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APPLIED MACROECONOMIC MULTISECTORAL MODELING

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This volume contains selected papers presented during the 23rd INFORUM World Conference held on August 24–28, 2015 in Bangkok, Thailand, the 24th INFORUM World Conference held on August 29 – September 2, 2016 in Osnabrueck, Germany, and the 25th INFORUM World Conference held on August 28 – September 1, 2017 in Riga, Latvia, and covers a wide range of topics with a common focus – multi-sectoral modeling. The topics covered include estimation aspects of the multi-sectoral models, analysis of the Tax reform in the USA and the related prospects of economic growth, assessment of interest rate capping on the South African Economy, long-term forecasts of Japan and Poland, modeling competitiveness in Latvia, China's domestic value chain from the global value chain perspective, modeling of human capital in Russia, evaluation of macroeconomic impact of nuclear power plant projects and modeling of imported energy price effects in Turkey.

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INTRODUCTION

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Economic development is an important aspect of our daily life. Faster economic growth usually implies an increase in welfare. However, economic development is not homogenous. It affects different groups of people, industries, and economic agents in different ways. It is important to understand these influences in order to plan policies, strategies and activities to make life in the future better than today.

Multisectoral macroeconomic models are useful tools for such analysis. They not only systemize all the available data in a common framework, but also include the disaggregation needed to understand the diverse development of separate parts of the economy. One of the best tools for such a multi-sectoral analysis is the INFORUM-type models, which combine input-output relationships with econometric equations in a common tool for more realistic representation of economies.

These models were first developed within the Interindustry Forecasting Project at the University of Maryland (INFORUM), USA, which was initiated in 1967 by Clopper Almon, now Professor Emeritus of the University of Maryland. Some years later INFORUM developed as an international group, attracting partners in most of the continents. Moreover, the international partners develop their own INFORUM models, most of which are linked through the BTM (Bilateral Trade Model), which ensures not only realistic representation of particular economies, but also their interrelations and thus global economic development in a more realistic manner. Since 1993, the INFORUM group has organized regular meetings in the form of scientific INFORUM World Conferences, where new developments and applications of models are discussed and group members exchange their experience.

This volume contains selected papers presented during the last three conferences, namely, the 23rd INFORUM World Conference held on August 24–28, 2015 in Bangkok, Thailand, the 24th INFORUM World Conference held on August 29 – September 2, 2016 in Osnabrueck, Germany and the 25th INFORUM World Conference held on August 28 – September 1, 2017 in Riga, Latvia and covers a wide range of topics with a one common focus – multi-sectoral modeling. The first section of the volume is related to the multi-sectoral model estimation aspects, the second focuses on model applications for policy analysis and forecasting, and the third deals with new model developments and data issues.

The Multisectoral Model Estimation Aspects section begins with the paper of one of the most experienced researchers in INFORUM modeling, Maurizio Grassini. In this paper he proves that the technical input-output coefficients not only can change over time and thus can be modelled, but they definitely need to be modeled, as in an open economy increased imports can lead to negative outputs if the technical coefficients are fixed. He also describes the algorithm to model technical coefficients in the INFORUM multi-sectoral models system.

Vadim Potapenko continues this section, presenting the results of PADS (Perhaps Adequate Demand System) with Russian data. PADS was proposed by Clopper Amon in 1979 and later developed by himself and other researchers like Bardazzi and Barnabani in 2001. In the paper of Vadim Potapenko, PADS is used for modeling of household consumption expenditures for 24 COICOP (Classification of Individual Consumption on Purpose) items and net purchases abroad in 2004–2013. When classification change issues are overcome and more recent data are available, the equations will be updated and improved and afterwards incorporated into the Russian INFORUM-type model RIM.

