Development of scenario as the key part of macroeconomic forecasting
Scenario problem

Structural macroeconomic forecasting requires implementation of definite scenario

Scenario 1
Scenario 2
Scenario n

1 or 2...or n - ?

Macroeconomic model

Forecast 1
Forecast 2
Forecast 3

Implemented variant should meet one crucial requirement – the consistency of exogenous variables.

The consistency of exogenous variables (or the consistency of scenario) means that combination of exogenous variables is apriori feasible in the future. Although, interconsistency of scenario doesn’t mean that scenario will necessarily come true.
Scenario worked out by Russian Ministry of economic development, base variant (2a) (date of publication – October 1 of 2009)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>World oil price, Urals, $/barrel</td>
<td>69.3</td>
<td>94.4</td>
<td>57</td>
<td>58</td>
<td>59</td>
<td>60</td>
</tr>
<tr>
<td>World GDP growth, %</td>
<td>2.2</td>
<td>1.1</td>
<td>-1.8</td>
<td>-2.7</td>
<td>0.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Ruble/dollar exchange rate (annual average), rubles per one US dollar</td>
<td>25.5</td>
<td>24.9</td>
<td>32.7</td>
<td>33.9</td>
<td>34.8</td>
<td>36.4</td>
</tr>
<tr>
<td>Trade balance, billion US dollars</td>
<td>130.9</td>
<td>179.7</td>
<td>94.7</td>
<td>107.0</td>
<td>101.9</td>
<td>97.4</td>
</tr>
<tr>
<td>Crude oil and oil products export, million tons</td>
<td>370</td>
<td>361</td>
<td>368.2</td>
<td>367.1</td>
<td>366.4</td>
<td>364.8</td>
</tr>
<tr>
<td>Crude oil and oil products export, billion US dollars</td>
<td>187.6</td>
<td>248.8</td>
<td>153.2</td>
<td>155.4</td>
<td>157.8</td>
<td>159.8</td>
</tr>
</tbody>
</table>

Source: Russian Ministry of economic development

The easiest solution of scenario problem – implementation of scenario prepared by authoritative organization – is not a guarantee for interconsistency of exogenous variables.
The possible reason of scenario inconsistency

World oil price forecast
source 1
source 2
source n

World GDP growth forecast
source 1
source 2
source n

Whether generalized estimation of world GDP growth consist with generalized estimation of world oil price?
Proposed approach to scenario problem solution

The consistency of scenario should be based on interdependences established between:

- World GDP growth and world oil prices;
- World oil prices, volume of petroleum export and ruble/dollar exchange rate;
- Net profit of petroleum industry and ruble/dollar exchange rate.

Exogenous variables in proposed approach:
- World GDP growth
- World oil price
- Ruble/Dollar exchange rate

Variables commonly used as scenario parameters:
- CPI in Russia
- Internal tariffs of natural monopolies (prices for electricity, natural gas, transportation)
- Tax rates
- Gross income of petroleum industry including income from petroleum export (in rubles)

Flowchart:

1. World GDP growth
2. World oil price
3. Ruble/Dollar exchange rate
4. Value of petroleum exports (US dollars)
5. Volume of petroleum exports
6. Fixed capital investment
7. Net profit of petroleum industry
1. World GDP growth and world oil prices matching

**GDP growth rates of world economy and separate countries**

**Estimation of world oil consumption**

- Crude oil production in oil importing countries
- Demand for crude oil import in oil importing countries
- Crude oil exports from major oil exporting countries

**World prices for crude oil, natural gas, coal**

- Index of nominal effective US dollar exchange rate
- Euro/dollar exchange rate
- Ruble/dollar exchange rate

**Volume of petroleum exports**

**Exogenous variables for the step 1**
**World primary energy consumption, thousand BTU per 1 dollar of GDP at constant 2000 prices**

GDP of separate countries are converted at a constant prices via market exchange rates

BTU – British Thermal Unit, 1BTU = 1 055.05585 Joules

- primary energy consumption per unit of GDP for the world economy (and for majority of separate countries) is stably declining value;

- specific primary energy consumption for separate country can be represented as a function, where time and primary energy price are taken as exogenous variables;

- specific primary energy consumption in the context of different sources can be represented as function, where total specific primary energy consumption and energy prices ratios are taken as exogenous variables.
**Regional breakdown**

