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DEVELOPMENT OF MACRO AND INTERINDUSTRIAL METHODS OF ECONOMIC ANALYSES

edited by
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This book is a collection of selected papers presented at the XXI Inforum World Conference. The conference was held in Listvyanka, Russia in August 2013. The Inforum (Interindustry Forecasting at the University of Maryland, USA) is the research group which was founded more than 40 years ago by Dr. Clopper Almon, now Professor Emeritus of the University of Maryland.

Participants from nine countries (China, Germany, Italy, Japan, Latvia, Poland, Russia, Turkey, USA) presented 21 reports. Participants are specialists in the field of macroeconomic modeling using Dynamic Input – Output Models. Most of them use Iforum approach to develop the dynamic forecasting of their national economies and use software developed by Inforum.

The book is of interest to the students of Economic Departments of universities and to specialists in the field of analysis and forecasting of the national economy development on macro, inter-sectoral and regional levels.

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СИБИРСКОЕ ОТДЕЛЕНИЕ АКАДЕМИИ НАУК

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ УЧРЕЖДЕНИЕ НАУКИ
ИНСТИТУТ ЭКОНОМИКИ И ОРГАНИЗАЦИИ ПРОМЫШЛЕННОГО
ПРОИЗВОДСТВА СИБИРСКОГО ОТДЕЛЕНИЯ
РОССИЙСКОЙ АКАДЕМИИ НАУК

НОВОСИБИРСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ

РАЗВИТИЕ МЕТОДОВ МАКРО И МЕЖОТРАСЛЕВОГО ЭКОНОМИЧЕСКОГО АНАЛИЗА

Ответственные редакторы:
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Р 17 **Развитие методов макро и межотраслевого экономического анализа.** *Сборник докладов 21-й Всемирной конференции ИНФОРУМ. Листвянка, 26–31 августа 2013 г.*/ под ред. д.э.н. А.О. Баранова, чл.-корр. РАН В.И. Суслова. – Новосибирск: Институт экономики и организации промышленного производства Сибирского отделения РАН, 2014. – 216 с.

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Настоящий сборник представляет собой статьи, написанные на основе докладов, представленных на XXI Всемирной конференции ИНФОРУМ. Конференция проводилась в России, в Иркутской области в поселке Листвянка. ИНФОРУМ (Межотраслевое прогнозирование в Мэрилендском университете, США) является исследовательской группой, которая была основана более 40 лет назад доктором Клоппером Алмоном, который в настоящее время является почетным профессором Мэрилендского университета.

Участники конференции из девяти стран (Китай, Германия, Италия, Япония, Латвия, Польша, Россия, Турция, США) представили 21 доклад. Все участники конференции являются специалистами в области макроэкономического моделирования с использованием динамических межотраслевых моделей. Большинство из них используют подход группы ИНФОРУМ для развития динамического прогнозирования национальных экономик и используют программное обеспечение, разработанное специалистами группы ИНФОРУМ.

Сборник представляет интерес для студентов экономических факультетов университетов и специалистов в области анализа и прогнозирования развития национальной экономики на макро, межотраслевом и региональном уровнях.

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PREFACE

This book is a collection of selected papers presented at the XXI Inforum World Conference. The conference was held on the bank of the Baikal Lake in Listvyanka, Russia in August 2013. The Inforum (Interindustry Forecasting at the University of Maryland, USA) is the research group which was founded more than 40 years ago by Dr. Clopper Almon, now Professor Emeritus of the University of Maryland.

Participants from nine countries (China, Germany, Italy, Japan, Latvia, Poland, Russia, Turkey, USA) presented 21 reports. Most of researches use Iforum approach and software to develop the dynamic forecasting of their national economies.

Clopper Almon in his paper “Progress on Gwx: the G Regression and Model-building Program Rewritten with Open-Source, Cross-platform Tools” describes new version of the G7 regression and model-building system with open-source, cross-platform tools, namely with wxWidgets and the GNU C++ compiler.

In the paper “The Transformation of Region’s Economic Area Governed by the Development of Industrial Region” which was written by **N. Bagautdinova, I. Gafurov, A. Novenkova** the authors formulated methodologies and practical guidelines that contribute to the transformation and restructuring of the region’s economic area by the development and implementation of the industrial enterprises potential. The research rests on the modern economy approaches and hypotheses on the regional administration, geopolitics, productive power distribution, network economics, the growth of manufacturing regions and clusters. It also considers materials on the identification, structuring of the economic area, its formation and transformation mechanisms backed by the state, the regularities of industrial markets performance. The information base of the research comprises data by the official federal and regional statistical offices.

Alexander Baranov, Victor Pavlov and Victor Suslov in their paper “The System of Dynamic Input-output Models for Forecasting the Development of Russian Economy at the National and Regional Levels” give the description of the Economic Models System, which have been developing at the Institute of Economics and Industrial Engineering Siberian Branch of Russian Academy of Sciences and at the Novosibirsk State University since mid-sixties of the XX century. The system includes subsystem of dynamic macro economic models and subsystem of dynamic interindustrial models. Second subsystem consists of the group of spot dynamic input-output models (without interregional block) and the group of dynamic interregional input-output models (with interregional block).

Loreto Bieritz in her paper **“**Export induced R&D-expenditures in Germany. Effects of a changed export structure to the USA and to China of German automotive industry products and of German pharmaceuticals” used a modelling approach that extends the dynamic macro-econometric input-output model INFORGE (Maier et al. 2013, Ahlert et al., 2009) to other economic areas: First, German exports are linked to and determined by a trade module that explicitly considers bilateral trade by countries and by products. Second, the sectoral analysis is extended by a Research and Development module that quantifies the R&D-expenditures by industries, universities and institutes as well as by the government.

The paper “A lot of Algebra and a Little Economics. Linkages in Input-Output Modeling” written by **Maurizio Grassini** refers to the problems of relationships between final demand components and primary inputs. The author made survey of these problems which were described in different papers by different authors (C. Almon, K. Miyazawa, G. Edgreen, K. Faxén, C. Odhner etc.).

Toshiaki Hasegawa in his paper “Gravity Analysis of Regional Economic Interdependence: In case of Japan” built the gravity model for Japan economy. In all analysis of Gravity model, GDP or GNP has been used as a proxy of economic size in regressing trade flows. Hasegava introduces the data of output aggregated in the international input-output table as the economic size in estimating the gravity equation.

In the paper “The Current Progress in the Russian Interindustry Model” **Sofia V. Kaminova** describes the progress of Russian Interindustry Model (RIM) in the period after 2010. During this period the government consumption block and the employment equations have been developed. The block for calculation taxes on products used has been built. Work on the investment equations is on-going.

The article “Characteristics and Trend of Structural Change in Chinese Economy. A Comparative Analysis Based on the 2007 and

2010 IO Tables" written by **Shantong Li, Sanmang Wu and Yunyi Liu** has taken comparative analysis of structural change of the Chinese economy from the aspects of structure of industry and intermediate input based upon data of Chinese 2007 and 2010 I/0 tables. Research shows: From the aspect of industrial structure, China has not only increased continuously its share of service of GDP, but also changed actively the internal structure of manufacturing and service. Manufacturing sector is transforming from labor intensive to technology intensive, from high energy intensity to low energy intensity, there is also increasing share of productive service in the sector of service. In regard to the intermediate input, there is rise of rate of intermediate input to China's whole economy due to increase of use of service to primary and secondary sector, especially the service of science, technology and transport. The significant rise of share of remuneration to laborers has caused a declining trend of rate of intermediate input to service. A comprehensive analysis of above shows, there is continuous improvement of structure of industry, while there is also increase of share of science, technology and service in intermediate input in the process of China's economic development.

Douglas Meade in his paper "Changing the Game: Industry Implications of the U.S. Natural Gas Revolution" describes a collaborative effort of Inforum and the Mitre Corporation to use the LIFT (Long-term Interindustry Forecasting Tool) and MARKAL (MARKet ALlocation) models in a coupled system to address the study objectives of the Energy Modeling Forum (EMF) 26. The focus of EMF 26 is on the natural gas market, and is motivated by the increased availability of shale gas discussed above.

The paper "The Conversion and Adjustment of National IO Table Series from WIOD. The Case of Turkey" written by **Gazi Ozhan**, **Wang Yinchu**, **Meral Ozhan** is devoted to the problem of conversions and adjustments of an IO table series from WIOD (World Input-Output Database) for building INFORUM model for Turkish economy.

In recent years, the rates of social security contributions have been one of the most discussed issues in Russian economic policy. Since 2009, the rates have been changed almost every year, and the changes were accepted under pressure from policy makers concerned with the financial soundness of the system. However, social security contribution rates affect not only the yield of the contributions but other aspects of the economy as well. The changes in these rates can influence the yield of other taxes, price levels, profitability of companies, wages of employees, fixed capital formation and so on. The problem is to quantify the effect of the rate changes on the whole economy. In the paper "The Consequences of Changes in the Social Security Contribution Rates in Russia" written by **Vadim Potapenko** presented the approach for estimation of some consequences of changes in social security contribution rates in Russia.

Ksenia Savchishina in her paper "The Belarus Economy as Part of the Common Economic Space: An Analysis and Forecast" describes the macroeconomic model of the Belarus economy, which includes about 65 endogenous variables, 39 exogenous variables, 50 regression equations and 20 identities.

Nikita Suslov in his paper "Large Investment Projects in Energy Sector of Russian Economy" discusses an approach to a long-term inter-sector and inter-regional analysis of interactions between a national economy and its energy production segment. The analysis is based on an optimization multi-sector multi-regional model (OMMM) which includes a natural block of energy production, processing and transportation (OMMM-Energy).

PROGRESS ON GWX: THE G REGRESSION AND MODEL-BUILDING PROGRAM REWRITTEN WITH OPEN-SOURCE, CROSS-PLATFORM TOOLS.

Clopper Almon

At the 20th Inforum World Conference, I announced (in absentia) that I was undertaking to rewrite the G7 regression and model-building system with open-source, cross-platform tools, namely with wxWidgets and the GNU C++ compiler. A year later, I am beginning to get results, but the program is still several months from reaching a useful stage. In this report, I want to explain again my motivation for undertaking this work and to give a report on progress to date.

■ Motivation

Initially, my motivation was simply fear. Gradually, however, other, nobler motives have emerged.

The fear motive arises from the fact that G7 is built with Borland Builder 6 and the Borland C++ compiler. Borland went out of business in 2003, and Builder was taken over first by CodeGear and then by Embarcadero Software, which offers a current version for about $2000. Before it went out of business, Borland produced a version of Builder that worked on a small number of Linux distributions but does not work on current distributions. Builder 6 did not work on Windows Vista but worked again on Windows 7. (Corel PhotoPaint also stopped working under Vista.) I do not know whether or not it works on Windows 8, with which I have had only enough experience to know that I don't like it. Recently, Microsoft has announced that it is terminating support for Windows XP; machines running XP in the University of Maryland are being converted to Windows 7. I mention these facts to emphasize (1) that there is a very close connection between Builder and Builder-like programs and the operating system and (2) that Microsoft has not the least interest in maintaining support for Builder, a program which for two years or so was far ahead of anything Microsoft had to offer.

On the positive side, the reasons for wanting to use cross-platform tools are increasing. The current versions of the Apple computers are doing very well commercially, in part because they are running on a solid, Unix-based operating system. Linux, while a minor player in the desk-top and lap-top market, is the major player in the hand-held devices, where it accounts for about two-thirds of the new sales, with Apple's similar Unix-based systems being most of the rest of the market. Consequently, a young programmer will definitely want to learn to deal with Unix and its look-alike Linux. I personally use Ubuntu Linux but with the Gnome desktop, which is more traditional than the Unity desktop currently the Ubuntu default. I took the time to become fairly proficient with Unity – which aims to be nearly the same on laptops and hand-held devices, hence the name – but in the end, I found it less efficient than the traditional Gnome desktop. (One of the nice things about Linux is that you have a choice of a number of different desktops; Apple and Windows remind one of Henry Ford's famous dictum: “You can have your Ford in any color you want so long as it is black.”)

I find Ubuntu Linux a very stable operating system with a wide variety of high-quality, free, open-source software available with a few mouse clicks. The LibreOffice suite, which installs with Ubuntu, includes Writer (a word-processor superior to MS Word), Calc, Impress, and Base closely paralleling Excel, PowerPoint, and Approach. I also use Gimp for image processing (a free alternative to PhotoShop), MuseScore for writing musical notation (a free alternative to Finale), the OpenShot video editor (a superior alternative to MS MovieMaker), the Gramps genealogical program, the Audacity audio editor, Google Earth and various utilities for Internet access, scanning, OCR conversion, and the full set of Unix command-line software. Code::Blocks with wxSmith and the GNU C++ compiler is fully the equivalent of Borland Builder 6 for writing programs – and it is cross-platform. All of that is free and most of it open-source. In fact, everything I ever want is there – except a good time-series regression and model-building program like G7. I would like for G7 to join this distinguished company.

As I dug into the project, I found that there were other reasons for doing it. The code for G7 has become very complicated and difficult to read. Any programmer new to the code who was expected to step into it and make some correction or add some feature would have a very difficult time. The original code was much simpler and clearer. The documentation of how it was supposed to work was, from the outset, limited to comments in the code. But many changes have been made in the code, usually with the original code left as a comment and the new code marked with the changer's initials and date but with no explanation of why the change was made. In the work that I have done so far, I have been able to simply copy G7 code in only three instances: (1) writing data to a standard G data bank, (2) the inversion part of the regression program, and (3) the GDate class. Elsewhere, the G7 code has become hopelessly – and I often feel – needlessly complex. I want to produce code which is eminently readable by humans and is documented not only with comments in the code but with a tutorial description of what it is doing. To date, this description is a document of over 150 pages. While I intend to make the whole code open-source, I also intend to keep my own copy and to keep it intelligible. I want it – in conjunction with the tutorials – to be easy and clear reading for anyone who understands the basics of C++ and the algorithms being used. The tutorials should serve as an introduction for anyone who later needs to maintain and update the code.

■ Overview of Progress to Date

At last year's Inforum conference, I was able to report getting the basic G7 mechanism set up with a command drop-down box, a results window, and two buttons, one for picking a starting directory and one to draw and save the Giotto figure – a red circle and an octagon around it. Since then have been added the following commands:

data –for adding time series one at a time to the workspace bank;

matdata – for adding a number of time series arranged in a matrix to the workspace bank;

type – for displaying a time series in the workspace numerically on the results screen;

f – for forming a new variable in the workspace bank by arithmetic operations with existing series. The log() and exp() functions are also recognized;

r – for performing linear regression of one variable on a number of others;

gr – for graphing one or more variables;

title – to provide a title for a regression or graph;

subtitle – to provide a subtitle for a regression or graph;

_dates – tdates, fdates, rdates, and gdates, to provide date ranges for the *type*, *f*, *r,* and *gr* commands;

add – to execute any of the above command from a file specified following the *add* command;

quit – to exit the program.

While that is a fairly short list, users of G7 will recognize that these commands cover much of the basic operation of the program. The main missing pieces are:

- enrichment of the graph command with vertical range control, saving and various options.
- other bank commands – *bank, cbk, hbk,* and *vam*
- extension of the *r* command with *con, sma, showt,* and the saving commands *sav* and *cat.*
- tabular display of items in a vam file
- matrix algebra on matrices and vectors in a vam file
- more functions for use in f commands.
- specialized regression commands *recur* and *sur*

I intend to work on these more or less in the order given.

In building models, G7 works with Build for macro models and IdBuild for multisectoral models. Both Build and IdBuild are pure command-line C++ programs and should convert to the cross-platform GNU compiler rather easily. I do not anticipate any major problems there.

Much recent work on G7 has concerned interaction with a spreadsheet program. Unfortunately, Excel was chosen instead of Calc so that none of that work can be carried over easily to the open-source environment, and I do not have on my personal agenda any plans for extension of Gwx in that direction.

■ Illustrations of Gwx at Work

I put some made-up data in a file called integers.dat and gave Gwx the command add integers.dat. Here is what I got in the Results pane, with the input set in bold italics:

 # Example with date on first line
data integers 1970
0 1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18 19
20 21 22;
tdates 1970 1990
tdateA input 1970

tdateB input 1990
Year 1970 Frequency 1 Period 1 Day 0.
Year 1990 Frequency 1 Period 1 Day 0.
type integers
Here is integers:

1970	0.0000	1.0000	2.0000	3.0000	4.0000
1975	5.0000	6.0000	7.0000	8.0000	9.0000
1980	10.0000	11.0000	12.0000	13.0000	14.0000
1985	15.0000	16.0000	17.0000	18.0000	19.0000
1990	20.0000				

 # Example without date on the first line:
data threes
1970 3 6 9 12 15
1975 18 21 24 27 30
1980 33 36 39 42 45;
type threes
Here is threes:

1970	3.0000	6.0000	9.0000	12.0000	15.0000
1975	18.0000	21.0000	24.0000	27.0000	30.0000
1980	33.0000	36.0000	39.0000	42.0000	45.0000
1985	–0.0000	–0.0000	–0.0000	–0.0000	1–0.0000
1990	–0.0000				

 # Example with date and all data on the first line
data fives 1970 0 -5 10 -15 20 -25 30 -35 40 -45 50;
type fives
Here is fives:

1970	0.0000	–5.0000	10.0000	–15.0000	20.0000
1975	–25.0000	30.0000	–35.0000	40.0000	–45.0000
1980	50.0000	–0.0000	–0.0000	–0.0000	–0.0000
1985	–0.0000	–0.0000	–0.0000	–0.0000	–0.0000
1990	–0.0000				

Handling of dates has been improved. Initially, G used floating point numbers to store dates. Annual dates looked like 2010, 2011, 2012. The four quarters of 2010 were expressed as 2010.1, 2010.2, 2010.3, and 2010.4. Monthly dates for January through December of 2010 looked like 2010.001, 2010.002, … 2010.012. The monthly dates looked rather strange, and the system could not be extended to daily dates, which become important in financial data. So a new system called GDate was devised and is available in G7 and Gwx, where it is implemented as a C++ structure, a ***struct***. Most of the coding here is new and simpler than in G7 for Windows.

A GDate can be specified by the user in any of the just-mentioned ways and also as shown by the following examples:

2010q1	the first quarter of 2010
2010m01	January of 2010
2010m07d04	2010 July 4

Note that the month and day must always be two characters.

When Gwx starts, a daily time series called *timed* is placed in the workspace bank. We can use it to illustrate daily dates and the *type* command with daily data.

tdates 1970m01d01 1971m12d31

```
tdateA input 1970m01d01
tdateB input 1971m12d31
Year 1970 Frequency 13 Period 1 Day 1.
Year 1971 Frequency 13 Period 12 Day 31.
ty timed
Here is timed:

1970 1
  1.000    2.000    3.000    4.000    5.000    6.000    7.000
  8.000    9.000   10.000   11.000   12.000   13.000   14.000
 15.000   16.000   17.000   18.000   19.000   20.000   21.000
 22.000   23.000   24.000   25.000   26.000   27.000   28.000
 29.000   30.000   31.000

1970 2
 32.000   33.000   34.000   35.000   36.000   37.000   38.000
 39.000   40.000   41.000   42.000   43.000   44.000   45.000
 46.000   47.000   48.000   49.000   50.000   51.000   52.000
 53.000   54.000   55.000   56.000   57.000   58.000   59.000
```

Note that the output looks a bit like a calendar, except that every month begins on a Sunday. Note also that the program knows that January has 31 days and that February of 1970 had only 28 days. It also knows the full rule for detecting a leap year. Daily data is given a frequency of 13.

Now here is real, quarterly data on coal usage introduced with the *matdata* command:

```
matdata 2009q1 21
CoalElec CoalCoke CoalOthInd CoalTotal
```

```
# The 21 in the first line means to skip the first 21 spaces
# on each       data line. A line beginning with a # is just a comment.
#                    U.S. Coal Consumption
#                     (Thousand Short Tons)
#       Year and        Electric Coke   Other       Total
#       Quarter         Power    Plants Industry
#
#
#2009
January – March                       236842      4398      12075      254383
April – June                          216502      3402      10542      231110
July – September                      244445      3450      11107      259621
October – December                    235838      4076      11590      252363
#
#2010
January – March                       246445      4857      12600      264939
April – June                          229469      5353      11914      247344
July – September                      267943      5491      12284      286361
October – December                    231195      5391      12490      249870
#
#2011
January – March                       234847      5188      12489      253541
April – June                          223540      5392      11036      240611
July – September                      261534      5407      11168      278638
October – December                    208637      5447      11543      226233
```

We can illustrate the f command with these lines:

```
f CoalSum=CoalElec+CoalCoke+CoalOthInd
f CoalResid=CoalTotal–CoalSum
f ShareElec=100.*CoalElec/(CoalElec+CoalCoke+CoalOthInd+CoalResid)
type ShareElec
```

with this result

Here is ShareElec:

2009q1	93.104	93.679	94.155	93.452
2010q1	93.020	92.773	93.568	92.526
2011q1	92.627	92.905	93.862	92.222

And we can now illustrate regression with a somewhat nonsensical example:

```
title Coal Used for Coke
```

r CoalCoke=CoalResid, CoalOthInd

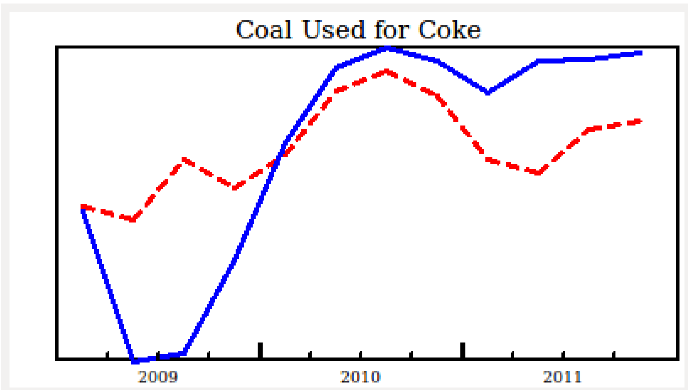
The result looks like this:
Coal Used for Coke
SEE=567.6 RSQ=0.870 RHO=0.735 DW=0.531

Variable name	RegCoef	Mexval	Elas	NorRes	Means
1 intercept	–162.19922	0.3	–0.03	7.69	1.00
2 CoalResid	–1.86559	12.2	–0.29	4.31	757.25
3 CoalOthInd	0.54496	107.5	1.33	1.00	11736.50

The graph of the fit is then obtained by
gr predic, depvar

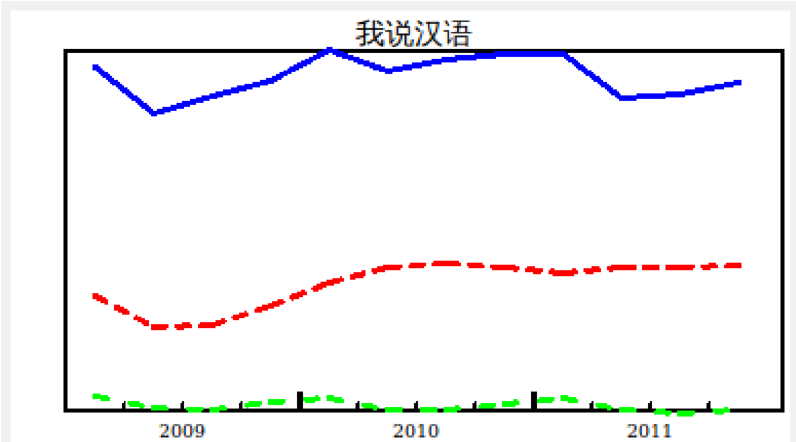
One tiny point should be noted: the comma between the two variable names. It is there because Gwx allows expressions in the list of items to be graphed, not just names of variables already in the data banks. Since spaces are legal in expressions, the comma is necessary to delimit the items to be graphed.

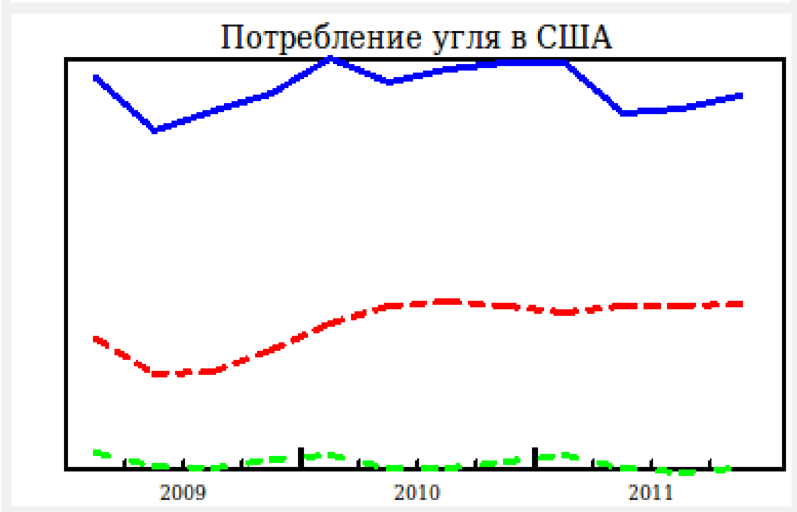
Here is the graph.



It is basically working, but it still lacks labeling of the vertical axis and the labeling of the horizontal presently works only with fairly short series of quarterly data. Moreover, the graph was not properly saved as a .png file but caught with a screen shot program. With a few days work, however, it should be a pretty competent graphing program.

Chinese and Russian colleagues may by pleased by these two graphs which were obtained simply by putting the Chinese and Russian on the *title* command.





This is somewhat less than I had hoped to have ready to present, but it at least represents progress on basics and shows that the project is still alive. Moreover, there is the 150+ page document *Tutorials on the Construction of Gwx, a Cross-Platform Version of G7* with 12 tutorials explaining the program thus far.

THE TRANSFORMATION OF REGION'S ECONOMIC AREA GOVERNED BY THE DEVELOPMENT OF INDUSTRIAL REGION

Bagautdinova N.G., Gafurov I.R., Novenkova A.Z.

■ Introduction

The progressive dynamics of macroeconomic indicators within the unbalanced region level speed activity characterize the present stage of Russia's socio-economic development. The increased strategic uncertainty and high chances of local crises are caused by numerous factors. Those are: the activation of globalization processes, the development of high-technology industries, the information's turn into manufacture's key element that stipulates the global economic area network, the growth of interstate and interregional resource mobility under low ratio of Russia GPD value adding sectors and its dependence on the export of raw materials.

In order to provide overall system stability and further implementations, the management should switch from the reflexive-situational to planned-strategic type. The latter embodies macro- and mezo-economic strategic initiatives and long-term projects. The strategies of regions' development inextricably entwine with the imperatives of the modern stage of state growth. It is predetermined by the global competition and modernization processes within global economic area. The macroeconomic level of Russia progressive dynamics and country's geoeconomic intentions generate a need for the economic area restructuring, the trace of advanced economic growth zones, and the realization of potential within businesses' innovations and investments domain. All the above mentioned would provide effective demand, balanced speed of economic growth and enable the increase of the regions' and federal districts' living standards.

The highly uneven development is peculiar to the national economic area. It entails the ineffective distribution of production factors, the maintenance and excess of interregional imbalances. The latter are reflected in the considerable gap between key mezoeconomic indicators, low number of competitive territorial industrial clusters and the underdevelopment of the infrastructures and life support sectors. The dynamics of socio-economic indexes variation illustrates the socio-economic development differentiation processes within certain territorial entities. This indicates that per capita GRP production fluctuation in a given time have increased considerably.

The issue of the national economic area differentiation is particularly represented within the regions with dominant industrial production GPD. It has been depicted in the decrease in demand for the products of real economy systemic enterprises' during the transformational shock and, inevitably, the unemployment in basic, service and axillary economic activity, the uprise of budget deficit and the social programs expenses sequestering. In order to form regional economic area "growth points", i.e. large industrial enterprises (within industrial and industrial-agricultural regions), one needs to maintain the resource potential and territory of certain businesses, to activate internal and external market competition, to single the development innovation model within the limited budget source of investment costs financing.

The lack of sufficient number of theories and valid methodology on the industrial enterprises and their complexes within the transformations of national and regional economic area, predetermine, to a large extent, the extension of intra- and interregional imbalance. This suggested the research line, its theoretical and practical significance.

■ Methods of research

In the course of the research the theories of regional growth and development were applied to. Namely, the neoclassical production function theories (G. Borts, Ch. Johns, H. Siebert, R. Solow, T. Swan, R. Hall); the cumulative expansion theory that comprises neo-Keynesian, institutional and economic and geographic models (J.R. Boudeville, H. Girsh, H. Lasuen, F. Perroux, P. Pothier, H. Richardson, G. Freedman, T. Hagerstrand, P. Hagget and others); new theories of regional growth that rest on the increasing return to scale and imperfect competition (D. Weinstein, E. Venables, A. Gilbert, G. Gagler, E. Glazer, D. Davis, L. Inn, P. Krugman, T. Mori, G. Myrdal, A. Pred, P. Romer, R. Fianm, M. Fudjita,

G. Harris, A. Hirschman, T. Holmes, G. Allison and others); new forms of enterprise territories resting on the industrial and regional clusters, the value-added chain, training economy, national and regional innovations (A. Anderson, B. Ascheim, G. Danning, A. Isaksen, B. Jonson, M. Lorenzen, B-O. Lundvall, G. Mantsinen, P. Maskell, M. Porter, E. Reinert, S. Resenfeld, M. Storper, K. Freeman, G. Humphrey, H. Schmitz, M. Enright and others). The basic principles of the research rest on the economic base theory proposed by P.L. Kurt and V. Sonbart, the staple theory by H. Innis, the sectors theory by A. Fisher, K. Clarsk, J. Fourastie, the flexible specialisation theory Ch.F. Seybi, the "input-output" model by V.V. Leontiev, the production allocation model by J. Tinbergen and H. Bos and others.

The methodologies and the character of research attributed to the modern economy fail to monitor and explain current changes. The scale of economic area transformation requires the resort to the interdisciplinary correlation and exchange and the application of theoretical tools.

Thus, foreign and national experience adapt to the regional economic area terms and postindustrial challenges. The national economy development within postindustrial times placed a priority on the maintenance and implementation of the industrial enterprises potential.

The target of the research is to formulate theories, methodologies and practical guidelines that contribute to the transformation and restructuring of the region's economic area by the development and implementation of the industrial enterprises potential.

The research rests on the modern economy approaches and hypotheses on the regional administration, geopolitics, productive power distribution, network economics, the growth of manufacturing regions and clusters. It also considers materials on the identification, structuring of the economic area, its formation and transformation mechanisms backed by the state, the regularities of industrial markets performance.

The information base of the research comprises data by the official federal and regional statistical offices.

■ Theory

In the frame of the research the regional economic area is defined as territorially detached set of transactions within which the economic agents (such as households, profit oriented businesses, state, local community) perform property rights for production factors and results. This ensures their interests implementation. The economic area quality is governed by the combination of its characteristics and static and dynamic properties, which correspond to agents' needs and strategic interests. The basic properties rest on the following principles: to activate the uniform economic area as a system (fractality, variability, stability, self-organisation, priority and integrity); to correlate economic area and external environment (cohesion and availability); to correspond to the external environment (balance, optimality, goal orientation, innovativeness, response).

The economic area configuration is determined by the correlation of 3 core elements. They are:

1) transactions that perform property rights;

2) economic time, which is relatively manifested in the transactions correlation;

3) institutions or (non-) formal transactions interwork limitations.

The economic area concentration level is constituted by the private/ agents' transactions ratio. The higher is the concentration, the less time is required to complete transaction. Its duration is generally caused by the deviation from limitations which are imposed by institutional environment.

The development of the region's economic area may be viewed as a fractal model of innovations distribution. The model suggests fluctuation- idea that appears in science as a result of fundamental researches, R&D, bench-marketing analysis or other studies. The fluctuation idea is substituted first by innovations, then, by fractal clusters (sets of basic, associated, support, expanding and clarifying innovations), and, finally, by multifractals. The latter provide change within one functional area that result in cascade transformations, innovations diffusion and generate an array of new phase fractals, accordingly.

The region's economic area is irregular due to the configuration distortion brought by innovations. This irregularity prevents the growth if economic area divergence caused inefficient resources allocation. Or it contributes to it if transactional interaction of inter- and intraindustry carries growth impulse.

The interaction of increasing return to scale within imperfect competition, transport costs dynamics and businesses resources mobility provide growth points formation that give rise to zones of advanced economic growth. The latter carries out clusters initiatives in efficient institutional environment. The growth centers follow 4 development stages. Those are:

1) the large number of local cores with little influence on the surrounding territories;

2) a growth pole (1 powerful core) with large-scale influence;

3) the polycentric growth poles;

4) poles' merge into urban linear structure with powerful periphery.

The peripheries (outside development frames and axes) emerge as a result of innovations diffusion. First, they mark the difference between innovations distribution sources and peripheral establishments, then lessen the number of differences as the fast-growing centers in distant regions arise. At the condensation stage they cause balanced development speed, whereas the saturation stage is described by the slow asymptotic rise to the highest point. The regularity of the diffusive distribution of innovations as the source of region's growth is proved by the socio-economic development of the Republic of Tatarstan. Here the south-east industrial district, urban agglomeration, oil and petrochemical industries were initiated as a result of oilfield strike in the second half of the XX century. At the present stage of development the techno parks that are being established and supported by the government and business community (OAO "Innovatsionno-proizvodstvenny tehnopark 'Ideya"; industrial platform KIP "Master"; high tech park (IT-park) and "Himgrad" technopolis) serve as growth points and territorial production agglomeration factor.

Admittedly, the considerable number of theories that reveal growth points' origin fails to present innovations diffusion mechanisms beyond axes of economic area development. The present research describes an organizational and economic mechanism that conveys growth impulses. It consists of core enterprise and service entities that reduce the amount of wasteful expenses within the allocated industrial district. The expenses include affiliated credit and insurance organisations, outsorting companies that specialize in business planning, marketing research, valuation of property and a set of consulting services, techno parks and technopolises. In this case the core enterprise is able to control service entities that operate by means of network interaction (i.e. joint directorate and other mechanisms). Moreover, the enterprise (the district core) establishes the following forms of organizational control that covers innovations' life cycle. The forms are as follows: investment control that provides service entity with absolute property, administration or operation of physical, financial resources represented by direct or portfolio investments. They are applied to in financing or crediting within R&D domain; information control that provides service entity with extra resources, represented by the results of intellectual activity, consulting, and market or other type of relevant information that is essential for services within civil-law contracts (commercial concession, license contract, etc.); resource control that provides service entity with communication network and rooms on easy terms (renting).

With this set of control tools at their disposal the industrial region's core enterprise is empowered to affect the service entities' strategies and tactics within the existing module structure. The region's core receives R&D results and information as the feedback in case it offers crediting, banking, insurance, consulting facilities. The industrial region module organization formed accordingly, introduces specialized businesses' advantages and favours cumulative regional growth.

■ Results

Industrial districts reach the form of advanced growth zones in the frame of development strategies hierarchy. It reflects the interaction of regional economy paradigms, economic area development stages and structural elements of the region's territory.

The industrial districts within complex hierarchical system, i.e. region's economic area, appear to be synergetic innovations that transform region's as well as adjacent industries and territories. Should this factor be omitted at the design stage, the industrial districts' (i.e. the multifractal's) allocation and development expectations fall short. The territory allocated entities strategic control model serves as a mechanism to support the industrial district's development and the fluctuation-idea implementation. The model is based on the economic synergetics paradigm; it creates synergetic effect by means of positive and negative feedback of industrial district's constituents. This provides the internal coherence (i.e. changes' control) and project's external synchronization (i.e. development control) of the object under control. The coherence within strategic control stages realization would increase the synergetic effect of innovations. The phases' synchronization is achieved through the object's changes' control mechanism. The basic functions of the object are as follows: formation of innovations susceptibility on each level of innovations process, including scheduling and work progress control; compensation of stages delay, resources budgeting and reservation.

Project's external synchronisation is performed in 2 ways:

1) environmental adaptation;

2) external dynamics reached through the flow of innovations.

In the course of time, following the increasing uncertainty factor, planned synchrony is lost when exposed to close and distant environment. The level of environmental uncertainty may either be continuous or incontinuous. The former corresponds to the stable, reactive or warning state, and the latter relates to the research or creative states, respectively. Changes within external environment of industrial district belong to 2 categories:

- structural change of the object under control that arise from distant environment impact;
- substructural change of the object under control that are caused by close environment impact.

In frames of the present research the regional economic area differentiation is defined as a source of economic growth. The excessive polarization, however, may cause fast decrease of its potential and activate state regulation measures that depend on the configurations of spatial organization.

The regions are grouped according to the levels of economic development. The classification is performed in several consecutive steps. They are:

1) the degree of Russia average deviation of arithmetic mean value of average per capita corrected GRD that is produced and utilised, and similar deviation of produced and utilised GRD balance;

2) regions distribution within 50% deviation groups;

3) problem regions selection; 4. regions' classification.

Table 1

The industrial districts' formation within region's economic area

Region's development stages	Region's economy development strategies	Environmental uncertainty level	Region's economic area development stages	Region's spatial structures		
				transactions	time	competition
Preparation (formation)	strategic planning, control by strategic positions	continuous	formation	integral	processes synchronization	Economic competition
Establishment (product adaptation)	control by strategic tasks ranging	continuous	development	optional	Processes acceleration	Processes merge
Organizational economy (production adaptation)	low signals control	continuous	recession	stabilising	Processes deceleration	Processes development
Effectiveness (new industrial district foration/ breakdown)	strategic chances control	incontinuous	depression	disintegrated	Processes desynchronization	Processes stabilization

Should the range of deviation be above 50%, but produced and utilised GRD – negative or zero, the region is classified as problematic. Subsequently, experts define 4 groups of regions: highly developed – above 150%; developed – 100–150%, less developed – 50–100% and problematic – 0–50%.

The first group is not found in the Volga federal district. Mezoeconomic indicators deviate above 150% in the regions where economic development depends on the presence of industrial districts that distribute synergetic innovations. The policy of government regulations should include measures to budget regional investment fund (by saving part of positive balance) in order to diversify region's economy. Structural reforms in economy would prevent region's economic area distortion, i.e. to prolong life cycle of advanced growth zones and innovations' multiplier effect, to turn to multifractal model of innovations distribution.

The 2^{nd} group (mezoeconomic indicators deviate to 100–150%) includes the Republic of Tatarstan, the Perm territory, the Samara and Orenburg regions, the Republic of Bashkortostan, the Nizhni Novgorod region (in descending order in the Volga federal district). In respect of regions that locate 1 or several industrial districts that are being formed or pass product or production stages, the state policy is supposed to:

1) restructure economic area by stimulating businesses' innovation activity within the realization of complex regional industries and target programs;

2) master territory's tax and rent income primary distribution between federal centre and region;

3) develop the production sharing system;

4) provide conditions for small and medium business development;

5) develop institutional environment that ensures effective transactional interaction among industrial districts.

The Volga federal district contains following territories of the 3^{rd} group (mezoeconomic indicators deviate to 50–100%, decay stage) the Udmurt Republic, the Saratov region, the Chuvash Republic, the Ulyanovsk region, the Republic of Mordovia. The state policy is supposed to:

1) fasten the restructuring of the businesses resource potential by government guarantee financing of new investments;

2) develop projects of public private partnership (concession agreements, state contracts, financial leasing, production sharing agreements, etc.);

3) conduct active policy on labor market in order to reduce structural unemployment.

The Volga federal district contains following territories of the 4^{th} group (mezoeconomic indicators deviate to 0–50%, no industrial districts) the Kirov and Penza regions, the Republic of Mari El. The government is to be actively involved in order to decrease the level of economic area polarization. The state influence is likely to: increase development budget financing of production and social infrastructures, direct and portfolio investments of registered and new enterprises; create positive institutional environment for small and medium business; current federal financing assistance in order to supply and compensate costs in frames of Federal reform of certain social sectors.

According to the research, supply factors are functionally dependent on agglomeration effect. The latter states that transport costs preserve localization within certain centers of investors' activity, resource market price variations within regional and national economic area and region's institutionalization level.

As a form of regional economy industrial enterprises and services integration, the industrial district is formed due to the scale effect increase of enterprise and regional market. The district is characterized by: overall / partial assets management set on the agreement; concerted production; external contract business processes (such as operational: supply, marketing, sales; and supporting: recruitment, technical support, business activity analysis); maintenance of separate legal entities status of industrial district's participants. Industrial districts are empowered to combine network results of service and ancillary activities with region forming enterprise core products by means of businesses basic competences synergism. The competences include: technical and technological, sales logistics, marketing, human capital, financing, organizational, scientific research, informational, entrepreneurial and floating capital.

Businesses basic competences and synergetic types classify forms of interfirm network territorial structures that constitute any industrial district. There are following types: operative and sales structures (enterprises' external interaction competences merge: informational, sales logistics, marketing); financial and management structures (financing, organizational and entrepreneurial competences merge); deep complex structures (technical and technological, scientific research, human and floating capital competences merge).

The postindustrial economy predetermines the increasing role of production services and innovations diffusion. This explains the industrialization of ancillary businesses within industrial district. They include: R&D, consulting, transport, banking and insurance organizations. Industrial enterprises make contracts with organizations of abovementioned services in order to fulfill a number of intentions, namely, to advance strategies (to cut expenses and increase effectiveness); to create strategic business impact (to improve contribution into companies within present business lines) and commercial realization of assets (to focus on the economic evaluation of technological assets).

The present post-crisis stage of Russia economy presents the following key problems for regional industrial enterprises:

1. highly depreciated assets;
2. irrational structure of manufacturing supplies;
3. application of traditional administration models to the informational economy;
4. strategic and tactic administration decisions notwithstanding the specifics of base district (i.e. range of infrastructure facilities, informational infrastructure level, mobility and amount of resources, district's transport accessibility).

Table 2

The matrix of industrial enterprise development strategy choice considering key characteristics of base district

District type / innovations infrastructure level	Old industrial district	New industrial district	Pioneer industrialization district
High	Expenses leadership strategy based on technological innovations	Diversification strategy based on innovative products supply	Focus strategy based on production of expenses dominant innovative products
Middle	Expenses leadership strategy based on administration innovations	Diversification strategy based on improved products supply	Focus strategy based on realization of production innovative technologies
Low	Expenses leadership strategy based on present technologies modernization	Diversification strategy based on improved procedures of products realization	Focus strategy based on realization of sales innovative technologies

All the above mentioned factors considered, industrial enterprises raise effectiveness and, thus, develop methodological approach to establish rational strategy of industrial business growth with respect to base district specifics. The key parameters that reflect base district specifics (i.e. its type, (innovations) infrastructure level,) and strategies of enterprises development (diversification, leadership and focus on expenses), in our opinion, would contribute to the effective businesses growth. Table 2 presents the matrix of industrial enterprise basic development strategy choice considering key characteristics of base district.

The matrix of industrial enterprises development strategy choice considering their location is based on the results of the held correlation analysis of industrial businesses economic activity indexes and the type of development strategy applied district-wise.

■ Conclusions

Forecasting results of the application of the methods introduced in the course of the research we resorted to OAO “Kazan Engine-building Production Enterprise” (OAO KEPE). The following scenarios were considered:

1. Low risks scenario – the introduced methods and mechanisms penetrate on an even basis and are completed in 3 years (in the estimation of specialists, realization chances are 10%).

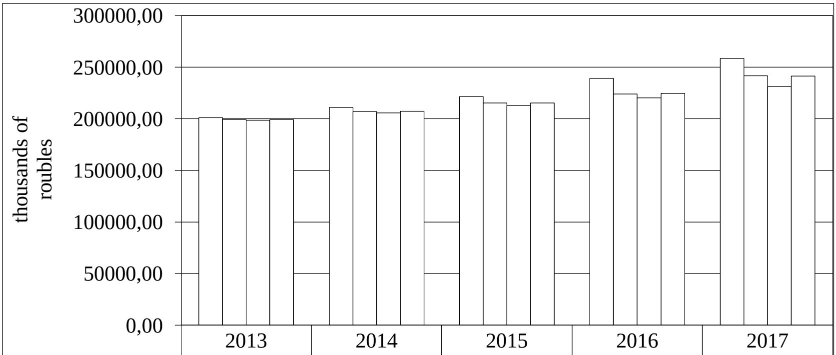
2. Risk scenario – the introduced methods and mechanisms penetrate discretely, influenced by external risks and are completed in 4 years (in the estimation of specialists, realization chances are 70%).

3. High risks scenario – the introduced methods and mechanisms penetrate discretely, influenced by external risks and are completed in 5 years (in the estimation of specialists, realization chances are 20%).

4. Weighted scenario represents a weighted average estimate of enumerated scenarios.

Forecasting results are depicted on Fig. 1.

According to the figure, the realization of introduced methods and mechanisms guarantees effective operation of the industrial enterprise. This leads to the increased regional budget income of the Republic of Tatarstan. As compared to the inertia development of given enterprise as described in the present research, weighted scenario provides enterprise with extra 40 mln roubles of net profit within 5 years.



	2013	2014	2015	2016	2017
□ low risks	200954,56	211002,29	221552,40	239276,59	258418,72
□ risk	199076,48	207039,54	215321,12	223933,97	241848,68
□ high risks	198700,86	205655,39	212853,33	220303,20	231318,36
□ weighted	199189,16	207158,99	215450,69	224742,08	241399,62

Fig. 1. OAO “KEPE” 2013-2017 net profit forecast

The obtained results prove the methods and mechanisms introduced to be effective and serve as key factors of region’s economic area restructuring.

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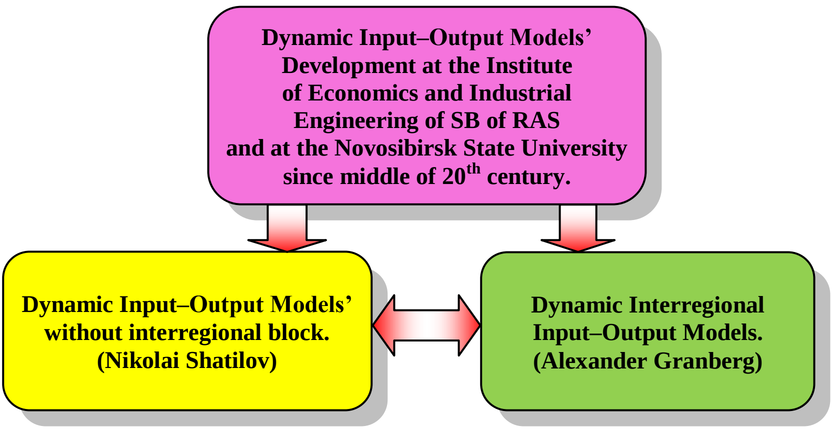
THE SYSTEM OF DYNAMIC INPUT-OUTPUT MODELS FOR FORECASTING THE DEVELOPMENT OF RUSSIAN ECONOMY AT THE NATIONAL AND REGIONAL LEVELS

Alexander Baranov, Victor Pavlov, Victor Suslov

■ Introduction

In the mid-sixties of the XX century, the Institute of Economics and Organization of Production Planning of the SB RAN and Novosibirsk State University started work on developing spot dynamic input-output models and interregional dynamic input-output models. Historically, this work has been developing in two directions by two groups of researchers. The first research team lead by A.G. Granberg created an Optimization Interregional Input-output Model (OIIM) and it various modifications. The second research team created by N.F. Shatilov and later headed by V. K. Ozerov worked on developing spot dynamic input-output models and it various modifications.