The Policy Issues and Forecasts section begins with an impact analysis of the proposed tax reform on the development of the USA presented by Douglas S. Meade. The paper presents a brief analysis of the current economic situation in the USA and the proposed tax reform. Further, it describes the modeling tools used for analysis. These are the *Lift* model, which is a highly detailed and internally consistent interindustry macroeconomic model developed since the early 1980s, and the microsimulation model developed by Quantria Strategies in such a way incorporating the best features of both types of models. The paper provides modeling results for 2018–2027, comparing static and dynamic effects of tax reform and giving a clearer picture on possible U.S. development if the tax reform is approved.

David Mullins, David Mosaka and Phindile Nkosi continue with an economic assessment of interest rate capping on the South African Economy. They explain positive and negative aspects of interest rate capping, the possible impacts on unsecured credit, credit facilities and consumer expenditure, and then provide a description of the modeling system used, the assumptions and the results. In this study the macroeconomic, dynamic and multisectoral SAFRIM (the South African INFORUM Model) is used, which can be considered as a classical INFORUM model adapted for South African conditions. The impact analysis is done by comparing the base scenario to the interest rate capping scenario for 2016–2025.

Next, the Japanese team – Yasuhiko Sasai, Mitsuhito Ono and Takeshi Imagawa – present their economic and industrial forecasts of Japan for 2013–2030, which are obtained using the revised model JIDEA9 (Japan Inter-industry Dynamic Econometric Analysis). The authors provide both the assumptions of their simulation and the detailed forecasts covering such aspects as GDP and consumption, output, employment and labor productivity, private investment, exports and imports, and input structure.

Michal Przybylinski, Iwona Swieczewska and Joanna Trebska provide their long-term forecasts of the Polish economy until 2050. Four scenarios are developed and compared, which are focused on different phenomena and processes. The first one focuses on demographic phenomena, where an increased number of retirees is expected. The second one focuses on changes in the intensity and structure of Polish foreign trade related to the deepening of the globalization process. The third one focuses on technological growth and growth of the knowledge capital in the economy. Finally, the fourth combines all the previously mentioned scenarios into one.

The New Model Developments and Data Issues section begins with the paper of Velga Ozolina, Remigijs Pocs and Astra Auzina-Emsina, which deals with competitiveness analysis and modeling. The paper presents several indicators, which can be used for competitiveness analysis, and also the results of such analysis for Latvian high- and medium-high-tech industries. The paper also shows the current state of the Latvian Macroeconomic Model and its use for competitiveness analysis.

Shantong Li and JianWu He present their research on the division of labor of China's domestic value chain from the global value chain perspective. The paper puts forward the unified framework of decomposition of external trade into international exports and interprovincial exports, analysis of the status of different regions of China in participating in the global value chain and domestic value chain and summarizes the relevant stylized facts.

Alexandr Baranov, Viktor Pavlov and Iuliia Slepenkova provide a description of the extended dynamic input-output model with a human capital block, based on the input-output model from the KAMIN system (the System of Integrated Analysis of Interindustrial Information). The paper also presents an analysis of human capital investment, private human capital expenses, output of human capital and accumulated human capital, and proves that labor productivity growth is related to the growth rate of human capital investment.

The section continues with the study of Alexander Shirov and Dmitriy Polzikov on the macroeconomic impact of nuclear power plant projects. The authors present the approach of multiplier effect assessment by using an iterative process in the implementation of a new international nuclear power plant project, where one country is building a nuclear power plant in another country. Thus the effects are distributed between the receiving country, where the power plant is being built, and the supplying country, which is responsible for building the power plant. The provided example shows that the investment and value added multiplier effect is higher for the supplying country, but the output multiplier – for the receiving country.

The final paper by Meral Ozhan analyzes the effects of exogenous price adjustments in energy markets using an input-output model for the Turkish economy. The paper provides analysis on the channels of influence of imported energy prices on domestic prices and calculates the effect using a static input-output model.

