MMRCHD) and import of services (MGFSRD) which is set exogenously:

$$MGNFSD = MMRCHD + MGFSRD.$$

Indices of import (MMRCHL, MGNFSL), submitted in dollar expression are translated in local currency with the help of exchange rate:

$$\begin{aligned} MMRCHL &= MMRCHD * REXCHL, \\ MGNFSL &= MGNFSD * REXCHL. \end{aligned}$$

**Current Account Balance**

**Trade balance** (TBMCHD, TBMCHL):

$$\begin{aligned} TBMCHD &= XMRCHD - MMRCHD, \\ TBMCHL &= XMRCHL - MMRCHL. \end{aligned}$$

**Balance of services** (TBFSRD):

$$TBFSRD = XGFSRD - MGFSRD.$$

**Balance of goods and services** (TBTRDD, TBTRDL):

$$\begin{aligned} TBTRDD &= XGNFSD - MGNFSD, \\ TBTRDL &= XGNFSL - MGNFSL. \end{aligned}$$

**Current Account** (TBCACD, TBCACL):

$$\begin{aligned} TBCACD &= TBTRDD + TBFSRD + \\ &+ TCAPID + TUNRTD, \\ TBCACL &= TBCACD * REXCHL, \end{aligned}$$

where TCAPID is net income set exogenously, and TUNRTD is net transfers set exogenously.

Currency stocks of a current year ( $TRESVD$ ) are equal to currency stocks of a previous year plus change in net currency reserves ( $TRESDD$ ), which are set exogenously:

$$TRESVD = previous(TRESVD) + TRESDD,$$

where previous ( $TRESVD$ ) are currency stocks of the previous period needed for external financing.

#### **Requirement for external financing**

Requirement for external financing represents total volume of the loans ( $TEXTVD$ ), necessary for financing of deficit of the Current Account. The requirement for additional financing ( $TAEXTD$ ) is defined as a difference between total requirement for foreign financing and net disbursement under the long-term credits ( $TLTDDD-TLTDAD$ ), i.e.:

$$\begin{aligned} TEXTVD &= -TBCACD + TRESDD - \\ &-TFDIVD - TOCFD - TEAOD, \\ TAEXTD &= TEXTVD - TLTDDD + TLTDAD, \end{aligned}$$

where  $TFDIVD$  are direct foreign investments,  $TOCFD$  are other capital flows,  $TEAOD$  are error and omission,  $TLTDDD$  is exogenously specified scheduled disbursement on official long-term loans from abroad,  $TLTDAD$  are scheduled amortization payments on these loans.

#### **Capital Account Balance (TCAPD).**

The Capital Account Balance is equal to a sum of requirement in external financing ( $TEXTVD$ ), disbursement on official long-term loans from abroad minus scheduled amortization payments on these loans ( $TLTDDD-TLTDAD$ ), direct foreign investments ( $TFDIVD$ ) and other capitals inflows ( $TOCFD$ ):

$$\begin{aligned} TCAPD &= TEXTVD + TLTDDD - TLTDAD + \\ &+TFDIVD + TOCFD. \end{aligned}$$

**External Debt.**

Volume of an External Debt (TEXTDD) pays off as a sum of External Debt of the previous year and requirement for additional financing (TAEXTD):

$$TEXTDD = previous(TEXTDD) + TAEXTD.$$

**National Account.**

**Investments.**

The total real investments (NTINVR) are subdivided into direct capital investments (NGFIVR) and change in stocks (NDINVR).

$$NTINVR = NGFIVR + NDINVR,$$

and the total nominal investments (NTINVL) are defined as:

$$NTINVL = NTINVR * NINVLP.$$

Here we suppose that investment deflator (NINVLP) is equal to GDP deflator (GDPLP):

$$NINVLP = GDPLP.$$

In turn, the direct capital investments (NGFIVR) depend on total real GDP level (NGDPR), total profit (NPRFTR) and real interest (NINTER) of previous year.