Graph. 1. Two directions of research using Dynamic I-O Models at the at the Institute of Economics and Industrial Engineering of SB of RAS and at the Novosibirsk State University.

■ **KAMIN System is the system of models used for forecasting the development of the economy at the national level.**

KAMIN System (the system for making a comprehensive analysis of intersectoral information) consists of the following main elements [1].

1. A dynamic input-output model for forecasting production and using the total output of the national economy with a distributed construction lag (MODI).

2. A model for prices forecasting (MOD2).

3. A Model for forecasting financial flows between financial entities /agents (MOD3).

4. A Monetary Block Model (MOD4).

5. A Model for forecasting ecological processes (MOD5).

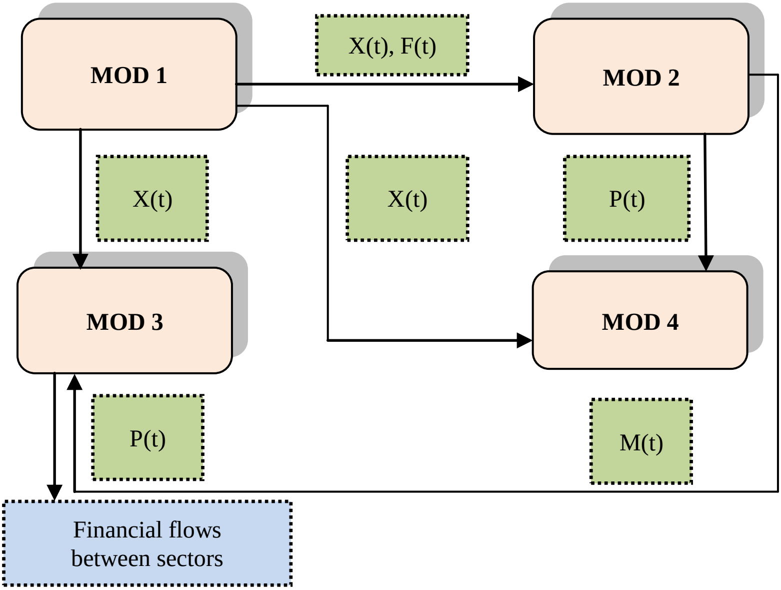
6. A model for forecasting incomes and expenditures of the federal and consolidated budgets (MOD6).

7. A dynamic input-output model with a balance-of-payments block (MOD7).

All the models included into the KAMIN System can be described in terms of fuzzy sets.

It is possible to carry out macro-economic analysis and forecast the consequences of applying a particular monetary or fiscal policy applying MOD1, MOD2, MOD3 и MOD4 models. A general interaction scheme of the above-mentioned four models in the process of economic analysis and the composition of information flows in the KAMIN System can be described as follows.

Variant 1. An input-output model for forecasting economic development, which takes into account the technological capacities of a sector (MOD1), calculates the dynamics of industrial indices in comparable prices. The trajectory of changing economic indices serves as a basis for all the other models. At the input to the model, control exogenous variables characterizing the dynamics of the investment activity, dynamics of change of the technological parameters in industries and the dynamics of the number of people involved in production are set. At the output from the model, the dynamics of the output (*X(t)*) and fixed assets (*F(t)*) in each of the industries are measured in comparable prices (see Graph. 2).



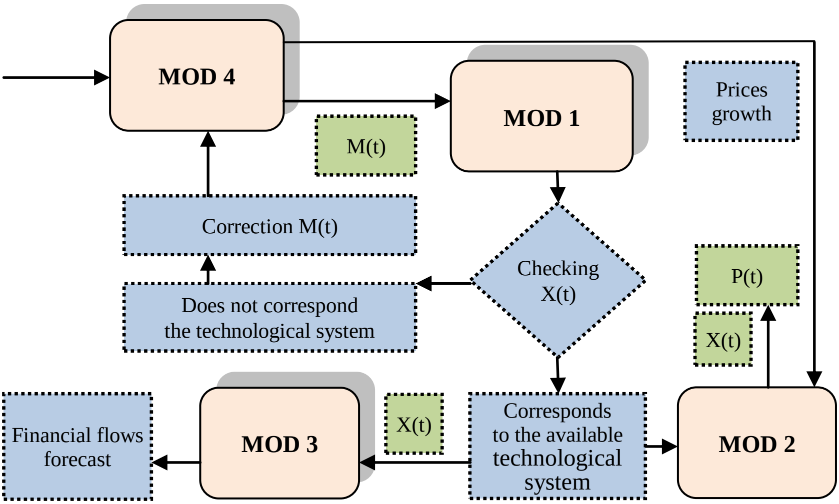
Graph. 2. Calculations in KAMIN System according to Variant 1.

The model of calculating the dynamics of sectoral prices (MOD2) determines the trajectory of sectoral prices change rates (*P(t)*) in relation to the comparable ones. At the input to the model, along with the trajectory calculated by the first model, there are data sets that describe the dynamics of such sectoral cost indices as remuneration of labour, profit, indirect taxes, the norms of industrial wear and tear, the composition and size of material expenditures. At the output from model there is a set of industrial prices change rates of end use.

The model for calculating the dynamics of financial flows (MOD3) forms the balance of incomes and expenses for each sector of the national economy /in the nomenclature of SNA sectors (Structure of National Accounts)/ or each type of economic activity /in the nomenclature of NACE (National Classification of Economic ACTIVITIES)/ depending on the necessary degree of specification of the financial activity analysis. At the input to the model there are sets calculated in accordance within the first and the second models as well as the dynamics of the structure of the payments matrix between the entities of economic sectors or types of economic activity. At the outcome there is a dynamics of the amount of payments matrix.

The monetary block model (MOD4) caries out a calculation of the required volume of money supply necessary for the functioning of the economy. At the input to the model there are sets calculated on the basis of the first two models. At the outcome there is a required dynamics of the volume of money supply.

Variant 2. The inclusion of the monetary block makes it possible to solve an inverse problem in the KAMIN System that consists in evaluating the consequences of changing the volume of money supply and other monetary parameters for the dynamics of both nominal and real gross output (measured in comparable prices) and the dynamics of prices (Graph. 3).

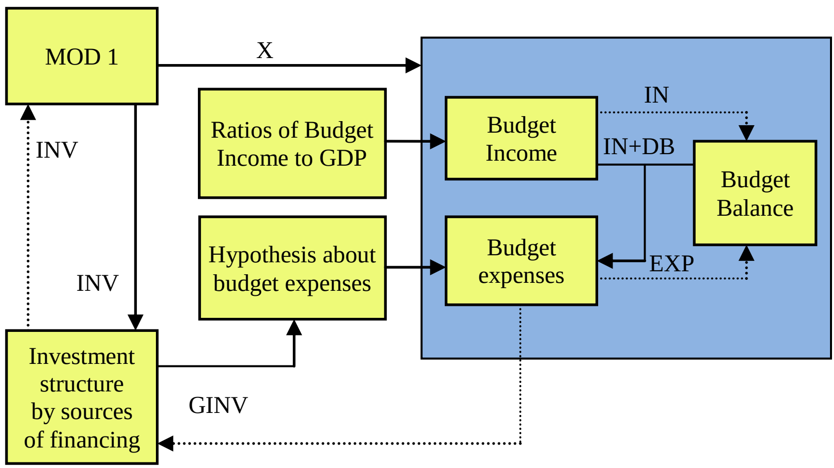


Graph. 3. KAMIN System calculations based on Variant 2

The anticipated dynamics of gross output in target prices that would correspond to the condition of a simultaneous equilibrium in the markets of money and goods is calculated within MOD4 model, with the dynamics of the volume of money supply, exchange rate of ruble to US dollar and interest rate in the forecasting period specified exogenously. This calculation is carried out with the help of regression equations, verified by retrospective information, that describe the connection between the gross output and the variation of monetary and other factors specified exogenously. MOD1 model makes it possible to carry out an industry “sweep” of the gross output in comparable prices and test the validity of the received value of gross output from the point of view of the possibility of realizing its dynamics calculated within MOD 4 in the framework of the existing technological system and considering its changes in the forecasting period. For example, receiving the gross output growth rates calculated within MOD4 would require an unrealistic increase of the size of fixed assets and labour resources in the forecasting period. MOD2 model makes it possible to “expand the vector” calculated within MOD4 according to the elements of the cost structure and to describe the price dynamics in the forecasting period.

MOD3 forecasts the size of financial flows between the sectors of the national economy (or types of economic activity) based on the results received within MOD4 and MOD1.

The interaction of KAMIN System models with the budget block is illustrated in Graph. 4.



Graph. 4. The interrelation of the budget block and the dynamic input-output model

The construction of the dynamic input-output model budget block gives additional opportunities for the practical application of this type of models for forecasting the development of the national economy. State government bodies receive an opportunity to justify consolidated and expanded budgets more thoroughly. The income part of the budget can be estimated on the basis of projections of the dynamics of gross output of national economy sectors and their cost structures. On the other hand, an opportunity arises to assess the impact of different variants of state expenditures on the economic development dynamics at the macro and sectoral levels.

On the basis of the parameters calculated within the dynamic input-output interregional model and accepted standards, the income part of the budget block is calculated. After that, on the basis of the implicit hypothesis related to the composition of expenses of the expanded budget, the expenditure budget is estimated that includes the size of investments into fixed assets financed from the budget *GINV* (as the main parameter in the dynamic input-output model within the budget block).

Moreover, the redistributive operations fulfilled within the expanded budget increase total expenses on final consumption and change the composition of aggregate demand and, consequently, are reflected in the composition of gross output of the national economy. The consideration of this factor will make it possible to fully reflect all the connections (both direct and reverse ones) between the budget of the expanded government and gross output. For this purpose, the following parts can be singled out in the budget expenditure block:

1. Investments into fixed capital: *GINV(t)* financed from the budget.

2. Expenses connected with servicing state debt, *D(t)*.

3. Expenses connected with organizing socio-cultural events: *SOC(t).* This part is supposed to be covered out of non-budgetary funds and expenditures of the consolidated budget on socio-cultural events.

4. Other expenses:

$$OEXP(t)=EXP(t)-GINV(t)-D(t)-SOC(t),\ t = 0,\ldots,\ T \quad (1)$$

where *EXP(t)* is the total volume of expenses of the expanded budget.

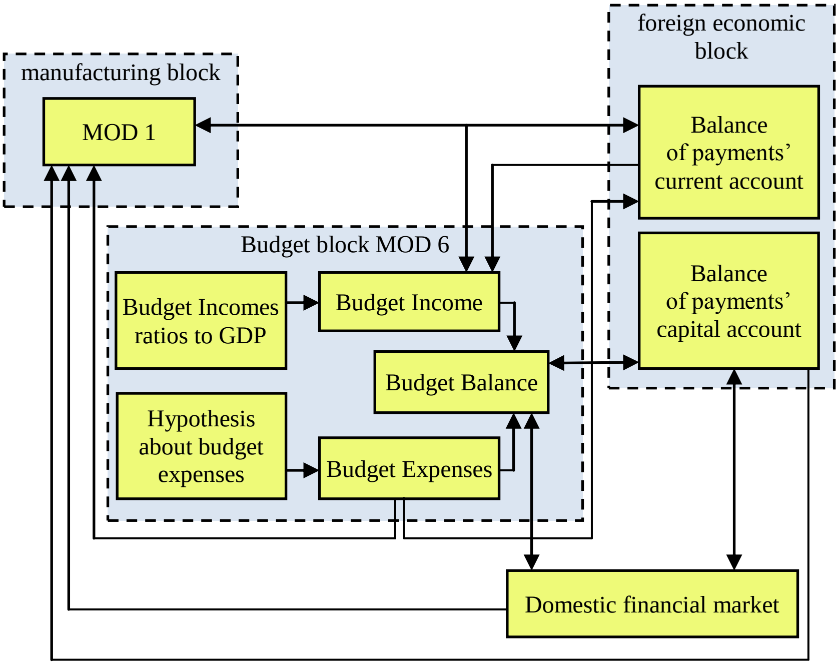
In this setting, the parameters of the dynamic input-output model in the budget block are controlled only by the size of investments into fixed capital financed from the budget.

At the input to the dynamic input-output model, the value of cumulative investments into fixed capital is introduced. It is calculated from the following equation:

$$INV(t) = GINV(t) \,/\, dgi(t)\,, \qquad t = 0, \ldots, T, \tag{2}$$

where *dgi(t)* is the share of investments into fixed capital financed from the budget in cumulative investments per year *t* (specified exogenously).

Graph 5 schematically illustrates the interrelationship between production, budget, and the rest of the world (foreign economic block) in the economy.



Graph. 5. Interrelationships between foreign economic, production and budget blocks of the economic system

Let us now focus our attention on the influence of external economic shocks on the budgetary subsystem and the development of the economy.

The variation of export arising due to a change in demand and/or prices on exported goods and services of a particular country in the world market leads to changes in budget earnings. For example, the reduction of export leads to a decrease of export duty receipts (see the arrow connecting the current capital account of the balance of payments and the expanded budget incomes, graph. 5). In its turn, the reduction of export is likely to lead to a decrease of production primarily in export-led industries (see the arrow from the foreign economic block to the production one). The latter will result in the reduction of VAT receipts in the budget, the reduction of profits tax, reduction of income tax paid to the employees of exporting enterprises and so on. As a consequence, there may be a growth of budget deficit or a reduction of budget surplus. If there is a growth in export, the reverse processes are observed.

Let us turn to capital account of balance of payments financial instruments. Direct investments affect production, contribute to its growth and provide growth of budget earnings (see the arrow going from capital accounts and financial instruments directly to the production block).

The influence of external shocks on the budgetary system connected with the movement of speculative capital has a more complicated character. The inflow of capital through the financial market (portfolio investments) increases the capacity of enterprises to finance their development and promotes economic growth (see the arrow pointing from the capital account of operations and financial instruments to the financial market and further to the production block). As a result, production grows and tax revenues in the budget increase.

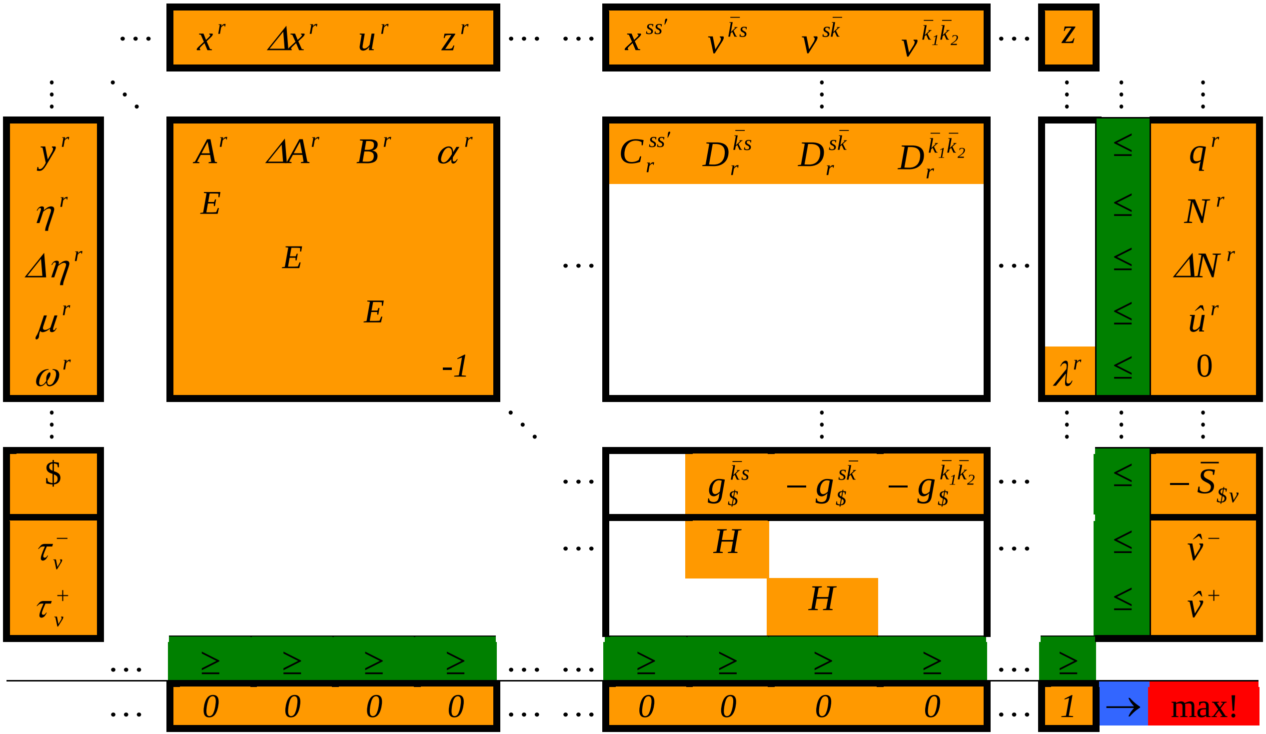
Moreover, when foreign portfolio investors buy state bonds in the financial market, they partly carry out debt financing of the state budget deficit. Sudden changes in the world financial markets that lead, for example, to a mass sale of corporate and state securities of a particular country contribute to the increase of interest rates and a decrease of the exchange rate of the national currency. Both the impacts have the opposite effect on production. The growth of interest rates decreases the economic activity, while the devaluation of national currency stimulates export, reduces import and, in the long run, promotes the growth of net export. The ultimate result of the impact of such external shocks on production depends on the correlation of the above-mentioned consequences.

■ Optimization interregional input-output model and its modifications

Optimization multi-regional input-output models (OMIOM) were proposed by A.G. Granberg in the sixties of the XX century. In more than 40 years of their existence and application, their structure and application methods in the theoretical and applied analysis they have significantly changed. However, their essence has remained unchanged: regional input-output models are united into linear-programming constructions with the help of interregional relations (of the transportation problem type) and conditions for equalizing regional consumption levels of the population and state (scalarizing vector of regional goals).

In some separate segments, these constructions linearize non-linear dependencies. In this way, in modern modifications of the models, the dependence of the investments made in the last year of the forecasting period on total investments into fixed capital, the dependence of investments on production capacity growth, the dependence of world market prices on the size of export and import and some other dependencies are non-linear. (It is natural for Russia as an important country on a world scale).

The limitations of the direct problems (in order of their presentation in Graph 6) are: the balances of production and resources (labour and investment ones), restrictions of available production capacities, of the growth of production capacity, restrictions of investment growth, of the territorial structure of non-production consumption, foreign trade balance, restrictions of export-import quotas. The limitations of the dual problem are: conditions of break-even production under the available capacities and under the available capacity growth, break-even of investments, non-production consumption, interregional product transportation, export-import delivery, and international transit.



Graph. 6. The model regional block

This is a new presentation of the optimization interregional input-output model. Along with ordinary variables (size of production, capital investments, non-production consumption, interregional transportation, export, import, international transit) and limitations of the direct problem (balance of products and resources, production capacity, foreign balances and quotas), special role is given to variables (prices of production and resources, tax rates on profit and turnover, exchange rates, export-import duties) and limitations of the dual problem (financial balances of current and investment activity, household and state consumption, interregional and foreign trade transportation).

The possibility of “price” interpretation of so-called unbiased appraisals of product balance (dual variables) is connected with the fact that in the model with open foreign trade (at present it is the main variant of the model) internal prices (dual assessment of production, i.e. the same unbiased appraisals of production balance) differ from the external or world ones by the size of export-import duties (due to which they are “tangible in content”): for exported goods they are lower than the external ones by the size of export duty, for imported goods they are higher by the size of import duty. At the same time, external prices in the model are “semi-exogenous): they are given but they are somewhat elastic to the volumes of Russian export-import.

As a result, the variables and limitations of the direct and dual problem of the optimization interregional input-output model create an integral theoretical-methodological concept of national spatial economy within the system of world economic relations. An important role in it is played by macro-financial aggregates that depend on variables of both direct and dual character and that create macro-financial balances. The latter show the dependence between “investments” of particular regions into national consumption and actual regional consumption. These dependencies are balanced by surplus macro-aggregates of interregional and foreign trade exchange. The realization of these macro-financial balances is guaranteed by the characteristic of complementary non-rigidity of optimal designs of linear-programming problems.

Unfortunately, in essence, these models are “subjectless”, they represent the field of possibilities for economic games, but not the economic games themselves. In fact, they (the models) consist of strict limitations, i.e. “laws of economic matter conservation”: in the region it is impossible to use more (products, services, resources) than are available and all that is available should be somehow used (loss is also viewed as a form of use).

One the directions of applying the models under study is building scenarios for socio-economic development of spatial economy (of the world economy, the economy of the USSR, Russia, and Siberia in applied works). In recent years, serious attempts have been made to increase the adequacy of applying the models to this and other problems (by introducing non-linearity into the dependencies of introducing production capacity on investment size and dependencies of world market prices on the volume of Russian export and import). Due to this, models begin to represent a real border of the area of acceptable states, and a change from one scenario to another is fulfilled by changing a small number of parameters rather than by a full rearrangement of many hundreds of borders into separate variables.

In constructing development scenarios, the main meaningful role in carrying out calculations is played by a group of experts in industrial and structural-functional problems. Expert teams have their own ideas about a possible course of events in their area, as they have expert information, local forecasts expressed in terms of variables both at the input to and output from the model. One of the tasks facing "model implementators" is to transform expert data into information to be fed into the model and, after the problem is solved, to transform the model output information into the formats that would be understandable for experts. However, experts and "implementators" usually use interface models of different types: models of direct calculation, imitational, economic, network models, etc.

Experts and their teams, proceeding from the set goal and scenario conditions (aims, problems, concepts, threats and challenges) and expert data, formulate an input to the optimization interregional input-output model. If the model solution transformed into expert data formats does not contradict initial goals and scenario conditions of none of the experts, the forecast is considered to have been formulated. The scenario reconciles the views of all the experts involved, i.e. local forecasts.

In reality, such a coordinated forecast is a result of long work in the course of which the experts adjust (coordinate) their opinions (set goals and scenario conditions, i.e. local forecasts), while the model represented by the group of specialists “leading it” plays the role of some central expert council. In order to get coordinated decisions on the central scenario, the optimization input-output model is made up several thousand times, and dozens of expert brainstorming meetings of the “leading team” and “exploiters” are held.

In 2009–2010, research on medium-term and long-term post-crisis development of Siberia and the whole of Russia was carried out. As a result, scenario conditions researched to varying degrees were prepared with the help of the optimization input-output model. To the full, model calculations were fulfilled for the central variant of development – the inertial scenario.

The ideas about a post-crisis world organization are still very vague. As the history of Genoese, Bretton-Woods and Jamaica agreements shows, the new order will be determined in five to ten years of post-crisis development, i. e. by the end of the 10^{s} – beginning of the 20^{s} of the XXI century. Oversimplifying the situation, all the multitude of possible development scenarios can be concentrated into two extreme ones:

A scenario – the world will resume its “normal course”;

B scenario – the world will become totally different.

The world order is determined by four major characteristics: the role of the dollar, oil, state and innovations. The “normal course” is: dollar is (almost) world currency, oil is the main good “managing” world financial flows, state is liberal, innovations are insufficient because decision makers focus on current momentary tasks.

The Russian development scenario within the framework of world scenario ***A*** can be called inertial or energy and raw materials-dependent, but with lower growth rates than under the energy and raw materials-dependent scenario of *the Concept of Long-term Development of Russia by 2020* (CLD) made by the Ministry for Economic Development, a little higher than for world economic development on the average. The share of the extracting sector in the total output will slightly decrease; the share of Siberia will continue to fall, with a symbolic increase of the Far East share.

This scenario will be carried out under the passive position of the Russian government that has existed until the present time: words about economic growth, innovations and development of the eastern part of the country are not supported with real actions.

Under this scenario, the economic development of Russia and Siberia assume a stable inertial character. In the long term, Russia will keep its position of an “average” country and will continue losing its national sovereignty. However, it can be assumed that, given a radical activization of state policy in this situation, an innovational scenario could be realized.

The situation would be quite different under scenario ***B*.** Russia would appear in an unstable position. If adequate measures are not taken, in the long term it will “slide down” to destruction and disintegration (a catastrophic development scenario). The main reasons for this will be a considerable fall in demand for natural resources and acceleration of world economic development based on high and research-intensive technologies. However, given Russia undertakes serious steps, the prospects for its development can be more than favourable (innovational scenario).

Under the catastrophic scenario, growth rates would fall and appear lower than the world average ones, macroeconomic rates would be suspended and the share of Siberia in total output would markedly decrease, with the share of the Far East being unchanged.

The hope for Russia to become one of the world leaders would be lost forever. The Russian state, which in the XVI–XVII centuries expanded from the Volga to the Pacific Ocean and farther, can return to its previous size only in 20 to 40 years giving rise to a whole multitude of pseudo-states, which would, to varying degrees, depend on developed countries and transnational capital.

The opportunity for realizing the innovational scenario will appear only in case the Russian government comes from slogans to real actions that will stimulate:

1) economic growth as a result of which the share of accumulation in GDP will grow from the present 18–19% to a minimum of 25–30% (in China this figure exceeds 40%);

2) research and development including corporate and technological update and innovations that would increase expenditures on research and development in relation to GDP up to 3–4% (4–5 times), the share of high technology research-intensive production, innovative enterprises in the range of 25–40%;

3) economic development and improvement of Asian and Arctic territories of Russia.

There is nothing unexpected or new in the list of required actions: adequate laws, prioritization, direct public financing, and tax incentives. They are well-known and are easily implemented provided there is political will and tangible success in anti-corruption and anti-monopoly policy.

Under this scenario, in 10–12 years the GDP will double, the share of the extractive sector will markedly decrease, and the share of Siberia and Far East will grow. The spatial architecture of Russia will change drastically: Russia will get a new foothold – South-East Asia. In late 20s, according to the scale of its economy, Russia will become one of the five (or even four) leading countries by the level of its economic development measured by GDP per capita and will rise to the upper quartile in the list of countries.

This innovational scenario is more optimistic than the one in the *Concept of Long-Term Development of Russia* developed by the Ministry of Economic Development.

The models can also be applied for analyzing interregional economic relations. The analysis is based on two parts of mathematical economics: the theory of economic equilibrium and the theory of cooperative games. The first one (Valrus equilibrium) concerns an ordinary commodity-money market and equivalent interregional exchange, the second one (Nash equilibrium, the nucleus of the system) concerns contract market and mutually beneficial exchange. If these approaches are taken, it is necessary to introduce “subjectivity” into the ideology of modeling. The “subjects” are regions represented by some government bodies – the bearers of regional goals (the increase of household and state consumption) and decision-making instruments (plans for economic development including foreign economic relations).

According to Valrus market conception, each “subject” of the market (region) determines its demand and supply (export-import of products) by maximizing their target function under budget restriction in the current exchange prices. Meanwhile, s/he does not care about partners or any common goals. At the same time, the markets operate under the law of supply and demand: the price grows if the aggregate demand (import) exceeds aggregate supply (export) and vice versa. The market subjects review their plans adjusting to new prices. It goes on until equilibrium is reached.

An equilibrium with zero budget balance is the condition of equivalent interregional exchange.

According to Nash, the principal notion of the market mechanism is an agreement or contract, consensus. The market mechanism is a negotiation process where the market subjects (regions in this case) conclude agreements on cooperation, that is, enter into coalitions. The subjects focus on their own interests and leave old agreements or coalitions if they see more promising partners. The equilibrium according to Nash is reached when none of the subjects and none of the subjects' coalitions is able to improve their position by changing the composition of partners.

One of the main results of the corporate games theory is that in the situation of equilibrium, all the subjects of the market enter into interaction and, if a subjects' coalition leaves the full system, it loses. The multitude of such equilibrium states is called the nucleus of the system. This is a specific multitude – the multitude of mutually beneficial interregional exchange.

In 2012, Sheply and Rot received the Nobel Prize for investigating these problems in the cooperative games theory.

For about thirty years, the theory of economic equilibrium and cooperative games has been successfully used in the applied analysis of multi-regional economic systems applying optimization multiregional input-output models (OMIM) However, it is only recently that rigorous proof has been received of the existence of Valrus and Nash equilibriums (as well as Edgeworth, fuzzy nucleus) in the economic systems presented by the models of OMIM type. The research was made in the framework of the integration project of the Presidium of the Siberian Branch of the Russian Academy of Sciences and carried out by researchers of the Institute of Economics and Industrial Planning and the Institute of Mathematics of SB RAS. The proof was found by V.F. Vasilyev.

As an example of the applied analysis of interregional economic interrelation we will give the results of calculations for the system of the Soviet republics made before the disintegration of the Soviet Union. Such calculations are also carried out for the macro-regions for Russia, but they are not very demonstrative yet, and the conclusions made are too general in nature, for example: "Siberia plays approximately the same role in Russia as Russia played in the USSR".

First, let us focus on the results of coalition analysis, calculations for all the possible coalitions of the former 15 Soviet republics. The share of the emergent (synergy) effect in the total final consumption by the Soviet republics accounted for about 55%. Only Russia, in the situation of total autarchy, could manage to keep the value of its target index at a rather high level. Moreover, the contribution of Russia into the total consumption of the system exceeded its own consumption, the balance of inter-republican interaction being positive. At the same time, the balance of the Ukraine was "indecently" negative.

A somewhat different picture was presented by the results of the equilibrium analysis (according to Valrus and Nash). The zone of the nucleus is strongly stretched in the direction of the increase of the share of Russia in the total non-production consumption of the system. It means that the non-production consumption of Russia could have been considerably increased at the expense of the other republics, but the inter-republican exchange would have still remained mutually beneficial because the coalitions of republics would have consumed less without Russia.

At the same time, the actual share of non-production consumption of Russia was higher than its share in the situation of an equivalent exchange because its consumption was overstated in comparison with that which would have existed under equivalent inter-republican exchange.

The same situation, but to a greater degree, was true for Kazakhstan and Central Asia, while the consumption of the Ukraine, Transcaucasia, the Baltic Republics and especially Byelorussia was understated in comparison with the equilibrium equivalent one.

To develop interregional input-output models of space economy further it is planned a) to go beyond the borders of the paradigm of perfect competition and take into account innovational monopolism (such an attempt based on Shtackleberg's equilibrium concept was made by V.L. Beresnev within the above-mentioned framework of the integration project of the Presidium of SB RAS and the Institute of Mathematics); b) to find a reasonable compromise between the continua and agent-oriented (subject) approaches including large investment projects as special subjects (along with large corporations, municipalities, cities and households) into the simulation; c) geoinformational and state-of-the-art computational technologies should be used together with traditional methods of mathematical programming, statistics, econometrics, simulation control and normative regulation.

Another direction for further research is harmonizing input-output models used in the Institute of Economics and Production Planning of SB RAS. At present, several spot and multiregional models of different specializations are being applied, each of them exploited in isolation from each other. This is an absolutely abnormal situation that leads to a dissipation and irrational use of research resources. A task to coordinate the models has been posed and is beginning to be solved in three areas: informational (oriented to creating a common data base), simulational-methodological (making a "construction" of different models out of a small number of model units connected by formalized "adapters"), software and mathematical (creating a common software platform – the language of model construction). In other words, here we have some kind of a "mild variant of reincarnation" of the idea of coordinating a system of territorial and industrial planning models created in the 60s of the last century

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EXPORT INDUCED R&D-EXPENDITURES IN GERMANY. EFFECTS OF A CHANGED EXPORT STRUCTURE TO THE USA AND TO CHINA OF GERMAN AUTOMOTIVE INDUSTRY PRODUCTS AND OF GERMAN PHARMACEUTICALS[1]

Loreto Bieritz

■ Introduction

The importance of Research and Development (R&D) for the optimization of production and gross value added is often highlighted, expecting that production and employment are positively influenced by higher R&D-expenditures .Reverted, it is also assumed that production has an influence on R&D-expenditures. The existing R&D-module of the multisectoral macroeconomic model INFORGE operates in that direction: The R&D-expenditures of industries, government and research institutions are calculated based on the respective production values.

In the present analysis, this approach has been extended by the effects of international trade to the R&D-expenditures. Assuming that the import demand provokes a shift in production and therefore a shift in R&D-expenditures, the aim of this analysis is to see how strong the effects of international trade are on R&D spendings in Germany.

The international trade itself has two aspects: the trading partner and the traded good. To ascertain if the good or the partner is decisive, this study focuses on the one hand on an R&D-intense good, pharmaceuticals, and on vehicles as an export-intense good On the other hand, two worldwide leading economies are focused: The USA – as the most important single trading partner for Germany and China

[1] Paper presented at the 21st Inforum Conference in Listvyanka (Russian Federation) on 28th August, 2013.

as the partner whose demand for German products has currently the highest rate of increase worldwide. Therefore, four different scenarios with an allocated period until 2030 were developed and compared to the baseline scenario of INFORGE.

In conclusion the aim of this analysis will be to see how strong the reactivity of R&D is on a shift in export. Especially, it should be found out which influence predominates with regard to its respective effect on R&D: the export structure – with a dominance of vehicles - or the higher reactivity of pharmaceuticals on R&D. A second question is to see whether the currently higher export volume to the USA is more decisive for German R&D expenditures or the more rapidly evolving German export volumes to the Chinese market. This gradual approach should help to answer the initial question of the importance of international trade for Research and Development.

■ Entering into the topic

Background information of Research and Development in Germany

With R&D spendings of more than 75 bn € in the year 2011, Germany nearly reached the 3-percent-aim of the EU Lisbon agenda. Two thirds were invested by companies, nearly 20% by universities and research institutes and less than 15% by government spendings.

Out of the companies, the manufacturers of motor vehicles, trailers and semi-trailers are the major investors in R&D with nearly 16 bn €. The second highest amount of 6 bn € derives from the manufacturing of computer, electronic and optical products succeeded by the manufacture of machinery and equipment (5 bn €). The pharmaceutical industrial sector ranks fourth with a spending of 4 bn € in 2011.

The relevance of the automotive and pharmaceutical industry is also reflected when looking at the German input-output tables:[1] The pharmaceutical industry makes up nearly 14% of R&D-intermediates and thereby ranks second after public administration and defense with 35%. The automotive industry is the third biggest recipient of R&D

[1] Observed year is 2008. The latest input-output table for Germany is for the year 2009, but it was published after the presentation of this paper.

intermediate products (9%). Therewith, the importance of the pharmaceutical and automotive industry for the R&D industry itself becomes clear. But to remain in the design of this analysis, the ratio of R&D intermediates for the automotive or pharmaceutical production needs to be considered because the shift of R&D-expenditures within these two observed industries will be caused by a shift in their respective production. The less important

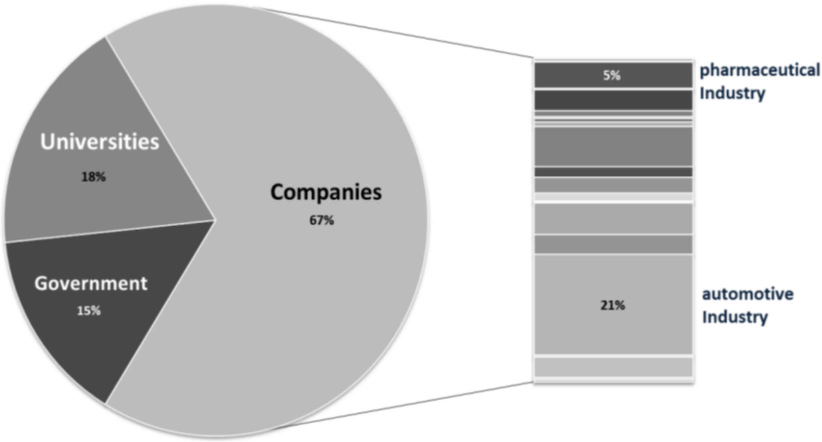

Fig. 1. R&D-expenditures in Germany by sector in 2011

Source: Statistisches Bundesamt (2013) and Stifterverband (2013).

R&D is for their production, the less potent it should act.

While the pharmaceutical and automotive industry are both significant for intermediate demand of R&D, a view from a different angle shows that the R&D-input of the pharmaceutical industry amounts to 12% of the total intermediates whereas the R&D-input of the automotive industry only represent 0.5% of the total intermediates. Therefore, it can be assumed that a variation in the pharmaceutical production will cause a measurable reaction in R&D-expenditures but a shift of automobile production will not necessarily have an effect on R&D-spendings.

The structure of German exports to the USA and China

At present the United States have an export share of 7% and are therewith the most important single trading partner for Germany in the world, followed by France (6.8%) and China (6.1%). The exports to the USA amount to approx. 90 bn € in 2011 and the imports from the US to Germany comprise 68 bn €. Since the German exports to this country grow faster than the imports, the German trading surplus with the USA becomes higher by the time. However, trade with China will be intensified causing a turnaround of the current trade deficit of Germany with this nation by 2016. The importance of China itself as a trading partner for Germany will grow at the same time and is expected to replace the US and France as the most important single trading partner until 2030. This evolution is pictured in Fig. 2.

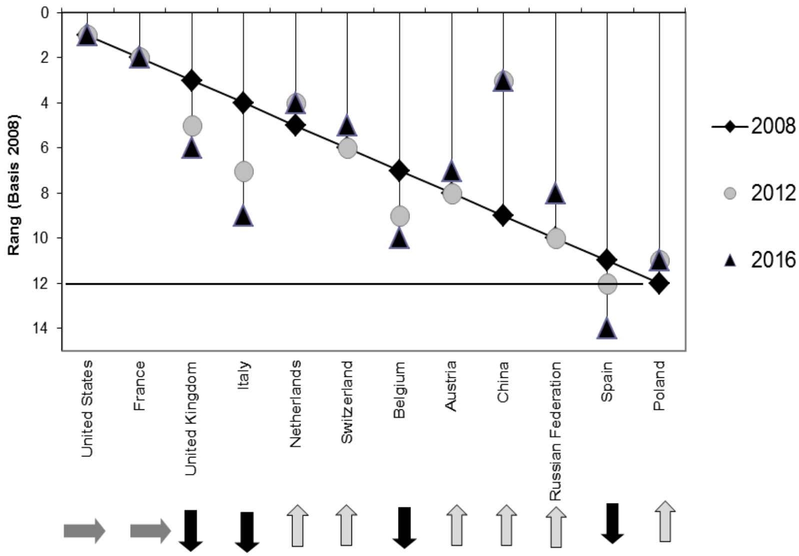

Fig. 2. Growing importance of China as a trading partner for Germany

Source: OECD (2012) & Inforge

A closer look to the German export structure reveals that out of all exports nearly 18% are motor vehicles and 5% are pharmaceuticals. Both to the USA and to China, the export share of vehicles is bigger with around 27% to each country (Tab. 1). The relevance of the trade with pharmaceuticals is, however, not comparable in the two surveyed countries: While the USA import 8% of all German pharmaceuticals, China's share only makes up 1.3%. Therewith pharmaceutical imports from Germany only weigh heavily in the US market. The high share of vehicles in both countries allows the assumption that a variation of the German export supply should cause a measurable reaction in R&D-expenditures.

Table 1

German export structure

% share of German export	World	USA	China
Pharmaceutical cars	4,9 17,8	7,7 26,8	1,3 27.5

Source: OECD (2012)

■ The Modeling Framework[1]

This analysis uses a modeling approach that extends the dynamic macro-econometric input-output model INFORGE (Maier et al. 2013, Ahlert et al. 2009) to other economic areas: First, German exports are linked to and determined by a trade module that explicitly considers bilateral trade by countries and by products. Second, the sectoral analysis is extended by a Research and Development module that quantifies the R&D-expenditures by industries, universities and institutes as well as by the government. Fig. 3 shows an overview of the modeling framework. Whereas the INFORGE model itself is basically constructed as a bottom-up model, the overall modeling framework follows a top-down approach with no feedbacks from R&D to the production. In the subsequent sectors, the macroeconomic INFORGE model and its trade module are described in detail followed by the specification of the R&D module.[2]

[1] The following model description was extracted and slightly adapted of this recent published paper: Mönnig, A. (2013): Trade and qualification. Linking qualification needs to Germany`s export flows, in: IAB-Discussion Paper July, 2013.

[2] Compare also www.qube-projekt.de

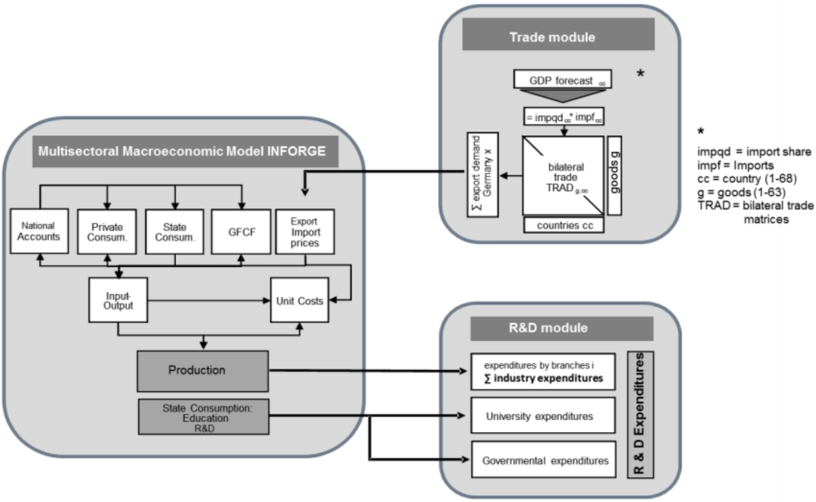

Fig. 3. Simplified illustration of the Modelling Framework

Source: Mönnig, A. (2013); own composition

The multisectoral macroeconomic model INFORGE

The INFORGE model has been developed by the Institute of Economic Structures Research (GWS) and has been tested in numerous applications in the field of research and policy analysis (Ulrich et al. 2012, Barker et al. 2011, Lindenberger 2010). The model belongs to the INFORUM family of modeling (Almon 1991) that rests on two basic fundamentals: Bottom-up construction and total integration. The former indicates that each industrial sector is modeled individually and that macroeconomic variables are calculated through explicit aggregation. This approach ensures that each individual sector is embedded within the economic context and that industrial interdependencies are explicitly incorporated and used to explain economic interaction. The latter describes a complex and simultaneous solution which takes into consideration inter-industrial dependence as well as the distribution of income, the redistribution effects of the state and the usage of income for goods. Thus, the input-output tables are fully implemented in the national accounts (Ahlert et al. 2009, Distelkamp et al. 2003). Both datasets are specified for improving the identification for gross fixed capital formation, private consumption, state consumption and foreign trade. Labour market specifics are consistently embedded in the macroeconomic context through output and unit costs. Macroeconomic indicators are determined by aggregation of 63 industries.

INFORGE operates simultaneously, is dynamic over time and is described by non-linear functions. Its basic dataset consists of input-output-tables and national accounts. The applied model in this analysis follows the school of evolutionary economics (Nelson/Winter 1982) as features like technological change, imperfect competition and interdependencies or partially sticky prices are standard characteristics. In INFORGE, parameters and their elasticity values are estimated econometrically with given time series for a large number of variables.

An integral element of input-output-modeling is the determination of intermediate demand between industries. Input coefficients represent the relation of intermediate demand to total production. In INFORGE technological change is identified by applying variable input coefficients. They are endogenously determined by relative prices and time trends. Using the Leontief-inverse $(I–A)^{-1}$ – with A as input coefficient matrix and I as identity matrix – and multiplying it with final demand, gross production by 63 industry-sectors is given.

The Trade Module: Determining exports

The world trade itself is handled as an exogenous factor in INFORGE, but with a more challenging modeling approach than normally observed at stand-alone, single-country models. In the trading partner economies, feedback effects via wage, price or volume adaptation are not considered. Exports are driven by exogenously given world trade dynamics for German goods which are modeled in two dimensions: By goods and services and by export demanding countries. This allows accounting for diverging speeds in economic development as well as for different demand structures by country.

Starting point in INFORGE is the economic forecast for 68 countries taken from the International Monetary Fund[1], the European Commission[2] and the International Energy Agency[3]. Then the import share (impq) is calculated for each country: The ratio is assumed

[1] World Economic Outlook Database of the International Monetary Fund (IMF).

[2] Ameco Database of the European Commission (EC).

[3] World Energy Outlook of the International Energy Agency (IEA).

to remain constant over time. The development of imports (impf) is specified by the economic growth path of each trading partner.

Bilateral trade matrices (TRAD) for Germany are applied to determine the share of Germany in each country's import function (impqd). In the baseline scenario, these shares remain constant. This implies that Germany can remain its strong international position within the import portfolio of its export partners, but it is not in the position to expand its impact any further.

Total export demand for German products can be derived by multiplying the import shares (impqd) with the projected import demand (impf) of each economy. The total export demand is distributed to 59 categories of goods by using the export shares on total export demand taken from the bilateral trade matrices (TRADQ). In the baseline scenario, these shares remain constant which means that Germany's exporting partners do not change their product demand structure towards Germany.

Modeling the Research and Development expenditures

The R&D module considers three different types of expenditures: First the industrial expenses, second the expenses by universities and institutes and third the expenditures by the government. The industrial expenses are based on a classification of the "Stifterverband für die deutsche Wissenschaft". It consists of 30 categories of branches which include production and services. The addition of the figures (e.g. R&D expenditures) for all branches result in the industrial expenditures (FUEUNT).

$$\mathrm{FUEUNT}[t] = \sum_{i=1}^{30} \mathrm{fueunt}\,[i]$$

Thereby $\mathrm{fueunt}[i]$ is moved by the input-coefficient and the production of each R&D-branch[i].

The expenses by universities and research institutes are defined by the macro variable FUEUNI, which is the result of the multiplication of last year's expenditures for universities (FUEUNI t-1) with the growth rate of the actual governmental expenditures for education.

The growth rate for governmental expenses for R&D is assumed to be the same as the growth rate of governmental expenditures for R&D.

■ Export induced R&D expenditure shift

Based upon the knowledge of the export-structure, the R&D-funds in Germany and the modeling framework, the scenarios for the calculation of the prior formulated questions can be developed. Having two countries and two goods to be surveyed, four scenarios that stipulate a change in the import share in the USA and in China will be needed. An analysis of the historic data of given import shifts leads to a reduction of imports for German pharmaceuticals and automotive products to the two countries by 30% each. Furthermore, the total import demand for German goods by China and the US will remain constant during the whole period reviewed. The import shock will take place in the years 2015 and 2016. The baseline import structure is assumed to be reached in 2030 again.

In the following evaluation of the scenario results the two countries will be contrasted.

The import reduction of motor vehicles

The strong import reduction of German automotive products by China and by the USA manifests especially in a decline of R&D expenditures by the manufacturing sector, within which the spendings of the automotive industry are the most affected ones. More than 85% of the manufacturing sectors-loss in 2015 is induced by that industry. Hereafter follow the expenses of the R&Dsector itself and the professional, scientific and technical activities. In general, the import reduction by the USA provokes a stronger expenditure cut than an import reduction by China. In total, the differences to the baseline scenario are over 390 m € in the first year of the import reduction by the USA and 420 m € in the second year (2016). The shock scenario of the import reduction by China provokes an R&D expenditure reduction of 340 m € (2015) and around 375 m € in the second year (2016). Considered in relative terms, the total difference in R&D expenditures between base and shock scenario amounts to 0.7% in the US scenario and of 0.6% in the Chinese scenario for each year. The cut in spendings by the automotive industry in the US-scenario amounts to a reduction in R&D spending of 1.8% in the two years of import reduction and to 1.6% each year in the Chinese scenario. Fig. 4 shows the relative difference between the expenditure shifts of the most affected industries in the two surveyed countries.