We expect that this collection of papers can provide a useful snapshot of the variety of research within the INFORUM group. However, it cannot be overemphasized that this work is growing and changing. Not only are the techniques of model building evolving, but also the types of questions which these models must address. As global trade continues to become ever more important to the economic growth of every country, the intersectoral trade linkages become more significant. We welcome more countries to join the INFORUM work as partners, and we offer to help them to develop new models using our software and techniques. The next INFORUM conference, which will be held in Lodz, Poland, in August 2018, will include a few sessions which further explore software and model building techniques.

The conference in Riga was significant, as it heralded the 25th year of successive INFORUM conferences. The first conference was in Rennes, France, in 1993, and since that time the accomplishments of the INFORUM researchers have been fruitful. Our approach is unique because the country models are each developed by the country partner, and there is great variety in structure among the models, though they can be linked in the Bilateral Trade Model. This approach makes extensive use of econometric estimation, as well as focuses on the "bottom up" macroeconomic analysis based on industry level calculations. The trade linkages are not static, as in some multi-country trade linked systems, but are also econometrically estimated. This approach provides a flexible and extensible tool for global as well as national policy analysis.

There is an old Latvian saying: "As long as you live, you learn". The life of the INFORUM group has already been long, and we have learned much. Since the younger members are now taking leadership, we will learn much more.

MULTISECTORAL MODELING ESTIMATION ASPECTS — 1

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WHEN TECHNICAL COEFFICIENT CHANGES NEED TO BE ENDOGENOUS: THE CASE OF IMPORTS IN THE INFORUM ITALIAN MODEL

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Introduction

In contrast to the basic properties of the standard input-output (I-O) model (Miller & Blair, 2009) stated for example by Erik Dietzenbacher (IIOA Newsletter, 2015), INFORUM models have quantities and prices integrated. This distinctive feature of this class of multisectoral dynamic models designed for long-term policy simulation analyses poses peculiar and challenging modeling approaches (see Almon, 1991; 2016). This paper focuses on the interactions among imports, technical coefficients and price formation. First, the modeling approach to cope with the divergence between imports econometrically estimated and imports computed by means of account identities is shown. Second, the need to model technical coefficient changes for long-run forecasting is presented as empirical evidence from the model builder's data set. Third, even taking into account the Hawkins-Simon (Hawkins & Simon, 1949) conditions, modeling imports in an open economy may easily lead to negative outputs. A procedure to "update" input-output technical coefficients to fix a multisectoral model during the forecasting process is developed. Although a number of contributions are devoted to the technical coefficients (for example Hewings & Sonis, 1992; Jalili, 1999; Nishimura, 2002; Sonis & Hewings, 1996) no one tackles the problem of modeling them.

Finally, the algorithm to model technical coefficients in the INFORUM multisectoral models system is described.

1. Import shares in an INFORUM model

If an I-O table is available in total domestic flows and imported flows, an import shares matrix, which includes intermediate consumption and domestic final demand components can be computed, which we will call "MM". In an INFORUM type model, imports are *modeled* like other endogenous final demand components (i.e. personal consumption expenditures, investments, and exports, while other components are placed among scenario variables). In principle, the total output vector obtained from the solution of the model can be used to compute back the I-O table flows and, using the matrix MM, the associated I-O import flow matrix is obtained. The row sum of such a matrix equals to the imports vector m (imports by type of product). This imports vector will in general be different (except in the base year) from the imports vector obtained with a system of equations, m^; namely $m \neq m$^. This discrepancy is due to the different content of imports in both intermediate consumption and final demand components induced also by structural changes in the resources side (sectoral imports – total resources ratios).

In general, changes in resource composition (imports + output) do not necessarily imply a change of the size of the technical coefficients; but if imports of good i grow faster than the corresponding output, the imports share in intermediate consumption and final demand supplied by product i necessarily increases. If the technical coefficients remain constant, the MM coefficients must change.

The MM matrix does not play any role in solving the real side of the I-O model. Actually, it is central in the nominal side where the impact of the import prices in the price equations is related to the import contents of intermediate consumption. Therefore, changes of technical coefficients and of import shares affect the price formation, so that changes in MM coefficients turn out to interact with the real side of the I-O model.