$$NGFIVR = g1(previous(NPRFTR),$$

$$previous(NINTER), NGDPR).$$

A real interest (NINTER) is a difference between nominal interest (NINTEL) and rate of inflation ( $GDPLP\%$ ):

$$NINTER = NINTEL - GDPLP\%.$$

The change in stocks (NDINVR) is determined as residual variable:

$$NDINVR = NGDPR - NGFIVR - NCONR - XGNFSR + MGNFSR.$$

**Private consumption.**

The private consumption (NPCNR) is specified to be a function of net population income (NYHSR) or of real GDP (NGDPR) and of relative prices (NPCNP/GDPLP):

$$NPCNR = g_2(NYHSR, NPCNP/GDPLP),$$

$$NPCNL = NPCNR * NPCNP.$$

Private consumption deflator (NPCNP) is specified to be equal to GDP deflator (GDPLP):

$$NPCNP = GDPLP.$$

**Total consumption.**

Real total consumption (NCONR) consists of private (NPCNR) and government consumption (NGCNR):

$$NCONR = NPCNR + NGCNR,$$

the same components determine total nominal consumption and nominal GDP:

$$NCONL = NPCNL + NGCNL,$$

$$NGDPL = NCONL + NTINVL + XGNFSL - MGNFSL.$$

**Public Sector Finances.**

The current incomes of public sector (NGCRL) consist of a general tax income (NGTXL), nontax income ( NGNTL) and capital income (NGYCL). In turn, tax income includes income of direct taxes (NGTDL) and incomes of indirect taxes ( NGTIL). The direct taxes

develop of the direct taxes from the enterprises (  $NGTCL$ ), direct taxes from the physical persons ( $NGTHL$ ) and other direct taxes ( $NGTOL$ ):

$$NGTDL = NGTCL + NGTHL + NGTOL.$$

The direct taxes from the enterprises and physical persons are calculated by the ratio:

$$\begin{aligned} NGTCL &= NYBSL * NCTX\%, \\ NGTHL &= NYHSL * NHTX\%, \end{aligned}$$

where  $NYHSL$  is income of the population,  $NYBSL$  is gross income of enterprises, and ( $NCTX\%$ ) and ( $NHTX\%$ ) are the tax rate for enterprises and population, accordingly. The last parameters are policy variables and can be used for the analysis of influence of tax policy on the development of national economy.

The indirect taxes consist of added value tax and excise tax ( $NGVTL$ ), tax to import ( $NGMTL$ ), other indirect taxes in the government budget ( $NGOIL$ ):

$$NGTIL = NGMTL + NGVTL + NGOIL.$$

For determination of the values of taxes for import and indirect taxes it is necessary to set such policy variable as rate tax for import ( $NMTX\%$ ) and tax rate on added value and excise ( $NVAT\%$ ). Means:

$$\begin{aligned} NGMTL &= MGNFSL * NMTX\%, \\ NGVTL &= NCONL * NVAT\%. \end{aligned}$$

The general tax income is defined as a sum of direct and indirect taxes:

$$NGTXL = NGTDL + NGTIL.$$

The current income ( $NGCRL$ ) consists of tax income ( $NGTXL$ ), nontax income ( $NGNTL$ ) and capital income ( $NGYCL$ ):

$$NGCRL = NGTXL + NGNTL + NGYCL.$$



The government consumption (NGCNL) is determined by a difference between current government expenditure (NGCEL), subsidy (NGSTL), by interest payments for internal (NGIDL) and external (NGEDL) debts, government transfers (NGTRL):

$$NGCNL = NGCEL - (NGSTL + NGIDL + NGEDL + NGTRL).$$

The real government consumption (NGCNR) is defined using the nominal one through a price index of government expenditure (NGCNP):

$$NGCNR = NGCNL/NGCNP.$$

As the government expenditure (NGCER) depend on real GDP (NDGPR), they are represented by the following behavioral function:

$$\begin{aligned} NGCER &= g_3(NDGPR), \\ NGCEL &= NGCER * NGCNP, \end{aligned}$$

where NGCNP is government expenditure deflator, which is also equal to GDP deflator:

$$NGCNP = GDPLP.$$

The subsidies (NGSTL) are subdivided into the subsidy, given to enterprises (NGSBL) and population (NGSHL), which are calculated as ratio of incomes of population (NYHSL) and enterprises (NYBSL). Given policy variables ( $SUBYH\%$ ) and ( $SUBYB\%$ ) are rate of the subsidy to enterprises and to the population accordingly:

$$\begin{aligned} NGSBL &= NYBSL * SUBYB\%, \\ NGSHL &= NYHSL * SUBYH\%. \end{aligned}$$