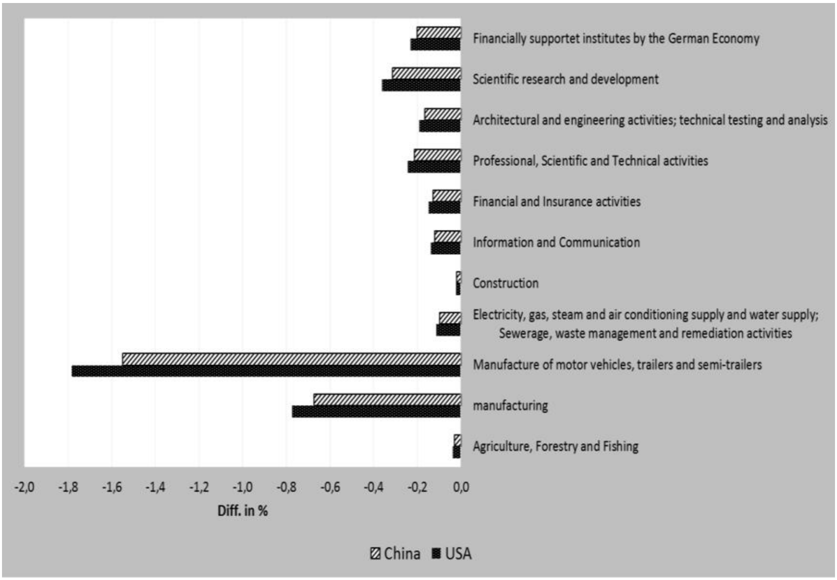

Fig. 4. R&D-expenditure shift by industries in the first year of export reduction to the USA and to China (difference in %)

Source: INFORGE

Focusing on the R&D-expenditure shift of the automotive industry over the whole scenario period, it becomes visible that the stronger effect of an import reduction of the USA is only a short-term-observation: Only five years after the shock the expenditure shift in the US scenario becomes weaker than in the Chinese one. This means that a shift of automobile exports to China has a more long-lasting effect.

In conclusion, the reduction of the import share of German automotive industry products to the USA and to China shows a decline on the German R&D-expenses, especially of the automotive industry itself. In the short-term, the German R&D-expenditures react stronger to an import reduction by the USA than by China. But in the long run, the increasing importance of the Chinese market for Germany predominates and changes in this emerging market have a longer lasting effect on the German expenses for R&D.

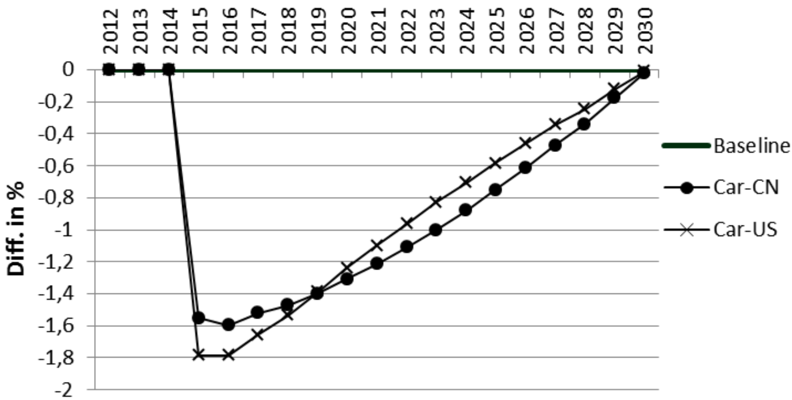

Fig. 5. R&D expenditure shift of the motor vehicle industry in the USA and in China during the whole scenario period

Source: INFORGE

The import reduction of pharmaceuticals

An import reduction of German pharmaceutical products of 30% by the USA and by China provokes a concentrated R&D-expenditure cut by the pharmaceutical industry itself in Germany. More than 80% of the expenditure cuts derive from the pharmaceutical industry. The second highest cut comes from the R&D-industry itself and moves around 5 to 6% in the years 2015 and 2016. The cutback by other industries is negligible.

The strongest R&D expenditure cut is caused by the diminishment of pharmaceutical imports by the USA: While the spending cut of the pharmaceutical industry amounts to 1.3% in the US-scenario, the cut in the case of an import shift by China results in a reduction of less than 0.2% of the pharmaceutical R&D-expenses in the first year of the import reduction. Within the scientific and research industry, the R&D expense cuts amount to 0.2% (US-scenario) and to only 0.03% (Chinese scenario) (Fig. 6).

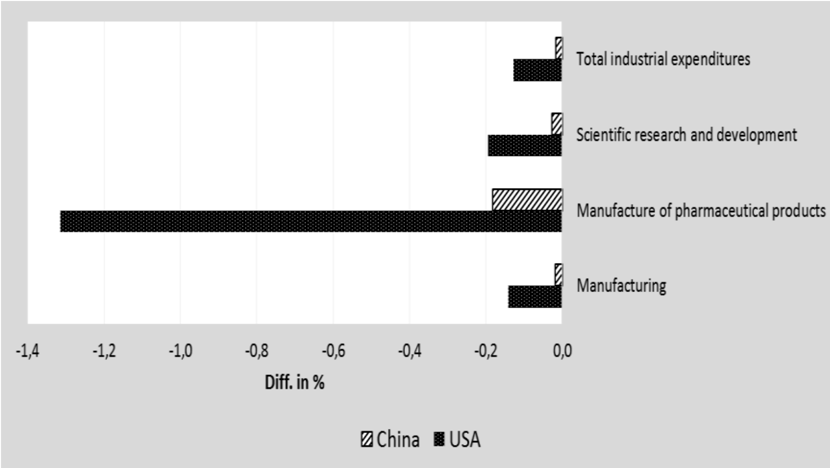

Fig. 6. &D expenditure shift by industries in the first year of export reduction to the USA and to China of pharmaceutical products (difference in %)

Source: INFORGE

In the second year of the import shift, the reaction diminishes strongly in both surveyed countries. This can be observed especially by having a look at Fig. 7, which focuses the expenditure shift by the pharmaceutical industry in Germany during the whole scenario period (2015–2030). In absolute amounts, the differences to the baseline scenario in 2015 are of 63 m € (US-import-shift) and of 8.7 m € with an import shift by China. In 2016, these amounts are reduced to 28 m € in the case of the USA and to 4 m € in the Chinese scenario.

In conclusion, an import reduction of pharmaceuticals by China and by the USA provokes a very poor deviation in R&D-expenses. Generally speaking, the reaction to an import decline by the US-market is stronger than that of a Chinese one. This is due to the almost six times higher import share of German pharmaceuticals to the USA compared with China. Therefore, it can be concluded that the export volume in the automotive industry predominates the higher reactivity of pharmaceuticals with respect to the input of R&D in their production.

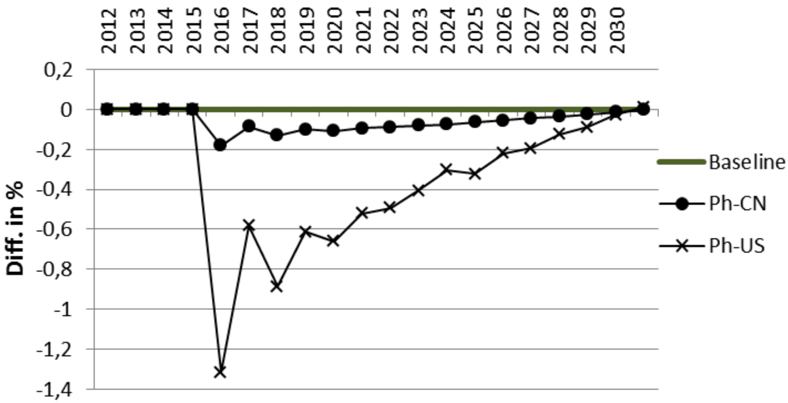

Fig. 7. R&D expenditure shift by the pharmaceutical industry during the whole scenario period

Source: INFORGE

The reaction of all investors in R&D

Regarding the three different types of R&D-expenditures – the ones by government, by institutes and by industries – it becomes apparent that the latter ones, which make up two thirds of all the expenditures, are affected most of a reduction of imports. Governmental expenses and the ones by universities and institutes decline insignificantly. In both scenarios, (see Fig. 8 and Fig. 9) the reaction on the institutional side is even positive in the first year. This evidence is valid both for China and for the USA. Hence the total expenditures are driven by the industrial expenses.

The growing importance of the Chinese market for German products becomes visible when looking at the long-lasting reaction of all three different R&D investors towards a Chinese import shift of automotive products. While the first years after the shock the percentage shift is stronger in the US-scenario compared with an export reduction to China, the shift becomes and remains stronger in the Chinese scenario only four years after the shock.

Similar to the industrial expenditures, the reactivity of the governmental and institutional investments towards an import shift of pharmaceutical products is much higher with a shift in US export rates than with a shift in Chinese exports.

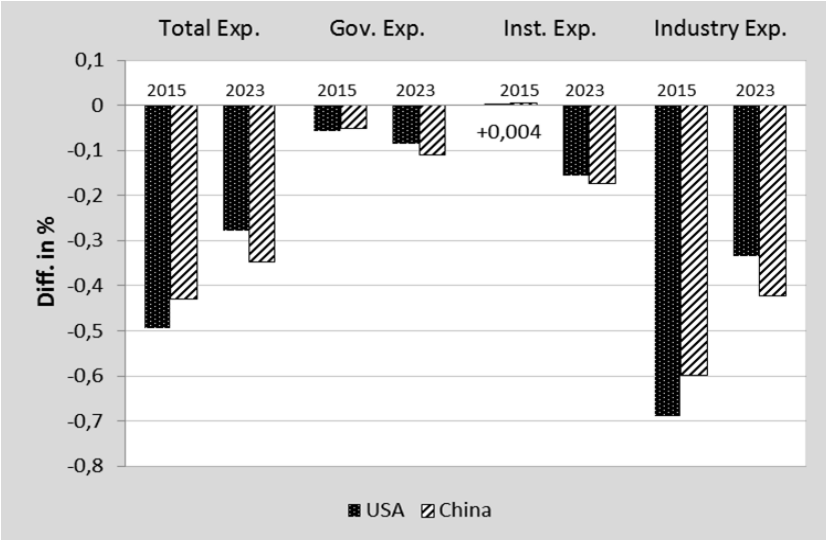

Fig. 8. R&D-expenditure shift by investors towards an import reduction of German automotive products

Source: INFORGE

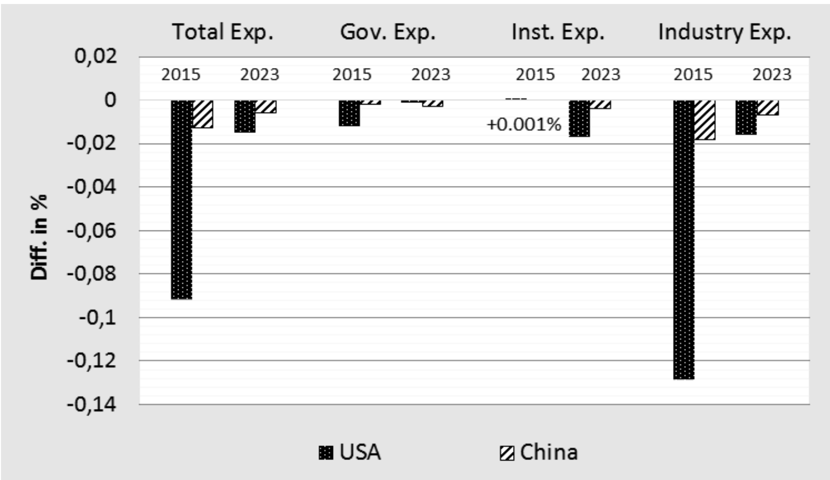

Fig. 9. R&D-expenditure shift by investors towards an import reduction of German pharmaceutical products

Source: INFORGE

■ Conclusions

The importance of international trade for the Research and Development expenditures in Germany was the focus of this analysis. Therefore, two trading partners and two different goods were chosen to approximate to this question: A trading partner with a high potential of becoming the most important importer of German goods in 2030 - China – and the currently most important single trading partner – the USA. The goods differentiate themselves on the one hand by the export volume and on the other hand by the importance of the R&D-input for their production.

The analysis of the scenarios emphasized that the reaction on an import shift of automotive products is much stronger than on pharmaceuticals – thus the export volume is decisive for the R&D-expenditures. This is attended by a stronger impact on a variation of imports by the USA than by China. Nevertheless, the increasing importance of the Chinese market for German exports predominates in the long run. Moreover, the investments for research carried out by industries are affected directly by the missing exports while the research expenses by government and institutes are lagging behind the export shiftsdue to their midterm budgeting.

To improve the hardly measurable reaction of the pharmaceutical industry towards the R&D-expenses, a further development of INFORGE could be valuable. This should contain a feedback from the R&D-module to INFORGE, because the actual lack impedes to analyze how R&D-expenses affect the production – probably pharmaceuticals would be influenced strongly by a shift of R&D-supply.

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A LOT OF ALGEBRA AND A LITTLE ECONOMICS. LINKAGES IN INPUT-OUTPUT MODELING

Maurizio Grassini

■ Introduction

Recently, within the framework of classic input-output analysis, a number of papers have dealt with the relationship between (sectoral) total output and (sectoral) value added. This brand of research is aimed at emphasizing links between final demand components and primary inputs; more precisely in input-output language, these links are limited to pouring backward linkages into forward linkages. Such linkages are mostly related to each final demand component and in particular to exports. The prevailing subject of research is to measure the amount of value added which is embodied in (sectoral) exports. Such a link between exports and primary factors may recall the problem tackled by the so-called Scandinavian model many years ago.

■ Modeling the supply side. The Scandinavian model

After the Second World War, the performance of the Swedish economy was sluggish and suffering from a trade balance in disarray. The relative high rate of inflation compared to that prevailing in the world market was considered the factor causing the economic weakness. At that time, a gradual shift from the emphasis on aggregate demand policy to the emphasis on supply or cost factors took place. First, the Norwegian economist Aukrust proposed a theoretical analysis of wage-price interdependencies in open economies; soon after, a pragmatic approach to the problem was taken by Edgreen G., Faxén K. and Odhner C. as respective representatives of the white-collar confederation union (TCO), the Swedish employer association (SAF) and the Swedish confederation of trade unions (LO); they built a model which has been referred to since then by the acronym EFO-model. Merging Aukrust's and Edgreen-Faxén-Odhner’s (1972) contributions, this model was correspondingly named the ‘Scandinavian model’.

It begins with the division of the economy into two sectors (which may be considered the first step towards a multisectoral representation of the economy, starting from a macroeconomic model): an open sector and a sheltered sector as regards international trade. The first sector is a price-taker; the second sector is not. The first sector is forced to follow the world trade price index; referring to the domestic market, the second sector is allowed to generate a rate of inflation which is different and unfortunately higher than the world trade price index. Due to the interdependence between the two sectors, the inflation generated by the sheltered sector may hit the price competitiveness of the open sector. Ultimately, the balance of trade turns out to be driven toward a deficit which proves unsustainable in a system of fixed exchange rates. To tackle this situation, the EFO-model was used to establish wage growth in both sectors taking the price-taker sector as benchmark and taking into account the sectoral productivity of both. The established rule was that the wage growth per unit of output in the open sector and the sheltered sector should have been the same. In other words, the EFO-model became the basis of the 'incomes policy' applied in many countries in the years to come.

All in all, the EFO-model appears to be a 'pure cost-push' model which assumes accommodating demand adjustments; it has a structure of a two-industry economy. As far as 'linkages' involving value added, in IO language, the EFO-model generates a value added under the constraint of equal sectoral value added per unit of output growth; only the supply side of the economy is modeled.

■ Some interactions between final demand and value added

Miyazawa (1973) presented a synthesis of the Leontief interindustry matrix multiplier and the Keynesian income multiplier in disaggregated form posing the problem as follows:

"In the standard interindustry analysis, consumption demand is treated as an exogenous variable. So that the usual Leontief matrix multiplier analysis lacks the multiplier process via the consumption function that one customarily finds in a Keynesian model. In order to treat consumption demand as an *endogenous* variable in the Leontief system, the household sector is routinely transferred to the processing sector, and is regarded as an industry whose output is labor and whose inputs are consumption goods. But the appropriate procedure in dealing with consumption is not to regard it as a fictitious production activity, but to introduce the Keynesian consumption function on a disaggregated level."

To tackle the problem, Miyazawa introduces the *subjoined inverse matrix*, which reflects the effect of endogenous changes in household consumption. This matrix is constructed assuming:

a) a peculiar structure of the value added in the input-output table;

b) the availability of a matrix of consumption coefficients.

This matrix contains the propensity to consume (or parameters of consumption functions) of each income group for each consumption good or service. No bridge matrix is mentioned.

The main components of the value added considered in Miyazawa's input-output model are wages and profits. Both are converted into disposable income so that value added is described as income distributed between income groups for each sector. Hence, value added is represented by an unusual matrix with *r* rows – the income groups – and *n* columns – the sectors. This value added matrix represents the basis for computing the above mentioned *subjoined inverse matrix.* Within this framework, Miyazawa distinguishes "the inverse reflecting endogenous consumption activity from the inverse reflecting production activity" and suddenly adds "if consumption coefficients and value-added ratios are not as stable as the input coefficients, it is desirable to have the "*subjoined inverse matrix*" expressed in a form which can be easily computed and revised". In other words, in evaluating 'consumption activity' and the 'production activity' impact over the sectoral production levels, one should consider that the 'structure' of the value added component is unlikely to be constant over time. Furthermore, value added components are implicitly assumed in constant value; prices are not taken into account.

Seven years before Miyazawa's book, Clopper Almon published "The American Economy to 1975. An Interindustry Forecast". In this book a new system for making long-range forecasts is presented; it incorporates many detailed forecasts which provide a background for a variety of business decisions. Since "the decision maker has to consider and compare the growth of a number of industries in the economy", he needs to take into account many interconnections among industries which control and drive economic stimuli. Among the demand components, Almon poses, as far as personal consumption expenditure and investment are concerned, the following questions: "How will consumers divide their income among the many goods and services they are offered? How much will each industry invest to achieve a given growth in sales?" These two questions are also posed by Miyazawa, but the answers are different. While Miyazawa confines hypothetical behavioral parameters into a matrix with no clear description of their source, Almon refers to economic theory to tackle the estimation problems for developing an econometrically estimated demand system. In fact, Miyazawa assumes that the cost of labor is entirely composed of wages (statistically) disaggregated in income groups; since these income groups are necessarily (from the statistical point of view) composed of 'income before tax', a matrix of income groups' propensity to consume parameters is assumed, but its computation procedure remains obscure. Almon tackles the estimation of household consumption looking at the 'source of information' where it becomes clear that industry and personal consumption item classifications are necessarily different. In fact, many personal consumption items contain products made by a number of industries. Almon's example is instructive: ' … boats, outboard motors, life preservers, fishing line, minnow buckets, cane poles, and fish hooks are all made by different industries; but in the consumer categories, they come together under "durable sporting equipment".' Hence, a classification conversion between industries and personal consumption items is required, while the conversion also includes a price conversion (output prices versus consumption prices). Prices are mentioned as exogenous variables but they are still not made endogenous in the input-output framework. In fact, at that time the multisectoral model was limited to the real side; the nominal side would be implemented later.

Meanwhile, relative to introducing a system of consumer's demand functions within an input-output framework, Almon declares: "Whither the consumers' dollar leads, the American economy follows; and where our consumption projections go, the rest of the model trails along." This statement reminds us that at that time macroeconomic models were mostly demand driven. The supply side did not receive special attention, although the Scandinavian model represented a remarkable example of an incisive exploration of the impact of price formation on economic performance.

1970's, oil crises, which began with the 1973 shock, gave evidence of the impact of inflation on the economy. Suddenly, macro models based on drastically aggregate macro variables turn out to be inadequate to describe the workings of the economy. Lawrence Klein (1977), who was involved precisely in this kind of macro modeling, perceived the need to change the modeling approach. He suggested that "The new system should combine the Keynesian model of final demand and income determination with the Leontief model of interindustrial flows" and, because of this proposal, focused attention on the supply side of the economy. Of course, the Leontief model was already well known and represented, the accounting cornerstone of any Input-output Macro Models. The Scandinavian model thus became the seminal model for developing the nominal side to marry the real side of a multisectoral model based on an input-output table. This marriage was soon celebrated at Inforum. Although the Inforum type model properly belongs to the Leontief family, a name more descriptive of the nature of the model might be Interindustry Macroeconomic model: 'Interindustry' to remind us of the presence of an input-output structure and 'Macroeconomic' to stress that all the variables which characterize a standard macroeconomic model (GDP, inflation, interest rates, employment, cost of labor, etc.) are covered.

This structure has also been named IO+econometric (West, 1995). As in any model, besides the accounting identities, there are many econometrically estimated equations; identities and equations constitute an inevitably non-linear system of equations. Given the size (in terms of number of equations and nonlinearities) multiplier may be computed only by simulations; an increase in a scenario variable, say z, is related to the impact on an endogenous variable, say y; and the ratio $\Delta y/\Delta z$ is called the multiplier of z over y. Or, in some input-output jargon, it is the linkage of z over y.

■ Linkages

Due to the interdependence among industries, in the input-output framework each sector demands inputs and supplies output. The demand for inputs stimulates the activity of other sectors and the supplies of output of a given sector support the production of other sectors. This is the basic source of the concept of linkage. Linkages can be investigated looking at the suppliers of inputs (looking backwards) or looking at the users of the output of the given industry (looking forwards). Although the concept of linkage seems very basic, input-output analysis uses a specific type of contributions to tackle the measurement of such kind of interdependencies. It is a matter of fact that an input-output table is the source for different modeling approaches which in turn may suggest different measurement criteria of such linkages.

For example, in 1958 Ghosh presented an alternative input-output model based on the same set of base-year data and compared the 'traditional' Leontief model with what has since then been named Ghosh's model:

> "Leontief's formulation thus takes up for consideration a situation where there is even in the short period a large unused capacity in most sectors such that any change in the final demands do not set up any disturbance in relative prices and certainly do not bring in any question of limited supply. Ignoring for the moment other criticisms of this simplified approach it may be said that where even in the short period nearly all industries have at their disposal a large surplus of plant and labour the supply curve is bound to be very elastic and the overall situation would be very much dominated by buyers' requirements. This position is easily illustrated by an advanced capitalist economy in depression."

and introduces his proposal as follows:

> "It is possible to build up a similar model with allocation functions in an economy where different sectors are under monopoly control and all except one resource is scarce. We can consider a planned economy under centralised control with scarce material resources and productive capacity with ample supply of available labour. The central authority has for each sector allocation schedules defining national or social welfare and it has been seeking that allocation which maximises welfare subject to possible production combinations. That is, any feasible combination of inputs which gives a higher welfare value may be preferred to one which

may be more efficient as a production combination, but is lower on the welfare scale. An illustration may be given of a controversy in the Indian second five-year plan which is centred around the objective of reviving cottage industries which are productively less efficient but which gives employment rather than keeping people on a dole. The objective of the planning authority is not a search for the optimum technical combination of production but for that feasible combination which makes the best use of resource made available for it on the basis of a welfare function."

Ghosh points out that an "advanced capitalistic economy' and a 'planned economy under centralized control' may be modeled on the basis of the same data set: an input-output table.[1] The first manipulation of the input-output table leads to a matrix of technical coefficients in Leontief's approach and to a matrix of allocation coefficients in Ghosh's . Both methods share common procedures for measuring the corresponding linkages. In general, the different kind of linkage is strictly confined to the structure of the intermediate consumption matrix. Total output (row sum and column sum of the input-output matrix) may help to give a meaning to a particular linkage indicator, but such an indicator is computed only by using input-output technical coefficients or allocation coefficients.

However, an input-output table (like any other system of accounts based on a double-book keeping system) is a quantitative economic model. In fact, from such a table a model like the Leontief model (as well as Ghosh's) can be easily built. Its analytical structure – a system of 'linear' equations – gives room for an extensive use of the tools of linear algebra. This is the context in which linkages indicators find their place.

[1] Furthermore, the objective of a planning authority may be the maximization of employment (or the minimization of unemployment) which is not equivalent to value added. Employment is simply a primary-factor which is behind part of the value added. Referring to so-called classic economists and their followers, Pasinetti investigated the relationship between sectoral output levels and the corresponding sectoral employment under the self-descriptive title "The Theory of Vertically integrated …". In an analytical investigation as brilliant as it was ponderous of the field usually named "Theory of production", he describes what we – unaware of such a distinguished theoretical basis – usually do when running a so-called modern input-output model such as the Inforum one.

■ Identity and identity-centered models

An identity model is just a set of equations derived from a system of accounts. Let us refer to the following basic notations of an input-output table:

Z the matrix (nxn) of intermediate input flows
$f_1, f_2, f_3 \ldots.. f_r$ the r vectors ($nx1$) of the final demand components
$f = f_1 + f_2 + f_3 + \ldots.. + f_r$
V a matrix (kxn) of incomes for k primary inputs
v a vector ($nx1$) obtained from the column sum of V
x a vector ($nx1$) of industries' output
l sum vector

Given the standard matrix of input coefficients, $A = [z_{ij}/x_j]$, the input-output system of accounts can be conveniently expressed as

$$x = Ax + f$$

and assuming that the final demand components are exogenous while the industry outputs are endogenous, an identity model is proposed as follows

$$x - Ax = f \quad \text{or} \quad (I - A)x = f$$

where the endogenous variables are on the *LHS* and the exogenous on the *RHS*.

This is the 'pure' identity model with no other specification than that coming from the system of accounts. The relationship between the endogenous and exogenous variables can be easily investigated by inspecting the structure of matrices A, $(I - A)$ and $(I - A)^{-1}$. These matrices delineate the domain of the linkages belonging to the field of 'input-output analysis' (see Miller and Blair, 2009, chapter 12).

As described in Almon (1995), 'identity-centered models' are macroeconomic models where the model builder has injected some of his economic knowledge (or even prejudice). Almon reminds us that: "While econometric textbooks have concentrated virtually all of their attention on regression equations with identities dismissed with the comment that they can be used to eliminate a variable, another school of modeling has grown up which uses no regression at all but concentrates all its attention on identities and some behavioral proportions."

Miyazawa's (1976) "Interindustry Analysis and the Process of Distribution and Expenditures of National Income" offers a good example of a basic 'identity-centered model' grounded on an input-output table and its impact on linkage foundations.

First of all, Miyazawa distinguishes the household consumption vector, f_c, and the other final demand components, f_o; the 'identity centered' model is thus now

$$(I–A)x=f_c + f_o$$

Furthermore, he introduces a peculiar structure of the value added matrix $V=[Y_{kj}/x_j]$, an rxn matrix where Y_{kj} is the k-th income-group income in sector i, and a consumption matrix $C=[c_{ik}]$, an nxr matrix of consumption coefficients c_{ik}; these coefficients are the propensity to consume of the k-th income group for the i-th commodity. This set of matrices allows us to substitute vector f_c with CVx[1]. Hence, the Leontief equation becomes

$$(I–A)x=CVx+ f_o$$

from which

$$x = (I – A – CV)–1f_o$$

Although on the basis of very specific assumptions about the household consumption model, once a final demand component is made endogenous (this could be done for investments as well as for imports and exports), matrix A loses any appeal for proceeding with linkage measurement.

This point was highlighted in Grassini (2001). Sketching out the analytical structure of the 'core' of an Inforum type model, he noticed: "Apart from the "identity" equations derived from the input-output table, most of the equations for final demand components are non-

[1] Miyazawa makes clear that this representation based on peculiar matrices may be made using a matrix C which contains any consumption function for given commodities and a given income group.

linear; in fact, in many cases it is hard to assume linear functions whereas, for instance, prices and demand factors influence each other as in private consumption demand functions, in import equations and others. The "identity" accounting equations and final demand equations inevitably compose a non-linear model." However, for the sake of simplicity, all the equations of the real side of the model were transformed into their linear approximation. The endogenous variables on the real side of the model are total output, x, and all the final demand component items, F, modeled by means of econometrically estimated equations. The system of equations of the endogenous variable F was represented by the following set of equations

$$F=Cx+DF+W_1x_{-1}+W_2F_{-1}+Pz_R$$

where matrix C contains parameters not equal to zero where there is influence of sectoral total output on total final demand components (mainly inventory changes, imports, investments and others); matrix D shows that interactions among final demand components are allowed. Matrices W_1 and W_2 take into account endogenous variable lagged effects; matrix P collects exogenous variables parameters, z_R, influencing the real side of the model (for example, domestic prices, foreign prices, population and so on).

The basic input-output identity is now

$$x=Ax+BF+f_{\text{exog}}$$

where B is a partitioned matrix composed of converters (unavoidable for personal consumption expenditures and investments) or simply identity matrices (B=[B_1 B_2 ….I I]) and f_{exog} are the final demand exogenous vectors. So that, the multisectoral model may be given the following linearized representation

$$\begin{bmatrix} x \\ F \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} x \\ F \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} x \\ F \end{bmatrix}_{-1} + \begin{bmatrix} f_{\text{exog}} \\ Pz_R \end{bmatrix}$$

and the reduced form of the model turns out to be

$$\begin{bmatrix} x \\ F \end{bmatrix} = \begin{bmatrix} (I-A) & -B \\ -C & (I-D) \end{bmatrix}^{-1} \left[\begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} x \\ F \end{bmatrix}_{-1} + \begin{bmatrix} f_{\text{exog}} \\ Pz_R \end{bmatrix} \right].$$

Investigating the structure of

$$\begin{bmatrix} (I-A) & -B \\ -C & (I-D) \end{bmatrix}^{-1} = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}.$$

The solution of the Leontief equation is

$x=H_{11}f_{\text{exog}}$, where $H_{11}=[(I–A)–B(I–D)^{-1} C]^{-1}$

where the accounting ratios a_{ij} and the bridge matrices B's are merged with matrices C and D which contain parameters of estimated econometric equations. The input-output table is no longer the basis of an identity economic model. The model builder has transformed a simple set of accounting identities into an 'identity-centered' macroeconomic model. Now the linkages that matters are dominated by the workings of the economy assumed and detected by the model builder so that the linkages cultivated in the field of 'input-output analysis' fade away.

■ The case of value-added linkages

More recently, measurements of linkages between output and value-added have been proposed. From the accounting point of view, GDP is equal to total final demand as well as to the total of value added. While final demand components are commodities or services, behind value added we find primary inputs and what is left to them in terms of income. The linkage between the production of commodities and services and the connected generated income may thus suggest insights about the value added content of total output different uses.

At present, the analytical approach to such linkages appears basically the same as that used in a recent World Bank working paper by J. Francois, M. Manchin, P. Tomberger (2013). The measurement of the linkage starts from the Leontief equation and its solution: $x=(I–A)^{-1}f$. The connection of these flows belonging to the real side of any input-output based model is established by means of a vector of value added shares, $v_j = V_j/x_j$, where V_j is the value added total for sector j.

Given V, vector of value added by industry, and v, vector of value added shares by industry, the relationship

$$V = \hat{v}\, x$$

where $\hat{v}$ is a diagonal matrix with the value added shares along the main diagonal, establishes the relationship between industry output and industry value added. This is also the yardstick for linking value added to any final demand component. In Bouwmeester, Oosterhaven, Rueda-Cantuche (2012) the value added by industry embodied in the final demand components is defined as follows;

$$V = \hat{v}\, x = \hat{v}(I - A)^{-1} f = \hat{v}(I - A)^{-1}(f_1 + f_2 + \cdots f_{\mathrm{k}} + \cdots + f_K)$$

with

$$V_k = \hat{v}(I - A)^{-1} f_k$$

the value added embodied in the k-th final demand component. Rather than showing the linkage between final demand and value added, this formula shows an analytical representation of the GDP in terms of value added or in terms of final demand

$$GDP = \iota' V = \iota' f.$$

But, value added is associated to the production of total output which includes intermediate consumption. In order not to include intermediate consumption among the commodities ‘generating’ value added, for example in Cappariello (2012), the value added embodied in the final demand components is defined as follows:

$$V_1 = \hat{v} f_1 \quad V_2 = \hat{v} f_2 \ldots\ldots V_k = \hat{v} f_k \ldots.\ldots.V_K = \hat{v} f_K$$

where the value added is not totally distributed (linked) to the final demand. The residual represents the value added embodied in intermediate consumption[1].

Although the value added associated to final demand components may be based upon different approaches, this branch of research seems to stem mostly from Belke and Wang (2005)'s very detailed paper.

These authors proposed developing 'innovative measures of openness towards bilateral trade'. They observed that 'The *degree of openness to trade* indicates the importance of international trade linkages for a country', but the most' widely applied ('traditional') openness indices are not able to accurately calculate the degree of trade openness'. So that 'In clear contrast to the mainstream', they correct 'the traditional concept by expressing trade in value-added terms instead of gross terms', and proudly affirm that 'The innovative actual openness concept is able to reflect the different structures of production among countries since the value-added created by trade is forecasted on the foundation of a sound theory of production'.

However, this statement is not deductible from the assumptions made to build the *openness to trade indexes* proposed. In fact, Belke and Wang choose the *open static Leontief system* as the theoretical foundation for the input-output analysis, consider 'the assumption of a static economy [to be] suitable even for noticeably dynamic economic systems because the changes in technical knowledge which affect the technical coefficients can normally be neglected[2] 'and assume that 'Price effects, economies of scale, or changes in technical knowledge that influence the requirement for inputs to produce output in an industry are not considered' and primary factors ('unskilled labor , skilled labor, capital, land , or natural resources') 'coefficients are constant'.

[1] Given this framework, the measurement of such kind of linkages is expected to give rise to many indexes as it is the case of those based on the matrix of technical coefficients, A (Miller, Blair, 2009. – P. 555–582).

[2] This assumpion is made quoting Pasinetti (1976)

At present, from the literature, any linkage involving value added goes through the Leontief equation; the allocation of value added is thus performed by means of manipulations such as those above mentioned. If the value added linkages are computed for a single input-output table, these indexes are necessarily related to a given set of prices (foreign and domestic); hence, in this case it is possible to range through variables measurable in real terms and approaching strictly nominal variables (those modeled on the nominal side of an interindustry model). When such linkages are applied to input-output table time series, the Belke and Wang assumptions reveal their crucial importance; in fact, removing the impact of prices and any other factor related to competitiveness (labor cost, world market prices, import substitution, economic cycle impact on operating surplus, other institutional factors, etc.), input-output tables time series are made comparable in current prices. In the literature on linkages involving value added, the absence of any emphasis on the relationship between variables measurable in constant prices and those having only a nominal measure is clearly not an oversight.

Investigating structural changes such as those which should be detected and/or measured by means of indexes measuring the content of value added embodied in exports, entails disentangling the linkages between variables necessarily measured in constant prices (that is to say, the variables in the Leontief equation) and those composing the value added.

A theorist may always evoke a bundle of *caveat*. Economists investigating structural changes cannot ignore the impact of prices in designing linkages between real side and nominal side variables.

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GRAVITY ANALYSIS OF REGIONAL ECONOMIC INTERDEPENDENCE: IN CASE OF JAPAN

Toshiaki Hasegawa

■ New Age of Input-Output Database

The development in International input-output table such as IDE-JETRO's AIIO (Asia International Input-Output) table or WIOD (World Input-Output Database) by European Joint Project have made us forward in the field of the research of international connectivity by industry level. Such international input-output tables are useful in comparing in same criteria and in measuring the mutual connectivity internationally. Even though the standalone national input-output tables made us limited in usage, it is quite useful in applying the developed tools to revitalize the description of the domestic economic activity in an international view point. Using the international input-output tables, this paper shows the Skyline Chart for the representative economies. Skyline Chart shows us the bird-eye view of its economic activity, but only illustrated domestically. There has no description of international connectivity by industry. International input-output table which has trade matrix by itself lead us to be flexible in analyzing in both ways, domestically and internationally. In all analysis of Gravity model, GDP or GNP has been used as a proxy of economic size in regressing trade flows. In this paper, we introduce the data of output aggregated in the international input-output table as the economic size in estimating the gravity equation.

In the above analysis, we use WIOD database. WIOD database has provided with the annual Intercountry Input-Output Table until 2009 for 40 countries plus the rest of the world (ROW), in current prices, (industry-by-industry, in millions of US$). The economies provided in WIOD table are as follows;

■ Coverage of Economies in WIOD Database

European Union: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak, Republic, Slovenia, Spain, Sweden, United Kingdom.

North America: Canada, United States.

Latin America: Brazil, Mexico.

Asia and Pacific: China, India, Japan, South Korea, Australia, Taiwan, Turkey, Indonesia, Russia.

+ **ROW (the rest of the world)**

■ Economic Structure in usage of Skyline Chart

The Skyline Chart shows the comparative proportion of output by industry and the comparative size of self-sufficiency, output and import by industry. In the input-output table, domestic demand (*DDM*) is equal to output (*OUT*) minus export (*EXP*) plus import (*IMP*);

$$DDM=OUT-EXP+IMP.$$

What we need in making Skyline Chart for the specific economy is the data of the domestic demand, export and import for each industry. The ratios of the domestic demand and the import to the output are measured with the vertical axis. Each sector's output share in the economy's total output are shown along with the horizontal axis in the following chart. The area colored in light grey shows the output for each industry. The line at 100% in the vertical axis means the self-sufficiency. The area colored in dark grey shows the import the industry.

As the representative economies in WIOD table, we constructed Skyline Chart for some major economies of Japan, China, Russia and USA.[1]

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[1] For the reference of many Asian economies' Skyline Charts, refer to Toshiaki Hasegawa (2013 forthcoming), "Industrial Structure and Interdependence in Asia Pacific region," in I. Yamazawa et al. (eds.), *New Trade Order in Asia Pacific*, Keiso-Shobo (in Japanese). In generating Skyline Charts, we referred to the following material; Kenjiro UDA (2011), "An Introduction to skyline chart generating tool "Ray" Version2", *Research of Economy Statistics*, 34(4). P. 41–57. Economy, Trade and Industry Statistics Association.

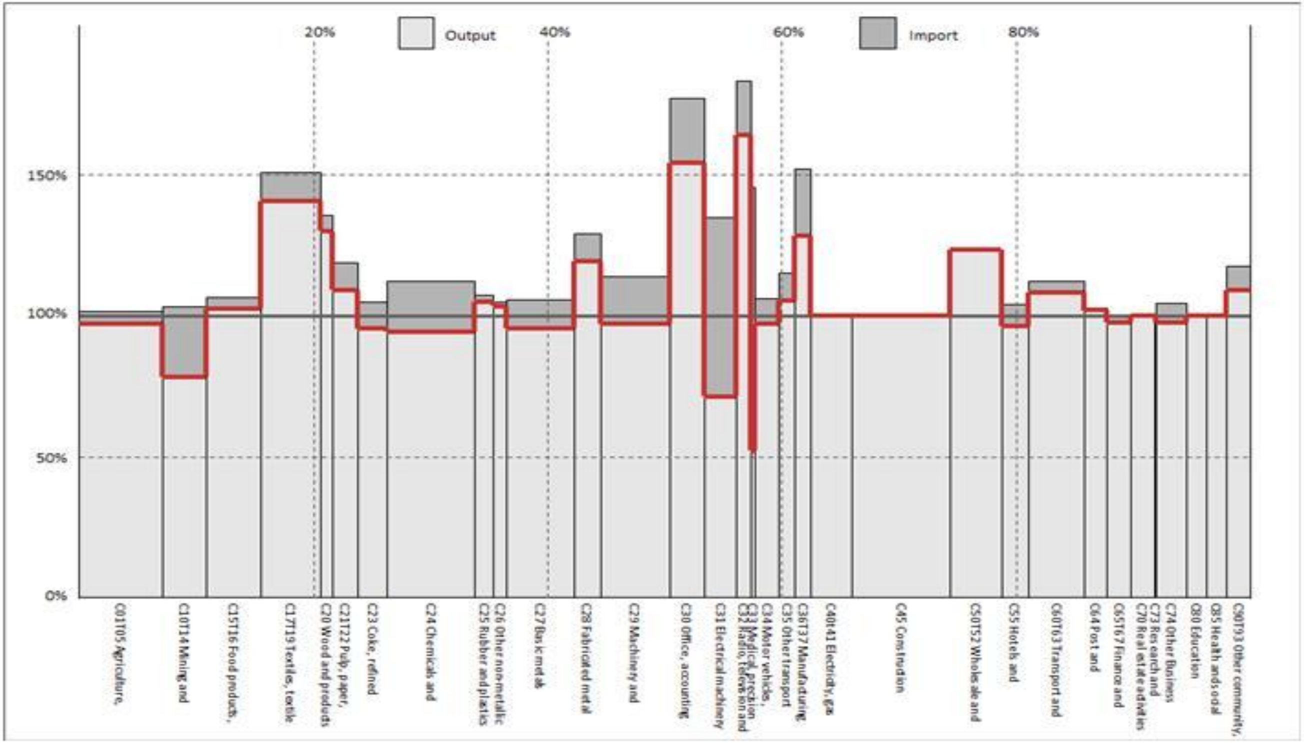


Fig. 1. Skyline Chart of Japanese Economy 2009 (calculated with WIOD Table)

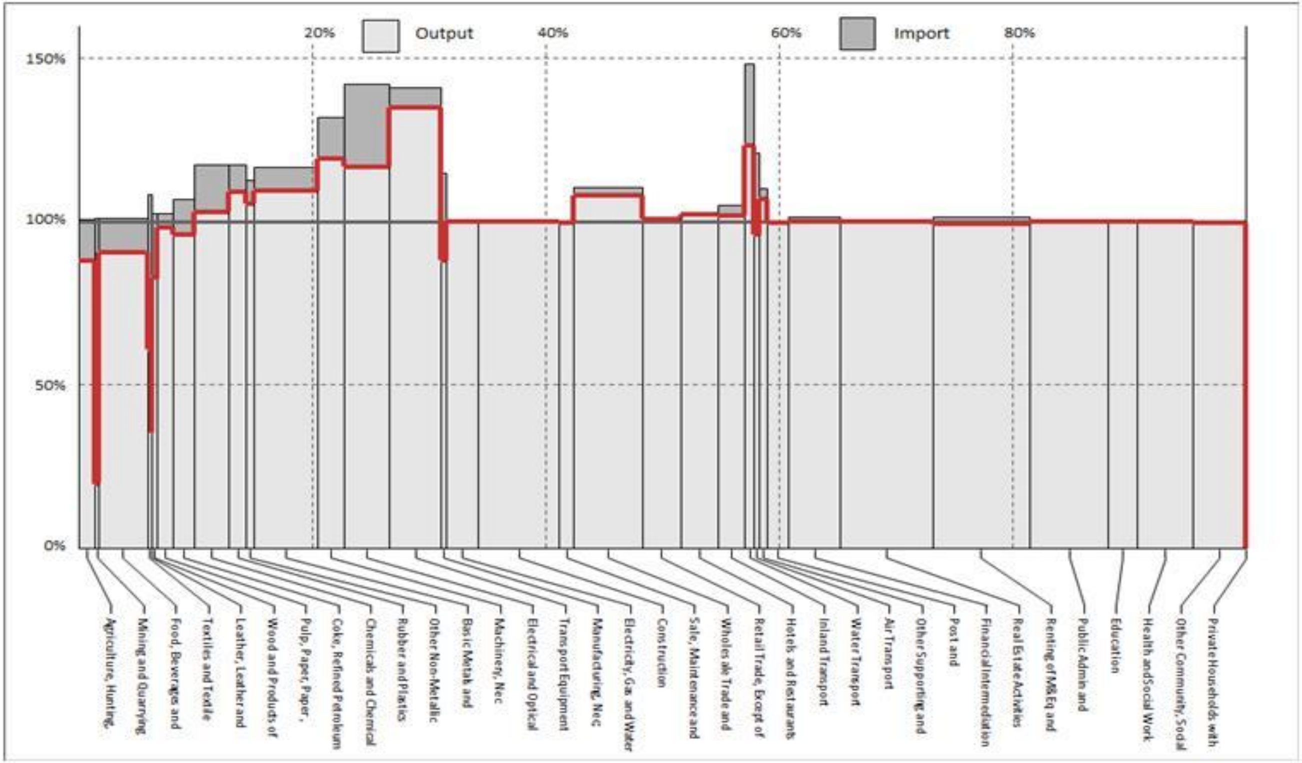


Fig. 2. Skyline Chart of Chinese Economy 2005 (calculated with OECD IO Table)

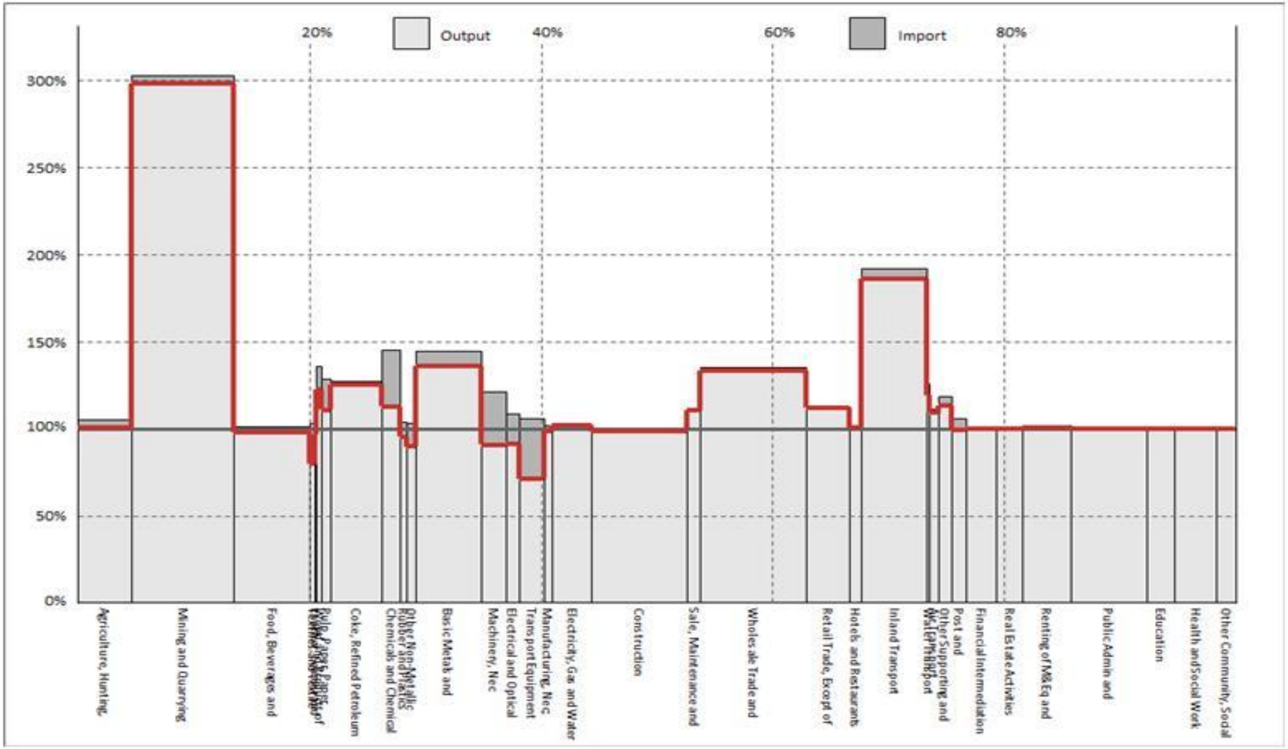


Fig. 3. Skyline Chart of Russian Economy 2005 (calculated with OECD IO Table)

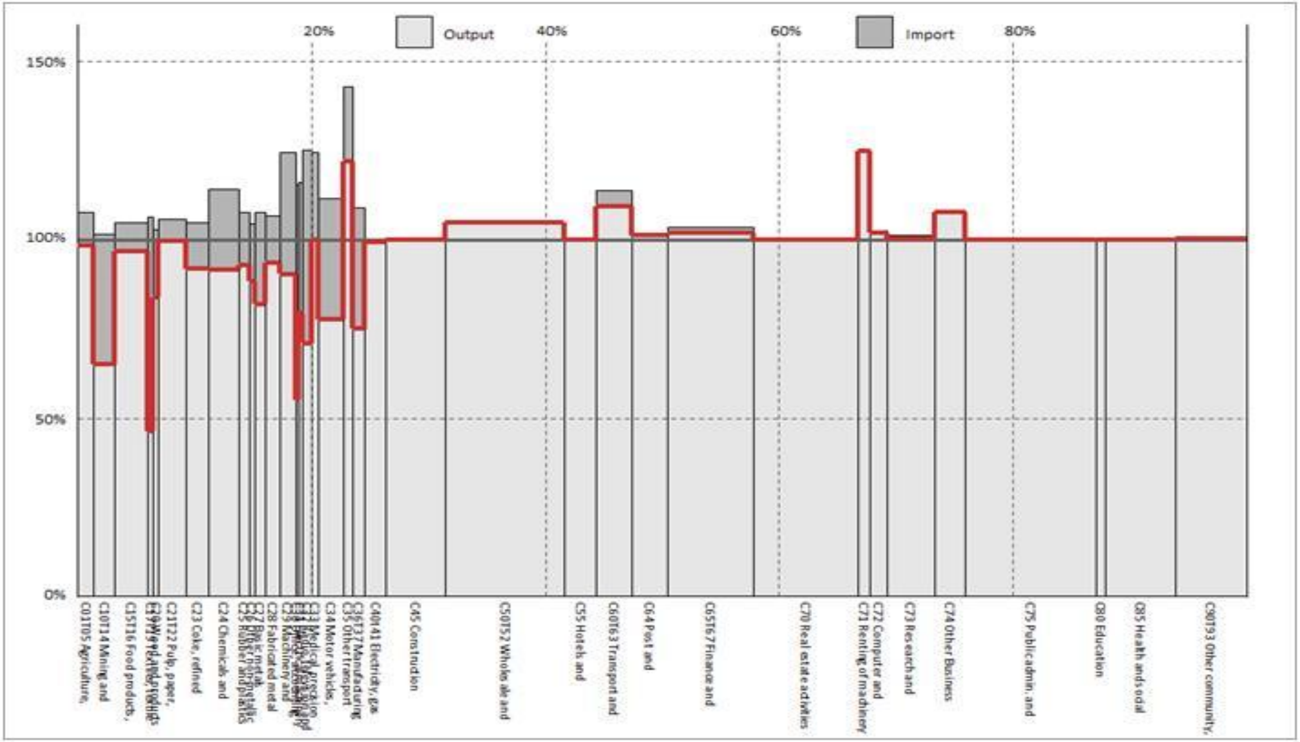


Fig. 4. Skyline Chart of USA Economy 2005 (calculated with OECD IO Table)

■ **Gravity Model of International Trade**

The standard equation of Gravity model[1] is regressed in the following form:

$$ln\, TRADE_{ij} = \alpha_0 + \alpha_1 ln\, OUT_i + \alpha_2 ln\, OUT_j + \alpha_3\, ln\, GEDST_{ij},$$

where $TRADE_{ij}$ is the sum of export and import of intermediate goods between the i-th economy and the *j*-th economy, and $OUT_i\ and\ OUT_j$ is are the output in the *i*-th economy and the *j*-th economy, and $GEDST_{ij}$ is the geographic distance (measured in mile) between the *i*-th economy and the *j*-th economy. In this paper, the *i*-th economy denotes Japan and the above all variables were transformed in legalism. Among 40 economies and a ROW, we extract the trade data directly related to Japan only. In such case, the data of OUT_i is the unchanged variable, to be omitted. The equation to be estimated becomes simple as follows;

$$ln\, TRADE_{ij} = \alpha_0 + \alpha_1 lnOUT_j + \alpha_2\, ln\, GEDST_{ij}.$$

The result of this equation[2] in terms of the method of the ordinary least squares is described as follows;

Estimation of Gravity Model
Method of estimation = Ordinary Least Squares

Dependent variable:	*ln* TRADE
Current sample:	1 to 39
Number of observations:	39

[1] For the broader review of Gravity literature, refer to Anderson E.J. (1979), “A Theoretical Foundation for the Gravity Equation,” *American Economic Review*, 69 (1). – P. 106–116.