**Countries share in world oil consumption in 2009, %**

<table>
<thead>
<tr>
<th>Country</th>
<th>Share in World Oil Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>22.1</td>
</tr>
<tr>
<td>EU-27</td>
<td>16.3</td>
</tr>
<tr>
<td>Japan</td>
<td>5.8</td>
</tr>
<tr>
<td>South Korea</td>
<td>2.6</td>
</tr>
<tr>
<td>India</td>
<td>4.0</td>
</tr>
<tr>
<td>China</td>
<td>10.5</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>21.7</td>
</tr>
<tr>
<td>OPEC</td>
<td>8.7</td>
</tr>
<tr>
<td>Canada</td>
<td>2.9</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.3</td>
</tr>
<tr>
<td>Norway</td>
<td>0.3</td>
</tr>
<tr>
<td>Russia</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Crude oil importers**

**Crude oil exporters**

**Major oil exporters** – OPEC, Russia, Canada, Mexico, Norway (oil exporters account for 64% of world oil supply and only 18% of world oil consumption).

**Major oil importers** – USA, EU-27, Japan, China, India, South Korea, rest of the world (oil importers account for 82% of world oil consumption and 36% of world oil supply).
1. In mid-term run world oil supply will cover world oil consumption (the usage of world oil extraction capacities will not raise to 100%).

2. World oil demand at every point of time is equal to world oil supply.

Price elasticity of world oil demand is low enough, when world oil demand is estimated via world GDP and energy commodity price ratios. Hence, the demand of major oil consumers for oil imports is almost independent of world oil price. At the graph of demand and supply world oil demand in this case can be represented as vertical straight line.

Since the volume of world oil exports is known and equal to world oil imports, world oil price can be estimated via function of oil supply, where world oil price depends on world oil exports.

The assumption described above make possible to estimate world oil price on a basis of GDP growth rates of separate countries.
The results of matching of world GDP growth and world oil price

Main scenario variables, representing external conditions

Growth rates of world GDP, %
2010-2013 – forecast based on IMF projections
2. World oil prices, petroleum export and ruble/dollar exchange rate matching

**Equation for ruble/dollar exchange rate**

\[
Rur\_usd = f( -brent \times (ruex\_oil + ruex\_pet); +(us\_gdp/us\_gdp(-1))/(ru\_gdp/ru\_gdp(-1)))
\]

- \(Rur\_usd\) – ruble/dollar exchange rate (rubles per 1 US dollar)
- \(brent\) – world oil price, brent, doll./barr.
- \(ruex\_oil, ruex\_pet\) – exports of oil and oil products, mln. t
- \(us\_gdp, ru\_gdp\) – US and Russian GDP at a constant 2000 US dollars

**World oil price and volume of petroleum export**

**Rouble/dollar exchange rate**

![Graphs showing world oil price, petroleum export, and exchange rate over time.](image-url)
3. Net profit of petroleum industry and ruble/dollar exchange rate matching

**Ruble/dollar exchange rate estimation**

- **World oil price**
- Ruble/dollar exchange rate
- Income from petroleum exports, US dollars

**Production function of petroleum industry**

- Income of petroleum industry, Russian rubles
- Transportation costs
- Cost of intermediate consumption
- Labor costs
- Taxes
- Net profit of petroleum industry
- Fixed capital investment
- Crude oil extraction

**Petroleum industry costs estimation**

- Transportation tariffs
- Electricity, natural gas and heat tariffs
- Inflation
- Tax rates
- Capital output ratio

**Scenario variables**

- endogenous variables
- exogenous variables
Comparison of scenarios worked out by Russian Ministry of Economic development and Institute of Economic Forecasting in June, 2010

World oil price, $ per barrel

Value of petroleum export, $billion

Ruble/dollar exchange rate

Exogenous variables equal for two scenarios

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>World GDP growth</td>
<td>4.0</td>
<td>3.9</td>
<td>4.0</td>
<td>3.7</td>
</tr>
<tr>
<td>CPI inflation, year-to-date</td>
<td>7.0</td>
<td>7.0</td>
<td>6.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Conclusion

*The Bad:*

- the solution of scenario problem shown above is a simplification of real economic interactions and a lot of them were left out of account;

- scenario consistency requires additional assumptions, which have essential influence on results.