The total sum of subsidies is defined as:

$$NGSTL = NGSBL + NGSHL.$$

Then the current savings (NGSVL) pay off as a difference between the current income (NGCRL) and state expenditures (NGCEL):

$$NGSVL = NGCRL - NGCEL,$$

and deficit of the government budget (NGDFL) is defined as a difference between the current government savings (NGSVL), capital expenditure (NGCCL) and net government loans (NGNLL):

$$NGDFL = NGSVL - NGCCL - NGNLL.$$

The nominal income of population (NYHSL) pay off as a sum of income of labor activity (NPWSL) and other income (NYHOL):

$$NYHSL = NPWSL + NYHOL,$$

and the real income of population is defined as:

$$NYHSR = NYHSL/GDPLP.$$

The income of labor activity (NPWSL), in turn, depends on the nominal rate of wages (NWAGEP) and amount of workers (NWORK):

$$NPWSL = NWAGEP * NWORK.$$

The nominal rate of a wages (NWAGEP) is a function of real wages (NWAGER) and GDP deflator:

$$NWAGEP = NWAGER * GDPLP.$$

The real wages (NWAGER) is defined as a behavioral function, dependent of real GDP (NGDPR) and on the previous year real salary (previous (NWAGER)):

$$NWAGER = g4(NGDPR, previous(NWAGER)).$$

The total income of enterprises (NYBSL) consists of total investments (NTINVL), general consumption (NCONL) and volume of export of goods and services (XGNFSL):

$$NYBSL = NTINVL + NCONL + XGNFSL.$$

The total nominal profit (NPRFTL) pays off as a difference between gross domestic product (NGDPL), net population income (NYHSL) and government transfers to private sector (NGTRL):

$$NPRFTL = NGDPL - NYHSL - NGTRL.$$

And the total real profit (NPRFTR) is determined as:

$$NPRFTR = NPRFTL/GDPLP.$$

The values of exogenous variables are determined on the basis of historical data, provided by statistical bodies.

Policy variables are: direct tax rate of enterprises and physical persons, indirect tax rate, the prospective level of grants to enterprises and physical persons.

Alongside with policy variables may be introduced target variables. As a such variable the rate of GDP growth -  $NGDPR\%$  is used in model. So the real GDP (NGDPR) is calculated as:

$$NGDPR = (1 + NGDPR\%) * previous(NGDPR).$$

#### **The behavioral equations of model.**

All behavioral equations of model describe interdependence between main macroeconomic parameters. Using a time series processor (TSP), these functions were appreciated with the help of the twostage least square method. As a statistical base the time series in real prices for period 1991-1995 served. The choice of this period is caused by that the values for this period are characterized by scheduled development of economy with rather stable price level and income, absence of unemployment. Taking into account short historical period and imperfection of statistical data, behavioral functions may be modified.

Proceeding from a general kind of behavioral functions, certain early, and using logarithm dependence between variables the estimation of meanings factors are obtained. Each equation was estimated by coefficient of multiple correlation (R), by Durbin-Watson statistic (D.W.), by significance level of the equations (F-statistics) and by their estimation coefficient (t-statistics).

Particular kind of behavioral functions, values of their parameters and corresponding statistical estimations are shown below:

#### **Private consumption (NPCNR):**

$$NPCNR = \exp(npcnr\ koe f1 + npcnr\ koe f2 * \ln(NYHSR)) +$$

$$npcnr\ koef3 * \ln(NPCNP/GDPLP) + npcnr\ koef4 * NICNP),$$

$$R = 0.9362 \quad D.W. = 3.6115 \quad F = 14.687$$

		t-stat
Npcnr koef1	-0.82	-1.5158
Npcnr koef2	1.33	5.0853
Npcnr koef3	-3.77	-3.3285
Npcnr koef4	0.00	0.00

**The direct investments** (NGFIVR):

$$NGFIVR = \exp(ngfivr\ koef1 + ngfivr\ koef2 * \ln(NGDPR) + \\ + ngfivr\ koef3 * \ln(previous(NPRFTR)) + \\ + ngfivr\ koef4 * \ln(previous(NINTER))),$$

$$R = 0.4185 \quad D.W. = 1.6093 \quad F = 0.7197$$

		t-stat
Ngfivr koef1	-3.11	-0.7773
Ngfivr koef2	1.28	1.1979
Ngfivr koef4	0.05	0.0362
Ngfivr koef5	0.0	0.0

**Government expenditure** (NGCER):

$$NGCER = \exp(ngcer\ koef1 + ngcer\ koef2 * \ln(NGDPR) + \\ + ngcer\ koef3 * D92),$$

where D92 is a binary variable, equal to unit in 1992 and zero - in the other years of historical period.