[2] The data source in our estimation are as follows:

Data of geographic distance was from *Time and Date AS 1995–2013*, timeanddate.com.http://www.timeanddate.com/information/copyright.html

Input-Output table was obtained from WIOD Database; http://www.wiod.org/database/iot.htm

Mean of dep. var. = 8.33779	LM het. test = .160999 [.688]
Std. dev. of dep. var. = 1.43858	Durbin-Watson = 1.75219 [<.311]
Sum of squared residuals = 13.2150	Jarque-Bera test = .786040 [.675]
Variance of residuals = .367084	Ramsey's RESET2 = 1.94865 [.172]
Std. error of regression = .605875	F (zero slopes) = 89.1171 [.000]
R-squared = .831960	Schwarz B.I.C. = 39.7309
Adjusted R-squared = .822624	Log likelihood = –34.2356

Estimated Standard

Variable	Coefficient	Error	t-statistic	P-value
C	8.61698	1.98582	4.33926	[.000]
ln OUT	.656869	.059444	11.0503	[.000]
ln GEDST	–1.07224	.197265	–5.43551	[.000]

Our anticipation in regressing the gravity equation of trade flow between Japan and the trading partners were well examined by the supposed variables, the trading partners' outputs with positive sign and the geographic distance with negative sign.

The economic interdependence among the economies will be amplified or damped by the change in the institutional framework or in the political and social atmospheres. If we could obtain enough numbers of Asian economies in using WIOD database, we would extend our analysis to the examination of the influence caused by Regional Trade Agreement (RTA). In WIOD database, there are only a limited numbers of Asian economies, in which there are only two economies, Indonesia and Mexico, settled the RTA with Japan as for in 2009. Instead, although AIIO (Asia International Input-Output) tables by IDE which was used in our former analysis[1] covered much more Asian economies closely related to Japanese trade. However, AIIO database has not been available since 2000, unavailable for 2005 table. 2000 AIIO table is the last updated one we can get. Further growing data coverage in WIOD and IDE will be useful for such researches in what the global value chains in business activities has been widely developed, especially in Asia-Pacific region.

■ Appendix

WIOD IO table classification

1	Agriculture, Hunting, Forestry and Fishing	23	Inland Transport
2	Mining and Quarrying	24	Water Transport
3	Food, Beverages and Tobacco	25	Air Transport
4	Textiles and Textile Products	26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
5	Leather, Leather and Footwear	27	Post and Telecommunications
6	Wood and Products of Wood and Cork	28	Financial Intermediation
7	Pulp, Paper, Paper , Printing and Publishing	29	Real Estate Activities
8	Coke, Refined Petroleum and Nuclear Fuel	30	Renting of M&Eq and Other Business Activities
9	Chemicals and Chemical Products	31	Public Admin and Defence; Compulsory Social Security
10	Rubber and Plastics	32	Education
11	Other Non-Metallic Mineral	33	Health and Social Work
12	Basic Metals and Fabricated Metal	34	Other Community, Social and Personal Services
13	Machinery, Nec	35	Private Households with Employed Persons
14	Electrical and Optical Equipment		
15	Transport Equipment		
16	Manufacturing, Nec; Recycling		
17	Electricity, Gas and Water Supply		
18	Construction		
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of		
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles		
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods		
22	Hotels and Restaurants		

[1] Toshiaki Hasegawa (2012), "External Backward Linkage and External Forward Linkage in Asian International Input-Output Table," The 20th NFORUM World Conference Firenze, Italy.

OECD IO table classification			
1	Agriculture, hunting, forestry and fishing	25	Manufacturing nec; recycling (include Furniture)
2	Mining and quarrying (energy)	26	Production, collection and distribution of electricity
3	Mining and quarrying (non-energy)	27	Manufacture of gas; distribution of gaseous fuels through mains
4	Food products, beverages and tobacco	28	Steam and hot water supply
5	Textiles, textile products, leather and footwear	29	Collection, purification and distribution of water
6	Wood and products of wood and cork	30	Construction
7	Pulp, paper, paper products, printing and publishing	31	Wholesale & retail trade; repairs
8	Coke, refined petroleum products and nuclear fuel	32	Hotels & restaurants
9	Chemicals excluding pharmaceuticals	33	Land transport; transport via pipelines
10	Pharmaceuticals	34	Water transport
11	Rubber & plastics products	35	Air transport
12	Other non-metallic mineral products	36	Supporting and auxiliary transport activities; activities of travel agencies
13	Iron & steel	37	Post & telecommunications
14	Non-ferrous metals	38	Finance & insurance
15	Fabricated metal products, except machinery & equipment	39	Real estate activities
16	Machinery & equipment, nec	40	Renting of machinery & equipment
17	Office, accounting & computing machinery	41	Computer & related activities
18	Electrical machinery & apparatus, nec	42	Research & development
19	Radio, television & communication equipment	43	Other Business Activities
20	Medical, precision & optical instruments	44	Public admin. & defence; compulsory social security
21	Motor vehicles, trailers & semi-trailers	45	Education
22	Building & repairing of ships & boats	46	Health & social work
23	Aircraft & spacecraft	47	Other community, social & personal services
24	Railroad equipment & transport equip nec.	48	Private households with employed persons & extra-territorial organisations & bodies

THE CURRENT PROGRESS IN THE RUSSIAN INTERINDUSTRY MODEL

Sofia V. Kaminova

The Russian Interindustry Model (RIM) is a rather ambitious model of the Inforum type. At its heart is an annual time series of 44-sector input-output tables going back to 1980. RIM's scope can be judged by a list of some of the other data which goes into it:

- national accounts, including institutional accounts;
- consumer prices;
- balance of payments, in what the Russian Central Bank calls the Analytical Presentation, which includes data on some major goods and institutions;
- employment by industry;
- wages by industry;
- population, labor force, total employment and unemployment;
- oil and gas prices;
- volumes in physical units of petroleum and natural gas extraction;
- volume of retail trade, catering and paid services;
- exchange rates between the ruble and the dollar and euro;
- the consolidated government budget;
- pension funds;
- prices on some natural monopolies (water, gas, electric energy, and railway services);
- some world indicators (USA GDP, European Union GDP, USA current account balance of payments, wheat price);
- capacities in some manufacturing industries. (These are a Russian specialty, described in greater detail below.).

Since the report to the Inforum Conference in Japan in 2010, RIM has been updated and expanded. The government consumption block and the employment equations have been developed. The block for calculation taxes on products used has been built. Work on the investment equations is on-going, as will be described below. We intend to build a block for financial flows beginning from the incomes of business and households.

The sequence of calculations in each iteration is shown schematically in Figure 1 below.

RIM Sequence of Calculations

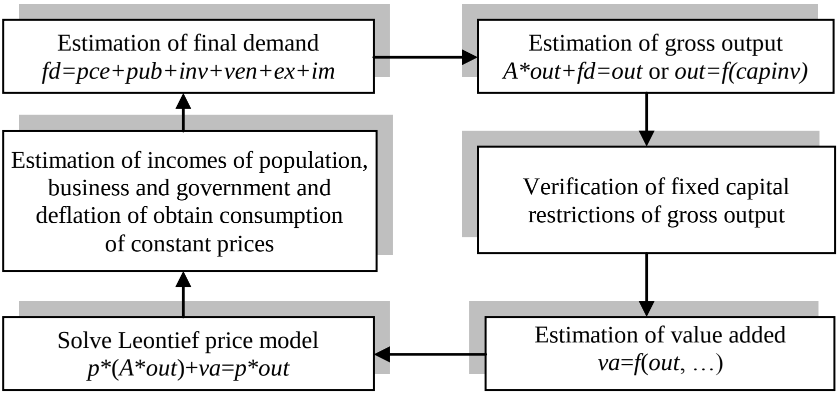


Fig. 1: Sequence of Calculations in RIM

■ Investment

In the work on investment, we have made use of an unusual body data prepared by the Russian Statistical Office (Rosstat) and, to our knowledge, unlike any data gathered elsewhere. This is data on what is called in Russian *moschnost'* and corresponds approximately to the notion of *capacity.* The data from Rosstat is for hundreds and hundreds of individual products, all measured in physical units of output of the product per year, or in some cases, in a 24 hour period. For each product, there are annual data on capacity at the beginning of the year, introduction of new capacity during the year, retirement of old capacity, changes in rented capital, changes in nomenclature, and finally capacity at the end of the year. Within the Institute of Economic Forecasting, these series have been converted to value terms and to some extent aggregated. One data set, which we may call Data Set A, is aggregated to 22 sectors, roughly corresponding to RIM sectors in mining and manufacturing. It contains two series for each sector: (1) investment in each year and (2) increases in capacity ready to use, ready to go online. The two series are in different units. The first is in rubles of investment at constant prices; the second is in rubles of output (at constant prices) of the investing sector. The increases in capacity are gross – that is, retirement has not been subtracted.

Regressions were run relating new capacity in each year to investment in the same year and two preceding years. These regression had no intercept. The initial regressions produced an implausible negative coefficient on some variable in about half the cases. In these industries, soft constraints were the imposed via the G7 *sma* command to pull the regression coefficients towards lying on a straight line. In all cases, non-negative coefficients were achieved with reasonably good fits. Tab. 1 shows the lag patterns, the sum of the lag weights, and the average lag for each industry.

Based on the lag values from the table below, the mining industries (Non-ferrous metals, Natural gas extraction) and Fabricated metal products have the highest values of lag average, while manufacturing industries (Machinery, Electrical apparatus) and Ferrous metals have the lowest values of lag average. So, the industries processing primary resources need increasing of productivity.

At present, investment by investing industry is exogenous in RIM. One set of rather simple investment functions combining replacement (calculated from capacity) with increases in peak output over the preceding three years has also been estimated and used in the model. We intended to also try more ambitious equations including also profits, and level of capacity utilization, and financial restrictions. New capacity by sectors we intend to calculate from past sector investment with weights, estimated beyond in the table.

To convert capital investment by the investing sector, a vector we may call **v**, to demand for investment goods, we need a capital flows matrix, B, so that Bv is capital investment by producing sector. Our B matrix is, in reality, not of full rank but is the product of two matrices. The first matrix, T, is 3x44 and divides each element of v into 3 components: Construction, Machinery and equipment, and Other. A second matrix, E, then converts each of these three components to demands on each of the 44 producing industries. Thus $ETv = Bv$ gives a vector of demand for investment goods by producing industry.

Table 1

The Lag between Expenditure and Increased Capacity

№	Industry	Lag in years			Lag	Lag
		0	1	2	Sum	Average
1	Petroleum extraction	0.156	0.296	0.285	0.737	1.176
2	Natural gas extraction	0.031	0.357	0.243	0.631	1.336
3	Coal mining	0.187	0.130	0.067	0.384	0.688
4	Mining of metallic ores	0.379	0.198	0.074	0.651	0.531
5	Food and berverages	0.470	0.229	0.075	0.774	0.489
6	Textile and apparel	0.355	0.237	0.118	0.711	0.667
7	Lumber and wood products	0.336	0.310	0.061	0.707	0.611
8	Paper and printing	0.070	0.485	0.155	0.711	1.120
9	Petroleum refining	0.208	0.213	0.148	0.569	0.894
10	Chemicals	0.158	0.205	0.223	0.586	1.110
11	Pharmaceuticals	N.A.				
12	Plastic resins and products	0.366	0.256	0.116	0.738	0.661
13	Stone, clay and glass products	0.219	0.251	0.102	0.572	0.796
14	Ferrous metals	1.004	0.315	0.262	1.581	0.530
15	Non-ferrous metals	0.034	0.117	0.207	0.358	1.483
16	Fabricated metal products	0.024	0.301	0.280	0.606	1.422
17	Machinery and equipment	0.315	0.147	0.041	0.503	0.456
18	Computers and office machinery	0.185	0.123	0.062	0.370	0.667
19	Electrical apparatus	0.428	0.328	0.194	0.950	0.754
20	TV, radio and communication equipment	0.501	0.441	0.183	1.125	0.717
21	Medical, optical and precision instruments	0.364	0.245	0.122	0.732	0.669
22	Transportation equipment	0.081	0.160	0.206	0.448	1.279

Personal Consumption Expenditure

We are trying the idea of comparing Russian consumption levels of individual products to "saturation" levels in selected high income countries. The greater the gap between the saturation level of a particular product and the Russian consumption of that product, the higher the income elasticity for the product. As people saturate their consumer demand, the income elasticity tends to reduce, till it becomes zero in the saturation point. But achieving saturation is constrained by the amount of income that people can spend on consumption. Under this restriction people get borrowings from banks and expend their savings. The closer household consumption to saturation level, the less people need credits and save more income. So the relationship between household consumption level, the saturation point, credits and savings can be estimated. The balance between these variables is achieved by using iterations.

	Elasticity	point			
Agriculture	0,50	118			
Food, beverages, tobacco	0,50	129			
Textiles, apparel, leather	1,01	212			
Petroleum refining	2,00	403			
Chemicals	2,45	416			
Pharmaceuticals	0,40	126			
Machinery	1,54	369			
Radio, television, communication equ	1,79	265			
Transport production and equipment	2,00	403			

Fig.2. Personal Consumption Elasticities and Saturation Points

The table on Fig. 2 demonstrates sector saturation points of a particular product to the level of 2010 and elasticities of personal consumption of a particular product by GDP per capita.

Government consumption

Government consumption in the RIM model is determined by consolidated budget expenditures. Because we have an opportunity to divide budget expenditures by items, consumption of government by sectors can be calculated. Total budget expenditures are equal to the budget revenues, subtracted by the surplus or the deficit of the budget, and added by the oil-and-gas transfer. The budget revenues are defied by taxable base and tax rates. The taxable base is formed by variables that calculated in the model.

Whether the tax rate is fixed or not the type of regression differs.

Tax revenues = regression coefficient * tax base * tax rate
(for the taxes with the fixed rate: VAT, profit and income taxes, single social tax)
Tax revenues = regression coefficient * tax base
(for the taxes without fixed rate: excises, payments for natural resources usage, tax duties)

Fig. 3. The Budget Equations

The surplus or the deficit of the budget is financed from external or internal sources such as government accounts, external debt, and government securities issues.

Forecast

The results of model simulation are presented on the next pictures:

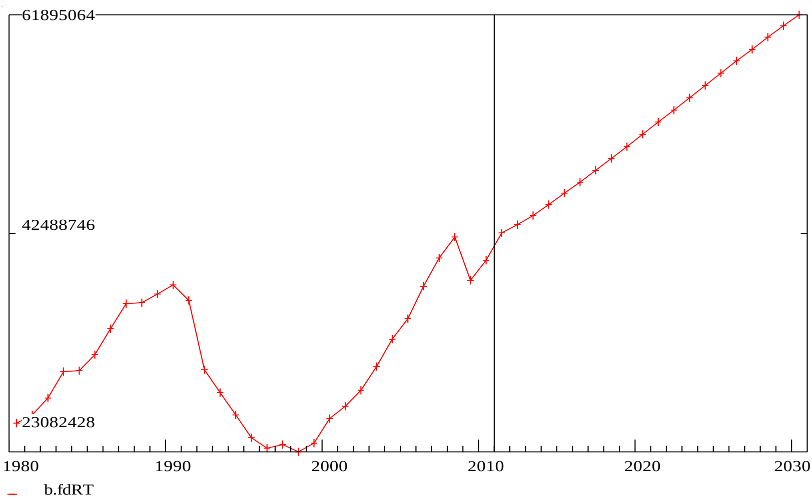


Fig. 4. GDP in constant prices

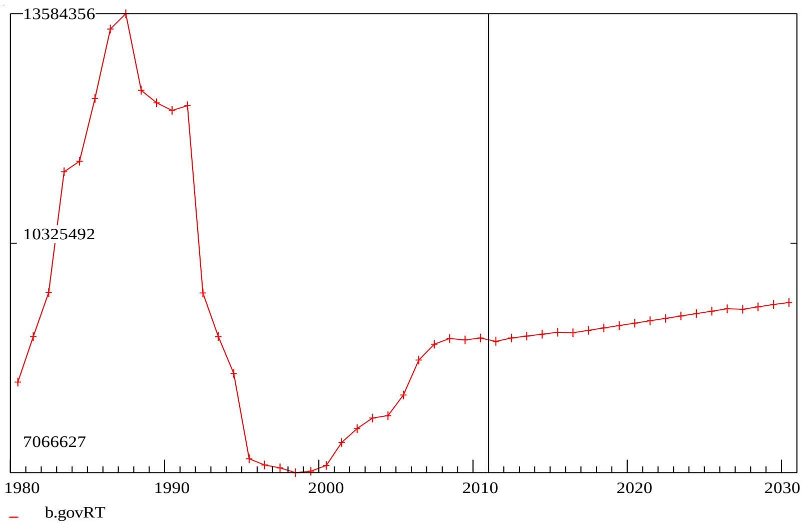


Fig. 5. Government expenditures in constant prices

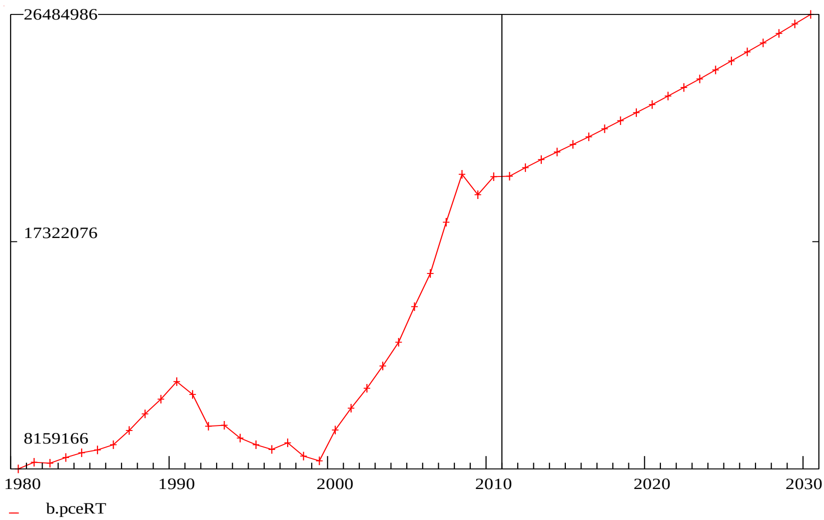
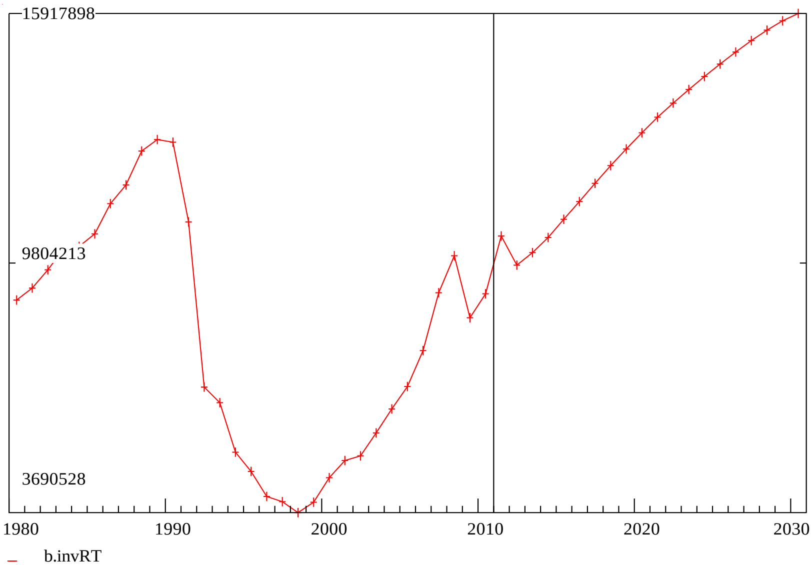


Fig. 6. Personal consumption expenditures in constant prices



Fig, 7. Fixed capital investment

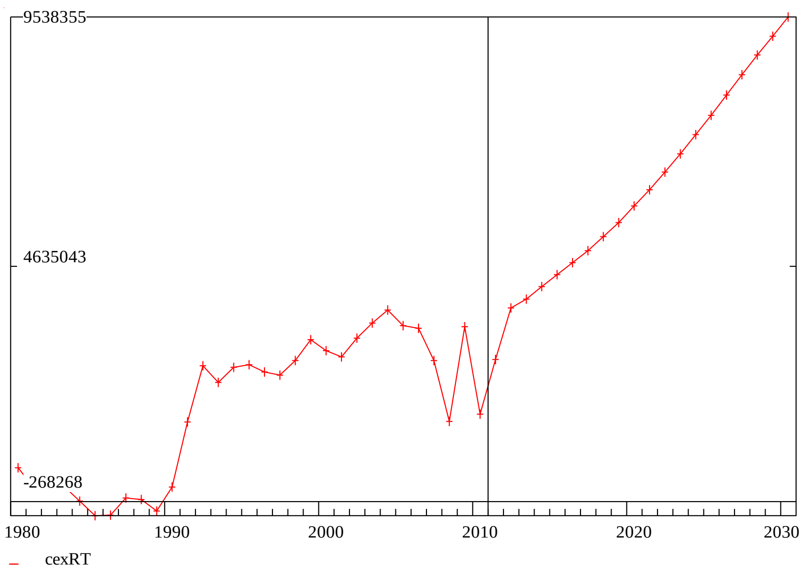


Fig. 8. Net export in constant prices

CHARACTERISTICS AND TREND OF STRUCTURAL CHANGE IN CHINESE ECONOMY. A COMPARATIVE ANALYSIS BASED ON THE 2007 AND 2010 IO TABLES

Shantong Li, Sanmang Wu, Yunyi Liu

Abstract: This paper has taken comparative analysis of structural change of the Chinese economy from the aspects of structure of industry and intermediate input based upon data of Chinese 2007 and 2010 I/0 tables. Research shows: From the aspect of industrial structure, China has not only increased continuously its share of service of GDP, but also changed actively the internal structure of manufacturing and service. Manufacturing sector is transforming from labor intensive to technology intensive, from high energy intensity to low energy intensity, there is also increasing share of productive service in the sector of service. In regard to the intermediate input, there is rise of rate of intermediate input to China's whole economy due to increase of use of service to primary and secondary sector, especially the service of science, technology and transport. The significant rise of share of remuneration to laborers has caused a declining trend of rate of intermediate input to service. A comprehensive analysis of above shows, there is continuous improvement of structure of industry, while there is also increase of share of science, technology and service in intermediate imput in the process of China's economic development.

Key Words: Structural Change of Economy; I/0 Analysis; Rate of Intermediate input

■ Introduction

In recent years, there are many features of pattern of growth of Chinese economy and its structural changes which are worthwhile to be noted. Especially, there are larger changes of domestic and international environment faced by Chinese economy in the period from 2007 to 2010. Firstly, energy saving and environmental indicators are constrained indicators based upon the theme of concept of scientific development of the “Eleventh-Five Year Plan ” while the period from 2007 to 2010 is critical for the achievement of Eleventh Five Year Plan. The second, the eruption of global financial crisis in 2007 had caused the decline of growth of the global economy which had important impact to China’s economic growth; the year 2007 had become the turning point of extraordinary high economic growth of China since the new Century. Thirdly, the cost of input factors such as land and laborers were rising relatively faster in this period, there were increasing constraints from resources and environment. How changes of the Chinese economic structure and their impacts to Chinese economic development in coming future under the influences of all above factors are worthwhile to be concerned. And I/0 model is a better tool in analyzing the economic structural change of a country: China has announced its new 2010 I/0 table recently. In consideration of the year 2007 to be an important turning point of Chinese economic growth, therefore, it is meaningful for this paper to do comparative analysis of the structure of industry, foreign trade and intermediate input in depth based upon utilization of the data of 2007 and 2010 Chinese I/0 tables.

■ Structural Changes of the Chinese economy

Structural change of components of GDP

The share of VA of three industrial sectors in the national economy has continued the past trend of change basically. The share of primary, secondary and tertially sectors in GDP has been changed from 10.8:50.6:38.7 in 2007 to 10.0:48.2:41.8 in 2010. The share of the primary sector has kept the patern in declining but its amplitude of declining is in slowness; the share of service is increased by more than three percentage points; but it is worthwhile to note the changing trend of share of the secondary sector which was in rising trend in the past, which there is a decline of 2.4 percentage points in this period. It can be seen from figure 1; the share of VA of the secondary sector in GDP reached its peak in 2007. While the share of VA of the secondary sector in GDP will be in decline continuously in accompanying the increasing of share of the VA of the tertiary sector in GDP continuously while there is gradual decline of the share of VA of the primary sector.

Table 1

GDP structure（%）

	2002	2005	2007	2010
Primary Industry	13.6	12.5	10.8	10.0
Secondary Industry	45.2	47.8	50.6	48.2
Tertiary Industry	41.1	39.7	38.7	41.8

Source: calculations based on input-output table (2002, 2005, 2007, 2010)

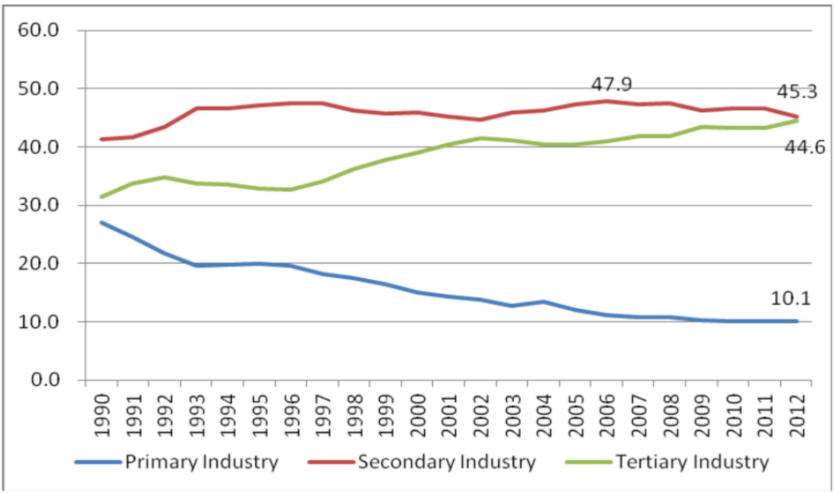


Fig. 1. GDP structure (1990–2012).

Internal structural change of the manufacturing sector

The manufacturing sector can be classified into types of labor intensive, capital intensive and technology intensive based upon the degree of concentration of factors of production.

It can be seen from table 2 that the share of labor intensive industry had kept a trend of decline in continuous with a decline of 2.39 percentage points within the period of 2007–2010; nearly all sub-sectors of labor intensive industry show a declining trend with exception of manufacture of foods and tobacco which are rising slightly in the period from 2007–2010. The share of capital intensive industry is rising slightly in the period from 2002–2010, but its amplitude of rise is gradually in decline, there are small decline of capital intensive industry in the period of 2007–2010 due to decline of share of smelting and pressing of metals with relatively large amplitude. The share of technology intensive industry is in rise around three percentage points in the period of 2002–2010; nearly most of the sub-sectors of this industry is in a rising trend with exception of manufacture of communication equipment, computers and other electronic equipment which have a small decline of their share, the manufacture of transport equipment, general and special machinery is rising with relatively larger amplitude in this period specially.

The manufacturing sector can be classified into low technology manufacturing sector, medium low technology manufacturing sector medium high technology and high technology manufacturing sector based upon the technological level of the manufacturing sector. The share of low and medium low technology sector is in decline in the period of 2007–2010 while the share of manufacturing sector with higher content of technology (including high technology manufacturing sector and medium high technology manufacturing sector) is increased by 3.5 percentage points (please refer to tab. 3). This shows the feature of transformation of the structure of China's manufacturing sector from low technological level to high technological level from the aspect of analysis of technological level.

Table 2

Manufacturing industry structure (%)

	2007	2010	2007–2010	2002–2005	2005–2007
Labor Intensive Industry	**31.44**	**29.05**	**–2.39**	**–2.77**	**–0.40**
Foods and Tobacco	10.54	10.64	0.11	–0.15	–1.08
Textile	5.09	5.03	–0.06	–0.55	–0.20
Textile Wearing Apparel, Footwear, Caps, Leather, Fur and Its products	4.1	3.47	–0.70	0.62	–0.71
Processing of Timbers and Manufacture of Furniture	2.70	2.17	–0.54	–0.59	0.48
Papermaking Printing and Manufacture of Articles for Culture, Education and Sports	3.68	3.20	–0.48	–1.93	–0.59
Other Manufacture	5.25	4.54	–0.71	–0.16	1.70
Capital Intensive Industry	**39.57**	**38.96**	**–0.61**	**2.22**	**0.90**
Processing of Petroleum, Coking, Processing of Nuclear Fuel	3.88	4.48	0.60	0.99	0.16
Chemical Industry	13.04	13.52	0.48	–1.13	–1.04
Nonmetallic Mineral Products	6.48	6.58	0.10	1.83	–0.34
Smelting and Rolling of Metals	12.35	10.95	–1.40	0.52	2.02
Manufacture of Metal Products	3.82	3.43	–0.39	0.00	0.10
Technology Intensive Industry	**28.99**	**31.99**	**3.00**	**0.55**	**-0.49**
General Purpose and Special Purpose Machinery	9.44	10.49	1.06	0.05	–0.16
Transport Equipment	6.65	8.40	1.75	–0.57	0.60
Electrical Machinery and Equipment	4.79	5.47	0.68	0.99	–0.69
Communication Equipment, Computer and Other Electronic Equipment	7.05	6.51	–0.53	–0.08	–0.01
Measuring Instrument and Machinery for Cultural Activity & Office Work	1.07	1.12	0.05	0.16	–0.23

Source: calculations based on input-output table (2002, 2005, 2007, 2010)

Table 3

Manufacturing industry structure (by technology, %)

	2007	2010	2007–2010
High-tech manufacturing	8.12	7.63	–0.49
Medium and high technology manufacturing	33.91	37.88	3.97
Low and medium technology manufacturing	26.53	25.44	–1.09
Low-tech manufacturing	31.44	29.05	–2.39

Source: calculations based on input-output table (2007, 2010)

The manufacturing[1] sector can be classified into low level energy consuming manufacturing sector, medium level energy consuming manufacturing sector and high level energy consuming manufacturing sector based upon the level of energy consuming of the manufacturing sector. There were rising of share of high level energy consuming manufacturing sector in the period of 2002 to 2007, especially there was a rise of 2.3 percentage points in the period of 2002–2005 with a relatively larger amplitude of rise; but there is a decline of share of high level energy consuming manufacturing sector in the period from 2007 to 2010 while there is increase of share of 2.3 percentage points of low level energy consuming manufacturing sector (See tab. 4). Looking as a whole, there is transformation of structure of manufacturing sector from high level to low level of consumption of energy post the year of 2007, but the decline of the share of high energy consuming manufacturing sector is not significant, and the share of medium and high energy consuming manufacturing sector is still biased on the higher side.

Table 4

Manufacturing industry structure (by energy Intensity, %)

	2007	2010	2007–2010	2002–2005	2005–2007
Low Energy Intensive Industry	33.2	35.5	2.3	1.2	–1.2
Middle Energy Intensive Industry	31.1	29.0	–2.1	–3.4	0.4
High Energy Intensive Industry	35.8	35.5	–0.3	2.3	0.8

Source: calculations based on input-output table (2007, 2010)

[1] Note: UNIDO is advoting to use energy intensity for the comparison of energy efficiency in its 2011 Industrial Development Reports. High energy intensity sector means sector with high level of consumption of energy.

Change of internal structure of the service

Service can be roughly classified into productive service, living service and public service based upon its object to be served and the nature of the products. The share of China's productive service is in the rising trend, which is increased from 26.63% in 2007 to 28.76% in 2010, this is caused mainly by the significant increase of share of wholesale and retail service, real estate, leasing and commercial service; the share of the living service is in a trend of decline but its rate is in lowering, it had a share of 4.17% in 2007 and declined to 4.13% in 2010, this is mainly caused by the declining share of hotels and restaurants; the share of public service is in the rising trend, which is increased from 7.86% in 2007 to 8.91% in 2010 caused mainly by the significant increase of share of public management and social organizations.

Table 5

Proportion of the added value of services in GDP (%)

	2005	2007	2010	2005–2007	2007–2010
Producer' Services	**26.30**	**26.63**	**28.75**	**0.34**	**2.12**
Traffic Transport and Storage	5.69	5.50	4.69	–0.20	–0.80
Post	0.16	0.13	0.12	–0.03	–0.01
Information Transmission, Computer Services and Software	2.58	2.26	2.20	–0.31	–0.06
Wholesale and Retail Trades	7.32	6.51	7.57	–0.80	1.05
Financial Intermediation	3.41	5.05	5.20	1.64	0.15
Real Estate	4.46	4.63	5.64	0.17	1.01
Leasing and Business Services	1.57	1.43	1.93	–0.14	0.50
Research and Experimental Development	0.25	0.23	0.28	–0.03	0.06
Comprehensive Technical Services	0.86	0.89	1.11	0.03	0.23

	2005	2007	2010	2005–2007	2007–2010
Consumer' Services	**4.60**	**4.17**	**4.13**	**–0.43**	**–0.05**
Hotels and Catering Services	2.27	2.09	2.00	–0.17	–0.09
Services to Households and Other Services	1.69	1.51	1.51	–0.18	0.00
Culture, Sports and Entertainment	0.64	0.57	0.62	–0.07	0.05
Public Services	**8.79**	**7.86**	**8.91**	**–0.93**	**1.05**
Management of Water Conservancy, Environment and Public Facilities	0.46	0.42	0.43	–0.04	0.02
Education	3.06	2.75	2.98	–0.31	0.24
Health, Social Security and Social Welfare	1.59	1.43	1.48	–0.15	0.05
Public Management and Social Organization	3.69	3.26	4.02	–0.43	0.75

Source: calculations based on input-output table (2005, 2007, 2010)

■ Changes in Intermediate Input Structure of Chinese Economy

It is generally regarded that intermediate input ratio is an important efficiency indicator. Other conditions being equal, a higher intermediate input ratio means a lower added value ratio and thus a lower efficiency. The following reasons may contribute to the change in the structure of intermediate inputs:

(1) Industrial structure upgrading. During the industrialization process, countries (especially low-income ones) usually follow a development path in line with their factor endowment advantages, and transform their labor-intensive structures into capital- and technology-intensive ones. Because labor-intensive structure has a lower intermediate input ratio, an upgrading of such a structure will increase the total intermediate input.

(2) Technological progress. Technological progress means that more labor is replaced by capital and technology and thus the intermediate input ratio rises.

(3) Intra-industry vertical division. The rapid advances in information and communications technologies (ICT) and reduced transportation and communications costs will promote further intra-industry vertical division and thus raise the intermediate input ratio.

(4) Improved management skills. The improved management skills may lead to more efficient resources allocation, and thus the change in the intermediate input structure.

Change in China's Total Intermediate Input Ratio

China's total intermediate input ratio has increased steadily since 1987. It increased from 55.48% in 1987 to 67.78% in 2010, 12.3 percentage points up within more than two decades. But in recent years, the growth rate has slowed down. For example, the increase in total intermediate input ratio is three percentage points from 1987 to 1990, but it is only 0.27 percentage point for the 2007–2010 period.

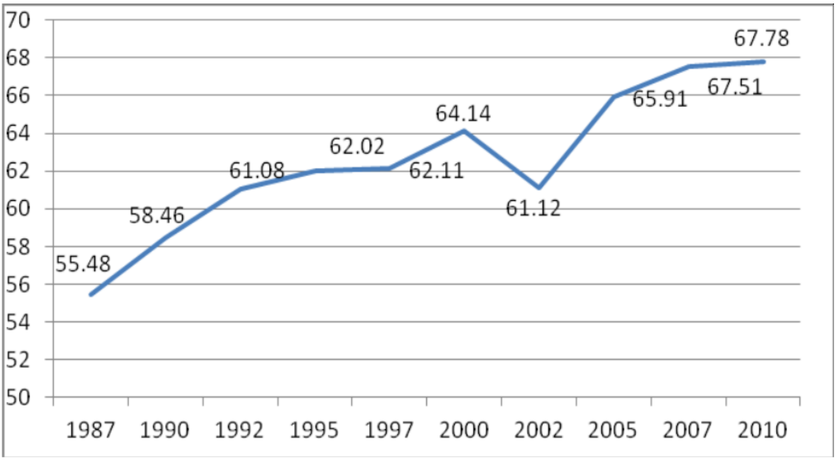


Fig. 2. Total Intermediate Input Ratio (1987–2010).

Change in Intermediate Input ratios for the Three Sectors

There are some new elements associated with the change in sectoral intermediate input ratios during the 2007–2010 period. The intermediate input ratios for primary and secondary sectors continued to rise, but at modest rates, with the latter up from 76.71 to 77.83%. By contrast, the intermediate input ratio for the tertiary sector was down from 46.52 to 44.92%.

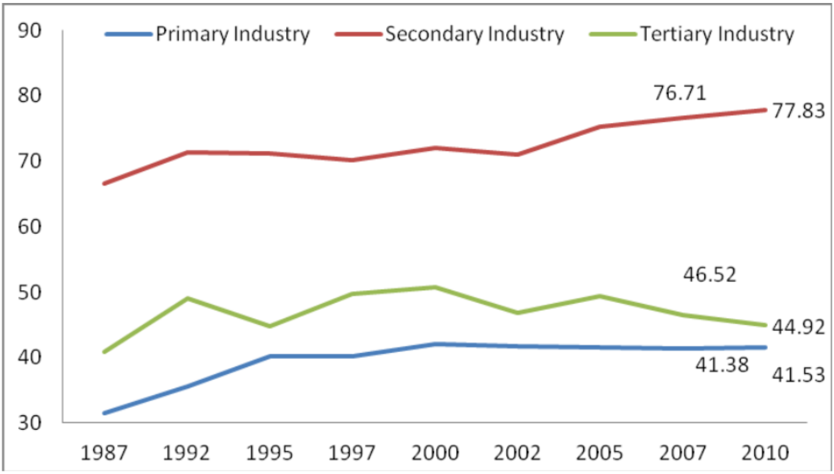


Fig. 3. Intermediate input ratio for the Three Sectors

The major reason for the rising intermediate input ratios in the primary and secondary sectors is that intermediate inputs from the tertiary sector (especially from transportation and technological services) into the two sectors rose significantly. The primary (secondary) sector saw its intermediate input ratio increase by 0.143 (1.12) percentage point(s) from 2007 to 2010, with the tertiary sector contributing 0.127 (1.21) percentage point(s) to the increase. On the other hand, the main reason for the reduced intermediate input ratio in the tertiary sector is that the share of labor earnings in the total input increased significantly, up 5.59 percentage points from 2007 to 2010.

We further decompose the change in China's total intermediate input ratio into two parts: the change due to change in the three sectors' intermediate input rates and the change due to sectoral structure change.[1] Our results show that the 0.27 percentage point increase in China's total intermediate input rate during the 2007–2010 period can be decomposed into 0.4 percentage point increase due to change in the three sectors' intermediate input ratios (0.008 percentage point for the primary sector, 0.78 percentage point for the secondary sector, and minus 0.39 percentage point for the tertiary sector) and 0.13 percentage point decrease due to sectoral structure change. The main

[1] See Appendix II for details.

reason for the negative contribution of the second part is that the share of the tertiary sector in the total output has increased while that of the secondary sector has decreased during the period. Because the intermediate input ratio is lower for the tertiary sector than for the secondary sector, the sectoral structure change during the 2007–2010 period contributed negatively to the change in China's total intermediate input ratio.

Change in Intermediate Input ratio in the Manufacturing Sector

The intermediate input ratio in China's manufacturing sector has experienced a steady increase in the past two decades, up from 70.8% in 1990 to 80.3% in 2010, a 9.5% increase. There are also some minor fluctuations during some specific periods (for example, 1995–1997 and 2000–2002 periods). From 2007 to 2010, the intermediate input ratio in China's manufacturing sector increased by 1.2 percentage points.

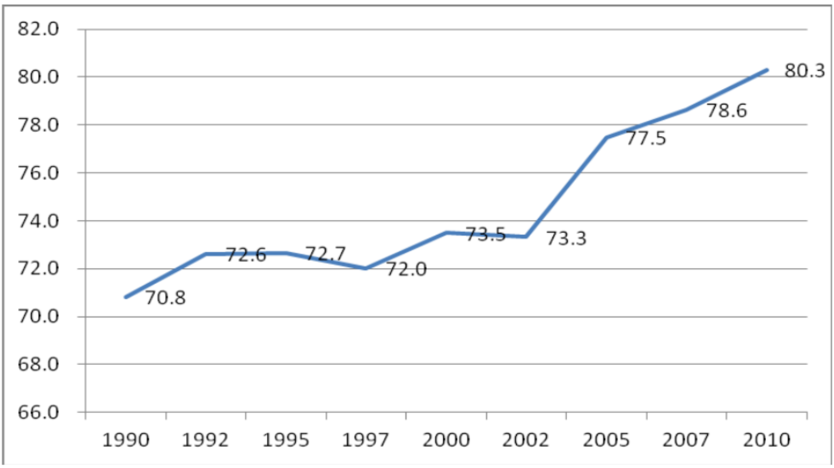


Fig. 4. Intermediate input ratio of Manufacturing

The intermediate input ratio in China's manufacturing during the 2007–2010 period shows the following patterns. First, labor- (techno-logy-) intensive manufacturing's intermediate input ratio was higher (lower) than that of the capital-intensive manufacturing.[1] Second, intermediate input ratios for the three types of manufacturing were all on the rise. Labor-intensive manufacturing saw its intermediate input ratio increase from 75.01% in 2007 to 77.66% in 2010, capital-intensive manufacturing from 79.3 to 80.73%, and technology-intensive manufacturing from 80.78 to 81.79%. The labor-intensive manufacturing saw the biggest growth of intermediate input ratio, a 2.65% increase, while the growth rates for capital-intensive and capital-intensive manufacturing were both moderate. The higher growth of intermediate input ratio in the labor-intensive manufacturing is mainly due to the rapid growth in related industries such as timber processing, furniture, craft, food, tobacco, paper printing and educational and sports goods. As for the capital-intensive manufacturing, the growth of intermediate input ratio for non-metallic minerals manufacturing was significant, up from 72% in 2007 to 78% in 2010, while the growth of other capital-intensive industries was rather modest. By contrast, technology-intensive manufacturing saw its growth of intermediate input ratio slow down during the 2007–2010 period.

By the similar token, we can decompose the change in intermediate input ratio in China's manufacturing into two parts: the change due to change in intermediate input ratios of the three types of manufacturing and the change due to their structure change. We find that the 1.7 percentage point increase in intermediate input ratio of China's manufacturing during the 2007–2010 period can be decomposed into 1.59 percentage point increase due to change in intermediate input ratios of the three types of manufacturing (0.67 percentage point for labor-intensive manufacturing, 0.57 percentage point for capital-intensive manufacturing, and 0.35 percentage point for technology-intensive manufacturing) and 0.11 percentage point decrease due to their structure change.