*The Good:*

- we hope the implementation of proposed approach helps to clarify the procedure of scenario development and increases the consistency of exogenous variables.
# Equations for energy intensity – USA case
*(energy intensity - BTU per 1 dollar of GDP at a constant 2000 prices)*

**Total primary energy consumption**

\[
\text{LOG (All)} = 12.37 - 0.78\times\text{LOG (time)} - 0.059\times\text{LOG (OGC[-2])}
\]

<table>
<thead>
<tr>
<th>t-stat</th>
<th>(153.9)</th>
<th>(-35.3)</th>
<th>(-6.3)</th>
<th>adj. R-squared 0.99</th>
</tr>
</thead>
</table>

**Renewable energy consumption**

\[
\text{LOG (Rest)} = 0.78\times\text{LOG (ALL)} + 0.1\times\text{LOG (OGC[-8])}
\]

<table>
<thead>
<tr>
<th>t-stat</th>
<th>(649.7)</th>
<th>(7.11)</th>
<th>adj. R-squared 0.88</th>
</tr>
</thead>
</table>

**Petroleum consumption**

\[
\text{OIL} = 0.45\times\text{ALL} - 384.9\times(\text{POIL[-2]}/\text{OGC[-2]})
\]

<table>
<thead>
<tr>
<th>t-stat</th>
<th>(32.9)</th>
<th>(-3.73)</th>
<th>adj. R-squared 0.98</th>
</tr>
</thead>
</table>

**Natural gas consumption**

\[
\text{GAS} = -0.73\times\text{COAL} + 0.44\times\text{ALL} -504.5\times(\text{PGAS}/\text{OGC})
\]

<table>
<thead>
<tr>
<th>t-stat</th>
<th>(-16.7)</th>
<th>(-38.7)</th>
<th>(-5.8)</th>
<th>adj. R-squared 0.95</th>
</tr>
</thead>
</table>

**Coal consumption**

\[
\text{COAL} = 7775.1 -1371.9\times\text{LOG (time)} - 365.3\times(\text{PCOAL}/\text{OGC})
\]

<table>
<thead>
<tr>
<th>t-stat</th>
<th>(40.2)</th>
<th>(-35.8)</th>
<th>(-1.9)</th>
<th>adj. R-squared 0.97</th>
</tr>
</thead>
</table>

**All** – total primary energy consumption (BTU per GDP)

**OIL, GAS, COAL, REST** – petroleum, natural gas, coal and renewables consumption (BTU per GDP)

**OGC** – average energy price (US dollar per BTU)

**POIL, PGAS, PCOAL** – prices for crude oil, natural gas and coal (US dollar per BTU)
Estimation of world oil prices

Crude oil demand (demand for crude oil imports) is defined as a difference between oil importers consumption and production

**Crude oil production in oil importing countries**

\[
\text{Prod}_c = 8805 + 0.699 \times \text{Prod}_c[-1] + 0.088 \times \text{brent}(-1) \times \text{usd\_rate\_ind}
\]

\[
t-stat \quad (5.7) \quad (12.9) \quad (3.27) \quad \text{adj. R-squared 0.96}
\]

**Demand for imports in oil importing countries**

\[
\text{Im}_c = \text{Con}_c - \text{Prod}_c = \text{Ex}_p
\]

**World oil price**

\[
\text{Brent} = -102.3 + 0.066 \times \text{Ex}_p - 0.87 \times \text{usd\_rate\_ind}
\]

\[
t-stat \quad (-4.8) \quad (10.1) \quad (4.66) \quad \text{adj. R-squared 0.86}
\]

**Natural gas price**

\[
\text{P\_Gas} = 0.95 + 0.06 \times \text{Brent}
\]

\[
t-stat \quad (23.6) \quad (10.2)
\]

**Coal price**

\[
\text{P\_Coal} = 13.1 + 0.95 \times \text{Brent}
\]

\[
t-stat \quad (3.7) \quad (9.9)
\]

**Index of nominal effective US dollar exchange rate**

\[
\text{usd\_rate\_ind} = 805.6 - 220.9 \times ((\text{GDP\_world}-\text{GDP\_usa})/\text{GDP\_usa}) - 553.8 \times (\text{OilCon\_usa}/(\text{OilCon\_world}-\text{OilCon\_usa}))
\]

\[
t-stat \quad (14.9) \quad (14.1) \quad (-8.0) \quad \text{adj. R-squared 0.92}
\]