In order to take into account such an interaction, INFORUM suggests and applies an algorithm to adjust the MM coefficients. Basically, the difference between imports estimated (m) and imports calculated (m^) of a product group i is used to modify the elements of the i-th row of matrix MM so that m_i is equal to m_i^. The adjustment cannot be simply proportional to the factor m_i^ / m_i since import shares are not allowed to be greater than one. The algorithm provides increases as well decreases of import shares (the elements of matrix MM), greater for low shares and lower for great shares under the constraint $mm_{ij} < 1$ (see Meade, 1995).

On rare occasions this algorithm may be unsuitable. This may happen when product i imports obtained from econometrically estimated equations are larger than product i imports calculated (from the MM matrix) and the required increase of import shares does not cover the difference $m_i - m\hat{}_i$. For example, if non-zero import shares are all equal to one and imports econometrically estimated are larger than imports calculated by means of the matrix MM, their difference cannot be covered by changing MM coefficients. Such a case reveals that the I-O table flows must change in order to get $m_i = m\hat{}_i$ and, consequently, changes of I-O flows as well as technical coefficients should take place.

2. Changes of technical coefficients

Technical coefficients cannot be assumed constant over time. In fact, if $A_0q_0 + f_0 = q_0$ is the Leontief equation of the interindustry multisectoral model in the base year (t = 0), given outputs and final demand (components) time series, let us say, …f_{-3}, f_{-2}, f_{-1}, f_0, f_1, f_2, f_3…and ….q_{-3}, q_{-2}, q_{-1}, q_0, q_1, q_2…, in general, out of the base year, $A_0q_t + f_t \neq q_t$. Therefore, the coefficient matrix A, must necessarily change over time.

However, in building input-output models for comparative static analysis, modeling a matrix of technical coefficients is not a priority; but it may be the cornerstone scenario variable when changes of technical coefficients are the crucial component of an experimental design. This is the case, for example, of those numerous research efforts investigating the impact of carbon oxide reduction policies that imply changes in production functions.

Suggestions for modeling the matrix of technical coefficients in dynamic multisectoral models come from accounting identities. In fact, if an I-O table time series is available, a coefficient matrix time series A_t (for t = ….–3, –2, –1, 0, 1, 2, …) can be computed, and a balanced Leontief equation in real term is obtained up to the last available year. A time series of matrix A_t may easily help projections of the technical coefficient matrix up to the time horizon of a planned simulation. In the model builder's strategy for building an Interindustry Multisectoral model, the econometric estimation of final demand components, value added primary inputs, price formation, and sectoral labor productivity, as well as macrovariables such as disposable income come before modeling matrix A. Therefore, at the beginning of the construction of an Interindustry Multisectoral model, a technical coefficients matrix may be not modeled, but placed among the scenario variables.

However, the impact of growing imports on the solution of the Leontief equation requires appropriate changes in the coefficient matrix. Let us state the Hawkins-Simon conditions (Hawkins & Simon, 1949) quoting their corollary using the present notation: "A necessary and sufficient condition that the q_i satisfying $Aq + f = q$ are all positive for any set $f > 0$ is that all principal minors of matrix A are positive". Furthermore, they remind us that this corollary comes from a theorem where it is assumed that the elements of matrix A are independent of the elements of f.

Let us consider the Leontief equation for a two sector economy:

$$\begin{bmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \end{bmatrix} \quad (1)$$

from which the final demand vector f, can be represented as a linear combination of two vectors and two scalars, q_1 and q_2:

$$\begin{bmatrix} 1-a_{11} \\ -a_{21} \end{bmatrix} q_1 + \begin{bmatrix} -a_{12} \\ 1-a_{22} \end{bmatrix} q_2 = \begin{bmatrix} C_1 \\ C_2 \end{bmatrix}. \quad (2)$$