[1] In terms of input factor intensity, manufacturing can be classified as labor-intensive, capital-intensive, and technology-intensive ones.

Table 6

Intermediate input ratio of Manufacturing (by production factors, %)

Category	2002	2005	2007	2010	2007–2010
Labor Intensive Industry	69.94	73.82	75.01	77.66	2.65
Foods and Tobacco	68.94	72.29	75.64	78.92	3.28
Textile	75.22	79.09	80.49	79.40	–1.10
Textile Wearing Apparel, Footwear, Caps, Leather, Fur and Its products	75.42	75.04	77.69	80.82	3.13
Processing of Timbers and Manufacture of Furniture	72.71	76.74	76.23	80.78	4.55
Papermaking Printing and Manufacture of Articles for Culture, Education and Sports	66.34	75.36	76.18	79.42	3.24
Artwork, Other Manufacture	50.96	55.28	51.91	55.62	3.71
Capital Intensive Industry	74.59	78.15	79.30	80.73	1.43
Processing of Petroleum, Coking, Processing of Nuclear Fuel	82.80	81.23	82.20	80.16	–2.04
Chemical Industry	73.07	78.19	79.69	80.64	0.95
nonmetallic Mineral Products	67.12	73.18	72.53	78.05	5.52
Smelting and Rolling of Metals	75.60	79.45	80.48	82.19	1.71
Metal Products	76.33	77.97	79.18	81.31	2.13
Technology Intensive Industry	75.11	79.76	80.78	81.79	1.02
General Purpose and Special Purpose Machinery	71.92	76.04	76.91	78.85	1.94
Transport Equipment	73.78	78.58	80.52	80.90	0.37
Electrical Machinery and Equipment	75.86	79.18	82.96	84.09	1.13
Communication Equipment, Computer and Other Electronic Equipment	78.98	84.34	83.47	84.62	1.15
Measuring Instrument and Machinery for Cultural Activity & Office Work	74.27	78.42	78.84	79.04	0.20

Source: calculations based on input-output table (2002, 2005, 2007, 2010)

Table 7

Composition of total output (by production factors, %)

	2002	2005	2007	2010
Labor Intensive Industry	30.72	27.38	26.89	25.61
Capital Intensive Industry	38.27	39.83	40.87	39.81
Technology Intensive Industry	31.01	32.80	32.24	34.58

Source: calculations based on input-output table (2002, 2005, 2007, 2010)

■ Conclusions

This paper has taken comparative analysis of structural change of the Chinese economy from the aspects of structure of industry and intermediate input based on Chinese 2007 and 2010 I/0 tables. The results show followings:

1. Chinese economic structure is upgrading. The share of service in GDP is increased from 38.7% in 2007 to 41.8% in 2010. And there are also active changes of the internal structure of manufacturing and service. Manufacturing sector is transforming from labor intensive to technology intensive, from low technology industry to Medium and high technology manufacturing, from high energy intensity to low energy intensity. There is also increasing share of productive service in the sector of service.

2. Upgrading of industrial structure and technological progress are main causes of change of intermediate input ratio. There is rise of rate of intermediate input to China's whole economy due to increase of use of service to primary and secondary sector, especially the service of science, technology and transport. The significant rise of share of remuneration to laborers has caused a declining trend of rate of intermediate input to service. A comprehensive analysis of above shows, there is continuous improvement of structure of industry, while there is also increase of share of science, technology and service in intermediate input in the process of China's economic development.

■ Appendix I

The classification of manufacturing industry (by production factors)

Category	
Labor Intensive Industry	Manufacture of Foods and Tobacco, Manufacture of Textile, Manufacture of Textile Wearing Apparel, Footwear, Caps, Leather, Fur and Its products, Processing of Timbers and Manufacture of Furniture, Papermaking Printing and Manufacture of Articles for Culture, Education and Sports, Manufacture of Artwork, Other Manufacture
Capital Intensive Industry	Processing of Petroleum, Coking, Processing of Nuclear Fuel, Chemical Industry, Manufacture of nonmetallic Mineral Products, Smelting and Rolling of Metals, Manufacture of Metal Products
Technology Intensive Industry	Manufacture of General Purpose and Special Purpose Machinery, Manufacture of Transport Equipment, Manufacture of Electrical Machinery and Equipment, Manufacture of Communication Equipment, Computer and Other Electronic Equipment, Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work

The classification of manufacturing industry (by Technology）

Category	
High-tech manufacturing	Manufacture of Communication Equipment, Computer and Other Electronic Equipment, Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work
Medium and high technology manufacturing	Chemical Industry, Manufacture of General Purpose and Special Purpose Machinery, Manufacture of Transport Equipment, Manufacture of Electrical Machinery and Equipment
Low and medium technology manufacturing	Processing of Nuclear Fuel, Chemical Industry, Manufacture of nonmetallic Mineral Products, Manufacture of nonmetallic Mineral Products, Smelting and Rolling of Metals, Manufacture of Metal Products
Low-tech manufacturing	Manufacture of Foods and Tobacco, Manufacture of Textile, Manufacture of Textile Wearing Apparel, Footwear, Caps, Leather, Fur and Its products, Processing of Timbers and Manufacture of Furniture, Papermaking Printing and Manufacture of Articles for Culture, Education and Sports, Manufacture of Artwork, Other Manufacture

The classification of manufacturing industry (by Energy Intensity）

Category	
Low Energy Intensive Industry	Manufacture of Textile Wearing Apparel, Footwear, Caps, Leather, Fur and Its products, Manufacture of General Purpose and Special Purpose Machinery, Manufacture of Transport Equipment, Manufacture of Electrical Machinery and Equipment, Manufacture of Communication Equipment, Computer and Other Electronic Equipment, Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work
Middle Energy Intensive Industry	Manufacture of Foods and Tobacco, Manufacture of Textile, Processing of Timbers and Manufacture of Furniture, Papermaking Printing and Manufacture of Articles for Culture, Education and Sports, Manufacture of Metal Products, Other Manufacture
High Energy Intensive Industry	Processing of Petroleum, Coking, Processing of Nuclear Fuel, Chemical Industry, Manufacture of nonmetallic Mineral Products, Smelting and Rolling of Metals

■ Appendix II

To split the effect of input coefficient and structure of output on ratio of intermediate input, the following equation is used:

$$R_t = \frac{u_t}{X_t} = \frac{u_1 + u_2 + u_3}{X_t} = \frac{u_1}{X_t} + \frac{u_2}{X_t} + \frac{u_3}{X_t} = \frac{u_1}{X_1}\frac{X_1}{X_t} + \frac{u_2}{X_2}\frac{X_2}{X_t} + \frac{u_3}{X_3}\frac{X_3}{X_t} = R_1T_1 + R_2T_2 + R_3T_3$$

Where, u, X and R denote intermediate input, output and the share of intermediate input in output. The subscripts t, 1, 2, and 3 refer to the aggregation and 3 sectors. R_1, R_2 and R_3 denote the share of intermediate input in output for each sectors. T_1, T_2 and T_3 are the share of each sector output in aggregated output, which reflect the structure of output by sector.

Then, the change of share of intermediate input in output in aggregation (VR_t) can be calculated as:

$$VR_t = R_t^t - R_t^0 = (R_1^t T_1^t + R_2^t T_2^t + R_3^t T_3^t) - (R_1^0 T_1^0 + R_2^0 T_2^0 + R_3^0 T_3^0) =$$

$$\begin{aligned}
&= \left(R_1^t T_1^t - R_1^0 T_1^t\right) + \left(R_2^t T_2^t - R_2^0 T_2^t\right) + \left(R_3^t T_3^t - R_3^0 T_3^t\right) + \left(R_1^0 T_1^t - R_1^0 T_1^0\right) \\
&\quad + \left(R_2^0 T_2^t - R_2^0 T_2^0\right) + \left(R_3^0 T_3^t - R_3^0 T_3^0\right) \\
&= \left(R_1^t - R_1^0\right) T_1^t + \left(R_2^t - R_2^0\right) T_2^t + \left(R_3^t - R_3^0\right) T_3^t + R_1^0 \left(T_1^t - T_1^0\right) \\
&\quad + R_2^0 \left(T_2^t - T_2^0\right) + R_3^0 \left(T_3^t - T_3^0\right) \\
&= \triangle R_1 T_1^t + \triangle R_2 T_2^t + \triangle R_3 T_3^t + R_1^0 \triangle T_1 + R_2^0 \triangle T_2 + R_3^0 \triangle T_3 \\
&= \sum_{i=1}^{3} \triangle R_i T_i^t + \sum_{i=1}^{3} R_i^0 \triangle T_i = A + B
\end{aligned}$$

Where, the superscript 0 and t denote the beginning and end of reporting period. With the above equation, the change of share of intermediate input in output in aggregation (VR_t) can be separated into two parts, *A* and *B*. *A* reflects the effect of share of intermediate input by sectors on share of intermediate input in aggregation; *B* is the effect of the structure of output on share of intermediate input in aggregation.

CHANGING THE GAME: INDUSTRY IMPLICATIONS OF THE U.S. NATURAL GAS REVOLUTION

Douglas S. Meade[*]

Shale gas is a game changer for the U.S. and for the world.
Wilbur Ross (2013)

■ Introduction

North American natural gas supplies have seen a remarkable increase since 2006, with the rapid expansion of horizontal drilling and hydraulic fracturing. Although the estimates of economically available gas supplies vary widely, there is general agreement that the recent U.S. shale gas boom will continue into the foreseeable future. Naturally, the increased supplies have led to a reduction in price, and even the long-range projections of the gas price have come down from previous projections of just a few years ago.

Natural gas use has recently seen dramatic increases in the electric power sector, with a corresponding reduction in the share of electricity from coal. The industrial sector, already a large user of gas, will probably experience an increase in exports and production, due to increasing competitiveness from cheaper natural gas. Natural gas use in the transportation sector is currently relatively small, but may increase dramatically if the necessary infrastructure is put in place.

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This paper describes a collaborative effort of Inforum and the Mitre Corporation to use the LIFT and MARKAL[1] models in a coupled system to address the study objectives of the Energy Modeling Forum (EMF) 26.

The focus of EMF 26 is on the natural gas market, and is motivated by the increased availability of shale gas discussed above.

Beyond the power generation demands for natural gas, there is an extensive search for new markets where natural gas may compete effectively with other energy sources. For example, there is potential for increased direct use of natural gas in transportation, as well as an increase in indirect use, via transformation of natural gas to a liquid fossil fuel, such as diesel. Furthermore, there may be significant potential to increase U.S. gas exports. Price-driven substitution of gas for other fuels is expected to be occurring world-wide, leading to an increase in demand by gas importing countries. In the short-run, the export potential is constrained by the capacity of LNG transport facilities, but with sufficient investment, this constraint will be ameliorated over time. Finally, substitution may occur in the residential market, with substitution of natural gas for electricity.

The EMF 26 examines factors that play a role in each of these markets, and study the implications of different economic environments on the interplay of gas supply and demand. Some of the particular issues outlined in the introductory summary for the study include:

- Which end-use sectors will absorb most of the increased natural gas supplies and by how much?
- Which energy sources in these sectors will be replaced by natural gas supplies?
- What is the likely range of natural gas prices at the wellhead and by end-use sector?
- How do these energy-market transformations influence carbon dioxide and other greenhouse gas emissions?
- Will North America become a major gas exporter in world markets?

[1] The LIFT model is Inforum's flagship interindustry macro model of the U.S. The MARKAL model, originally developed at Brookhaven National Laboratory, is an optimizing model that works with a detailed database of systems characteristics of energy conversion processes and technologies.

■ The Energy Modeling Forum (EMF) 26 Study

The objectives for the EMF 26 were to apply scenario-based analysis using a broad array of economic and energy models, and to glean lessons about natural gas supply and demand issues through a comparison of the models and their results, and an understanding of their differences. Inforum teamed with the Mitre group to use the Inforum LIFT model, with the MARKAL optimization model. As described below, LIFT is particularly well suited for examining the interactions between energy industries and other industries, as well as providing a consistent picture of demand and supply in all industries. LIFT contains industries for natural gas extraction and natural gas utilities, and can trace the sources of demand for each industry to other industries and final demand, including exports and imports. The sectors and final demand categories in LIFT are mapped to the residential, commercial, industrial, transportation and electric power sectors identified in the National Energy Modeling System (NEMS) and many other energy models. The input-output structure in LIFT can be used to introduce hypothetical new industry relationships, such as those determined by an expansion of biofuels or synthetic liquid fuels production. LIFT also tracks investment at the detailed industry level, so that capacity requirements for the construction of new synthetic fuel production facilities or LNG transport facilities can be modeled in a way that directly shows their impact on total investment and GDP. MARKAL is used to show detailed microeconomic optimization decisions that may occur in response to changes in prices and/or technology. Alternative assumptions about fuel prices, capital costs and technology costs can be introduced to understand how different types of equipment or production processes may be chosen to satisfy a particular end use requirement. Outputs from MARKAL can then be fed to the LIFT model as exogenous or auxiliary assumptions, to examine the implications for the industry and macro economy.

■ LIFT and MARKAL

Overview of LIFT

The *LIFT* model (Long-term Interindustry Forecasting Tool) is the U.S. representative of the INFORUM style interindustry macroeconomic (IM) model[1]. As is typical of this family of models, the *LIFT* model builds up macroeconomic aggregates such as employment, investment, exports, imports and personal consumption from detailed forecasts at the industry or commodity level. This modeling framework is not only applicable to scenario analysis where the interaction of macroeconomic and industry behavior is important, but also for the development of satellite models to study issues such as energy use, greenhouse gas emissions or research and development expenditures[2]. In the current study, we make use of the consistent database of IO tables in current and constant prices, detailed investment and capital stock matrices, and the full set of value added history and forecast in the *LIFT* model to compile historical and projected measures of MFP by industry and for the aggregate economy.

The newest version of *LIFT* is based on the U.S. 2002 Benchmark IO table, and a series of annual IO tables from 1998 to 2010. INFORUM has compiled a time series of estimates of the detailed IO framework at the 399 commodity level, using information from the 2002 Benchmark, the annual IO, and time series of industry output from BEA and commodity imports and exports from the Census Bureau. All industry data in *LIFT* is now classified according to the same sectoring scheme. These industry data include employment, hours, labor compensation and other value added components, investment and capital stock, and industry output. The LIFT model has 110 commodities, and this is the level of detail maintained for the IO table, final demands and commodity output. The IO quantity and price solutions are calculated at the commodity level. Value added at the industry level is bridged to the commodity level using an industry to commodity value added bridge, and the commodity output solution is converted to industry output using a commodity output proportions matrix.

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[1] Grassini (1997) portrays the typical features of an INFORUM model. Meade (1999) introduces an earlier version of the current model.

[2] Meade (2009) is an example of using an expanded module for crops and biofuels to study economic impacts of increased ethanol production and use in the U.S.

The LIFT model includes econometric equations for each of the main categories of final demand and value added. Both output and prices are solved using the fundamental IO identity, so there is complete interdependence of all prices and quantities. A macroeconomic accounting structure (the "Accountant") handles aggregation of industry and commodity data as well as the relationships and identities in the national accounts. (See Figure 1 for a block diagram that summarizes the operation of LIFT).

The MARKAL Model

The MARKAL (MARKet ALlocation) model is a data driven, bottom-up energy systems model. The initial version of the model was developed in the late 1970s by international teams at Brookhaven National Laboratory and elsewhere. The model currently is used by many countries for research and energy planning. At its core, MARKAL is a least cost optimization model which incorporates numerous dynamic relationships and user-defined constraints which allow for a simulation of the energy system.

The MARKAL energy system representation is formed by an input database that captures the flow of energy and technology adoption associated with the extraction or import of resources, the conversion of these resources into useful energy, and the use of this energy in meeting the end-use demands. MARKAL optimizes technology penetrations and fuel use over time, using straightforward linear programming techniques to minimize the net present value of the energy system while meeting required energy service demands and various energy, emissions, and behavioral constraints. Outputs of the model include a determination of the technological mix at intervals into the future, estimates of total system cost, use of energy carriers (by type and quantity), estimates of criteria and greenhouse gas (GHG) emissions, and estimates of marginal energy commodity prices. MARKAL outputs a least cost pathway to meet energy needs, but using scenario analysis, the model can also be used to explore how the least cost pathway changes in response to various model input changes, such as the introduction of new policy measures like a carbon tax or subsidies on energy efficient technologies. The multi-sector coverage of a MARKAL database allows simultaneous consideration of both supply- and demand-side measures in meeting emissions or other system goals.

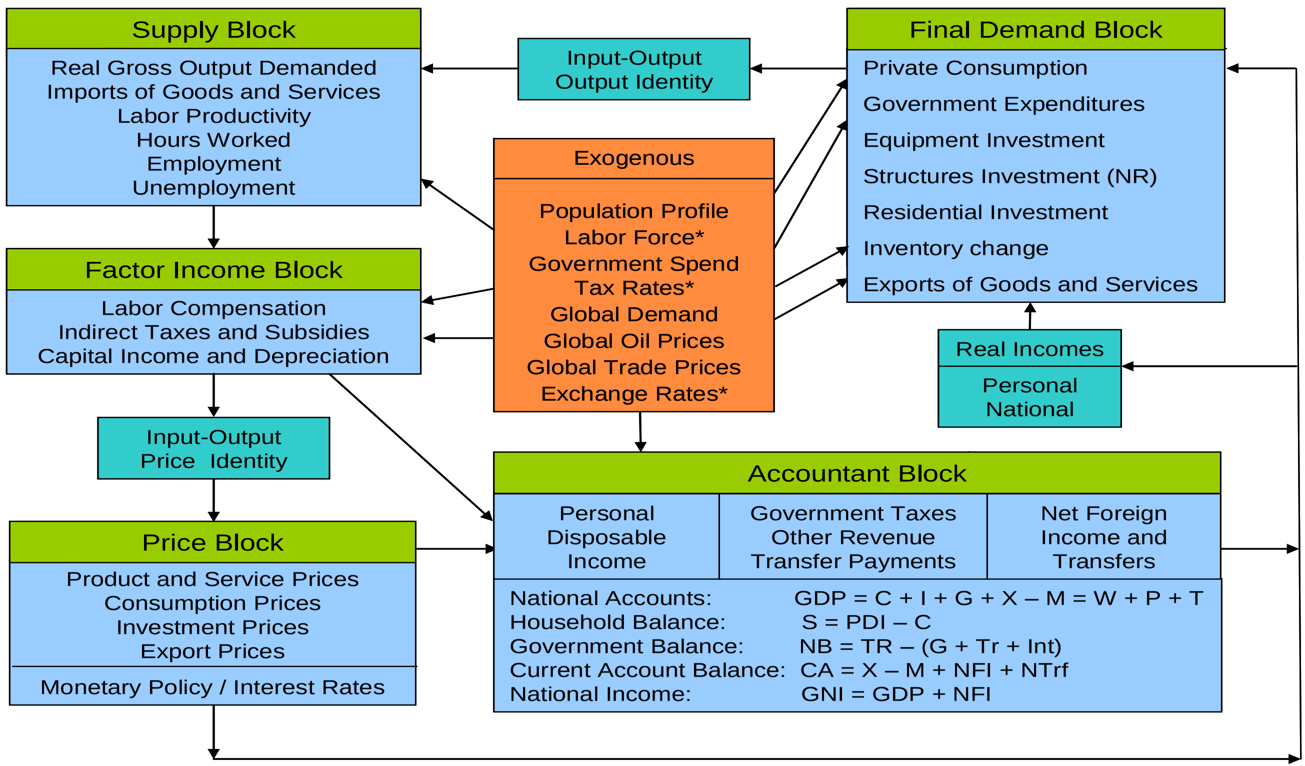

Fig. 1. Block Diagram of the LIFT Model

The basis of the MARKAL model framework is a network diagram called a Reference Energy System (RES), which is pictured in Fig. 2. The RES represents energy sources and flows that comprise an energy system. Coverage of the energy system ranges from the import or extraction of primary energy resources, to the conversion of these resources into fuels, and through the use of these fuels by specific technologies to meet end-use energy demands. End-use demands include items such as residential lighting, commercial air conditioning, and automobile vehicle miles traveled. Data used to represent these items include fixed and variable costs, technology availability and efficiency, and pollutant emissions. For a more detailed description of MARKAL see Loulou et al. (2004).

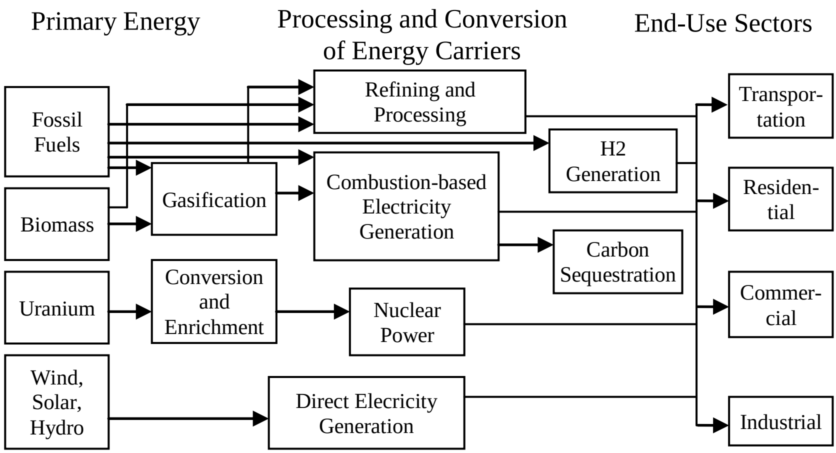

Fig. 2. MARKAL Reference Energy System

Model Coupling

The idea of the model coupling is to combine the detailed treatment of the energy system and technology options for energy supply and utilization in MARKAL with the detailed treatment of the U.S. economy in Inforum LIFT. The aim is to capture insights on the response of the energy system to the various scenarios, including changes to the energy mix and end-use technologies, and see how these changes interact with the broader economy.

In this application, prior to the coupling, both models ran a reference scenario calibrated to *Annual Energy Outlook* 2012. For each of the policy scenarios, the policy was first implemented in MARKAL and the resulting fuel mix and efficiency changes for the entire period out to 2035 relative to the reference case were then incorporated into a LIFT scenario. The LIFT scenario therefore captures the interaction of the broader economy with the policy and energy system responses induced by the policy as measured in MARKAL. Following the LIFT scenarios energy service demands from the LIFT run were estimated and compared to the exogenous MARKAL energy service demands. For any deviations judged to be significant the MARKAL service demands would have been adjusted and the coupling procedure repeated. The methodology used to guide the coupling is shown in Figure 3.

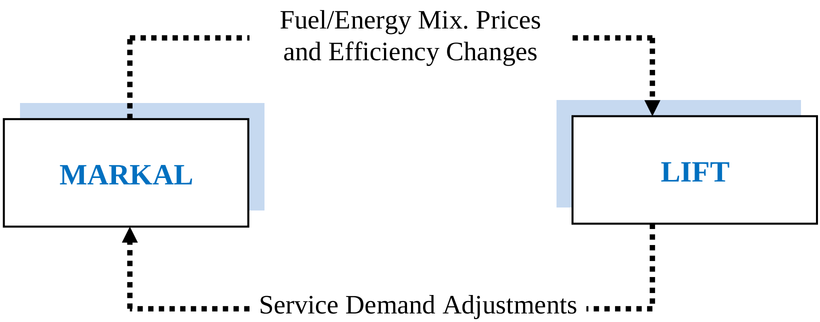

Fig. 3. Model Coupling Methodology

Overview of Scenarios

The EMF 26 working group decided on a set of 9 common scenarios to explore, using 14 different modeling teams[1]. The scenarios were chosen to highlight both demand and supply issues in the U.S. natural gas market. The full set of scenarios included:

1. *Reference case*: This case was calibrated as closely as possible to the *AEO 2012* reference case.

[1] Models represented in EMF 26 include: AMIGA, LIFT, ADAGE, USREGEN, FACETS, MARKAL_US, MARKAL_EPA, IPM, NewERA, NEMS, MRN-NEEM, ReEDS, MarketPoint and Energy2020.

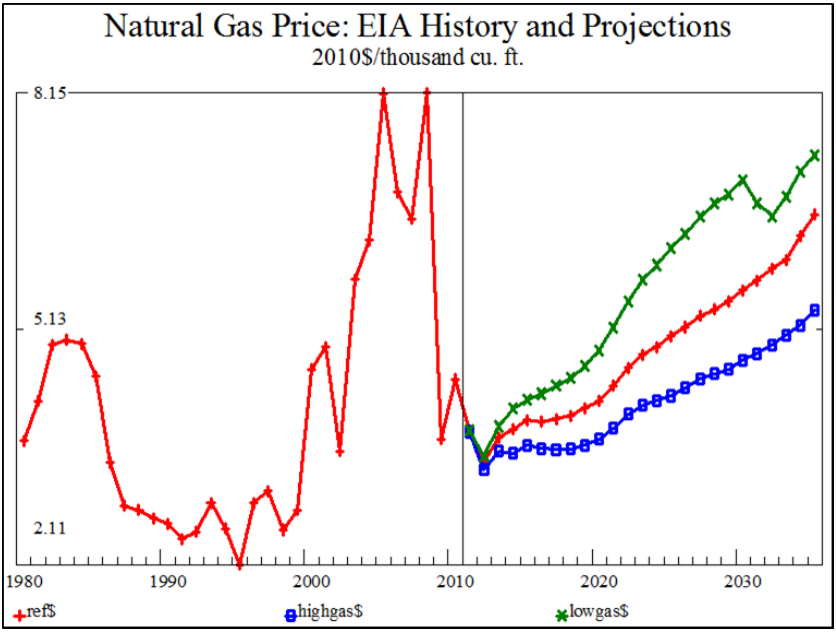

Fig. 4. Comparison of Natural Gas Prices in Reference, High Shale and Low Shale Scenarios

2. *High shale supply*: This case assumed faster growing U.S. shale gas supply, with a corresponding lower price than the reference case.
3. *Low shale supply*: This case incorporates more pessimistic assumptions about shale supply growth, with a corresponding higher gas price.
4. *High GDP growth*: The case assumed faster labor force and productivity growth, along with increased growth in exports and investment, to assess the effect of faster growth on gas demand.
5. *Advanced demand*: Demand for gas will be accelerated through the introduction of aggressive expansion of ethylene production and of gas-to-liquids plants, in combination with the high supply assumed in case 2.

6. *High shale, high economic growth*: A combination of assumptions from cases 2 and 4.
7. *Carbon constraint case*: Carbon price is introduced starting at $25 in 2020 and rising to $52 by 2035.
8. *High shale, with carbon constraint*: A combination of assumptions from cases 2 and 7.
9. *High export scenario*: This scenario examined the potential of faster export growth to absorb additional supply.

Although the Inforum / Mitre modeling team implemented all 9 of the scenarios listed above, in this paper, space permits only focus on the advanced demand scenario, which will be compared with the reference case. Comparison of Natural Gas Prices in Reference, High Shale and Low Shale Scenarios see in Fig. 4.

Advanced Demand Scenario

The advanced demand scenario incorporates the high shale supply assumptions of case 2, with production reaching a level 14% higher than the reference, and price reaching a level 24% below the reference case. In addition, there is increased investment in ethylene production capacity and gas to liquids technology, that both serve to drive gas demand higher than in the case with high shale supply alone.

It is perhaps first useful to look at the effect of the lower gas prices on the prices of other sectors that use gas. Fig. 5 shows the top industries ranked by the share of gas cost in the value of total output, shown in percent. The data in this chart are derived from the LIFT IO table. The IO table does not distinguish between gas used as a feedstock and gas burned for energy.

Sectors with a larger share of gas input will benefit proportionally more from a decline in gas prices. These sectors will become more competitive internationally.

The LIFT export equations determine exports based on relative export prices to those of competing exports. Each commodity has its own equation, with some commodities having a higher price elasticity (more price response) than others. Figure 6 shows the sectors having the highest increase in exports in response to the increase in competitiveness. The figure shows that chemicals, metals, plastics and stone, clay and glass all show significant increases in exports.

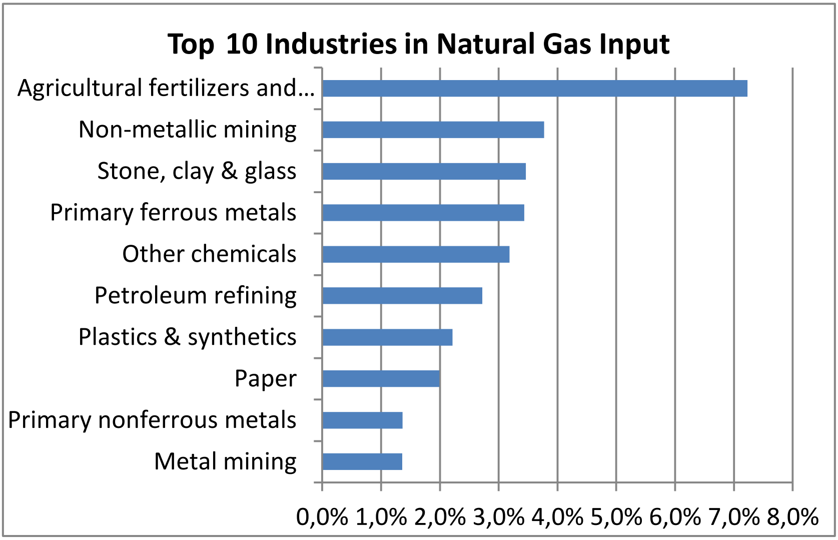

Fig. 5. Gas Intensive Sectors

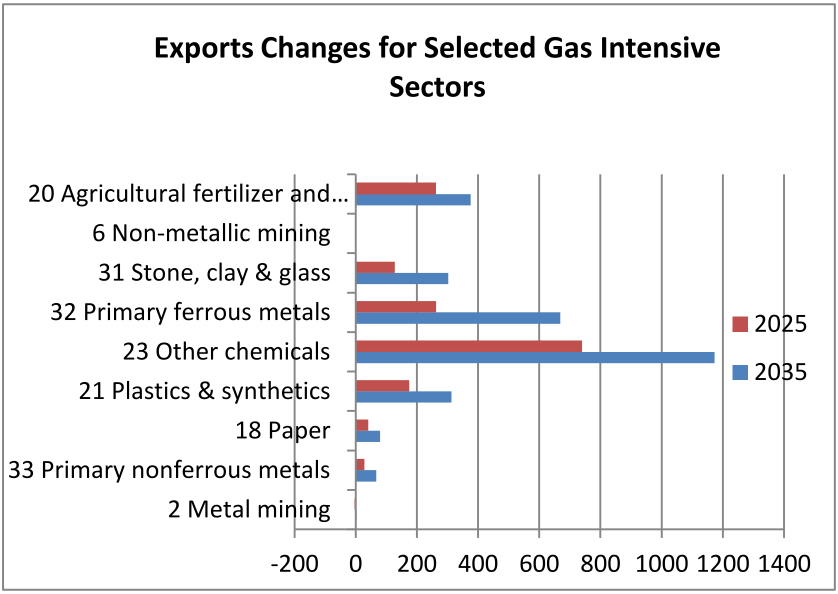

Fig. 6. Export Changes.

In addition to the increased demand for gas due to the higher exports, this scenario also explored the impact of increasing ethylene production and capacity by 25%, based on a American Chemistry Council report[1]. An additional module was added to the LIFT model, that calculates detail relating to feedstocks of natural gas, quantities and prices of ethylene production, and incremental capacity necessary to support that production. The results from this module are fed back to the main LIFT model in the form of assumptions of increased investment in the chemicals sector, and a higher IO coefficient of natural gas into chemicals, reflecting the increased share of ethylene production in total output. The import share of chemicals was also reduced to enable the model to satisfy more demand from domestic production.

This scenario also explored aggressive penetration of gas-to-liquids (GTL) diesel fuel production, whereby liquid fuel is produced from natural gas feedstock. Fig. 7 shows a range of investment cost assumptions and the resulting penetration of GTL into total diesel use by 2030. By assuming a faster decrease in the cost of GTL capacity, this scenario attains a level of natural gas use into this production chain of 1.5 tcf[2] by 2030. This is all additional gas demand relative to the reference case, which had no GTL production.

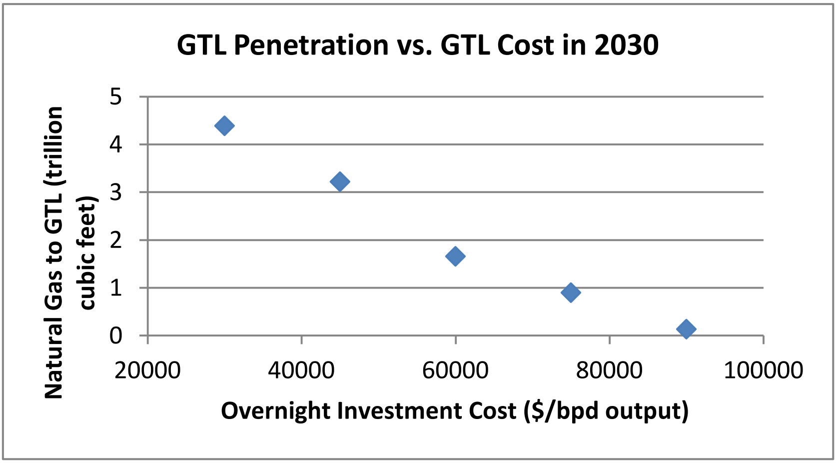

Fig. 7.

[1] American Chemistry Council (2011).
[2] Trillion cubic feet.

Scenario Comparison

Fig. 8 summarizes the comparison of natural gas uptake in the advanced demand case with the reference case. By 2035, the sum of natural gas and natural gas liquids demand in the advanced demand scenario is up 15% over the reference case. GTL drives increases in natural gas to the industrial sector (Petroleum refining), and ethylene production drives increases in natural gas liquids to the industrial sector (Chemicals). Chemicals exports increase by about 2% relative to the reference (see fig. 9). By 2035, 11% of total diesel consumption is being created through GTL (fig. 10). Total natural gas consumption is 10% above the reference case.

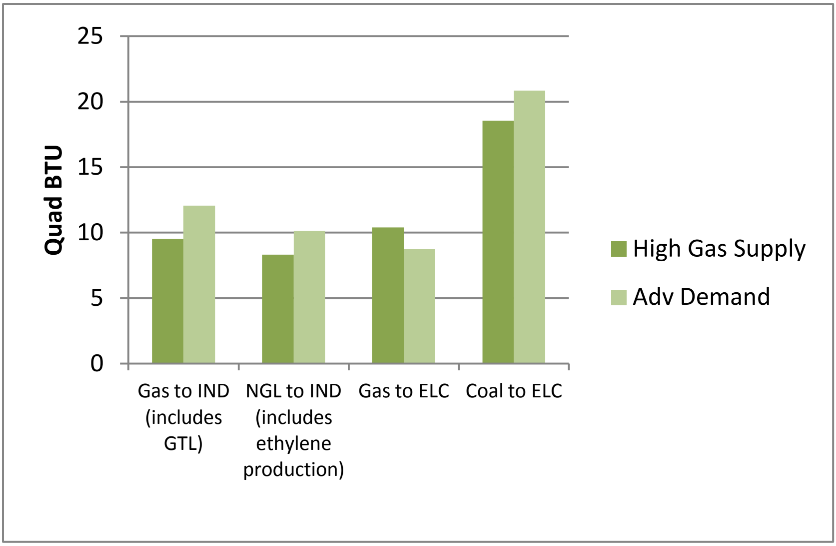

Fig. 8. Energy Sector Dynamics

Potential GDP gains in the advanced scenario case stem from:

- stimulation of additional manufacturing in the US in industries downstream from ethylene (plastics, rubber, and some textiles)
- additional chemical sector growth beyond ethylene (propene, benzene and styrene)
- reduction of oil imports due to GTL production

The increase of GDP relative to the reference case is 0.3% by 2035, or about $730 billion in 2005 dollars.

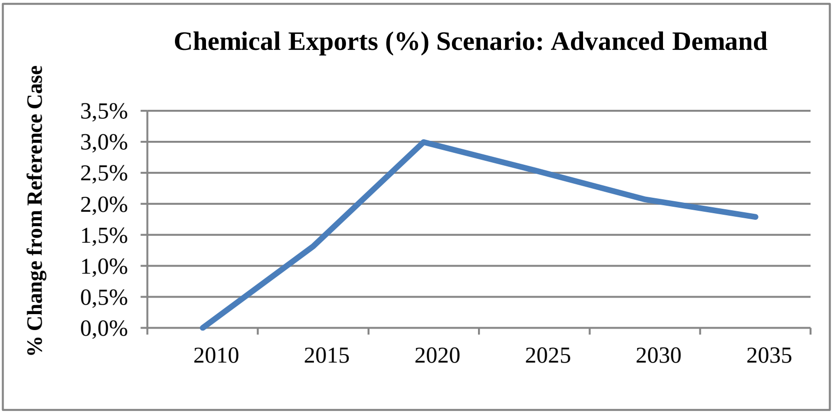

Fig. 9

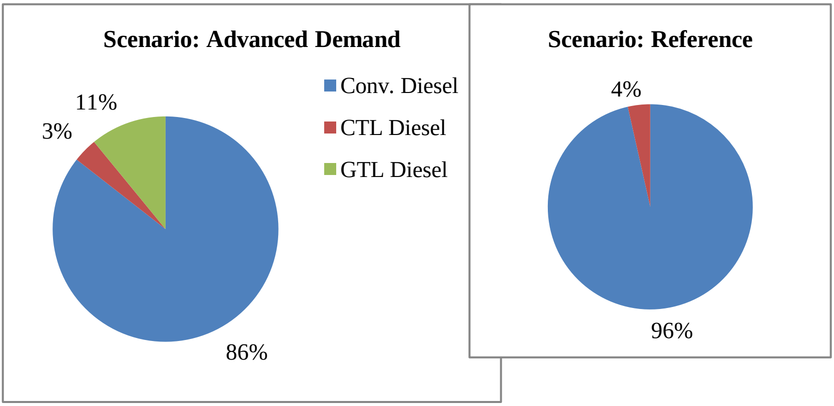

Fig. 10. Diesel by Source (in 2035)

■ Conclusions

This paper presented selected results comparing the advanced demand case with the reference case from the Inforum / Mitre collaboration in the EMF 26 study. In addition to the summary results presented here, there are several interesting results that stand out in the study, listed below:

Price response to the lower natural gas prices appears mostly in the electric power and industrial sectors. Not as much was seen in commercial or transportation.

The general potential for natural gas use in transportation appears to be small, with the exception of heavy-duty trucks and fleet vehicles.

Favorable technologies and investment cost for ethylene and gas-to-liquids can make sizeable differences for the uptake of natural gas into the industrial sector, and the contribution of that sector to GDP.

The shape of the long-run supply curve for natural gas is still not well-known, i.e., we don't know how much prices will increase in response to higher demand.

The export potential for natural gas itself remains highly uncertain.

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THE CONVERSION AND ADJUSTMENT OF NATIONAL IO TABLE SERIES FROM WIOD. THE CASE OF TURKEY.

Gazi Ozhan, Wang Yinchu, Meral Ozhan

Abstract The WIOD (World Input-Output Database) created from a research project funded by the European Commission and published in 2012 is a great database which includes Input-output table series with 35 sectors, from 1995 to 2009, for 40 countries and regions plus international linkage table series, all in both of current price and previous year's price.

The format of national Input-Output table in WIOD is different from the normal format of national Input-Output table which can be directly used for building INFORUM model. It is necessary to make some adjustments and conversions which are the contents of this paper, by using Turkey table as an example.

■ The conversion from the national IO table of WIOD into the one used in building INFORUM model

The national Input-Output tables from WIOD (World Input-Output Database) are of the format as shown in Fig. 1 below.

It can be seen that the table has different form comparing with the IO table used in INFORUM model. The differences are:

There is much rich information about imports. There are import flow matrix for intermediate input and import flow for various final demands. Not like the IO table used in general INFORUM model which has only one column for import listed in final demand aspect and is of minus sign in the row sum equation of IO model.

From the income side, there is item "taxes less subsidies on products" which is normally included in the item of value added in IO table of INFORUM style model. There is also item "taxes less subsidies on products" for the final demand (expenditure) components.

			Agriculture, Hunting, Forestry and Fishing		Private Households with Employed Persons	Final consumption expenditure by households	Changes in inventories and valuables	Exports	Total output
			TUR		TUR	TUR	TUR	TUR	TUR
			c1	......	c35	**c37**	**c42**	**c44**	
Agriculture, Hunting, Forestry and Fishing	TUR	c1							
......		......							
Private Households with Employed Persons	TUR	c35							
Agriculture, Hunting, Forestry and Fishing	Imports	c1							
		......	IMPORTS	IMPORTS	IMPORTS	IMPORTS	IMPORTS		
Private Households with Employed Persons	Imports	c35							
Total intermediate consumption	TOT	**r60**							
taxes less subsidies on products		r99							
Cif/fob adjustments on exports		r61							
Direct purchases abroad by residents		r62							
Purchases on the domestic territory by non-residents		r63							
Value added at basic prices		**r64**							
International Transport Margins									
Output at basic prices		r69							

Fig.1 The Format of Analytical National Input-Output Table from WIOD

1. There is item "CIF/FOB adjustments on exports". CIF is the Cost-Insurance-Freight and FOB is Free-On-Board. They are all related to international trade but there are only zero values for Turkey for this item.

2. There is item "Direct purchase abroad by residents". It has all zero values in the table except one number in the column of "Final consumption expenditure by households" of the final demand side. This number says how many import products were bought from abroad directly by households and not included in the import flow above.

3. There is item "Purchases on the domestic territory by non-residents". Like the item "Direct purchase abroad by residents", this item has all zero values in the table except one number in the column of "Final consumption expenditure by households" of the final demand side. This number says how many domestic products were consumed directly by non-residents.

4. There is item "International Transport Margins" which is the international transportation cost for imported products. For the purpose of international trade linkage analysis, the WIOD split the transportation cost so that the import price of one product in the imported country has the same price as in the export country.

It would be necessary to convert the WIOD tables into the IO table format used in INFORUM model from the objective of building INFORUM model.

How to do this conversion and also not lost the rich information about imports? Several steps will be taken.

Step A. To allocate the item "International Transport Margins" to the corresponding columns of import matrices for intermediate input and for final demand components. The reason is the transport cost should be included in the import products when they are measured in domestic use. Their import shares will be used for the allocation operation.

Step B. To merge the import matrix into intermediate input matrix and final demand component matrix. Meanwhile, to create import share matrix for the resulted intermediate input matrix and import share matrix for the resulted final demand component matrix. These shares will be used for analysis related to imports.

Step C. To ignore the two numbers "Direct purchase abroad by residents" and "Purchases on the domestic territory by non-residents" mentioned in 4 and 5 above, according to the advices from a Turkish expert of input-output. These two numbers are estimated related to the issue of international tourism.

Step D. To treat the item "taxes less subsidies on products" of the income side as one component of value added. For the item "taxes less subsidies on products" on the final demand (expenditure) components, which is about 5% of the total final demand for domestic products, it would be better to allocate it into different categories of corresponding component, although it is proposed to ignore them. However, it must be treated from both sides: row (final demand side) and column (income side) plus corresponding adjustment for gross output. Otherwise, the balances of the table from row and column will be destroyed. After this treatments for the item "taxes less subsidies on products", the value added and the gross output will be, in general, converted from at basic prices into at purchase prices which are the case of price measure of Input-output table in INFORUM style model.

Step E. To create a 35 sector vector variable, import, as one of the component of final demand and with minus sign in the balance equation for rows of the table. The elements of this vector are just the corresponding row sums of the import matrices in the step A after allocating the item "International transport Margins".

At this stage, the resulted table will have the form of the Input-output table applied by INFORUM model. The resulted table looks like the Fig.2 below.

		Agriculture, Hunting, Forestry and Fishing		Private Households with Employed Persons	Final consumption expenditure by households		Changes in inventories and valuables	Exports	Import	Gross output
		c1	......	c35	**c37**	**......**	**c42**	**c44**		
Agriculture, Hunting, Forestry and Fishing	c1									
......	......									
Private Households with Employed Persons	c35									
Total intermediate consumption	**r60**									
Value added	**r64**									
Gross Output	r69									

Fig.2. The Form of Resulted Input-Output Table for INFORUM Model

■ The adjustments at aggregate level

A GDP comparison was done for two data sources: one is the GDP in TL (Turkish Lila) term, at current price which is from the Ministry of Development of Turkey (MOD) and another is the GDP in TL term, at current price which is converted from the IO tables created in above section in US$ term by using the implicit exchange rate in WIOD. The results are shown in Tab. 1.

Table 1

Comparison between two data sources, at GDP level

	1996	1997	1998	1999	2000	2001	2002
GDP from MOD	19857	38763	70203	104596	166658	240224	350476
GDP from WIOD	19967	39335	70203	104596	166658	240224	350476
Difference (%)	–0.55	–1.46	0.00	0.00	0.00	0.00	0.00
	2003	2004	2005	2006	2007	2008	2009
GDP from MOD	454781	559033	648932	758391	843178	950534	952559
GDP from WIOD	454781	559033	648932	758391	843179	950535	952559
Difference (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

From Tab. 1 above, it can be seen that there is no difference at the aggregated level of GDP from the two data sources. However, a comparison at GDP component level says there are quite big differences among consumption, export and import, as shown in Tab. 2.

Table 2

Comparison between two data sources, at GDP component level

	1996	1997	1998	1999	2000	2001	2002
From MOD							
Cons	12839	25347	46669	71641	117499	164299	238399
Exp	3750	8352	14980	20333	33495	65920	88381
Imp	–3996	–8519	–14167	–20172	–38488	–56009	–82652
Sum	12593	25180	47481	71802	112506	174210	244128
From WIOD							
Cons	13671	26990	49694	74994	124768	179987	259441
Exp	2794	6466	11507	16298	25170	47842	63614
Imp	–3873	–8276	–13720	–19490	–37433	–53619	–78928
sum	12593	25180	47481	71802	112505	174210	244128
Difference							
Cons	–832	–1643	–3026	–3353	–7269	–15688	–21042
Exp	955	1886	3473	4035	8324	18077	24766
Imp	–123	–243	–447	–682	–1056	–2390	–3724
Sum	0	0	0	0	0	0	0
Dif. (%)							
Cons	–6.09	–6.09	–6.09	–4.47	–5.83	–8.72	–8.11
Exp	34.19	29.17	30.18	24.76	33.07	37.79	38.93
Imp	3.18	2.94	3.26	3.50	2.82	4.46	4.72
Sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
From MOD	2003	2004	2005	2006	2007	2008	2009
Cons	324016	398559	465402	534849	601239	663944	680768
Exp	104575	131661	141826	171926	188225	227253	222103
Imp	–109321	–146386	–164514	–209172	–231738	–269388	–232632
Sum	319270	383834	442714	497604	557725	621809	670239

	1996	1997	1998	1999	2000	2001	2002
From WIOD							
Cons	345723	423620	490692	564897	628734	695620	714245
Exp	79185	102982	112665	137550	155103	185760	182088
Imp	–105637	–142768	–160643	–204844	–226111	–259570	–226094
Sum	319270	383834	442714	497604	557725	621810	670239
Difference							
Cons	–21707	–25061	–25290	–30048	–27495	–31676	–33477
Exp	25390	28679	29161	34376	33122	41493	40015
Imp	–3683	–3619	–3871	–4328	–5627	–9817	–6538
Sum	0	0	0	0	0	0	0
Dif. (%)							
Cons	–6.28	–5.92	–5.15	–5.32	–4.37	–4.55	–4.69
Exp	32.06	27.85	25.88	24.99	21.35	22.34	21.98
Imp	3.49	2.53	2.41	2.11	2.49	3.78	2.89
Sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A further investigation was done and it was discovered:

The “Final consumption expenditure by households” in the IO tables from WIOD is the “Final Consumption Expenditure of Resident and Non-Resident Households on the Economic Territory” from MOD source. For example, the value of this indicator in 1998 is 49,694 in both sources.