$$R = 0.9547 \quad D.W. = 2.5885 \quad F = 21.0664$$

		t-stat
Ngcer koef1	-3.35	-3.0241
Ngcer koef2	1.67	5.3089
Ngcer koef3	-0.56	2.8023

Added value of economic sector (VLAD2) is estimated as a function of total real consumption (NCONR) and direct real investments (NGFIVR):

**Added value of economic sector (VLAD2):**

$$VLAD2 = \exp(vlad2\ koef1 + vlad2\ koef2 * \ln(NCONR) + vlad2\ koef3 * \ln(NGFIVR)),$$

$$R = 0.9902 \quad D.W. = 2.7733 \quad F = 101.136$$

		t-stat
vlad2 koef1	-0.39	-2.3016
vlad2 koef2	0.79	10.8159
vlad2 koef3	0.08	1.9730

The real rate of wages (NWAGER) is estimated as a function of real GDP and real wage of the previous year.

**Real wage payment (NWAGER):**

$$NWAGER = \exp(nwager\ koef1 + nwager\ koef2 * \ln(NGDPR) + nwager\ koef3 * \ln(previous(NWAGER))),$$

$$R = 0.9571 \quad D.W. = 2.063 \quad F = 22.3367$$

		t-stat
nwager koef1	-3.49	-5.161
nwager koef2	1.6 0	5.934
nwager koef3	-0.13	-0.668

Some components of the Balance of Payment were described by the following functions:

**Export of goods (XMRCHR):**

$$XMRCHR = \exp(xmrchr\ koef1 * \ln(NGDPR) + xmrchr\ koef2 * \ln(XMRCHDP/(GDPLP/REXCHI))),$$

$$R = 0.9591 \quad D.W. = 2.2272 \quad F = 46.9288$$

		t-stat
xmrchr koef1	0.85	7.2255
xmrchr koef2	-0.54	-11.5711

In turn, price index for the export of goods (XMRCHDP) is described by the function:

**Price index for export of goods (XMRCHDP):**

$$XMRCHDP = \exp(xmrchdp\ koef1 + xmrchdp\ koef2 * \ln(TMUVPD) + xmrchdp\ koef3 * TREND),$$

where TREND is a temporary variable.

$$R = 0.9999 \quad D.W. = 3.2653 \quad F = 99022$$

		t-stat
xmrchdp koef1	-0.02	-20.5498
xmrchdp koef2	-0.10	-3.5046
xmrchdp koef3	0.04	32.1270

**Import of power resources (MOILR):**

$$MOILR = \exp(moilr\ koef1 * \ln(NGDPR) + moilr\ koef2 * \ln(MOILD(P(R)EXCHL/GDPLP)) + moilr\ koef3 * D92),$$

where D92 is a binary variable, equal to unit in 1992 and to zero in other years of historical period.

$$R = 0.7612 \quad D.W. = 2.7824 \quad F = 1.59$$

		t-stat
moilr koef1	0.42	1.0293
moilr koef2	-0.94	-3.9245
moilr koef3	-0.21	-0.7128

**Import of other goods (MOTHR)**

$$MOTHR = \exp(mothr\ koef1 * \ln(NGDPR) + mothr\ koef2 * \ln(MOTHDP(R)EXCHL/GDPLP) + mothr\ koef3 * D92),$$

where D92 is a binary variable, equal to unit in 1992 and to zero in other years of historical period.

$$R = 0.9999 \quad D.W. = 2.798 \quad F = 2366.725$$

		t - stat
mothr koef1	0.24	28.4994
mothr koef2	-1.14	-232.0734
mothr koef3	0.44	68.6139

**The price index for import of power resources (MOILD P):**

$$MOILD P = \exp(moildp\ koef1 + moildp\ koef2 * \ln(TMUVPD)),$$

$$R = 0.9999 \quad D.W. = 2.801 \quad F = 167858$$

		t-stat
moildp koef1	0.003	0.6456
moildp koef2	1.51	409.7047

**The price index for import of other goods (MOTHDP):**

$$MOTHDP = \exp(mothdp\ koef1 + mothdp\ koef2 * \ln(TMUVPD)),$$

$$R = 0.9950 \quad D.W. = 2.0792 \quad F = 399.8221$$

		t-stat
mothdp koef1	0.04	7.4856
mothdp koef2	0.90	19.9956

Using the offered model and developed program the experimental calculations were carried out and the results were obtained, which are submitted in four tables: National Account, Public Sector Finances, Balance of Payment, Main Macroeconomic Parameters.

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Received April 1, 1997