The Hawkins-Simon conditions are conditions for assuring a strictly positive solution (namely, q_1 and q_2) of a linear system where the parameters a_{ij} are assumed greater than or equal to zero and less than one. In the Hawkins-Simon paper, the empirical source of these parameters is not stated. INFORUM Interindustry models and any other input-output models that refer to an observable economy are based on I-O tables. Since the Leontief equation is a transformation of the accounting system of the I-O table, its standard solution $q = (I - A)^{-1}f$ is a strictly positive vector: the output vector of the I-O table. However, such a solution is not necessarily due to a strictly positive vector f as stated by the Hawkins-Simon conditions. In fact, net exports is a vector with negative and positive elements and the negative elements may prevail over the other non-negative components of final demand; however, the solution is still productive because the Leontief equation is simply an analytical transformation of the I-O table.

The geometrical representation of the above equation is shown in Fig. 1; it gives evidence of the solutions of the Leontief equation with strictly positive f_1 and non-strictly positive f_2 final demands; following the parallelogram rule, the representation of these vectors with the vector basis (the column vectors of matrix I-A) is obtained with positive scalars: the outputs.

Let us consider the case of the final demand vector shown in Fig. 2; this vector basis fails to relate the final demand to a positive set of outputs. A vector basis giving a positive solution with vector f may be obtained by changing (increasing) the vector's second coordinates a_{21} and a_{22} to a^*_{21} and a^*_{22}.

This geometrical representation has a rational economic base as shown in the following numerical example. Let us consider the product by product I-O table (Table 1) with three products, one domestic final

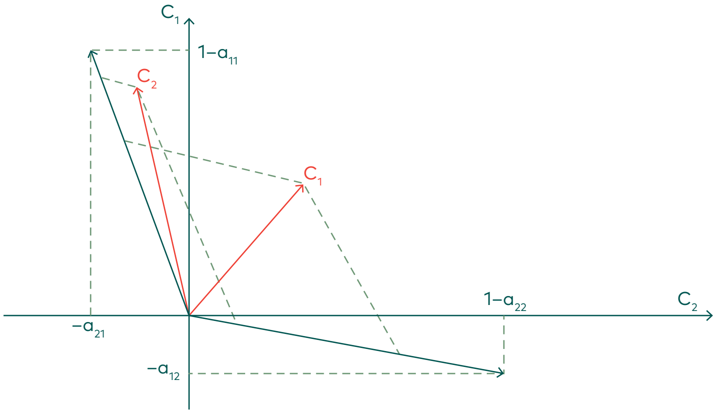

Fig. 1. Geometrical representation of the Leontief equation.

demand (DFD) vector on the USES side and imports and output on the RESOURCES side.

The coefficient matrix is

$$A = \begin{bmatrix} 0.30 & 0.29 & 0.56 \\ 0.21 & 0.22 & 0.31 \\ 0.16 & 0.15 & 0.22 \end{bmatrix}. \tag{3}$$

And its Leontief inverse is

$$(I-A)^{-1} = \begin{bmatrix} 2.30 & 1.26 & 2.16 \\ 0.89 & 1.87 & 1.39 \\ 0.65 & 0.61 & 1.99 \end{bmatrix}. \tag{4}$$

And, of course, multiplying the Leontief inverse by the final demand from the I-O table (Table 1), the total output in the table is replicated:

$$(I-A)^{-1} \cdot (\text{DFD} - \text{imports}) = (I-A)^{-1} \cdot \begin{bmatrix} 9 \\ 20 \\ 17 \end{bmatrix} = \text{output} = \begin{bmatrix} 61 \\ 55 \\ 32 \end{bmatrix}. \tag{5}$$

If imports of Product 3 increases from 8 to 18, the corresponding element of the final demand becomes –3 and the outputs from the Leontief equation are still positive:

$$(I-A)^{-1} \begin{bmatrix} 9 \\ 20 \\ -3 \end{bmatrix} = \begin{bmatrix} 39.4 \\ 41.2 \\ 12.1 \end{bmatrix}. \tag{6}$$