The “Purchases on the domestic territory by non-residents” in the IO tables from WIOD is the “Final Consumption Expenditure of Non-Resident Households on the Economic Territory” from MOD source. For example, the value of this indicator in 1998 is 3,473 in both sources.

The “Direct purchases abroad by residents” in the IO tables from WIOD is the “Final Consumption Expenditure of Resident Households in the Rest of the World” from MOD source. For example, the value of this indicator in 1998 is -447 in both sources.

If the value of the item “Purchases on the domestic territory by non-residents” is added into export, in the framework of WIOD, the export in 1998 will be 14,980 which is just the same as the one from MOD.

1. If the value of the item “Direct purchases abroad by residents” is added into import, in the framework of WIOD, the import in 1998 will be –14,167 which is just the same as the one from MOD.

2. If the sum of the items, mentioned in 4 and 5 above, is subtracted from the item “Final consumption expenditure by households”, in the framework of WIOD, the resulted number in 1998 will be 49,694–(3,473–447)=46,669 which is just the same as the “private final consumption expenditure” from MOD.

3. It is clear, therefore, the adjustment of WIOD tables for the three vectors of consumption, export and import can be adjusted according to following steps:

(A) To allocate the item “Purchases on the domestic territory by non-residents” and add to export, according to the share information of “Purchases on the domestic territory by non-residents”, even so this share information is probably rough. There is tourism statistics from TURKSTAT (Turkish Statistics) and some information can be obtained from downloading table “Tourism Income and Other Expenses, (Foreigner and citizens resident abroad)”.

(B) To allocate the item “Direct purchases abroad by residents” and add to import vector, according to the share information of “Direct purchases abroad by residents”, even so this share information is probably rough. There is tourism statistics from TURKSTAT and some information can be obtained from downloading table “Tourism Expenditure and Other Expenses For (Resident citizens inside Turkey)”.

(C) To subtract the sum of the numbers added to export in (A) and the numbers added to import in (B) from the vector “Final consumption expenditure by households”. The structure information mentioned in (A) and (B) will help to have no negative result comes from the subtraction operation. It is also important to have a reasonable private final consumption vector. The resulted vector will be a new “final consumption expenditure by households” vector in IO tables and its aggregation value should be the same as the one from MOD. To do the vector subtraction, rather than to have scale operation at aggregation level, is not to destroy the balance in rows of the IO tables.

After the adjustments from step (A) to (C) above, the WIOD table series will have consistent values not only at GDP level, but also at GDP expenditure components level. Tab. 3 shows the comparison of “export”, “import” and “final consumption expenditure by households" between WIOD and MOD sources after the adjustments mentioned above. The biggest difference now is only 2.31% which happens in the export for year 2008.

Table 3

Comparison after Adjustments on the Three Components in Discussion

	1996	1997	1998	1999	2000	2001	2002
From MOD							
Cons	12839	25347	46669	71641	117499	164299	238399
Exp	3750	8352	14980	20333	33495	65920	88381
Imp	–3996	–8519	–14167	–20172	–38488	–56009	–82652
Sum	12593	25180	47481	71802	112506	174210	244128
Adjusted WIOD							
Cons	12839	25347	46669	71641	117499	164299	238399
Exp	3750	8352	14980	20254	33495	65632	87501
Imp	–3996	–8519	–14167	–20093	–38488	–55722	–81772
Sum	12593	25180	47481	71802	112505	174210	244128
Dif. (%)							
Cons	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp	0.00	0.00	0.00	0.39	0.00	0.44	1.00
Imp	0.00	0.00	0.00	0.39	0.00	0.51	1.06
Sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
From MOD	2003	2004	2005	2006	2007	2008	2009
Cons	324016	398559	465402	534849	601239	663944	680768
Exp	104575	131661	141826	171926	188225	227253	222103
Imp	–109321	–146386	–164514	–209172	–231738	–269388	–232632
Sum	319270	383834	442714	497604	557725	621809	670239
From WIOD							
Cons	324016	398559	465402	534849	601239	663945	680768
Exp	104038	131661	141827	171576	186845	222001	221976
Imp	–108783	–146386	–164514	–208821	–230358	–264136	–232506
Sum	319270	383834	442714	497604	557725	621810	670239
Dif. (%)							
Cons	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp	0.51	0.00	0.00	0.20	0.73	2.31	0.06
Imp	0.49	0.00	0.00	0.17	0.60	1.95	0.05
Sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00

■ The adjustments at sector level

On the basis of adjustment at aggregation level, next step is to allocate the two items, “Purchases on the domestic territory by non-residents” and “Direct purchases abroad by residents”, into vector export and import respectively, at sector level. It is necessary to have their share information. Fortunately, this kind of share information can be obtained from downloading tourism statistics tables from TURKSTAT.

Tab. 1 is the share information of the expenditure of foreign visitors in Turkey, from the table “Tourism Income and Other Expenses, (Foreigner and citizens resident abroad).

Table 4

Share Information of the Expenditure of Nonresidents in Turkey

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total of Individual Expenditures	100	100	100	100	100	100	100	100	100
Total of food-beverage	24.2	24.5	24.3	25.8	26.6	28.3	31.0	32.0	34.5
Total Accommodation	19.7	20.5	20.0	20.5	19.4	17.0	17.0	15.8	14.6
Health Total	1.6	1.6	1.9	2.3	2.5	2.8	2.9	2.7	2.6
Total Transport	6.3	5.9	5.7	7.4	7.9	9.2	10.0	10.6	11.6
Total sports, education, culture	2.6	2.6	2.6	1.9	1.8	1.3	1.1	1.0	0.9
Total tour Services	1.4	1.6	1.5	1.8	2.0	1.7	1.5	1.5	1.3
Total of Other Goods and Services	44.1	43.3	43.9	40.4	39.8	39.7	36.6	36.4	34.6
Clothes and Shoes	9.5	12.0	12.8	14.9	15.2	15.6	14.9	15.2	14.7
Souvenirs	7.0	7.4	8.3	9.1	9.6	10.1	9.8	9.9	9.1
Carpet, Rug	3.5	3.2	2.7	3.3	2.9	2.6	2.2	2.2	2.2
Other Expenses	24.1	20.7	20.1	13.0	12.0	11.4	9.6	9.1	8.6

It can be seen that the expenditure categories are different from the 35 sector classification used in WIOD. Therefore, merge and split operations on these shares should be done to adjust them into corresponding sectors in our model. Normally, merge is much easier than split. After comparison between the categories in table 1 above and the 35 sector's definition, the shares for splitting different numbers are assigned arbitrarily and listed in Tab. 2 below. In that table, the first column is the name of the category which has expenditure share data, the second column is corresponding sector number(s) in 35 sector classification, the last column is the percentage(s) to allocate the "category share" listed in first column into corresponding sectors. For example, in the 5th row of the table, the first column is "Total Transport", and the numbers in second column are 23–26, which means the category share of "Total Transport" will be allocated to sector 23, 24, 25 and 26, respectively. The percentage numbers (35, 15, 40, 10) listed in last column says the category share of "Total Transport" will be split, by using the percentage 35%, 15%, 40% and 10%, into sector 23(Inland transport), sector 24(Water transport),sector 25 (Air transport) and sector 26 (Supporting and auxiliary transport activities; activities of travel agencies). As pointed before, these percentages are assigned arbitrarily by me. It is welcome to have any reasonable adjustment proposals.

Table 5

Assigned Split Shares for Categories in Tab. 4

Type of expenditures	Sector number	sector share of assigned
Total of food-beverage	3	100
Total Accommodation	22	100
Health Total	33	100
Total Transport	23-26	35,15,40,10
Total sports, education, culture	32,34	50,50
Total tour Services	34	100
Total of Other Goods and Services		
Clothes and Shoes	4,5	50,50
Souvenirs	16	100
Carpet, Rug	4	100
Other Expenses	7,19,21,27,28,30	10,20,20,20,10,20

The resulted shares for different sectors are listed in Tab. 6. Since there are no data for the years before 2001, a rough estimation of these shares for the year 1995 was made from the tendency of the time series from 2001 to 2009. For the years between 1995 and 2001, interpolation was done under G7.

Table 6

The Shares for Allocating "Nonresident Consumption in Turkey"

Sec-tor	1995	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	22.69	24.19	24.53	24.27	25.75	26.64	28.29	30.99	32.04	34.45	34.73	34.64
4	9.33	8.19	9.20	9.07	10.75	10.49	10.42	9.71	9.84	9.49	8.96	9.29
5	4.15	4.73	5.98	6.39	7.45	7.61	7.79	7.47	7.61	7.33	6.92	7.32
7	2.07	2.41	2.07	2.01	1.30	1.20	1.14	0.96	0.91	0.86	0.92	0.75
16	7.01	7.01	7.38	8.34	9.11	9.65	10.08	9.77	9.89	9.13	8.93	8.80
19	4.15	4.83	4.14	4.03	2.61	2.40	2.29	1.93	1.81	1.73	1.83	1.51
21	4.15	4.83	4.14	4.03	2.61	2.40	2.29	1.93	1.81	1.73	1.83	1.51
22	21.66	19.75	20.51	20.03	20.50	19.42	17.03	16.97	15.82	14.61	15.05	16.49
23	1.86	2.21	2.07	2.00	2.58	2.78	3.20	3.49	3.69	4.06	3.97	3.89
24	0.83	0.95	0.89	0.86	1.10	1.19	1.37	1.49	1.58	1.74	1.70	1.67
25	2.49	2.53	2.37	2.28	2.95	3.17	3.66	3.98	4.22	4.64	4.54	4.44
26	0.52	0.63	0.59	0.57	0.74	0.79	0.92	1.00	1.06	1.16	1.13	1.11
27	5.16	4.83	4.14	4.03	2.61	2.40	2.29	1.93	1.81	1.73	1.83	1.51
28	2.89	2.41	2.07	2.01	1.30	1.20	1.14	0.96	0.91	0.86	0.92	0.75
30	5.16	4.83	4.14	4.03	2.61	2.40	2.29	1.93	1.81	1.73	1.83	1.51
32	1.55	1.31	1.32	1.31	0.95	0.88	0.67	0.57	0.50	0.44	0.53	0.45
33	1.24	1.64	1.57	1.94	2.31	2.48	2.77	2.88	2.70	2.58	2.58	2.61
34	3.11	2.71	2.88	2.81	2.77	2.89	2.37	2.04	1.98	1.73	1.81	1.74

For the item “Direct purchases abroad by residents”, share information is obtained from the table “Tourism Expenditure and Other Expenses For (Resident citizens inside Turkey)”. Similar treatment is done as for nonresident expenditure and resulted shares are listed in Tab. 7. Since there are no data for the years before 2004, a rough estimation of these shares for the year 1995 was made from the tendency of the time series from 2004 to 2009. For the years between 1995 and 2003, interpolation was done under G7.

Table 7

The Shares for Allocating “Direct Purchase Abroad”

Sector	1995	2004	2005	2006	2007	2008	2009	2010	2011
3	29	32.26	31.03	34.94	36.43	36.06	37.21	37.50	36.28
4	3	3.26	3.34	3.16	2.78	3.12	3.22	3.10	3.20
5	3	2.98	2.93	2.76	2.44	2.85	3.07	2.93	3.07
7	1.3	1.18	1.53	1.24	1.20	1.11	1.07	0.92	0.99
16	15	12.79	14.49	11.71	11.82	10.98	8.85	7.71	8.76
19	3	2.37	3.06	2.48	2.41	2.21	2.13	1.84	1.97
21	3	2.37	3.06	2.48	2.41	2.21	2.13	1.84	1.97
22	24	23.06	21.07	20.60	21.12	22.68	23.65	25.15	24.91
23	2	2.71	2.84	3.79	3.52	3.44	3.34	3.76	4.02
24	1	1.16	1.22	1.62	1.51	1.48	1.43	1.61	1.72
25	2.8	3.10	3.25	4.33	4.03	3.94	3.81	4.30	4.60
26	0.6	0.77	0.81	1.08	1.01	0.98	0.95	1.08	1.15
27	2	2.37	3.06	2.48	2.41	2.21	2.13	1.84	1.97
28	1.2	1.18	1.53	1.24	1.20	1.11	1.07	0.92	0.99
30	2	2.37	3.06	2.48	2.41	2.21	2.13	1.84	1.97
32	2.5	2.07	0.94	0.87	0.94	1.21	1.42	1.38	0.98
33	1.8	1.53	1.50	1.45	1.16	0.85	0.84	0.79	0.44
34	2.8	2.49	1.30	1.28	1.22	1.35	1.54	1.48	1.03

After these conversions and adjustments, an IO table series from WIOD can be used for building INFORUM model for Turkish economy.

THE CONSEQUENCES OF CHANGES IN THE SOCIAL SECURITY CONTRIBUTION RATES IN RUSSIA

Vadim Potapenko

■ Introduction

In recent years, the rates of social security contributions have been one of the most discussed issues in Russian economic policy. Since 2009, the rates have been changed almost every year, and the changes were accepted under pressure from policy makers concerned with the financial soundness of the system. However, social security contribution rates affect not only the yield of the contributions but other aspects of the economy as well. The changes in these rates can influence the yield of other taxes, price levels, profitability of companies, wages of employees, fixed capital formation and so on. The problem is to quantify the effect of the rate changes on the whole economy. In this paper, an approach is presented to estimate some consequences of changes in social security contribution rates in Russia.

■ Recent Changes in Social Security Contribution Law

Changes of values of thresholds and rates for the contributions were introduced in 2010, 2011 and 2012. In 2013 employers pay for their employees 30% of wages as social security contributions until its accumulated year amount is under 568 thousand rubles (about 160% of average wage in Russia) and 10% of the amount above 568 thousand threshold. Most of the contributions go to pension system: 22% of 30% under the threshold and all 10% above the threshold.

Previous variant of the system had only 34% rate before the threshold, but it was criticized hardly. Nowadays Russian pension system is being reformed again. One of the reform proposals is to change social security contribution rates. There are three variants of the threshold and rates' values for next years:

- *Scenario 1*. The threshold and rates are to be the same as in 2013
- *Scenario 2*. It proposes that the threshold will be the same as in 2013. But the rate of social security contributions before the threshold should be increased by 4 percentage points to become 34%, and, simultaneously, 10% above the threshold rate should be abolished
- *Scenario 3*. The scenario is not to change 30% and 10% social security contribution rates. However, it proposes to increase the threshold from 160% of average wage in Russia to 230%.

Table 1

Systems of social security contribution rates in Russia

		2009	2010	2011	2012–2013	Afterwards		
						Scenario 1 (the same as in 2013)	Scenario 2	Scenario 3
Number of thresholds		2	1	1	1	1	1	1
Value of thresholds, % of average wage	the first	115	165	164	About 160			230
	the second	247	–	–	–	–	–	–
Social security contribution rates for intervals , %	before the first threshold	26	26	34	30	30	34	30
	between the first and the second thresholds	10	0	0	10	10	0	10
	above the second threshold	2	–					

According to current legislation, there will be return to the system of scenario 2. But it will be a very unpopular decision, therefore it is probable that the legislation will be changed. Nevertheless, Russian Ministry of Finance supports return to 34% rate. At the same time, Russian State Pension Fund which administrates the contributions' collection insists on choosing scenario 3. The future scenario is not yet chosen, and it is necessary to quantify possible consequences of choosing one of the above-mentioned variants.

■ International comparison

As shown in tab. 2, in comparison with most European countries, yield of social security contributions in Russia is not great. It was only 6.1% of GDP in 2012, while in France, Germany and Italy the values were 14.8%, 14.7%, and 13.1% of GDP, respectively.

Some countries of Eastern Europe have the contributions yield that are much more than Russian one too. For example, in Czech Republic it was 15.5%, in Poland – 11.4%, and in Estonia – 11.9% of GDP. Besides, these countries have such yields for many years without disastrous consequences for economy. In this way, international comparison demonstrates that Russia has room for increasing social security contribution rates. Probably, this will be one of the most obvious solutions to future demographic challenges.

Table 2

Social security contributions in Russia and European countries in 2011, % of GDP

Russia	6.1*	Norway	9.5
Germany	14.7	Portugal	6.4
France	14.8	Czech Republic	15.5
United Kingdom	7.1	Poland	11.4
Italy	13.1	Latvia	8.4
Spain	11.1	Estonia	11.9
Sweden	7.2	Greece	8.0

* In 2012

Note: Without imputed contributions

Source: Russia Federal Service of State Statistics, Eurostat

■ Temporal comparison of social security contribution indicators

In spite of all changes of thresholds and rates for social security contributions that have occurred recent years, their yields' fluctuations were rather moderate (fig. 1). An exception is 2011's change when the yield rose by 1.4 percentage points of GDP (even this value is moderate in comparison with room for its increasing).

In other cases modifications of the contribution rates' system did not affect indicators regarding total economy. In 2005–2010 the yield was 4.9–5.3% of GDP, while an effective rate of the contributions was 19.1–21.5%. In 2011 the effective rate reached 26.2%. But notwithstanding radical changes of the system in 2012, the effective rate decreased only by 0.8 percentage points.

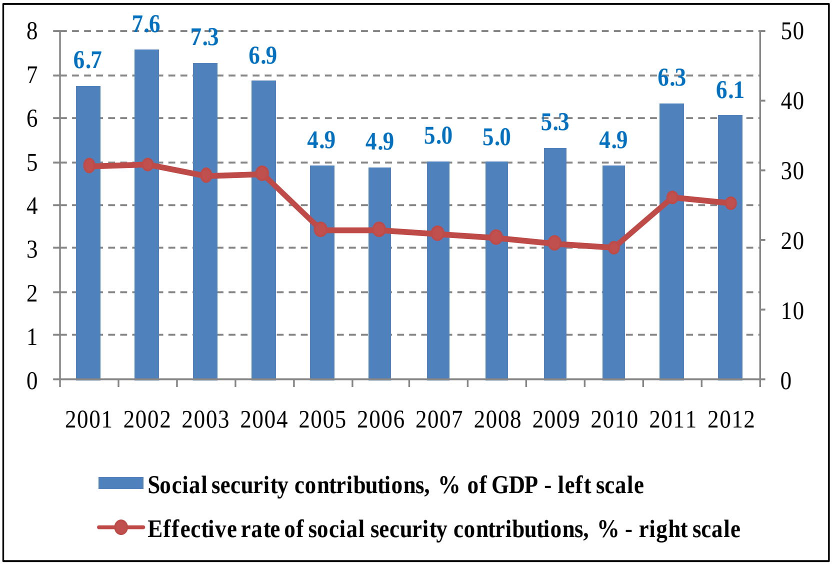


Fig. 1. Some indicators of social security contributions system in Russia in 2001–2012

■ Differences in costs on social security contributions between economic activities

Costs on social security contributions differ significantly by economic activities. For instance, in 2011 the contributions formed only 0.4% of costs in Coke and refined petroleum products and 2.0% of costs in Mining and quarrying. At the same time. the corresponding values in Textiles and Construction were 5.0%, and it was 5.5% in Machinery and equipment (tab. 3).

Table 3

Indicators of social security contributions and wages by some economic activities in 2011 in Russia

	Social security contributions, % of costs	Effective rate of social security contributions, %	Wages, % of costs	Average wage for economic activity, % of average wage in Russia
Agriculture and forestry	3.6	21.4	16.9	52
Mining and quarrying	2	22.7	8.8	191
Manufacturing	2.7	28.1	9.7	92
Food products, beverages and tobacco products	2.5	27	9.3	80
Textiles	5	29.7	16.9	46
Coke and refined petroleum products	0.4	20.7	2	204
Chemicals and chemical products	2.6	27.3	9.5	107
Other non-metallic mineral products	4	29.6	13.4	87
Basic metals and fabricated metal products	2.4	28	8.4	102
Machinery and equipment	5.5	27.9	19.8	98
Construction	5	26.1	19.1	102
Wholesale and retail trade	3.4	24.4	13.9	88

Source: Russian Federal Service of State Statistics

Costs on the contributions are determined by costs on wages and effective rates. In turn, the effective rates depend on the next factors:

- Values of thresholds and rates for social security contributions;
- Level of wages;
- Distribution of wages among employees.

Consequently, changes of social security contribution rates and thresholds impact economic activities in different degrees changing amount and structure of their costs. For example, it is probable that increase of the contribution rate before the threshold and decrease of the rate above it will increase costs on the contributions for economic activities with low level of wages, while costs of activities with high one will fall. Thus, it is very important to take into account an interindustrial aspect while analyzing consequences of changes in social security contribution rates.

■ Scheme of modeling

On fig. 2 a scheme of modeling of effective rates and yield of social security contributions by economic activities and decile income groups of employees is presented. To calculate them, an exogenously set system of social security contribution rates, data on wage distribution and variables from interindustrial model of Russian economy are used. Then calculated values of effective rates and yield of the contributions are incorporated in the model of Russian economy.

In response to increase/decrease of the rates, companies can choose a number of different actions. The most obvious ones are

- to decrease/increase wages of employees (it means that their wages are less/more than in the case if the rates are lower/higher);
- to decrease/increase profits.

In fact, companies can react to the rates' changes using a mixture of variants of actions. Besides, changes of social security contribution rates can provoke companies increase of decrease prices. But in the paper only two above-mentioned exogenously set edge variants are considered.

■ Results of modeling

Calculations show changes in government revenue items (total yield of social security contributions, tax on individual income, and tax on profit of companies) in case of realization of scenario 2 will increase by 0.22–0.23 percentage points of GDP in comparison with scenario 1 (tab. 4). Realization of scenario 3 will increase government revenue by 0.32–0.35 percentage points of GDP.

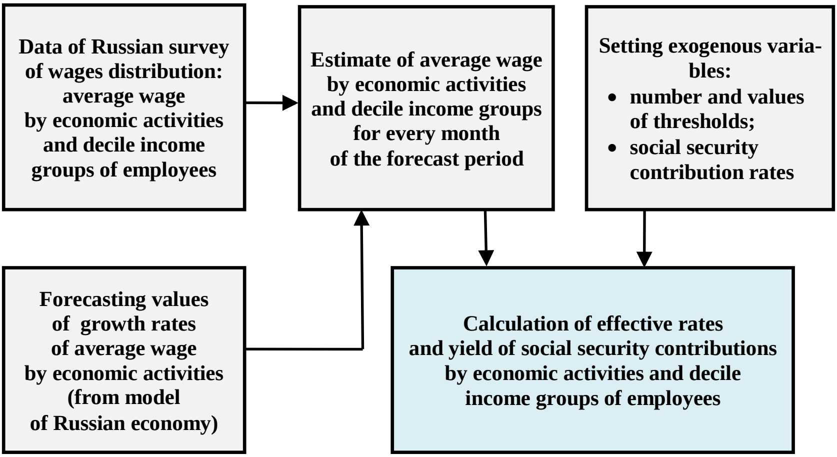


Fig. 2. Modeling of yield of social security contributions.

Table 4

Change of government revenue items, percentage points of GDP in 2014

	Scenario 2 in comparison with scenario 1		Scenario 3 in comparison with scenario 1	
	Variant of change of wages	Variant of change of profits	Variant of change of wages	Variant of change of profits
Social security contributions	0.27	0.28	0.41	0.40
Tax on individual income	–0.04		–0.06	
Tax on profit of companies		–0.06		–0.08
Total	0.23	0.22	0.35	0.32

Source: author’s calculations

Possible changes of the thresholds and rates will not affect the contributions' effective rates for the 1–8th decile income groups of employees (tab. 5). The changes will increase the rate for the 9th group by 2.4 and 1.7 percentage points for scenarios 2 and 3, respectively. At the same time, scenario 2 will lead to decrease of the rate for the 10th group by 3 percentage points, and scenario 3 will increase the rate by 4 percentage points.

Table 5

Effective rates of social security contributions for income decile groups of employees in 2014, %

Decile group	Scenario 1	Scenario 2	Scenario 3
1st – 8th groups	≈ 30	≈ 34	≈ 30
9th group	27.7	30.1	29.4
10th group (with the highest amount of wage)	19.7	16.7	23.8

Source: author's calculations

Table 6

Effective rates of social security contributions for total economy and some economic activities in 2014, %

	Scenario 1	Scenario 2	Scenario 3
Total economy	25.9	27.0	27.6
Mining and quarrying	24.6	24.0	27.0
Manufacturing	25.3	27.0	26.8
Food products	25.4	26.9	26.9
Textiles, leather and related products	23.4	25.4	23.4
Coke and refined petroleum products; chemical products; rubber and plastic products	25.2	26.8	26.7
Other non-metallic mineral products	23.9	26.1	24.9
Basic metals and fabricated metal products	26.8	28.6	28.4
Machinery and equipment; electronic equipment; transport equipment	24.8	26.9	26.2
Construction	23.3	24.1	24.9
Wholesale and retail trade	19.6	19.7	21.4
Financing	21.6	20.2	23.5
Education	22.5	24.9	23.5

Source: author's calculations

According to the forecast, in 2014 effective rate of social security contributions will be 25.9% if system of the rates is not changed. With realization of scenario 2 the effective rate will be by 1.1 percentage point higher. Scenario 3 will increase the rate by 1.7 percentage point.

Despite of growth of the effective rate for total economy both for scenario 2 and for scenario 3, influence of the scenarios on separate economic activities will be different (tab. 6). Scenario 3 will lead to significant increase of effective rates for Mining and quarrying, Financing, Coke and refined petroleum products (which have little shares of costs on labour) and Trade in comparison with scenario 2. In turn, for most of activities with bigger costs on labor – Machinery, Textile, Non-metallic mineral products and so on – the effective rates with scenario 3 will be lower than with scenario 2.

■ Conclusions

Possible changes of social security contribution rates by plans proposed by Russian government will not affect significantly yield of government revenue. Increase of the total yield will not exceed 0.35 percentage points of GDP, and increase of only social security contributions will not exceed 0.4 percentage points of GDP.

Consequences of realization of scenario 2 and scenario 3 will be different for economic activities. Generally, scenario 3 is more profitable (in comparison with scenario 2) for economic activities that have great shares of costs on labour (mainly for manufacturing activities) and less profitable for such activities as Mining and quarrying, Financing and Trade.

Scenarios 2 and 3 will increase effective rate of social security contributions for the 9th income group of employees almost similarly. For the 10th income group realization of scenario 3 will increase effective rate, but in case of scenario 2 the rate will be decreased.

To sum, if social security contribution rates are changed, scenario 3 is more preferable than scenario 2.

THE BELARUS ECONOMY AS PART OF THE COMMON ECONOMIC SPACE: AN ANALYSIS AND FORECAST

Ksenia E. Savchishina

Since 2012, a system of models for the member countries of the Common Economic Space has been developed in the Institute of Economic Forecasting. The Common Economic Space is an economic union created January 1, 2012 and involves the Russian Federation, the Belarus Republic and Kazakhstan. The main purposes of this organization are:

- To change economic structures to increase economic efficiency;
- To open tax-free trade between the members;
- To facilitate bank transfers between firms in member countries without costly exchange operations.

At the present only the tax-free trade has been achieved.

The system of models consists of three main blocks:

(1) models for short-term forecasting (1 year ahead);

(2) for medium-term forecasting (2–4 years ahead);

(3) for long-term forecasting (5 and more years ahead).

The first block is a system of leading and coincident indicators not tied together by accounting identities. The indicators are calculated as sum of a set of weighted economic variables. A list of the variables and their weights are determined by minimizing the average deviation of the indicator growth rates from the GDP growth rates. The coincident indicator is estimated with the following variables:

(1) employed population;

(2) turnover of retail trade;

(3) services rendered to population;

(4) manufacturing production indices;

(5) transport freight turnover;

(6) growth rate of investment.

The leading indicator for each country is estimated with the following variables:

(1) manufacturing production indices for European Union;

(2) real growth rate of average wages;

(3) cement production;

(4) index of business confidence (published by Federal State Statistics Service);

(5) bank lending to corporations;

(6) price of the crude oil.

The second block consists of macroeconomic models (with accounting identities) for the Russian, Belarus and Kazakh economies. And finally, the third block involves inter-industry models for these countries. This report is about the Belarus macroeconomic model in the second block of the system. Before presenting the model, we should have a quick look at Belarus and its recent economic development.

■ Fundamental Features of Belarus and its Economy

Fig. 1. Location of the Belarus Republic

Belarus is surrounded by Russia, Poland, Ukraine, Lithuania and Latvia. This location allows Belarus to transport Russian energy resources by rail, highway and pipeline systems to Europe. Belarus has a population of about 9.5 million people. There are about 130,000 companies, of which about 15% are state-owned.

The Belarus economy was rather successful in the years 2000–2008. The average rate of the real GDP growth was about 6% per year until 2003 and then rose to about 10% in 2004–2008. Problems started in 2009 when exports in constant prices decreased by 12%. This drop was caused by falling demand in Russia, Ukraine and the Baltic countries, which buy about 50 percent of Belarus exports. In 2011–2012, the Belarus economy met new difficulties: the consumer price index more than doubled in 2011 and increased more than 20% in 2012.

Table 1

Belarus economy: GDP, inflation

	2005	2007	2009	2011	2012
GDP, real growth rate, %	9.4	8.6	0.2	5.5	1.5
Personal consumption	15.0	6.6	0.1	2.3	10.9
Government consumption	0.3	–0.2	–0.1	–3.6	–1.2
Gross capital formation	19.2	7.6	3.9	13.9	–9.8
Exports	–1.2	2.8	–11.9	29.5	10.6
Imports	–3.1	3.5	–12.2	15.8	9.4
CPI, %	8.0	12.1	10.1	108.0	21.8
GDP, trillion of current Belarus rubles	65.1	97.2	137.4	297.2	527.4
Personal consumption	33.0	49.2	75.0	140.0	246.5
Government consumption	13.5	148.0	23.2	41.4	76.8
Gross capital formation	17.3	30.5	49.3	113.2	173.2
Exports	38.9	59.2	69.4	241.1	430.5
Imports	38.4	65.3	84.9	244.3	406.6
GDP structure, % to total	100%	100%	100%	100%	100%
Personal consumption, %	50.6%	50.6%	54.6%	47.1%	46.7%
Government consumption, %	20.8%	18.5%	16.9%	13.9%	14.6%
Gross capital formation, %	26.5%	31.4%	35.9%	38.1%	32.8%
Net exports, %	0.7%	–6.3%	–11.3%	–1.1%	4.5%

The main foreign trade flows of Belarus are the following:

- import of crude oil from Russia;
- import of oil products from Russia;
- export of oil products to European countries.

The share of these flows is about 35% of export and 30% of import. This trade structure was supported by a disparity in the import and export prices for energy resources.

The export prices of crude oil and oil products are equal to the world prices level and are significantly higher than the import prices of these goods from Russia. Fig. 2 shows the import and export prices (in dollars per barrel, left scale) of crude oil for the period 2000–2012; the left (white) bar in each year shows the export price while the right (grey) bar shows the import price. The black line shows the percentage by which the export price exceeds the import price (right scale). Fig. 3 shows a similar graph for refined oil products.

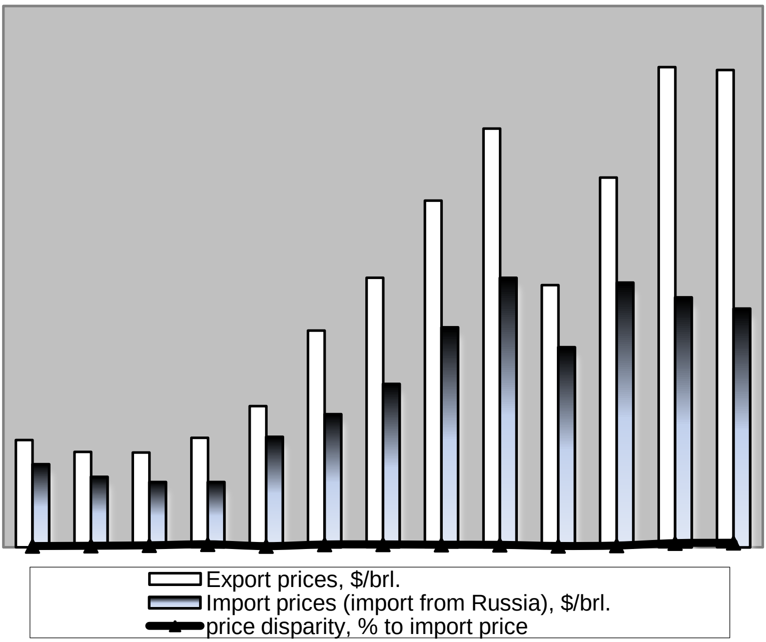


Fig. 2. Crude oil prices

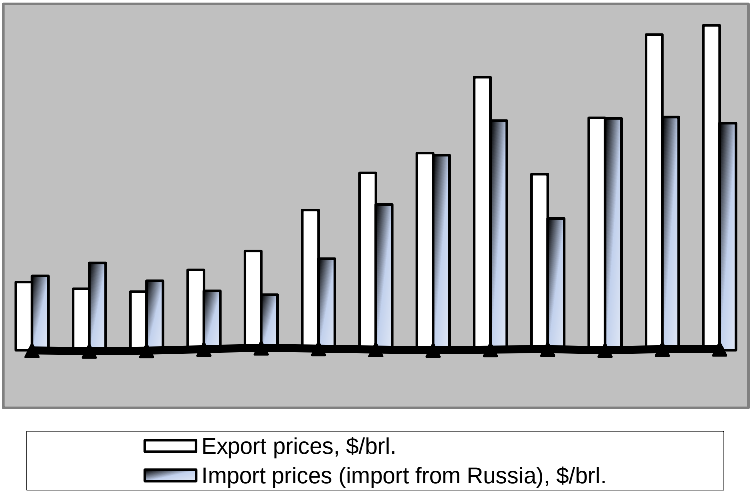


Fig. 3. Oil products prices

Despite this exceptionally fortunate position, in 2007–2010 the Belarus balance of foreign trade was negative and its absolute value increased from $4 billion to $9 billion – or about 35% to the export volume. In 2011–2012 the negative trade balance fell to $2 billion, but at the same time foreign domestic investment fell by 40% in 2011 and another 60% in 2012. As a result, the exchange rate increased from 2200 Belarus rubles per dollar in 2007–2008 to 8400 Belarus rubles per dollar in 2012. This weakening of the national currency led to growth of the public external debt from 5% to GDP in 2007 to 34% in 2011.

■ The Belarus Macroeconomic Model

The macroeconomic model of the Belarus economy includes about 65 endogenous variables, 39 exogenous variables, 50 regression equations and 20 identities. The variables and relations are shown schematically in Fig. 4 (the blue squares contain the exogenous variables).

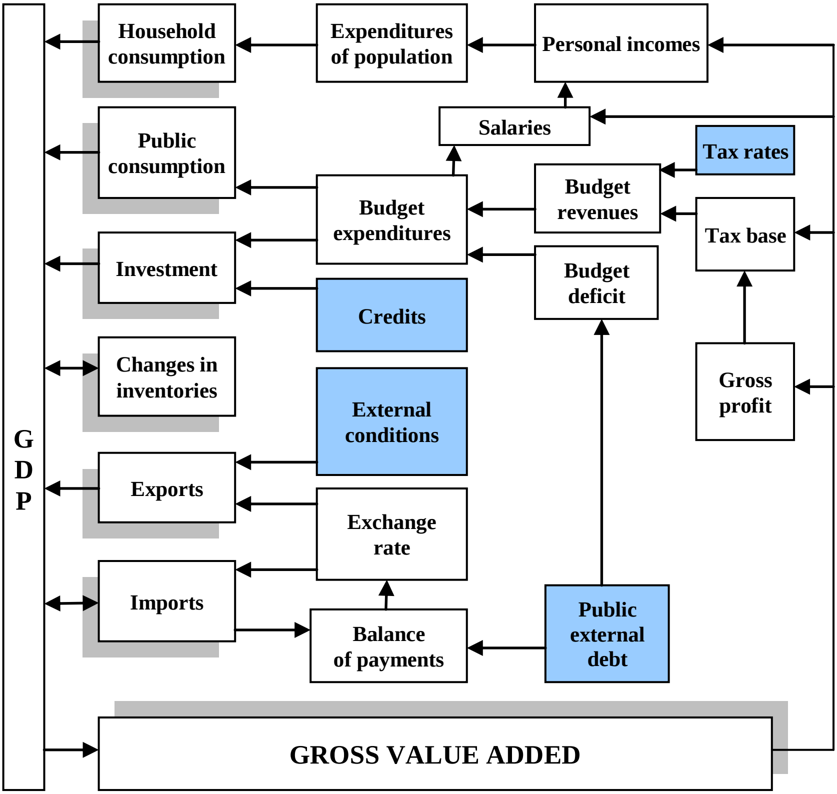


Fig. 4. Schematic Picture of the Belarus Macroeconomic Model

The GDP value is calculated as the sum of personal and public consumption, investment for capital formation, changes in inventories and net export. Household consumption is determined by household income; public final consumption is determined by government revenues.

Personal incomes are estimated by salaries and other incomes (pensions and other social transfers, incomes from property and so on). Total salaries in the private sector are modeled as a function of Gross Value Added in this sector, and salaries in the public sector are a function of the budget expenditures of the public sector.

The government (or budget) income is estimated by multiplying of the tax rates (which are exogenous) and tax base, which is a function of gross value added.

Total investment is modeled as a function of the budget expenditures for capital formation and the bank lending to non-financial companies.

The export and import flows are divided between energy and non-energy trade. The growth rate of non-energy exports is determined by the GDP growth rates in the European Union and in Russia. The growth rate of non-energy imports depends on the growth rate in Belarus of consumption+investment+exports. The GDP growth rates in the European Union and in Russia are exogenous (called "External conditions" in Fig. 4).

As for the energy imports and exports, we estimate regression equations and identities. The physical volume of Belarus imports of crude oil and the refined oil products from Russia are exogenous variables.

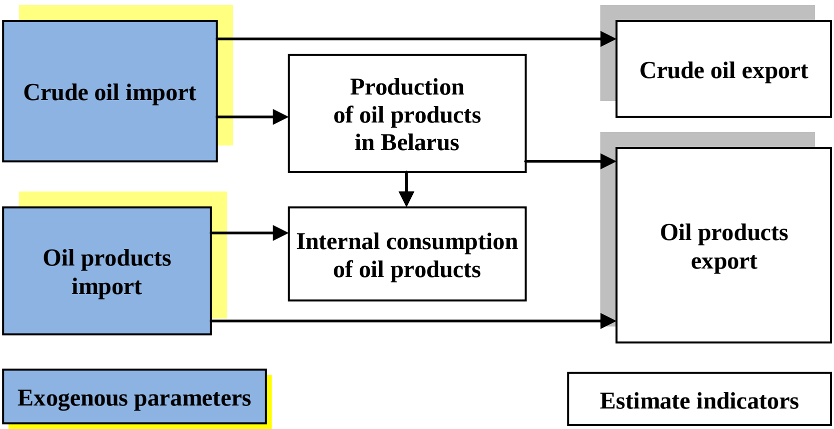


Fig. 5. Exports and Imports of Crude Oil and Refined Oil Products

The imported oil can be used for export and for internal usage for oil products production. The import oil products can be used for export and for internal consumption which is determined by the GDP dynamics.

The value of oil products exported is estimated by the equation:

Exports = oil product imports + domestic production – domestic consumption.

The last main block of the model calculates the balance of payments and exchange rate. The balance of payments is calculated by the balance on current account plus net changes in public and private external debt (including foreign investments).

The public external debt value is an exogenous variable that affects both the balance of payments and the budget expenditures. An increase in the public debt allows the government to increase public consumption and investment as well as salaries in the state-owned companies. But, on the other hand, the growth of public debt requires more and more debt service payments.

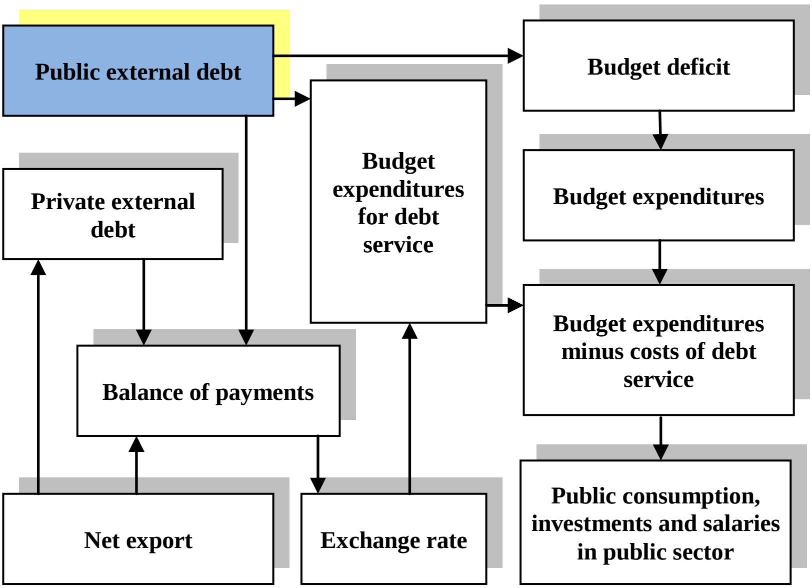


Fig. 6. Relation of Public External Debt, Exchange Rate, and Public Expenditure

■ Regressions and Identities

Some important regressions and identities with the main endogenous variables are shown below.

Personal consumption:

taxsna=taxgoodK+vedK–subsK+othertaxK (1)

profits=(fdC–wagessna–taxsna)*(1–rtaxprofit) (2)

exRyq=(exR+exR[1]+exR[2]+exR[3]) / 4
invRyq=(invR+invR[1]+invR[2]+invR[3]) / 4
conspw=(invRyq+exRyq) / poptrudT
goswage=wagesK / emp_gos
r wagessna=conspw, dpce, goswage (3)

SEE=80.85 RSQ=0.9938 RHO=–0.06 Obser=36 from 2004.100
SEE+1=80.69 RBSQ=0.9932 DW=2.13 DoFree=32 to 2012.400
MAPE=4.88

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 wagessna	–	–	–	–	1210.90	–
1 intercept	–338.66664	13.0	–0.28	161.28	1.00	
2 conspw	53.01991	3.9	0.22	28.63	5.07	0.057
3 dpce	609.04778	35.6	0.56	3.80	1.11	0.379
4 goswage	299.96141	94.9	0.50	1.00	2.01	0.573

income=incdep+wagessna+pension*pens (4)

r moneyinc=!income*moneyincfs, profits (5)

SEE=4052.86 RSQ=0.9695 RHO=0.27 Obser=25 from 2006.400
SEE+1=4054.08 RBSQ=0.9682 DW=1.46 DoFree=23 to 2012.400
MAPE=9.10

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 moneyinc	–	–	–	–	33208.23	–
1 income*moneyincfs	3.02901	93.9	0.61	1.94	6702.51	
2 profits	0.81616	39.2	0.35	1.00	14078.68	0.413

consexp=moneyinc*(1–rtaxinc)*(1–saverate) (6)

pceR=consexp / dpce (7)

Public consumption:

r taxpropK=fdC, invC[1], invC[2], invC[3], CPI/CPI[4] (8)

SEE=54.59 RSQ=0.9731 RHO=0.12 Obser=29 from 2005.400
SEE+1=54.29 RBSQ=0.9672 DW=1.76 DoFree=23 to 2012.400
MAPE=8.84

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 taxpropK	–	–	–	–	532.16	–
1 intercept	219.21816	19.6	0.41	37.13	1.00	
2 fdC	0.00388	13.4	0.36	2.75	50026.10	0.446
3 invC[1]	0.00873	29.4	0.26	1.89	15623.69	0.321
4 invC[2]	0.00378	4.0	0.10	1.84	14088.32	0.122
5 invC[3]	0.00798	12.0	0.19	1.20	12702.06	0.227
6 CPI/CPI[4]	–138.77235	9.5	–0.32	1.00	1.24	–0.120

r soctaxK=!wagessna*rtaxinc, incKfs (9)

SEE=734.25 RSQ=0.9662 RHO=0.66 Obser=24 from 2007.100
SEE+1=568.82 RBSQ=0.9647 DW=0.67 DoFree=22 to 2012.400
MAPE=11.73

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 soctaxK	–	–	–	–	6420.67	–
1 wagessna*rtaxinc	1.82058	428.2	0.83	1.73	2938.75	
2 incKfs	4304.78871	31.6	0.17	1.00	0.25	0.043

r vedK=!(imC+exC), incKfs[1], fdCfs, fdCfs[1], rateusd/rateusd[1] (10)

SEE=366.87 RSQ=0.9638 RHO=0.31 Obser=36 from 2004.100
SEE+1=365.77 RBSQ=0.9592 DW=1.39 DoFree=31 to 2012.400
MAPE=14.67

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 vedK	–	–	–	–	1895.45	–
1 (imC+exC)	0.02907	377.1	0.94	1.48	61597.49	
2 incKfs[1]	–13233.36569	12.8	–1.75	1.47	0.25	–0.245
3 fdCfs	–5299.86816	16.1	–0.70	1.43	0.25	–0.115
4 fdCfs[1]	12604.50192	13.0	1.67	1.31	0.25	0.276
5 rateusd/rateusd[1]	1503.31987	14.4	0.83	1.00	1.04	0.092

r taxgoodK=!rvat*(fdC-exC+imC), incKfs, expKfs[1] (11)
SEE=627.16 RSQ=0.9788 RHO=0.55 Obser=31 from 2005.200
SEE+1=547.04 RBSQ=0.9773 DW=0.91 DoFree=28 to 2012.400
MAPE=7.75

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 taxgoodK	–	–	–	–	6461.32	–
1 rvat*(fdC-exC+imC)	0.56555	555.8	0.83	2.19	9477.93	
2 incKfs	5708.33750	15.8	0.22	1.02	0.25	0.048
3 expKfs[1]	–1286.00382	1.0	-0.05	1.00	0.25	–0.014

profit=rtaxprofit*(fdC-wagessna-taxsna)

r taxprofitK=!profit[1], profit[3], fdCfs[1], incKfs[1] (12)

SEE=640.31 RSQ=0.9470 RHO= –0.12 Obser=28 from 2006.100
SEE+1=635.53 RBSQ=0.9404 DW=2.23 DoFree=24 to 2012.400
MAPE=15.72

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 taxprofitK	–	–	–	–	3790.56	–
1 profit[1]	0.82942	129.7	0.92	1.84	4182.15	
2 profit[3]	0.07151	1.3	0.07	1.52	3488.08	0.067
3 fdCfs[1]	–30257.73778	21.5	–2.00	1.50	0.25	–0.475
4 incKfs[1]	30737.04422	22.6	2.02	1.00	0.25	0.416

incK=othertaxK+notaxK+taxpropK+soctaxK+vedK+taxgoodK+
+taxprofitK (13)

outfinK=govdebt, rateusd (14)

SEE=1302.17 RSQ=0.5627 RHO=0.29 Obser=28 from 2006.100
SEE+1=1301.37 RBSQ=0.5277 DW=1.42 DoFree=25 to 2012.400
MAPE=359.58

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 outfinK	–	–	–	–	986.69	–
1 intercept	539.58128	2.0	0.55	2.29	1.00	
2 govdebt	2.49256	47.5	0.90	1.04	358.01	0.722
3 rateusd	–0.12116	2.2	–0.45	1.00	3674.90	–0.139

defK= –(outfinK+otherfinK) (15)

expK=incK–defK (16)

del_govdebt=govdebt–govdebt[1]
r percentK=! govdebt*rateusd (17)

SEE=201.27 RSQ=0.8994 RHO= –0.30 Obser=28 from 2006.100
SEE+1=191.66 RBSQ=0.8994 DW=2.59 DoFree=27 to 2012.400
MAPE=46.13

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 bpercentK	–	–	–	–	515.35	–
1 govdebt*brateusd	0.00002	306.1	1.00	1.00	31627341.30	

r pubexR=(expK[1]–percentK[1])/dpubex[1],
(expK–percentK)/dpubex, wagesK[1]/dpubex[1], fdR (18)

SEE=92.75 RSQ=0.5056 RHO=0.37 Obser=36 from 2004.100
SEE+1=87.99 RBSQ=0.4418 DW=1.27 DoFree=31 to 2012.400
MAPE=1.31

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 pubexR	–	–	–	–	5758.18	–
1 intercept	5470.81459	636.0	0.95	2.02	1.00	
2 (expK[1]-percentK[1])/dpubex[1]	0.02004	2.1	0.05	1.95	14538.85	0.353
3 (expK-percentK)/dpubex	0.02809	9.7	0.07	1.28	14693.60	0.458
4 wagesK[1]/dpubex[1]	–0.24903	13.1	–0.14	1.16	3188.70	–1.088
5 fdR	0.01155	7.6	0.07	1.00	32665.28	0.535

Investment:

rcred=(credgov+cred) / dfd
budinvr=(expK–wagesK–percent–socposK) / dfd

r invR=pceR, exR, rcred, budinvr (19)

SEE=1561.24 RSQ=0.8205 RHO=0.05 Obser=24 from 2007.100
SEE+1=1566.68 RBSQ=0.7827 DW=1.90 DoFree=19 to 2012.400
MAPE=9.80

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 binvVT	–	–	–	–	13283.26	–
1 intercept	–10532.88252	31.9	–0.79	5.57	1.00	
2 bpceVT	0.12427	1.8	0.18	3.92	19725.23	0.111
3 bexVT	0.44638	41.2	0.69	3.02	20460.50	0.468
4 rcred	0.16734	43.0	0.54	2.18	43097.34	0.544
5 budinvr	3.39763	47.5	0.38	1.00	1477.44	0.470

External trade:

r imC_res=(pubexR+pceR+invR+invnR), imCfs (20)

SEE=826.01 RSQ=0.8170 RHO=0.45 Obser=40 from 2003.100
SEE+1=738.63 RBSQ=0.8071 DW=1.10 DoFree=37 to 2012.400
MAPE=12.19

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 imC_res	–	–	–	–	5100.53	–
1 intercept	–1420.21145	4.4	–0.28	5.47	1.00	
2 (pubexRbpceR+invRT+invnR)	0.18271	125.1	1.20	1.01	33371.41	0.892
3 imCfs	1693.96218	0.5	0.08	1.00	0.25	0.043

imR=(imC_res+gas_imp$+oil_imp$+pet_imp$)*rateusd / dim (21)

r RU_exp=rfdR_sa/rrateusd, exCfs, rateusd (22)

SEE=340.88 RSQ=0.8633 RHO=0.33 Obser=40 from 2003.100
SEE+1=322.26 RBSQ=0.8519 DW=1.35 DoFree=36 to 2012.400
MAPE=11.90

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 RU_exp	–	–	–	–	2251.06	–
1 intercept	–1107.08139	8.0	–0.49	7.31	1.00	
2 rfdR_sa/rateusd	7.71912	56.2	1.14	4.87	331.99	0.451
3 exCfs	–1200.49523	1.2	–0.13	4.79	0.25	–0.059
4 rateusd	0.34137	118.9	0.49	1.00	3209.66	0.750

r Other_exp=EUgdpind, exCfs, rateusd (23)

SEE=841.86 RSQ=0.8723 RHO=0.52 Obser=40 from 2003.100
SEE+1=737.54 RBSQ=0.8617 DW=0.96 DoFree=36 to 2012.400
MAPE=12.87

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 Other_exp	–	–	–	–	4838.10	–
1 intercept	–36943.41309	79.9	–7.64	7.83	1.00	
2 EUgdpind	13.16420	86.1	8.04	3.07	2955.05	0.596
3 bexVCTfs	3672.89560	1.8	0.19	2.83	0.25	0.070
4 brateusd	0.61130	68.1	0.41	1.00	3209.66	0.526

r exR=pet_exp, Other_exp, RU_exp, exCfs (24)

SEE=1264.53 RSQ=0.8851 RHO=0.03 Obser=40 from 2003.100
SEE+1=1264.58 RBSQ=0.8719 DW=1.93 DoFree=35 to 2012.400
MAPE=5.28

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 exR	–	–	–	–	19013.71	–
1 intercept	5258.97037	21.5	0.28		8.70	1.00
2 pet_exp	3.56066	8.2	0.36	2.18	1900.64	0.942
3 Other_exp	–0.82565	2.9	–0.21	2.18	4838.10	–0.522
4 RU_exp	1.63284	12.1	0.19	1.97	2251.06	0.404
5 exCfs	29212.78768	40.3	0.38	1.00	0.25	0.354

fdR=pceR+pubexR+invR+invnR+exR–imR (25)

Used abbreviation (in alphabetical order):

CPI – consumer price index;
cred – bank leading to private companies;
credgov – bank leading to state companies;
defK – the budget deficit;
dfd – GDP deflator;
dim – deflator of imports;
dpce – deflator of the personal consumption;
dpubex – deflator of the public consumption;

emp_gos	–	employees of the state companies (thousands people);
exC	–	exports in current prices;
exCfs	–	seasonality coefficient of the exports in current prices;
expK	–	the budget expenditures;
expKfs	–	seasonality coefficient of the budget expenditures;
exR	–	exports in constant prices;
EUgdpind	–	real GDP growth rate in the European Union;
fdC	–	GDP in current prices;
fdCfs	–	seasonality coefficient of the GDP in current prices;
fdR	–	GDP in constant prices;
gas_imp$	–	gas imports from Russia to Belarus (in mln. dollars);
govdebt	–	total external public debt (mln. dollars);
imC	–	imports in current prices;
imCfs	–	seasonality coefficient of the imports in current prices;
imC_res	–	non-energy imports in current prices;
imR	–	imports in constant prices;
incdep	–	personal incomes from the bank deposits;
incK –	–	the budget revenues;
incKfs	–	– seasonality coefficient of the budget revenues;
invC	–	investment in current prices;
invR	–	investment in constant prices;
invnR	–	changes in inventories in constant prices;
moneyinc	–	total personal incomes;
moneyincfs	–	seasonality coefficient of total personal incomes;
notaxK	–	non-tax budget revenues;
oil_imp$	–	crude oil imports from Russia to Belarus (in mln dollars);
otherexpK	–	other budget expenditures;
otherfinK	–	internal resources of the budget financing;
othertaxK	–	other tax income of the government;
Other_exp	–	non-energy exports from Belarus to European countries in constant prices;
outfinK	–	external resources of the budget financing;
pceR	–	personal consumption in constant prices;

pens	–	retirees (thousands people);
pension	–	average pension (per person, it depends on the budget expenditures for social policy);
percentK	–	percent budget expenditures;
pet_exp	–	oil products exports from Belarus in constant prices;
pet_imp$	–	oil products imports from Russia to Belarus (in mln dollars);
poptrudT	–	employed population (thousands people);
profits	–	net profits of business;
pubexR	–	public consumption in constant prices;
rateusd	–	exchange rate of Belarus ruble to US dollar;
rrateusd	–	exchange rate of Belarus ruble to Russian ruble;
rfdR_sa	–	real GDP growth rate in Russia (seasonally adjusted);
rtaxinc	–	rate of personal income tax;
rtaxprofit	–	rate of company profit tax;
rvat	–	rate of VAT;
RU_exp	–	non-energy exports from Belarus to Russia in constant prices;
saverate	–	savings ratio for population;
socposK	–	budget expenditures for social policy;
soctaxK	–	social taxes;
subsK	–	budget subsidies;
taxgoodK	–	taxes for goods and services (VAT and excises);
taxprofitK	–	company profit tax;
taxpropK	–	real estate tax;
taxsna	–	net taxes for production and imports;
vedK	–	taxes for external trade (export and import duties);
wagesK	–	budget expenditures for salaries;
wagessna	–	compensations of employees.

■ Some experiments

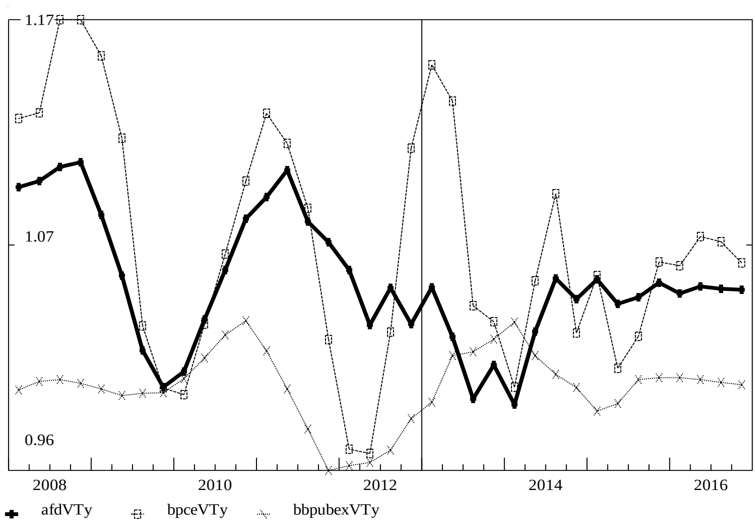
Using the model I ran three scenarios. The base scenario is "business as usual" with the exogenous parameters continuing the trends observed in 2008–2012. Tab. 2 shows the resulting growth rates from some of the principal variables.

As you can see in the table, keeping the recent policies will not allow the Belarus economy to get the high GDP growth rates that were observed until 2009. Moreover, the growth of net imports will cause a dramatic drop in the exchange rate of the Belarus ruble to the dollar which will lead to an extremely high inflation rate.

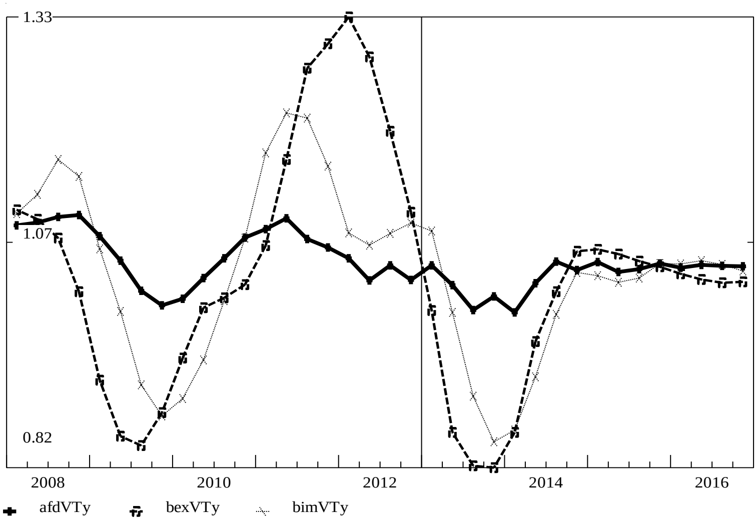
Table 2

Base Scenario Results

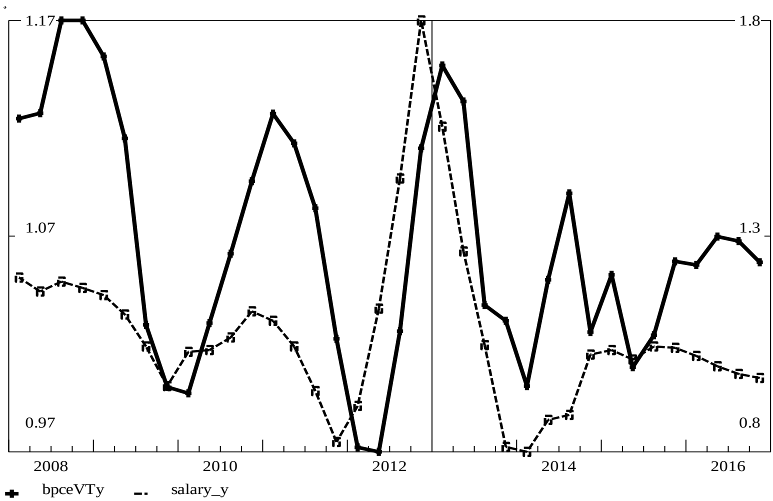
	2012	2013	2014	2015	2016
GDP dynamics in 2008 prices, %					
GDP	1.5	2.4	4.1	4.2	3.8
Households consumption	10.9	2.4	3.3	7.5	5.6
Public consumption	–1.2	1.8	0.5	0.5	0.3
Investments	–9.8	2.3	5.3	3.9	3.4
Exports	10.6	–15.4	6.0	2.9	3.0
Imports	9.4	–13.2	5.6	5.4	4.1
Rate of inflation, %	21.8	6.2	26.5	29.6	43.7
STATE BUDGET					
Revenues (% to GDP)	41.4	40.8	37.5	36.4	34.8
Expenditures (% to GDP)	40.8	42.7	37.9	36.8	34.8
incl. public debt service (% to GDP)	1.4	1.5	1.5	1.4	1.3
BALANCE OF PAYMENTS, mln $					
Balance of current account	–1819.3	–5608.0	–5181.1	–6245.1	–6624.5
% to GDP	–3.0	–10.0	–9.5	–10.6	–10.3
Changes in reserve assets	81.0	–4251.7	–4404.8	–6278.1	–6515.4
FINANCIAL INDICATORS					
Exchange rate (ruble to dollar)	8351.6	9153.6	12708.5	16496.5	22111.6
Public external debt, mln. $	12568.6	12901.0	13151.0	12800.0	12923.0
% to GDP	20.4	25.5	25.9	24.2	21.8



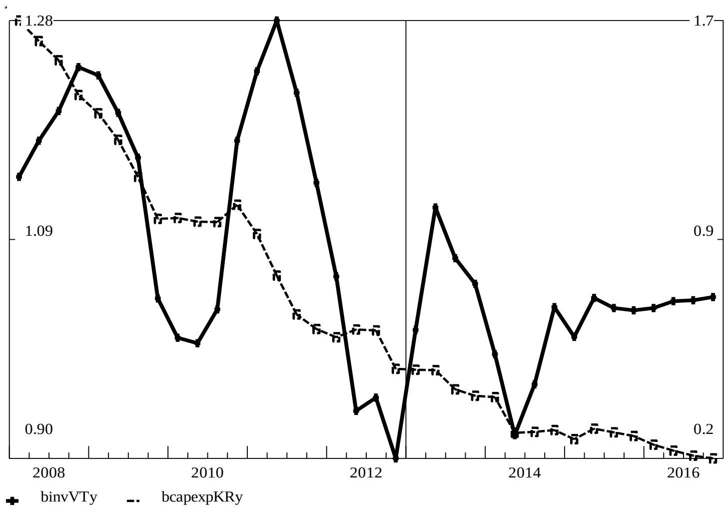
afdVTy – GDP growth rate, % to the previous year,
bpceVTy – personal consumption growth rate, % to the previous year,
bbpubexVTy – public consumption growth rate, % to the previous year.



afdVTy – GDP real growth rate, % to the previous year,
bexVTy – exports real growth rate, % to the previous year,
bimVTy – imports real growth rate, % to the previous year.



bpceVTy – personal consumption real growth rate, % to the previous year (left scale),
salary_y – average wage in state sector, % to the previous year (right scale).



binvVTy – investment real growth rate, % to the previous year (left scale),
bcapexpKRy – government investment real growth rate, % to the previous year (right scale).

Having estimates the economic dynamics for the business as usual scenario, I developed two alternative scenarios, the first of which can be called Moderate Optimism and the second, Pessimism.

In the Moderate Optimism scenario, I try to determine an optimum increase of the public external debt. What does optimum debt mean? The external debt growth can be used to eliminate the negative effects from the net import increase. The more debt assumed, the higher the national currency will be relative to the dollar and the euro. But optimum debt also means that the debt service costs should not decrease the budget expenditures for other purposes – consumption, investments and salaries. Hence, the optimum debt increase produces the maximum possible GDP growth rates.

After the model simulation with this scenario, we can compare its results with the business-as-usual scenario. In the tab 3, the first line for each indicator is the base scenario and the second line is the scenario with optimum public external debt. As we see, the deceleration of the CPI in the second scenario relative to the first one will allow some acceleration in the GDP growth. But in 2016, the decrease of the growth rate in exports and internal consumption will lead to the GDP growth in the second scenario being lower than in the base.

What is the reason for such results? In 2014–2016, the growth of the public external debt will lead to a stronger Belarus ruble relative to the dollar. This stronger ruble produces a lower inflation rates than in the base scenario. But at the same time, it will lead to lower growth of exports. However, the public debt service will rise and other public expenditures will have to be reduced. The same reasoning implies lower budget transfers to the population by way of pensions and salaries.

The growing public external debt influences GDP growth both in the positive and the negative ways. To determine the optimum level of the public debt, I have done many simulations using the model. As we see above, the increase of the public external debt will lead to higher GDP growth. I increased the exogenous variable of the public debt and received better and better results. But when the public debt exceeded 55% of GDP, I found that GDP growth rate became lower than for the Base scenario. And if we continue to increase the public debt, the GDP growth rate will be positive but elasticity of the GDP growth to the public debt growth will reduce.

Table 3

Comparison of Base and Moderate Optimism

	2012	2013	2014	2015	2016
GDP dynamics in 2008 prices, %					
GDP	1.5	2.4	4.1	4.2	3.8
		2.5	5.7	6.9	2.1
Households consumption	10.9	2.4	3.3	7.5	5.6
		2.6	6.1	12.3	2.6
Public consumption	–1.2	1.8	0.5	0.5	0.3
		1.9	0.7	0.7	0.0
Investments	–9.8	2.3	5.3	3.9	3.4
		2.5	8.2	9.4	2.6
Exports	10.6	–15.4	6.0	2.9	3.0
		–15.4	6.0	2.4	2.1
Imports	9.4	–13.2	5.6	5.4	4.1
		–13.1	7.5	8.7	2.6
Rate of inflation, %	21.8	6.2	26.5	29.6	43.7
		6.3	24.6	19.4	33.8
STATE BUDGET					
Revenues (% to GDP)	41.4	40.8	37.5	36.4	34.8
		40.8	37.5	36.9	35.9
Expenditures (% to GDP)	40.8	42.7	37.9	36.8	34.8
		43.0	39.8	40.3	40.7
incl. public debt service (% to GDP)	1.4	1.5	1.5	1.4	1.3
		1.5	1.9	2.2	3.0
BALANCE OF PAYMENTS, mln. $					
Balance of current account	–1819.3	–5608.0	–5181.1	–6245.1	–6624.5
		–5667.2	–6125.5	–9152.1	–9302.8
% to GDP	–3.0	–10.0	–9.5	–10.6	–10.3
		–10.0	–10.7	–13.3	–11.9
Changes in reserve assets	81.0	–4251.7	–4404.8	–6278.1	–6515.4
		–3847.2	–954.6	–2264.8	4444.4
FINANCIAL INDICATORS					
Exchange rate (ruble to dollar)	8351.6	9153.6	12708.5	16496.5	22111.6
		9153.8	12248.8	13287.4	15269.2
Public external debt, mln. $	12568.6	12901.0	13151.0	12800.0	12923.0
		13448.0	18828.0	26359.0	42175.0
% to GDP	20.4	25.5	25.9	24.2	21.8
		26.5	33.6	39.9	55.4

Thus, we can say that the public external debt, equal to 55% of GDP, is the highest possible level for the Belarus economy.

The last scenario, Pessimism, is a negative one. We assume that the oil prices for imports from Russia will be equal to the world level minus the transportation costs and the export duties. In Fig. 9, the import oil prices for the base scenario are shown by the line -□-, import oil price for Pessimism – by the line –x–, and the Brent Crude prices[1] – by the line -♦-.

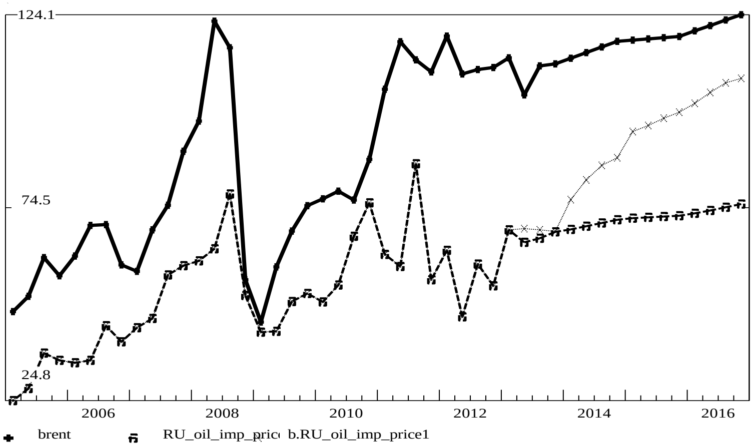


Fig. 9. The oil import prices in the Base and Pessimism Scenario.

Now let compare results of the business-as-usual (the first line in tab. 4) and Pessimism (the second line for each indicator) scenarios. The results of the Pessimism scenario are dramatic enough. The GDP will decrease until 2016. The inflation rate will rise to 52% per year by the end of the forecast period. The imports growth will be higher than exports growth, and the Belarus ruble will weaken.

Thus, in case of negative changes in the foreign trade conditions, the Belarus economy will not be able to support the positive dynamics without considerable growth of the external debt.

[1] The Brent Crude price is a major trading classification of sweet light crude oil that serves as a major benchmark price for purchases of oil worldwide. Brent Crude is sourced from the North Sea. The other well-known classifications are the OPEC Reference Basket, Dubai Crude, Oman Crude, and West Texas Intermediate. Brent Crude is the leading global price benchmark for Atlantic basin crude oils. It is used to price two thirds of the world's internationally traded crude oil supplies.

Table 4

The Pessimism scenario compared with the Base

	2012	2013	2014	2015	2016
GDP dynamics in 2008 prices, %					
GDP	1.5	2.4	4.1	4.2	3.8
		2.9	–0.6	–3.1	–2.0
Households consumption	10.9	2.4	3.3	7.5	5.6
		2.6	1.8	0.0	0.8
Public consumption	–1.2	1.8	0.5	0.5	0.3
		1.9	0.1	0.0	0.1
Investments	–9.8	2.3	5.3	3.9	3.4
		3.2	1.0	–3.3	–2.0
Exports	10.6	–15.4	6.0	2.9	3.0
		–14.6	4.8	3.4	3.3
Imports	9.4	–13.2	5.6	5.4	4.1
		–12.4	7.9	5.7	5.3
Rate of inflation, %	21.8	6.2	26.5	29.6	43.7
		6.2	29.2	39.9	55.0
STATE BUDGET					
Incomes (% to GDP)	41.4	40.8	37.5	36.4	34.8
		40.8	37.8	36.9	35.4
Expenditures (% to GDP)	40.8	42.7	37.9	36.8	34.8
		42.6	38.2	37.2	35.3
incl. public debt service (% to GDP)	1.4	1.5	1.5	1.4	1.3
		1.5	1.5	1.5	1.4
BALANCE OF PAYMENTS, mln $					
Balance of current account	–1819.3	–5608.0	–5181.1	–6245.1	–6624.5
		–5589.9	–6791.8	–7911.8	–8933.7
% to GDP	–3.0	–10.0	–9.5	–10.6	–10.3
		–9.9	–12.5	–14.4	–15.2
Changes in reserve assets	81.0	–4251.7	–4404.8	–6278.1	–6515.4
		–4233.6	–6022.1	–8016.7	–8912.9
FINANCIAL INDICATORS					
Exchange rate (ruble to dollar)	8351.6	9153.6	12708.5	16496.5	22111.6
		9153.4	12783.9	17819.0	25064.8
Public external debt, mln $	12568.6	12901.0	13151.0	12800.0	12923.0
		12901.0	13151.0	12800.0	12923.0
% to GDP	20.4	25.5	25.9	24.2	21.8
		25.4	26.6	26.8	24.3

■ Conclusions:

- The Belarus economy depends on the trade with Russia to a rather strong degree. This dependence is determined by the physical volumes of exports and imports as well as by ratio between the world resources prices and prices for crude oil and refined oil products imported from Russia.
- The negative balance of payments is the main problem of the Belarus economy that leads to a weakening of the national currency and high inflation.
- According to the business-as-usual scenario, the GDP growth rate will be much less in 2014–2016 than it was before 2008.
- For acceleration of economic growth, a public external debt increase will be required to strengthen the Belarus ruble and hold down the growth in consumer prices. The optimum value of the public debt is estimated as 55% of the GDP.
- The possibility of positive economic growth in Belarus depends on the availability of Russian energy resources at below market prices. If the price disparity disappears, then the Belarus economy will suffer losses for several years.

ESTIMATION OF COMPETITIVENESS OF RUSSIAN REGIONS BY ECONOMIC ACTIVITY

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Abstract

This article examines the growth of labor productivity in the regions of the Russian Federation. Particular attention is paid to the Republic of Tatarstan. The comparative data from the World Economic Forum. This article study the relation of labor productivity, capital productivity and capital-labor ratio.

Keywords: competitiveness, competitive advantage, quality, the Global Competitiveness Index, productivity

■ Introduction

Productivity is the major and practically only element explaining medium-term indicators of growth of national economy. Though economic growth can be caused by many reasons – for example, accumulation of the capital or an increase in population, – it can be steady only on condition of productivity increase. In 2011 gross domestic product of Russia per capita exceeded 10 521 US dollars (15 806 US dollars at par purchasing power – PPS).

Figure 1 presents the index of global competitiveness in interrelations with size of the gross domestic product per capita in terms of some countries of the world, characterizing and confirming considerable influence of microeconomic factors on competitiveness of national economies [2].

From 2000 for 2010 Russia reached rather high growth rate of gross domestic product in 5.5% a year that allowed it to start reducing lag from average values of the countries of OECD. And never-

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theless, the gap between economy of Russia and the countries of OECD according to average per capita gross domestic product makes about 47%. In other words, low level of the income in the country doesn't allow Russia to approach welfare of the population to level of inhabitants of the developed countries of the world. At the same time, Margaret Drzhenek Hanuz's in her report notes that despite the fact that general performance level in Russia, is higher than in India and China, excess of a salary leads to the fact that for each earned ruble the Russian worker makes a half of that the worker in China or India makes.

Thus, in her opinion, for increase of competitiveness of Russia it is necessary to lead a ratio between a salary and productivity to the average world level [2].

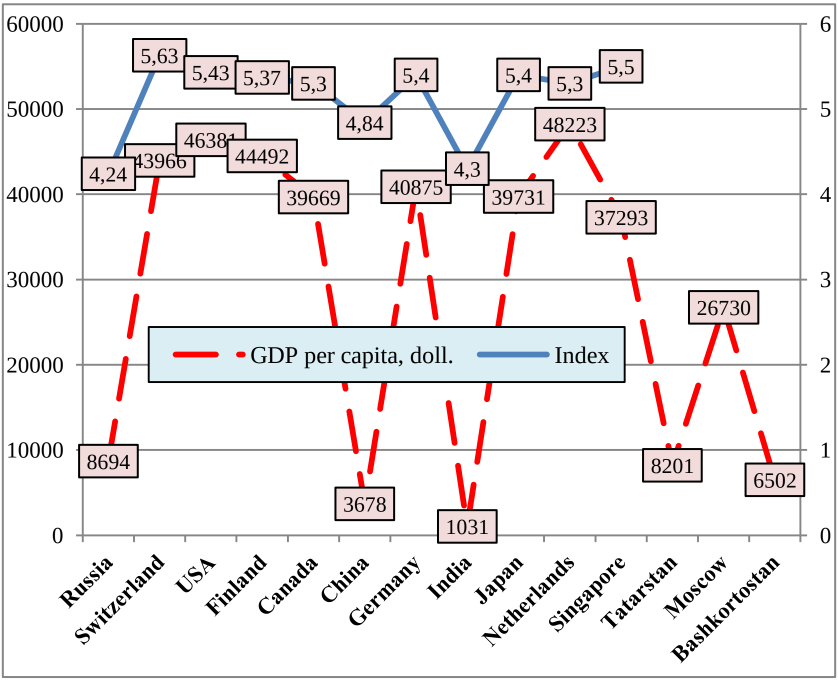

Fig. 1. Interrelation of an index of global competitiveness with gross domestic product per capita.

As an international experience shows, the majority of factors are formed today mainly at mezoscale which unites territorial and branch in terms of competitiveness. Within the general institutional, organizational and legal conditions, the allocated national priorities and macroeconomic tasks, possibility of a choice of the directions of social and economic development and ways of their realization with use of a reasonable tool kit holds true in favor of territories.

■ Result

In our research we choose only one indicator in terms of a number of regions of Russia and by several types of the economic activity, data on which are formed by the State committee on statistics of the Russian Federation. This analysis allows conducting research over the whole range of economic activity at the level of the territory in terms of branch.

Let's note that capital productivity is the generalizing indicator characterizing level of use of business assets of branch, is calculated the pays by division of volume of produce for a certain period of production by average for this period cost of the fixed business assets. Let's consider dynamics of indicators of efficiency of use of the capital in terms of branches of industry. The assessment of use of fixed assets by types of economic activity of the Republic of Tatarstan assumes the analysis of indicators of capital productivity and a capital-labor ratio in terms of branches of the Republic of Tatarstan and their comparison with other regions.

Capital productivity is the generalizing indicator characterizing the level of use of business assets of branch, and it can be calculated by division of produce volume for a certain period of production by average for this period cost of the fixed business assets [5].

As this figure shows, the Republic of Tatarstan is behind the average Russian level in such types of economic activity, as retail trade, production of oil products, construction, communication and some other in efficiency of use of the fixed business assets.

At the same time, on positions with the greatest specific weight (production of crude oil, production of synthetic rubber, animal husbandry, plant growing and others) both in structure of a gross regional product, and nationwide this indicator exceeds the average Russian level.

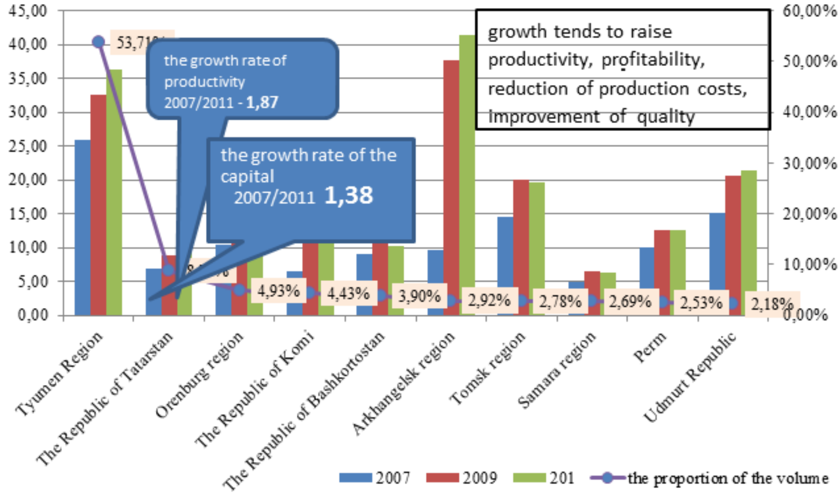

Fig.2. Capital-labor ratio on production of crude oil in terms of regions of the Russian Federation

Let's take a look at some types of economic activity with a considerable share in structure of the Tatarstan economy.

The Republic of Tatarstan on production of crude oil (specific weight in production volume nationwide) takes 8.78% the 2nd place in the volume of a turn-round of the organizations, conceding to the leader – the Tyumen region (41.45%). The next competitors are: Orenburg region (4.93%), Republic of Bashkortostan (4.43%) and Arkhangelsk region (3.9%).

According to an indicator capital productivity ratios of Tatarstan (1,55) look more modest. Leaders by data by the beginning of 2012 became: Moscow, Samara region, Penza region, Orenburg region and Volgograd region. Tatarstan took only the 6th place, having outstripped the Republic of Bashkortostan, the Udmurt Republic, Perm Krai and what isn't less remarkable the average level nationwide.

The capital-labor ratio analysis – an indicator characterizing equipment of employees of the enterprises of the sphere of production of goods by the fixed business assets, in the Republic of Tatarstan it also remains on low positions (8,9), below the all-Russian level (23,97) and concedes to such regions as: Arkhangelsk region, Tyumen region, Irkutsk region, Udmurt Republic, Tomsk region, Kaliningrad region, Orenburg region, Komi Republic, Perm Krai, Saratov region and Republic of Bashkortostan. However in comparison with average value of a gain of a similar indicator nationwide (37,44) there is a lag of 22%. The same situation is observed practically among all leading regions according to this indicator.

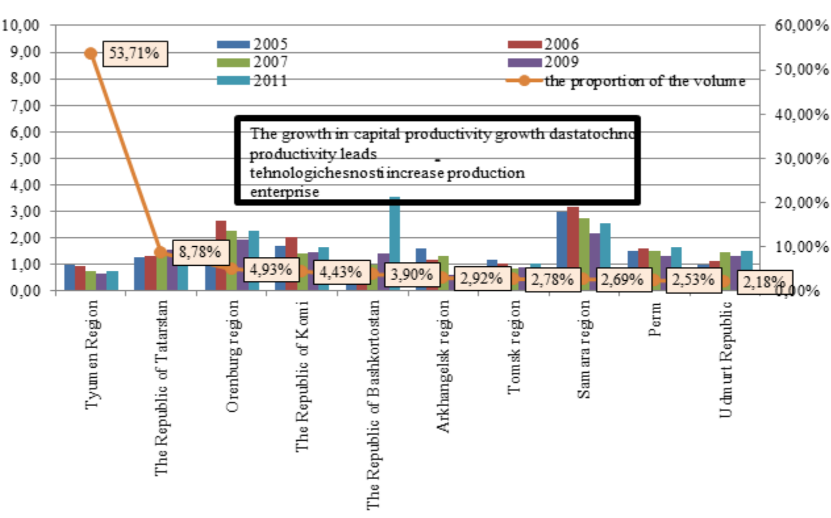

Fig. 3. Capital productivity in production of crude oil in terms of regions of the Russian Federation

Comparing the general tendency of change of an indicator of capital productivity, we can see the situation when the Republic of Tatarstan took only the 10th place (1,33), having conceded to the Samara region, the Orenburg region, the Novosibirsk region, the Penza region, Perm Krai, the Udmurt Republic, the Volgograd region and the Komi Republic.

High competitive positions on the volume of made production allowed the region to reach leading positions on a capital productivity indicator. Tatarstan took the 6th place out of seven regions of Russia presented in production of synthetic rubber. Thereby statistical data on capital productivity were distributed as follows: Samara region (14,17699), Republic of Bashkortostan (11,709), Omsk region (3,5057), Tula region (2,445), Voronezh region (1,5066), Republic of Tatarstan (1,1125), Krasnoyarsk Krai (0,8945).

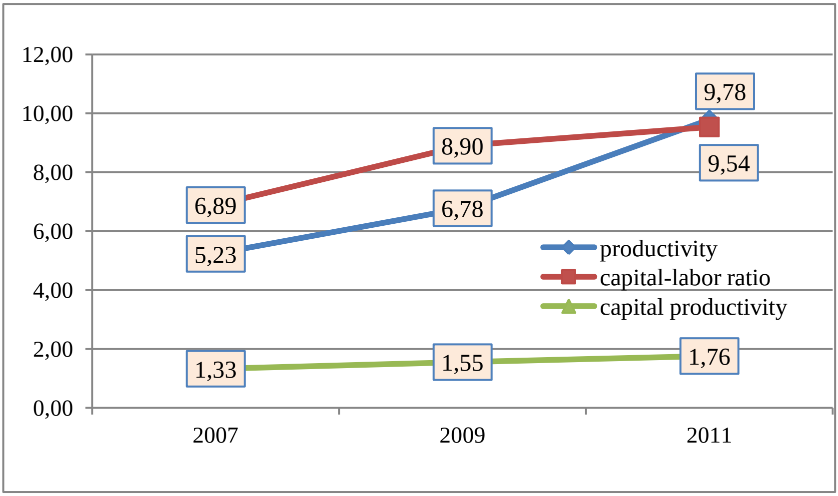

Fig. 4. Dynamics of indicators of labor productivity, capital productivity and capital-labor ratio on production of crude oil in the Republic of Tatarstan.

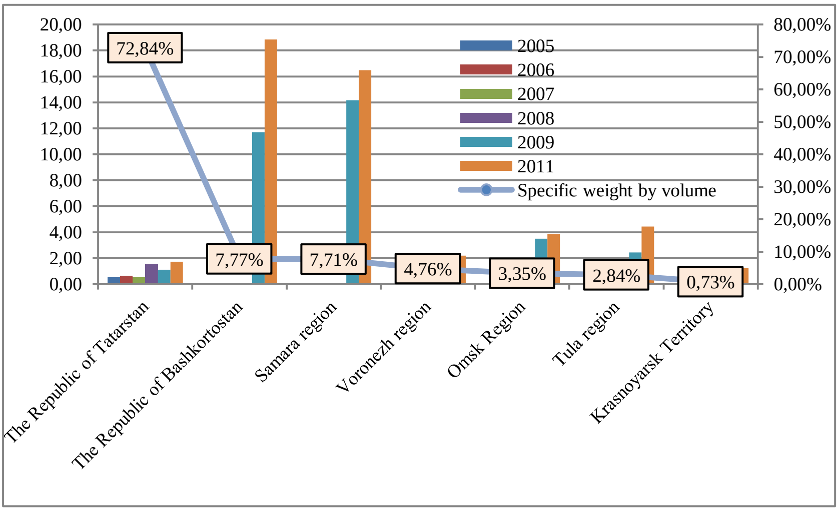

Fig. 5. Capital productivity on production of synthetic rubber in terms of regions of the Russian Federation.

In dynamics during the five years capital productivity increased almost by 119.13%. Nevertheless, from the end of 2007 till 2011there was a decrease in capital productivity by 28% that in turn significantly reflected on competitive positions of Tatarstan.

It is necessary to define optimum ratios of a gain of labor productivity and a capital-labor ratio at the enterprise due to technical equipment, to estimate influence of these indicators on capital productivity growth by types of economic activity that finally, will cause competitiveness growth at macro level. Due to the limitation of resources other things being equal it is necessary to make priority distributions of the most effective new equipment depending on degree of competition of production to create competitive advantages for domestic producer of a high order.

The report gives data on a gap in productivity between Russia and the countries of OECD in separate branches and economy sectors. Three groups of branch sectors are allocated: basic, supporting and infrastructure. Figure shows 6 labor productivity on groups of branch, infrastructure, supporting and basic sectors in Russia and OECD.

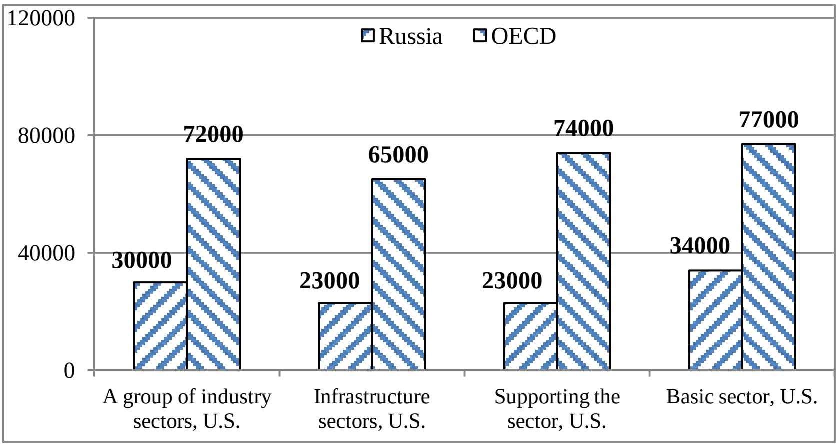

Fig. 6. Labor productivity in Russia and OECD.

To basic sectors, as it seen from the report, belong the agriculture, extracting and manufacturing sector and activity in the field of information technologies – that is, all branches making goods which can potentially be on sale in the global market and therefore often work in the conditions of the real competition.

Supporting sectors is a sphere of market services, including branches, which provide distribution of goods (for example, wholesale and retail trade), support production (for example, business services) or make such goods and services which can be on sale only in the local market (for example, construction, real estate, activity of hotels and restaurants). Infrastructure sectors are, first of all, non-market services and the industry, including, public administration, education and health care, transport and communication [2].

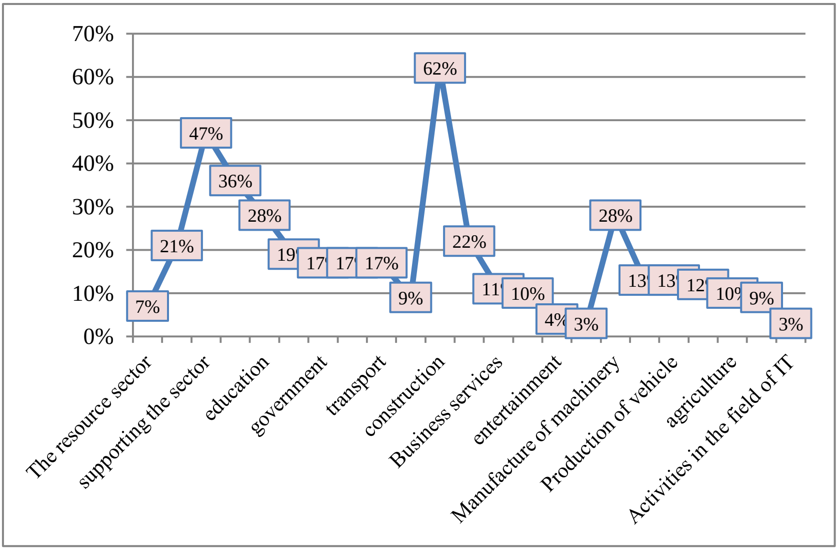

Fig. 7. Gap in productivity between Russia and OECD.

Lag in supporting sectors by more than a half determines a low performance level of productivity in construction and real estate where production is labor-consuming. Though productivity in this sector is growing, a set of unresolved problems remains. In the majority of basic sectors in Russia some growth of productivity and employment reduction is observed.

The performance level also defines return on investment coefficient (in physical and human capital, in technology). Coefficients of return on investment are fundamental driving factors of growth rates of economy, so, more competitive economy develops quicker in medium-term and long-term prospect.

■ Conclusions

The concept of competitiveness implies static and dynamic components: though productivity obviously defines ability of the country to support high level of the income, it also in many respects defines return on investment that, in turn, is one of the key factors explaining potential of growth of economy [2].

Natural resources are allocated as the first advantage.

Russia controls 5,6% of world reserves of oil and 23,7% of stocks of gas (by data for the end of 2009). It allows it to be the world's largest exporter of mineral fuel and oil products (in 2009) and to occupy 10,6% of the world market.

The second essential competitive advantage of the country – the big size of the market. The large market promotes productivity growth because it allows the companies to realize economy at a scale. Domestic market of Russia is one of the world's largest: on this indicator the country takes the 8th place out of 139 countries that unambiguously gives essential advantages.

Third advantage: well educated population

According to data of the Index of global competitiveness, for fuller realization of potential of Russia it is necessary to solve the main problems in five spheres. First, it is necessary to make large-scale reforming and development of the institutional environment. Secondly, at a remaining high share of the learning population quality of education decreases. Thirdly, more intense competition in the internal and external markets of the country could considerably increase efficiency of all spheres of economy. Fourthly, further improvement of supervision of the financial markets and development of the banking sector is necessary. Fifthly, introduction and use of improved methods of management.

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INTER-SECTOR INTER-REGION ANALYSIS: ESTIMATING CONSEQUENCES OF REALIZATION OF LARGE INVESTMENT PROJECTS IN ENERGY SECTOR OF RUSSIAN ECONOMY

Nikita Suslov

■ Introduction

The paper discusses an approach to a long-term inter-sector and inter-regional analysis of interactions between a national economy and its energy production segment. It is based on an optimization multi-sector multi-regional model (OMMM) which includes a natural block of energy production, processing and transportation (OMMM-Energy) (Suslov et. al., 2007). The latter, in its turn, is an advanced version of the model suggested and developed by Prof. Alexander Granberg (Granberg, 1973) – a famous Soviet and Russian economist who has made a noticeable contribution to the theory of regional structure analysis. At present, this version combines 45 products of different economic sectors including 8 ones of an energy sector (rough oil, gas and coal, two kinds of petroleum products, coal processing, electricity and heat), and 6 Russian macro-regions; it is a composition of two sub-models for 2 time periods: 2008–2020 and 2021–2030. Each of the sub-models treats time changes in simplified manner – it means that all the variables are defined for the last year of the period and the variables of the basic year are fixed as exogenous ones.

The dynamics of investments into fixed capital is treated as non-linear functions being adapted with the help of linearization techniques.

A basic advantage of the OMMM-Energy is a combination of different approaches such as the input-output, inter-regional and energy balances. This allows evaluating the complex effects and efficiencies of the policy measures undertaken in the spheres of production, processing and consumption of energy. Previously, the model was applied to evaluating economic consequences of the:

- concentration of energy-intensive productions and gasification in the South Siberia regions;
- fast development of nuclear energy in the national economy;
- a reduction of energy intensity of production in the national economy;
- wide application of heat pumps technologies in the different regions of the national economy

and many others but less significant issues.

The next section of the paper briefly describes a history of how the Soviet Union applied and later Russia continued to apply the input-output interregional analysis and OMMM, and what are their basic characteristics in comparison with IO, IRIO and MRIO approaches. The section 3 discusses both methodology and history of developing the original OMMM resulted in an OMMM-Energy version of the model. The sections 4–5 are devoted to setting and analyzing the problem of energy intensity in Russia and other world economies which we call “Energy intensity puzzle”. Section 6 presents some results of our analysis conducted by applying the model, and finally, the last section presents our conclusions.

■ OMMM: Identification and History

Russia is the largest country in the world covering 12% of the Earth's land area and spanning four climate zones (Canada, being the second largest country, covers twice less area). Russia extends from the East to the West for about ten thousand kilometers. The enormous size of Russia results in the different climate conditions, landforms and remoteness of many regions from the seas. Average January temperatures in different regions varies from 6°C to −50°C; June ones – from 1°C to 25°C; and atmosphere precipitations – from 150 to 2000 mm per year. The extent of permafrost is 65% of a total Russian territory (in the regions of Siberia and the Russian Far East). Moreover, the natural resources are unevenly distributed within the territory of the country – about 80% of them are concentrated in the western areas (in Siberia and the Far East). The proximity of the Russian European regions to seas and European markets, as well as historical factors made these regions more economically developed. These regions cover 23% of the total area of Russia; 82% of all the

Russian population lives here and they produce ¾ of the Russian GDP. There are 83 administrative regions in Russia, and the difference between them in levels of production and populations' incomes per capita is rather high.

Due to the high environmental and economic heterogeneity of the Russian territory, the development and implementation of regional policies becomes one of the key factors of the national development. Awareness of this fact resulted in the progress of regional studies in the Soviet Union and later in Russia. In the 1960s we started the application of MRIOs.