The Hawkins-Simon corollary assumes that final demand is strictly positive and clearly even if final demand has some negative element, the

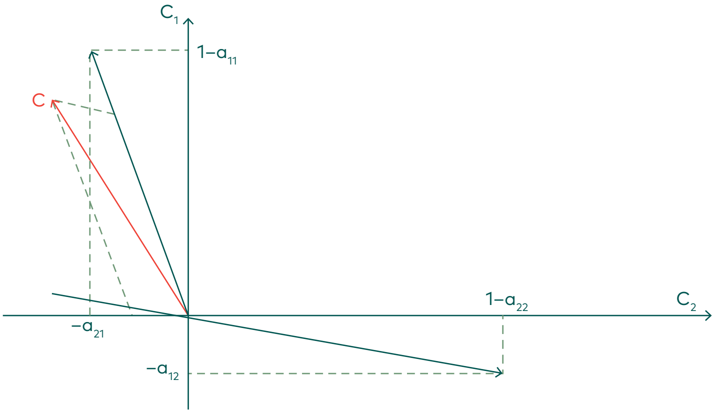

Fig. 2. Matrix A fails to match a positive set of outputs.

solution can still be productive (C_2 in Fig. 1). But if Product 3 imports change from 8 to 25, the corresponding element of final demand moves from 15 to –10 and

$$(I-A)^{-1}\begin{bmatrix}9\\20\\-10\end{bmatrix}=\begin{bmatrix}24.3\\31.5\\-1.8\end{bmatrix}. \tag{7}$$

The negative output of Product 3 reveals that the coefficient matrix does not match a "suitable" representation of Table 1 (C in Fig. 2). With the increase of imports from 8 to 25, resources of Product 3 change from 40 to 57 and the I-O table becomes unbalanced, because the uses of Product 3 remain 40. If the final demand of Product 3 is assumed to maintain the previous level (15) as well as the output of Product 3, the identities in the table imply that the total intermediate consumption of Product 3 needs to increase by the same amount that imports increase. This leads to tackling of the problem of "updating" technical coefficients in matrix A.

Table 1

Product I-O table

	RESOURCES			USES				
	Output	Imports	Total	Prod 1	Prod 2	Prod 3	DFD	Total
Prod 1	61	25	86	18	16	18	34	86
Prod 2	55	28	83	13	12	10	48	83
Prod 3	32	8	40	10	8	7	15	40

3. Updating the technical coefficients in matrix A

One of the primary uses of Leontief input-output economics is impact analysis based on output multipliers for measuring the effect of a change in final demand (Miller & Blair, 2009). Every input-output analysis is based on the Leontief equation deduced from I-O accounting identities from which the basic "identity" structure $q_0 = (1 - A_0)^{-1} \cdot f_0$ is computed. If f_1 is the final demand chosen according to a given research strategy, then the impact analysis is usually measured with $q_1 = (1 - A_0)^{-1} \cdot f_1$.

Vectors q_1 and f_1 are now a part of a new I-O table where intermediate consumption flows can be computed back from matrix A_0. In an I-O table built this way, row identities (resources versus uses) fail to match. Since final demand components are part of the scenario, variables chosen by the model builder and output is a dependent variable, the identities can be restored only by changing the technical coefficients matrix, so that $q_1 = (1 - A_1)^{-1} \cdot f_1$ where A_1 is the "updated" matrix. If the changes in the final demand are expected to occur in the short run, let's say one year, changes in matrix A may be considered a minor point. On the other hand, if the impact analysis refers to long run forecasting, matrix A may become seriously "outdated". Furthermore, an outdated matrix A cannot be compatible with a positive output vector.