The OMMM was proposed in the 1960s and described in (Granberg, 1973) for the first time. The first Soviet Union experimental forecasts for 1966–1975 involving 16 economic sectors and 11 regions were made in 1967. Another series of forecast calculations for 1975–1990 was made in the next years up to 1978. MRIOs of a Siberian type were involved in the UN Project on The Future of the World Economy in 1978–1982 at the suggestion of the UN AG Secretariat. Two systems of models – SYRENA and SONAR, both OMMM-based ones – were developed in the middle of the 1980s. The first model focuses on a national economy – region problem, while the second one (consisting of OMMM-Energy and several models for economic sectors) – addresses a national economy – economic sector problem. Since that time such OMMM was applied to forecast economic regional and sector development as well as to analyze how regions and sectors interact. This model also allows understanding how the supply shocks and investment project impact upon the national economy and regional ones.

To model regional interactions instead of specifying trade coefficients, the import/export of products to/from neighboring regions are added to the equations for balances of products. Therefore, such model includes not only production IO matrixes, but also matrixes of the inter-regional transportation of products (Fig. 1). An international export-import is represented only for regions capable to do so, i.e. the frontier ones. In such basic model, which we describe here, the volumes of export/import are determined for each identified sector; however, in some further versions of this model, they are endogenous, and the models include a national foreign export -import balance assuming that the country has a zero balance of trade (in the prices of the world markets) (Granberg et al., 2007).

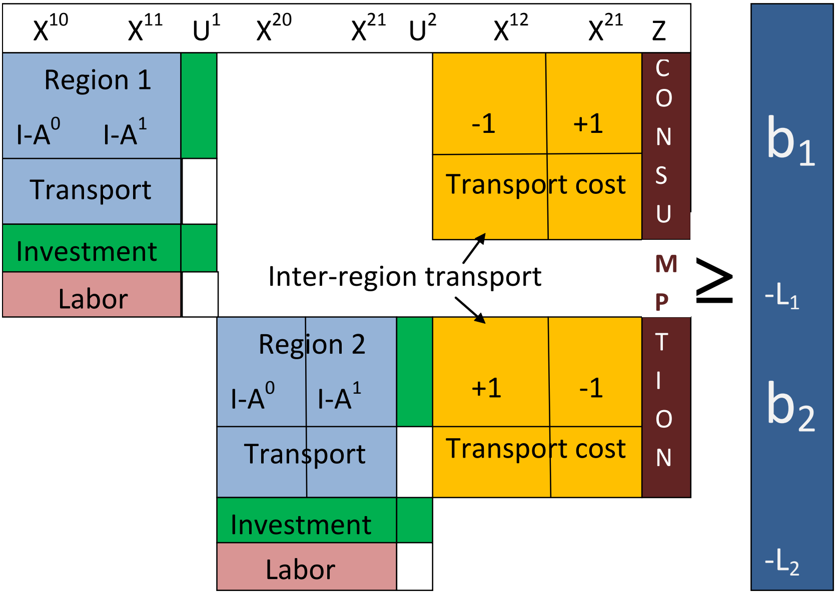

Fig. 1. A Principle structure of OMMM for 2 regions:
Intra-regional IO matrixes for all identified regions
are the basis of the OMMM.

In our opinion, such approach to modeling regional interactions has its advantages and disadvantages. The fact that it hampers an analysis of spillovers between regions – it is difficult to find out the dependence of output increments and final demand – make up such disadvantage. Moreover, a number of methodical and informational issues concern a transportation block – no counter flows are included into models of sector products transportation, and this brings about the roughening solutions which are the higher, the bigger the level of aggregation of sectors is. Certain difficulties lie in calculating coefficients of intra- and inter-regional transportation. In fact, a segment of demand for transportation sectors has to be set endogenously (to include counter flows costs) while coefficients of transportation costs – proportionally to average distances of transportation. (Granberg, 1973, Suslov et. al., 2007).

However, the transportation matrixes introduced into such model allows an optimization setting of the problem which is also desirable. This, in its turn, makes the structure of production and transportation more flexible, and this fact can be regarded vital for long-term forecasting made by applying such models. A comparative analysis of production efficiencies in different regions is available too as well as an introduction of additional alternative production technologies to produce a product of one species. However, as the model is linear, it is supplemented with the constraints for the output variables – (5).

An investment block of the model reflects the dynamics of production. All the variables of output, final demand, interim demand and demand for production factors in each region are defined for the last year of the time period of the model. Total investments for each kind of fixed capital are also specified. This is done through setting a law of investment growth and such laws for each kind of fixed capital as well. Generally, a power law is applied to specify functional dependencies of investments made in the last year of the time period on total investment made over the whole time period. Such dependencies enter the model as linear approximations. There are two kinds of output variables to model an investment process – the outputs received on production capacities existed up to the beginning of the period (old capacities) and those received on production capacities incorporated during the period (novel capacities) the investment coefficients for which are calculated according to different techniques.

An objective function of the model is households' total consumption including consumption of public goods. Generally, such model has the fixed sector and regional structure of consumption. A sum of α_i^r coefficients in the constraint (1) is equal to 1:

$$\sum_{i=1}^{n}\sum_{r=1}^{R}\alpha_i^r = 1$$

and the model is resulted to be a closed one for most variables of the final demand such as capital investments, investments in reserves (they are included in the sector's consumption of their own products $a_{jj}^{r1} \cdot x_j^{r1}$ – see the balance constraints 1), population's consumption, and variables of domestic net export.

We present principle constraints of the basic OMMM below. It includes n segments of products and services (except transport services), T kinds of transport and R regions. Within the model there are several investment-generating sectors (which enter a set G) and as many kinds of investment, respectively. Each regional block r includes 5 kinds of constraints – the inequalities (1)–(5). The objective function is set not for a regional block but for the model in whole.

$$x_i^{r0} + x_i^{r1} - \sum_{j=1}^{n} a_{ij}^{r0} \cdot x_j^{r0} - \sum_{j=1}^{n} a_{ij}^{r1} \cdot x_j^{r1} - u_i^{r1} - \alpha_i^r \cdot Z -$$

$$\sum_{\tau=1}^{T} \sum_{s \neq r} x_i^{rs} + \sum_{\tau=1}^{T} \sum_{s \neq r} x_i^{sr} - NEX_i^r \geq b_i^r, \quad i = 1, \ldots, n \tag{1}$$

$$x_\tau^{r0} + x_\tau^{r1} - \sum_{j=1}^{n} a_{\tau j}^{r0} \cdot x_j^{r0} - \sum_{j=1}^{n} a_{\tau j}^{r1} \cdot x_j^{r1} - \sum_{s \neq r} \sum_{j=1}^{n} a_{\tau rj}^{rs} \cdot x_j^{rs} - \sum_{s \neq r} \sum_{j=1}^{n} a_{\tau rj}^{sr} \cdot x_j^{sr} \geq b_\tau^r,$$

$$\tau = 1, \ldots T \tag{2}$$

$$\sum_{j=1}^{n} l_j^{r0} \cdot x_j^{r0} + \sum_{j=1}^{n} l_j^{r1} \cdot x_j^{r1} + \sum_{\tau=1}^{T} l_\tau^{r0} \cdot x_\tau^{r0} + \sum_{\tau=1}^{T} l_\tau^{r1} \cdot x_\tau^{r1} \leq L^r, \tag{3}$$

$$\sum_{j=1}^{n} k_{gj}^{r0} \cdot x_j^{r0} + \sum_{j=1}^{n} k_{gj}^{r1} \cdot x_j^{r1} + \sum_{\tau=1}^{T} k_{g\tau}^{r0} \cdot x_\tau^{r0} + \sum_{\tau=1}^{T} k_{g\tau}^{r1} \cdot x_\tau^{r1} - f(u_g^{r0}, u_g^{r1}) \leq 0, \; g \in G \tag{4}$$

$$\xi_i^{r0} \leq x_i^{r0} \leq \zeta_i^{r0}, \quad \xi_i^{r1} \leq x_i^{r1} \leq \zeta_i^{r1}, \; i = 1, \ldots, n \tag{5}$$

$$\max Z \tag{6}$$

Here endogenous variables are:

x_i^{r0} и x_i^{r1} – production outputs of i-sector in r-region obtained by old and novel production capacities;

x_τ^{r0} и x_τ^{r1} – transportation work made by transport of kind τ in r-region within the framework of transport capacities of the transport infrastructure available as of the beginning of the period and that one developed over the period, respectively;

u_i^{r1} – a volume of capital goods i invested in r- region in the last year of the period;

Z – total consumption of households;

x_i^{rs} – a fraction of output of *i*-sector transported from *r*-region to *s*-region;

Exogenous variables are:

a_{ij}^{r0} и a_{ij}^{r1} – intra-regional input coefficients (*i*-sector product per output of *j*-sector in) in *r*-region at old and new production capacities correspondently;

$a_{\tau j}^{r0}$ и $a_{\tau j}^{s1}$ – amount of transport service of kind τ consumed per a unit of sector *i* product at old and new production capacities correspondently;

$a_{\tau r j}^{rs}$ и $a_{\tau r j}^{sr}$ – amount of transport service of kind τ consumed to bring a unit of sector *j* product from *s*-region *r*-region;

l_j^{r0}, l_j^{r1}, l_τ^{r0} и l_τ^{r1} – labor input coefficients at old capacities and novel capacities in production sector *j* and transport sector τ respectively in *r*-region;

k_{gj}^{r0}, k_{gj}^{r1}, $k_{g\tau}^{r0}$ и $k_{g\tau}^{r1}$ – investment input coefficients of *g*-kind of investment good at old capacities and novel capacities in production sector *j* and transport sector τ respectively in *r*-region;

α_i^r - a share of sector *i* from region *r* in the Russian total volume of consumption;

u_g^{r0} – investments of kind *g* made in *r*-region in a basic year;

NEX_i^r – net international export (export minus import) of products of *i*-sector from *r*-region;

b_i^r – a fixed share of demand for products of *i*-sector in *r*-region.

The inter-regional production and distribution balances of products and services (except transportation services) reflect both intraregional consumption flows and export ones (1). However, how the exported products and services are going to be consumed is not presented in these balances while the imported products and services are included into domestic consumption. The export and import between counties are fixed values in this version of the model.

The transportation balances reflect intra-regional transportation flows as well as export/import ones. The $a_{\tau j}^{rs}, a_{\tau j}^{sr}, a_{\tau rj}^{rs}$ и $a_{\tau rj}^{sr}$ coefficients are calculated on the basis of both average transfer distances and indices of weight of a transferred product unit of a given sector.

The labor balances are the constraints describing labor demand in a given region, while supply is specified exogenously on the basis of the demographic forecasts available.

The investment balances specify the investments made not over the last year of the period but over the time period in whole. They balance the demand represented as a sum of the output multiplied by investment coefficients and total output of capital goods produced over the whole period. The functions $f(u_g^{r0}, u_g^{r1})$ which represent a total volume of *g*- investment made in *r*-region play a key role. In assumption that $u_g^{r1} = (1+\rho_g^r) \cdot u_g^{r0}$ where ρ_g^r is an average annual rate of growth of *g*-investment made in *r*-region, the functions $f(u_g^{r0}, u_g^{r1})$ depend on ρ_g^r and could be easily calculated and then substituted by their linear approximations. In fact, it is the rates of investment growth ρ_g^r which we approximate.

Modern versions of OMMM are based on the following statistical data:

- Aggregated Input-Output Tables for the Russian national economy for each year from 1995 up to 2004 which include 20 sector products;
- tables of goods and services consumed in Russia (in consumer prices of next year) which include 20 sector products,
- Russian National Input-Output Table for 1995 which includes more than 100 sector products, and
- other statistics provided by the Russian Statistics (ROSSTAT).

There some difficulty in calculating regional input-output tables. Unfortunately, neither ROSSTAT, nor regional statistical bodies have started with issue such data since the beginning of the economic reforms, at least in regularly and in complete patterns. That is why we, since the end of 1980s, have to adjust regional differences of input coefficients to update current regional IO tables. For this purpose we apply certain kinds of RAS methods.

■ OMMM-Energy

Russian energy sector is the largest and most important one for the economy of the country. Russia possesses about 13% of the world oil reserves, more than 35% of the world gas reserves and 12% of the world coal reserves, and this could be regarded as a basic competitive advantage of our economy which could last long. The energy sector produces about 15% of GDP while it consumes approximately a quarter of the national investments. However, it produces about 60% of a total Russian export and as many percent of a consolidated budget of the Russian Government. This fact displays that energy production has an extremely strong indirect influence on the economy of Russia, and therefore, there is a need for a comprehensive analysis of interrelations between the national economy and its energy sector. Moreover, given the extremely heterogeneous distribution of energy resources – mostly in Siberia and the Far East regions, and high concentration of the population and non-energy productions in European area of the country, of inter-regional interactions plays a key role.

The studies on interactions between the national economy and its energy sector, which has brought the relatively noticeable results, started only the 1970s due to the energy crisis (Mann, 1978, Bullard and Pilati, 1976, Dantzig and Parikh, 1976, Hogan, 1976, Hudson and Jorgenson, 1974, Van der Voort, 1982). They applied both large models with an energy sector included and combinations of economic and energy models united in a general model. The researchers' priority issues were the problems of tax and trade policies and how prices for energy resources influence the structures of energy consumption and national economy. Later, the modeling focuses on long-term forecasting of energy consumption, the development of fuel-energy complexes and what such complexes could contribute to economic development of the country (Chateau and Quercia, 2003, The Energy Market, 2002, The National Energy, 2009, Voß et. el., 1995, Wade, 2003). These studies were made in the Soviet Union and later in Russia by the ISEM SB RAS, INEI RAS, IEIE SB RAS by applying IO models. Having started the development of its own approach since the 1980s, the IEIE SB RAS applies a multi-regional IO model, later called as OMMM-Energy.

OMMM-Energy is an optimization multi-sector multiregional model which presents an energy sector and its energy production in their physical indicators. It was developed on the basis of "classical" OMMM discussed before. A current model includes 45 economic sectors, with 8 products among them, and 6 Russian economic zones (the European zone, Ural region, Tyumen Oblast, West Siberia, East Siberia and Far East). It succeeds basic advantages and disadvantages of the OMMM-prototype and differs from the latter in a number of aspects.

Firstly, it is a two-period forward recurrence model containing two sub-models – one for 2008–2020 and the second – for 2021–2030. The investment dynamics is reflected in both of them through an OMMM-prototype; this means that a law of investment growths is set as a non-linear one and then it is linearized. The solutions of the first model become basic indicators for the second one.

Secondly, the energy sectors are presented in greater detail. This was done, among other purposes, to present energy products in physical indicators. A current model includes 8 energy products such as solid fuel, processed coal, oil and associated gas, gas and condensed fluid, dark-oil products, light oil, electric power and heat. This allows monitoring ratios between primary and final energy produced.

Thirdly, some non-energy sectors which are important for analyzing the energy sector were specified such as the industry producing equipment required for production, transportation and consumption of energy, petroleum chemistry and some others.

Finally, we modified the model to allow for the specifics of how any fuel-energy complex can operate such as:

- specific reproduction of capacities in the oil-and-gas sector;
- the development of resource industries highly depends on whether geophysical prospecting have been done and its results if it has been done; it also depends on to what degree the fuel resources have been developed in different regions and in the country in whole;
- complementary outputs of different energy technologies (e.g. oil and associated gas, or gas and condensed fluid);
- specific transportation of oil and gas (a pipeline system);

- availability of alternative technologies for energy and heat production at heat stations, condensing plants, nuclear power plants, boiler plant, and etc. which operate on different fuel (coal, fuel oil, and gas).

A classic OMMM assumes that any sector product is manufactured by “old” and “novel” production capacities. The capacities, which operated from the beginning to the end of a predictable period and by which the product was produced over the period, we consider as old ones. Those, which were produced through investments into extension of capacities to yield a sector output growth, we consider as novel ones. A notion of “old capacities” for resource industries differs from that for processing industries as the resource industries deal with production of irreproducible resources. In this context, each share of investments requires an additional share of the commercial oil and gas reserves and can be regarded as new capacities costs. Moreover, an annual volume of capacities retired in oil-and-gas sectors is relatively high.

Due to the said specifics, we applied another approach to modeling reproduction process in these industries, not that one which was applied in the OMMM prototype, i.e. the variables of investments are considered as nonlinear functions of extracting capacities put into operation over the predictable period. Such functions, firstly, reflect the rises in costs for new capacities because of transition from more to less efficient oil and gas fields, and secondly, they allow us to take into account an increased volume of capacities retired.

In addition, we introduced a new block of oil-and-gas reserves which reflect a ratio between novel production capacities and new commercial reserves put into operation in a given region or in the sector in whole. To do so, we consider urgent as we need know a ratio between a degree of redundancy of oil reserves and annual gas production. According to the reproduction laws for these industries, such redundancy lies in certain fixed limits. If it is higher than an allowable value, the freezing of large funds invested into geological prospecting may occur; if it drops below the bottom, our forecasts of oil-and-gas production may happen unreliable. Thus, such degrees of redundancy being fixed serve as an upper limit for variables of commissioning novel facilities while the investments into reserves (geological prospecting) are included into a total investment balance.

We use OMMM-Energy both as individual analysis instrument and together with some other constructions. Its supplementation with econometric models of energy consumption is seen as a fruitful approach. E. g. we use regressions for energy intensity (energy input) coefficients to explain factors influencing them and to substantiate their values for future periods which helps to improve our forecast scenarios. Another function of econometrical analysis of energy consumption is setting the problem to be analyzed with the help of IRIO model. As a such we select and treat the problem of energy intensity differences seen in the scope of the world economies.

■ Energy Intensity Puzzle

Before the energy crisis of 1970s, the main trends in energy consumption especially evident in the countries with average income were increased per capita energy consumption and growing energy intensity. Thus, we observe that the average per capita consumption of commercially produced energy had practically doubled in today's OECD countries from 1960s to 1973, out of which in Japan, Portugal, and Spain this growth was 2.5–3 times, and in Greece the increase was almost 5 times. Accordingly, the energy intensity of the income produced grew too. The average growth index of energy intensity for OECD countries over this period was 120%.

During the decade following the energy crisis break-up, the energy consumption trends were reversed in most countries. By 1983, the average reduction index of GDP energy intensity for OECD countries was 10%, and by the end of the century this index dropped by further 4%. At the same time, however, in such OECD member countries as Australia, Belgium, Denmark, Italy, Japan, Great Britain, and USA, the reduction in the GDP energy intensity exceeded 20% over the first post-crisis decade and 30–40% – before the end of the century (see Fig. 2). Obviously, such a striking improvement of the energy consumption efficiency in the above-mentioned countries should be attributed not only to the skyrocketing energy prices in the efficient markets but also to the special measures of government policy aimed at better energy conservation.

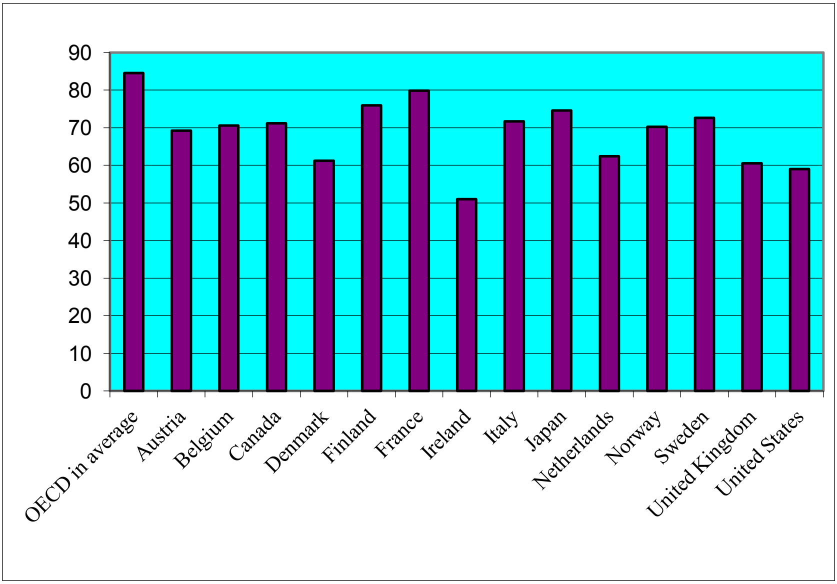

Fig. 2. Change in the GDP Energy Intensity in Selected OECD Economies: 2000 to 1973, %

The available data for the countries with socialist economy show that there too was a certain reduction in the output energy intensity in 1970s and 1980s, although is already universally recognized that the official statistics in socialist countries overestimated the output growth indices, and, consequently, the data on the energy intensity dynamics lack reliability. In the early 1990s when the economic reforms were launched, the GDP energy intensity in transitional economies significantly – as often as not several fold – exceeded the levels of market economies, and the situation has not changed significantly since that time (see Fig. 3). The initial transformation period in former socialist countries was characterized by increasing energy intensity of production resulting from the shrinking output. After this, however, in most of the above-mentioned countries energy intensity of production decreased fairly fast, although not everywhere it approached the pre-crisis levels. As was shown in (Suslov and Ageeva, 2005), the reduction in the energy intensity of production over the above-named period was little related to the increase in the energy prices, and was rather a "byproduct" of increase in the production and capacity utilization.

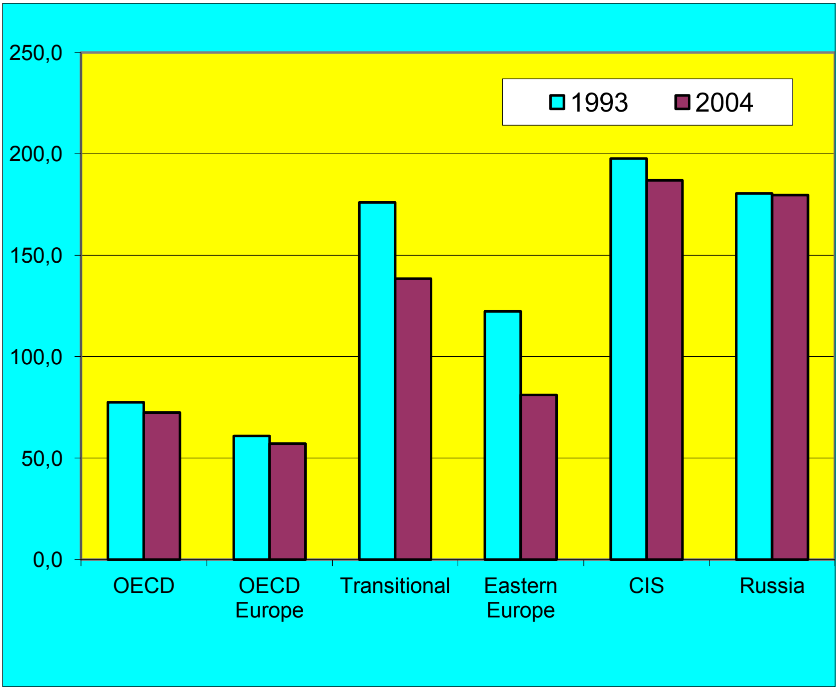

Fig. 3. Energy Intensity of GDP in World Economies and Groups of Economies, USA in 1993=100%

Higher energy inputs in former socialist countries may partially be attributed to the inclement climatic conditions: in this part of the East Europe and the Asian part of the former Soviet Union average annual temperatures are significantly lower and the amplitude of seasonal variations is much higher than in, say, Western Europe. However, as our analysis showed (Suslov and Ageeva, 2005), this factor fails to account for the entire difference in the levels of energy intensity. This suggests that a significant factor affecting the levels of specific energy consumption is the quality of economic institutions determining the key aspects of economic system performance mechanism. Our hypothesis is that weak institutional development can lower the incentives for economic agent to take energy conservation measures, including the implementation of investment projects aimed at energy saving.

We use the following specification:

$$\ln(e) = \beta_0 + \beta_1 \cdot DISTE + \beta_2 \cdot INST \cdot \ln\left(\frac{P}{p_E}\right) +$$

$$+ \beta_3 \cdot \ln\left(\frac{P}{p_E}\right) + \varepsilon \qquad (7)$$

though the variable *INST* may designate different institutional variables from their total list presented in the section 4.1. We used in our analysis both several individual variables and their combinations but present in our paper the most satisfactory version of this variable being a sum of two institutional indices – Government Effectiveness and Control of Corruption:

$$INST = GE + CC \qquad (8)$$

The variable of a combined influence of the real energy price and institutions $INST \cdot \ln\left(\frac{P}{p_E}\right)$ is called the interaction term, which we use following Polterovich and Popov (Polterovich and Popov, 2004). If it proves significant, one could suggest that the institutions affect energy intensity through the price system. On the other hand, a simple transformation in (7) helps to see that the value $\beta_2 \cdot INST + \beta_3$ is the price elasticity of output energy intensity as a function of the institutional strength index, which fit our theoretical model.

■ Estimation Results: What are the Main Reasons for High Transaction Cost?

We estimated the model (7) keeping (8) for 5 years: 2002 trough 2006. The reason why we omitted the year of 2001 is absence of institutional indices for it in the World Bank databases. The main results are presented in the Tab. 1.

Using in the regression a variable of seasonal temperature fluctuation which we consider a good reflection of climate severity rather than a mean annual temperature one is caused by the fact that the first indicator works better in all the regressor's combinations we tried. We address this phenomenon to two things. First, it represents better technologic specifics brought about by the climatic conditions in the country: equipment should fit to both low and high temperature regimes; on the other hand more enduring technologies are more energy intensive. Secondly, the variable of seasonal temperature fluctuation is at the same time a measure for a geographical continentality of the countries taking into account that the economies located more distantly from the sea shores incur additional (energy) cost of the world economic integration.

Table 1

Estimated Energy Intensity of Production in the World Countries (dependent variable: ln[Energy Consumption in production sphere per a unit of GDP PPP], White covariance matrix method)

Variables	2002, 75 observ.	2003, 77 observ.	2004, 74 observ.	2005, 75 observ.	2006, 77 observ.
Constant term	–.1718 *t*–Value= –1.30	–.1665 *t*–Value= –1.25	–.1511 *t*–Value= –1.26	–.2771 *t*–Value= –2.30	–.2872 *t*–Value= –2.49
Variable of climate conditions: *DISTE*	.0025 *t*–Value =4.84	.0023 *t*–Value= 4.30	.0019 *t*–Value= 3.97	.0021 *t*–Value= 4.48	.0022 *t*–Value= 4.15
Real energy price for previous year: $\ln(P/p_E)_{-1}$	.5155 *t*–Value= 5.13	.4592 *t*–Value= 4.95	.4429 *t*–Value= 4.94	.2536 *t*–Value= 2.56	.2841 *t*–Value= 2.67
Interaction term: $\ln(P/p_E)_{-1} \cdot INST^*$	.1153 *t*–Value= 3.29	.1005 *t*–Value= 2.49	.1133 *t*–Value= 2.76	.1124 *t*–Value= 2.96	.1239 *t*–Value= 2.54
R-squared	0.4835	0.4231	0.3979	0.3189	0.3343
F-value	19.75	18.90	16.40	10.96	8.73
Root MSE	.38297	.39872	.36507	.36192	.37684
Hausman test, Chi2**	0.00, Prob>chi2= 0. 0.9999	0.03, Prob>chi2= 0.9984	0.76, Prob>chi2= 0.8582	0.27, Prob>chi2= 0.9661	0.90, Prob>chi2= 0.8246

* Combination of Government Effectiveness and Control of Corruption indices.

** Instrumental variables are logarithm of import cost of oil in the previous year for the real energy price variable and in addition a combination of latitude degree and infant mortality variables for the interaction term; IVS and OLS models are compared for the samples of economies for which is the data on import cost of oil accessible.

Endogeneity of regressors problem is expected to be present with respect of use in the regression of both the institutional and energy price variables which could be affected with the energy intensity one. Trying to soften it for the real price of energy factor we used in the regression a variable for the previous year rather than for current one: $\ln\left(\frac{P}{p_E}\right)_{-1}$ instead of $\ln\left(\frac{P}{p_E}\right)$. Besides this a proper method to treat the problem of endogeneity is application of IVLS estimator in addition to OLS employing Hausman test. A serious difficulty here is existence of consistent instrumental variables for energy price. The only possible one which we could imagine was crude oil import cost for corresponding economies. We applied the data from IEA database containing statistics on only 25 OECD countries. Thus the sample used to test the problem was of only this dimension what, of cause reduced the reliability of the estimates which we obtained. Nevertheless we present the results of Hausman test suggesting that the effective model should be preferred. Institutional index was instrumented with the help of latitude degree and infant mortality variables.

As it could be seen, significance of institutional variables is still well preserved and for the services sector proves o be even higher than for overall energy intensity. However, transaction term visibly loses its explanation power in the regressions for the goods production sector. This fact has a transparent explanation: share small and medium-sized enterprises in services sector is essentially higher than in goods producing one. At the same time small and medium-sized business, at least in economies with not good enough institutions, suffer from overregulation and corruption considerably higher than large enterprises. Thus, the implicit transaction cost burden for it is higher as well.

We provide our calculations of price elasticity of production energy intensity both by the groups of the economies (Tab. 2) and for each country from the sample (Tab. A1 in Appendix). One can see that these results confirm our theoretical assumption: the better the institutions the stronger consumption of per output unit responds to changes in real energy price. Particularly, in CIS countries, adjustment of energy demand to changes in real energy prices is to be regarded as weak:

the absolute value of average price elasticity coefficient of energy intensity is about one third of that in OECD countries; in the East European and Baltic countries this value is also visibly lower than in the developed countries though not so crucially (it is “only” one half of the OECD level). This fact means weak incentives of firms for energy conservation and, thus, serves an important reason for the higher energy intensity of production.

Table 2

Coefficients of Price Elasticity of Production Energy Intensity by the Economies and the Groups Economies of the World

	2002	2003	2004	2005	2006	In average
World in Average, 118 economies	–0,546	–0,519	–0,506	–0,278	–0,317	–0,433
OECD, 26 economies*	–0,889	–0,838	–0,910	–0,596	–0,666	–0,780
Former Socialist, 27 economies	–0,451	–0,436	–0,406	–0,212	–0,243	–0,349
East Europe and Baltic, 14 economies	–0,559	–0,540	–0,551	–0,322	–0,362	–0,467
CIS, 11 economies	–0,318	–0,308	–0,234	–0,082	–0,102	–0,209
Russian Federation	–0,374	–0,374	–0,320	–0,124	–0,128	–0,264

* Without new members.

■ Application of OMMM-Energy: Some Results

Using econometrical analysis to explain both the values of energy input coefficients and factors influencing them. This information could be further used to calculate future energy input coefficients for forecasting model. But this analysis by itself is not sufficient for estimation of economic efficiency of measures to reduce energy intensity of the economy. In this the roles we consider to be appropriate just the OMMM-energy.

A basic advantage of the OMMM-Energy is a combination of different approaches such as the input-output, inter-regional and energy balances. This allows evaluating the complex effects and efficiencies of the policy measures undertaken in the spheres of production, processing and consumption of energy. Previously, the model was applied to evaluating economic consequences of the:

- concentration of energy-intensive productions and gasification in the South Siberia regions;
- fast development of nuclear energy in the national economy;
- a reduction of energy intensity of production in the national economy;
- wide application of heat pumps technologies in the different regions of the national economy;

and many others but less significant issues.

To illustrate what can be obtained by applying such models, we present the results of our analysis concerning the efficiency of different arrangements undertaken to widen application of heat pump technologies in Russia and Russian regions. For this purpose we applied a previous OMMM-Energy covering 1999–2010 which is practically analogous to the above model.

Annual market for compression heat pumps in Russia was estimated to be 40–55 million of coal equivalent. According to the results of the calculations conducted with the help of OMMM-Energy, spreading compression heat pump can bring about a significant reduction in energy intensity, forcing out fossil fuels combusted at traditional heat plants. At the same time, an increase in capital intensity of national economy takes place. It happens because, first, heat pumps are more expensive as compared to traditional heat producing engines; second, additional electricity generation capacity is needed since compression heat pumps are highly electricity intensive; third, additional gas pipelines could be needed.

Our calculations suggest that heat pumps are efficient in Siberia under the transformation coefficient[1] of level 4, while in European regions of Russia – under the transformation coefficient of level 5. This difference is explained by the fact that electricity which is essentially cheaper in Siberia than in the Western part of Russia is the main production resource to run the heat pump technology.

[1] Transformation coefficient is a technical characteristic of *compression* heat pump technology showing a ratio of heat provided by an engine to the electricity consumed to run it; both of them measured in comparable units.

Another calculation series was conducted to estimate economic consequences of heat conservation in the regions of Russia. To do this we incorporated into our model additional technologies producing output for each region which included only output components. Their contents were providing gratuities heat energy which could be utilized through improving organization and management systems. The purpose of this analysis was to determine just the efficiency of use of additional energy: either will it result in reductions of heat provided by heat plants, or will it be recycled to produce additional goods and with what economic outcomes? So, we run calculations for each region of the model in order to see responds of the total national economy to providing additional heat just in a certain region. After that we looked at the change of energy output in total and of some macroeconomic indicators.

Speaking in general, in different regions both the shares of energy recycled to produce additional goods in its total additional output and the levels of economic efficiency of these events were different. For instance in Western Siberia almost all the additional heat was used to increase production outputs in industry, on the contrary in European Russia it was used instead of energy provided by the heat plants. In turn this reduction of production resulted in further reduction of energy consumption at the transport and industrial enterprises and, thus, in decreasing the total energy output. Finally total energy consumption reduction per a unit of heat additionally provided in Western Siberia equaled one unit while in European Russia – about 3,5 units (see right box of Fig. 4). However, increase of GDP per unit of additional heat (as measured in tones of coal equivalent) was higher in Western Siberia (see left box of Fig. 4). The reason was that in Siberia the conditions to develop the energy intensive products are more favorable than in European part of Russia. So, additional energy can be used with higher economic output.

The latest calculations carried out on the basis of OMMM-Energy were aimed at identifying permissible and economically justified cost limits of installed electricity generation facilities using RES. We have found out that such a cost limit for the regions included in the model equals to USD 2100 per 1 kW, which means that, given the estimated long-run *average* conditions, production technologies of electric energy from RES requiring additional investments above the specified level, do not seem to be economically justified and feasible. At the same time, the obtained assessment of marginal cost of power appeared to be slightly lower than the average expected price on electricity generation from RES which in the State Program of the Russian Federation "Energy efficiency and energy development" is established at the level of RUB 75 thousand per 1 kW. This fact proves that RES development in Russia requires special attention and support from the government.

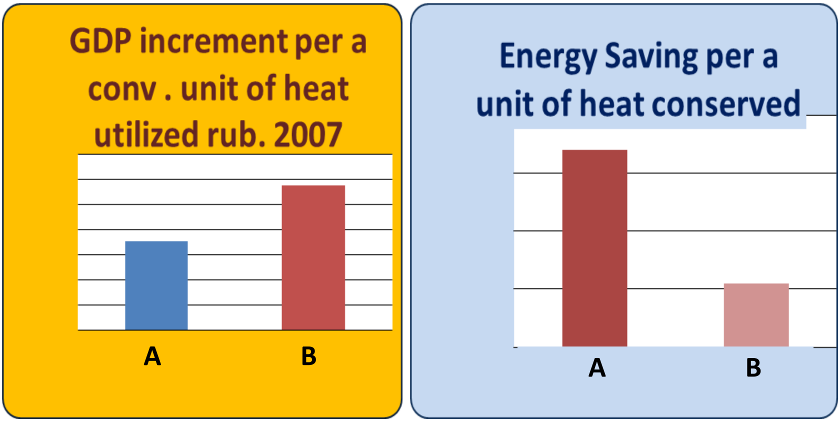

Fig. 4. Effects of heat recycling in Western Siberia (B) and European Russia (A) compared

■ Conclusion Remarks

OMMM-Energy is an optimization multi-sector multiregional model which presents an energy sector and its energy production in their physical indicators. It was developed on the basis of "classical" OMMM discussed in the section 2 of this paper. A current model includes 45 economic sectors, with 8 products among them, and 6 Russian economic zones (the European zone, Ural region, Tyumen Oblast, West Siberia, East Siberia and Far East). It succeeds basic advantages and disadvantages of the OMMM-prototype and differs from the latter in a number of aspects.

This model has been applying in IEIE SB RAS since the middle of 1980ths. A basic advantage of the OMMM-Energy is a combination of different approaches such as the input-output, inter-regional and energy balances. This allows evaluating the complex effects and efficiencies of the policy measures undertaken in the spheres of production, processing and consumption of energy.

Further use of this model is associated with conducting scenario analysis of energy sector and national economy interactions within the future period up to 2030.

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■ Appendix

Table A1

Estimated Coefficients of Price Elasticity of Energy Intensity in the Years of 2002–2006

	2002	2003	2004	2005	2006	In average
ALBANIA	–0,352	–0,339	–0,317	–0,103	–0,148	–0,252
ALGERIA	–0,355	–0,361	–0,315	–0,163	–0,173	–0,273
ANGOLA	–0,244	–0,234	–0,125	–0,001	0,021	–0,117
ARGENTINA	–0,385	–0,409	–0,388	–0,182	–0,223	–0,317
ARMENIA	–0,412	–0,392	–0,356	–0,178	–0,186	–0,305
AUSTRALIA	–0,947	–0,924	–1,045	–0,688	–0,768	–0,874
AUSTRIA	–0,978	–0,924	–1,008	–0,658	–0,738	–0,861
AZERBAIJAN	–0,298	–0,290	–0,189	–0,066	–0,077	–0,184
BANGLADESH	–0,315	–0,280	–0,173	–0,015	–0,031	–0,163
BELARUS	–0,288	–0,263	–0,156	–0,023	–0,038	–0,154
BELGIUM	–0,931	–0,861	–0,928	–0,604	–0,677	–0,800
BENIN	–0,362	–0,378	–0,329	–0,084	–0,149	–0,261
BOLIVIA	–0,382	–0,356	–0,288	–0,076	–0,133	–0,247
BOSNIA AND HERZEGJVINA	–0,351	–0,353	–0,327	–0,148	–0,171	–0,270
BRAZIL	–0,487	–0,502	–0,474	–0,219	–0,247	–0,386
BULGARIA	–0,513	–0,480	–0,497	–0,281	–0,288	–0,412
CAMEROON	–0,296	–0,328	–0,214	–0,020	–0,056	–0,183
CANADA	–0,991	–0,938	–1,021	–0,688	–0,785	–0,884
CHILE	–0,829	–0,752	–0,851	–0,547	–0,590	–0,714
CHINA	–0,457	–0,431	–0,385	–0,166	–0,217	–0,331
COLOMBIA	–0,409	–0,413	–0,422	–0,218	–0,259	–0,344
CONGO	–0,242	–0,236	–0,179	0,015	0,010	–0,127

COSTA RICA	–0,664	–0,621	–0,596	–0,337	–0,361	–0,516
CROATIA	–0,585	–0,531	–0,558	–0,328	–0,355	–0,471
CYPRUS	–0,769	–0,720	–0,729	–0,463	–0,537	–0,644
CZECH REPUBLIC	–0,661	–0,612	–0,624	–0,417	–0,456	–0,554
DENMARK	–1,025	–0,978	–1,112	–0,746	–0,869	–0,946
DOMINICAN RE-PUBLIC	–0,430	–0,383	–0,318	–0,133	–0,158	–0,284
ECUADOR	–0,309	–0,316	–0,242	–0,051	–0,052	–0,194
EGYPT	–0,428	–0,401	–0,371	–0,157	–0,154	–0,302
EL SALVADOR	–0,406	–0,424	–0,397	–0,184	–0,233	–0,329
ERITREA	–0,443	–0,378	–0,281	–0,111	–0,086	–0,260
ESTONIA	–0,695	–0,696	–0,751	–0,481	–0,547	–0,634
ETHIOPIA	–0,349	–0,318	–0,274	–0,064	–0,127	–0,226
FINLAND	–1,053	–0,990	–1,101	–0,758	–0,869	–0,954
FRANCE	–0,859	–0,820	–0,876	–0,576	–0,630	–0,752
GABON	–0,413	–0,374	–0,272	–0,100	–0,087	–0,249
GEORGIA	–0,303	–0,312	–0,327	–0,161	–0,223	–0,265
GERMANY	–0,954	–0,865	–0,933	–0,639	–0,718	–0,822
GHANA	–0,446	–0,421	–0,390	–0,202	–0,269	–0,346
GREECE	–0,679	–0,636	–0,661	–0,372	–0,406	–0,551
GUATEMALA	–0,385	–0,355	–0,302	–0,087	–0,111	–0,248
HAITI	–0,150	–0,140	–0,036	0,071	0,064	–0,038
HONDURAS	–0,352	–0,348	–0,290	–0,102	–0,117	–0,242
HONG KONG	–0,830	–0,801	–0,909	–0,627	–0,727	–0,779
HUNGARY	–0,700	–0,651	–0,678	–0,407	–0,454	–0,578
ICELAND	–1,012	–0,992	–1,105	–0,783	–0,851	–0,949
INDIA	–0,450	–0,443	–0,417	–0,206	–0,246	–0,352

INDONESIA	–0,314	–0,318	–0,282	–0,103	–0,133	–0,230
IRAN	–0,419	–0,395	–0,317	–0,106	–0,129	–0,273
IRELAND	–0,895	–0,839	–0,898	–0,628	–0,694	–0,791
ISRAEL	–0,740	–0,697	–0,740	–0,450	–0,556	–0,637
ITALY	–0,712	–0,668	–0,649	–0,364	–0,386	–0,556
IVORY COAST	–0,308	–0,274	–0,123	0,045	0,037	–0,125
JAMAICA	–0,453	–0,431	–0,413	–0,187	–0,257	–0,348
JAPAN	–0,755	–0,741	–0,789	–0,526	–0,632	–0,689
JORDAN	–0,534	–0,544	–0,544	–0,294	–0,342	–0,452
KAZAKHSTAN	–0,288	–0,294	–0,218	–0,085	–0,111	–0,199
KENYA	–0,310	–0,310	–0,257	–0,049	–0,090	–0,203
KOREA, SOUTH	–0,668	–0,616	–0,640	–0,422	–0,461	–0,562
KUWAIT	–0,654	–0,616	–0,631	–0,391	–0,414	–0,541
KYRGYZ REPUBLIC	–0,344	–0,320	–0,231	–0,034	–0,052	–0,196
LATVIA	–0,597	–0,587	–0,597	–0,365	–0,419	–0,513
LEBANON	–0,438	–0,403	–0,346	–0,164	–0,132	–0,297
LITHUANIA	–0,622	–0,616	–0,629	–0,385	–0,404	–0,531
LUXEMBOURG	–1,022	–0,919	–1,041	–0,680	–0,748	–0,882
MACEDONIA	–0,373	–0,391	–0,382	–0,168	–0,223	–0,308
MALAYSIA	–0,649	–0,611	–0,655	–0,396	–0,444	–0,551
MALTA	–0,738	–0,732	–0,783	–0,477	–0,583	–0,663
MEXICO	–0,517	–0,480	–0,442	–0,212	–0,256	–0,381
MOLDOVA	–0,339	–0,318	–0,214	–0,086	–0,095	–0,210
MOROCCO	–0,494	–0,465	–0,447	–0,214	–0,247	–0,373
MOZAMBIQUE	–0,391	–0,356	–0,322	–0,143	–0,158	–0,274
NAMIBIA	–0,532	–0,505	–0,476	–0,267	–0,320	–0,420
NEPAL	–0,427	–0,399	–0,277	–0,061	–0,100	–0,253

NETHERLANDS	–1,007	–0,935	–1,040	–0,698	–0,774	–0,891
NEW ZEALAND	–0,986	–0,957	–1,101	–0,720	–0,807	–0,914
NICARAGUA	–0,370	–0,362	–0,331	–0,097	–0,073	–0,247
NIGERIA	–0,236	–0,248	–0,156	–0,023	–0,033	–0,139
NORWAY	–0,999	–0,940	–1,047	–0,710	–0,811	–0,901
PAKISTAN	–0,351	–0,343	–0,253	–0,083	–0,119	–0,230
PANAMA	–0,482	–0,455	–0,446	–0,227	–0,254	–0,373
PARAGUAY	–0,248	–0,249	–0,178	–0,016	–0,040	–0,146
PERU	–0,437	–0,420	–0,345	–0,133	–0,179	–0,303
PHILIPPINES	–0,436	–0,413	–0,357	–0,176	–0,180	–0,312
POLAND	–0,620	–0,587	–0,558	–0,336	–0,368	–0,494
PORTUGAL	–0,811	–0,757	–0,787	–0,498	–0,525	–0,676
ROMANIA	–0,460	–0,436	–0,415	–0,220	–0,257	–0,358
RUSSIA	–0,374	–0,374	–0,320	–0,124	–0,128	–0,264
SAUDI ARABIA	–0,540	–0,486	–0,435	–0,219	–0,253	–0,387
SENEGAL	–0,506	–0,423	–0,415	–0,215	–0,202	–0,352
SINGAPORE	–1,031	–0,978	–1,107	–0,744	–0,832	–0,938
SLOVAK REPUBLIC	–0,586	–0,587	–0,635	–0,411	–0,443	–0,532
SLOVENIA	–0,714	–0,693	–0,747	–0,465	–0,536	–0,631
SOUTH AFRICA	–0,633	–0,596	–0,637	–0,413	–0,432	–0,542
SPAIN	–0,890	–0,834	–0,854	–0,562	–0,551	–0,738
SRI LANKA	–0,480	–0,443	–0,399	–0,178	–0,230	–0,346
SUDAN	–0,268	–0,214	–0,123	0,067	–0,003	–0,108
SWEDEN	–1,013	–0,954	–1,058	–0,708	–0,815	–0,909
SWITZERLAND	–1,022	–0,951	–1,080	–0,724	–0,826	–0,920
SYRIA	–0,379	–0,320	–0,234	–0,048	–0,060	–0,208
TAJIKISTAN	–0,263	–0,246	–0,152	–0,011	–0,043	–0,143

TANZANIA	–0,355	–0,351	–0,327	–0,129	–0,181	–0,269
THAILAND	–0,497	–0,482	–0,481	–0,277	–0,280	–0,403
TOGO	–0,295	–0,257	–0,143	0,004	0,048	–0,129
TRINIDAD AND TOBAGO	–0,548	–0,544	–0,539	–0,287	–0,299	–0,443
TUNISIA	–0,642	–0,592	–0,575	–0,301	–0,349	–0,492
TURKEY	–0,472	–0,471	–0,458	–0,272	–0,303	–0,395
UKRAINE	–0,322	–0,328	–0,250	–0,142	–0,142	–0,237
UNITED KINGDOM	–0,980	–0,917	–1,012	–0,663	–0,750	–0,865
UNITED STATES	–0,939	–0,870	–0,964	–0,609	–0,657	–0,808
URUGUAY	–0,677	–0,620	–0,629	–0,408	–0,443	–0,555
UZBEKISTAN	–0,271	–0,254	–0,159	0,013	–0,028	–0,140
VENEZUELA	–0,283	–0,265	–0,202	–0,046	–0,073	–0,174
VIETNAM	–0,382	–0,377	–0,300	–0,134	–0,144	–0,268
YEMEN	–0,346	–0,330	–0,221	–0,068	–0,075	–0,208
ZAMBIA	–0,313	–0,299	–0,236	–0,067	–0,104	–0,204
ZIMBABWE	–0,263	–0,234	–0,132	0,058	0,048	–0,105

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