An economic example may help understand why technical coefficients need to be updated. Let us consider the case of an increase in oil imports due to an energy policy addressed to increase the production of energy based on fossil fuel in a country with no oil fields. Oil is a pure intermediate consumption commodity; it is neither in the household basket nor an investment good. Therefore, the oil intermediate consumption flows necessarily increase, final demand does

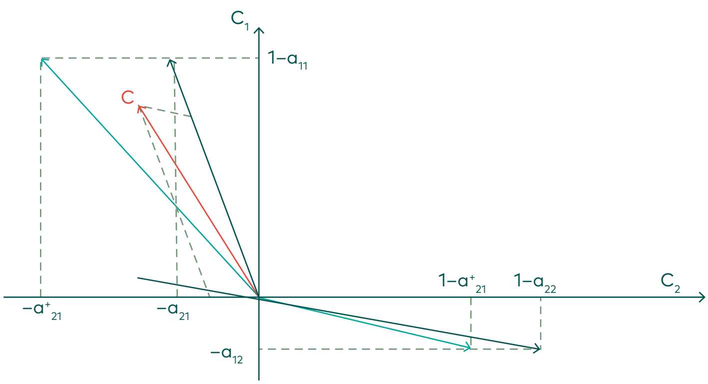

Fig. 3. Solution with positive outputs changing the second row of matrix A.

not change and, consequently, outputs remain unchanged while technical coefficients of oil increase.

A geometrical representation of this economic example shows the impact of a technical coefficient change for "restoring" a productive solution. In Fig. 3 there are two vector bases that differ from matrix A second row technical coefficients where a^*_{21} and a^*_{22} are greater than, respectively, a_{21} and a_{22}; thereafter, the representation of vector f is still a linear combination of matrix A column vectors with positive scalars: a solution with positive outputs.

However, matrix A_0 is the industry technology obtained from an I-O table and is necessarily assumed to be measured in real terms, and each column sum of matrix A_0 is less than one. Substituting elements a_{21} and a_{22} with a^*_{21} and a^*_{22}, column sums of matrix A_1 turn out to be greater than those of A_0. It is known that the A_1 output multiplier is greater than that of A_0. Figure 3 shows the geometrical impact on matrix multiplier of moving from the A_0 vector basis to the A_1 vector basis. The angle between the vector basis in A_1 is wider than that in A_0, so that the "scalars" – the outputs – of vector f represented in term of A_1 vector basis are greater than those in A_0. On the other hand, in a long run forecast, the above mentioned annual updating of matrix A increases progressively the column sum of matrix A, which, sooner or later, leads to a non-productive economy. However, a way to prevent such an outcome is scaling the column sum of matrix A_1 with respect to that of A_0.

4. Modeling technical coefficient changes in an INFORUM type model

Outputs, investments, imports and exports are the main endogenous variables of the real side of the INFORUM model that is a member of a system of country models linked through a Bilateral Trade Model (BTM); this (truly bilateral) model generates country exports based on country imports so that exports turn out to be endogenous in the system of models. In particular, the generation of country exports takes into account endogenous variables from the price side of the models, specifically the prices themselves. Household consumption depends on prices and disposable income; disposable income comes from the primary and the secondary income distribution and is computed in the process of aggregation (bottom-up) of sectoral variables to compute endogenous macrovariables.

However, the solution of the model implies the solution of the standard Leontief equation that is one cornerstone of the model real side. To tackle the problem of displaying a functioning economy, the relations described above between output and imports have to be properly modeled.

Remarks

INFORUM country models are designed to run together with the Bilateral Trade Model (BTM). BTM (Ma, 1996; Bardazzi & Ghezzi, 2018) is a model designed to take the sectoral imports from each country model and allocate them to the exporting countries within the system; this allocation is done by means of import share matrices computed from trade flow matrices built for several commodities (the number of commodities in BTM is larger than a country sectoral imports detail). For each commodity, the sum of imports demanded by each country in the system to a given country turns out to be equal to its exports; then BTM ensures that for each commodity in the world market total imports are equal to total exports.

The key task of the model is to calculate the movement in import-share matrices. Each import share in each import-share matrix is assumed to be influenced by price and technology competitiveness. Price competitiveness is measured with domestic price versus world price, and technology competitiveness is related to industry capital stock with special attention to the weight of new investment.

First, imports by product, prices by product, and capital investment by industry are taken from the national models. Then the model allocates the imports of each country among supplying countries by means of the import share matrices mentioned above. BTM takes prices, imports and investments from country models and gets back import prices and exports to them.

To take advantage of being a part of the INFORUM system of models, each country model needs to properly supply the BTM with its domestic prices, imports and investments, as well as to receive import prices and exports. In this respect, modeling imports described in the present paper is not an end in itself, but a cornerstone of the INFORUM system of models.

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PADS FOR RUSSIA: TENTATIVE RESULTS

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Introduction

Russian household consumption expenditures have been growing for the last two decades, beginning at the peak of the transformation crisis in the middle of the 1990s, and have become one of the main engines of economic growth. Several times during the period, consumption expenditures slumped abruptly, but every decline was followed by further increase.

At the same time, Russian household consumption patterns have a few intricate and unexpected features. There is a need for a tool that can explore these patterns and features, explain past changes of consumption, and forecast its structure. The tool must cover consumer choice theory and simultaneously allow the user to build a model that takes into account (1) changes of income and the relative prices of goods and services, and (2) substitutability and complementarity of goods and services, and a wide range of other variables.

The Perhaps Adequate Demand System (PADS) proposed (Almon, 1979) and then developed by both the founder of the system (Almon, 1996) and his colleagues (Bardazzi & Barnabani, 2001) is a perfect tool for the task. This paper describes the use of some PADS applications for Russian data and presents its tentative results.

1. Data availability

One of the constraints imposed on applying PADS for Russia is the absence of required long-term time-series for household consumption expenditures. The Russian State Statistics Service has been collecting data in a national accounts framework since the beginning of the 1990s, therefore we have decent historical data for total household consumption expenditures. However, data that corresponds to the widely used Classification of Individual Consumption on Purpose (COICOP) has only been collected since 2004.

Moreover, a couple of years ago Russian State Statistics made the transition from SNA1993 to SNA2008 methodology. The main difference of the methodologies that affects household consumption is the calculation of imputed rentals for housing in SNA2008. Together with other changes, old and new time series are not quite commensurable. It is aggravated by the fact that there are no long parallel time series for these methodologies. As a result, nowadays researchers cannot correctly compare household consumption in 2004–2013 with period 2014–2016.

In this paper, we analyze household consumption expenditures in period 2004–2013 for 24 COICOP items and net purchases abroad. These 25 items demonstrate the most detailed picture of household consumption that Russian national accounts can give.

2. Russian household consumption expenditures: retrospective

Russian household consumption expenditures in constant prices have increased by 3 times in 1996–2014 (Fig. 1). In spite of the economic crisis and slump of household consumption in 2015–2016, its volume is still 2.5 times higher than two decades ago. Notably, such rapid growth of household consumption is not an indicator of incredibly prosperous conditions, but largely the implication of its dramatic drop in the 1990s, during the transformation crisis.

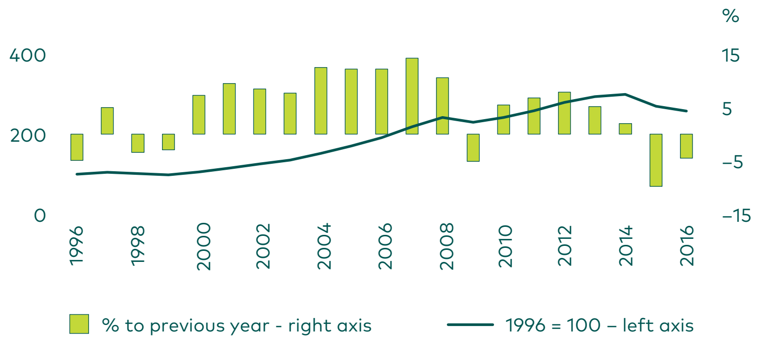

Fig. 1. Dynamics of total household consumption expenditures.

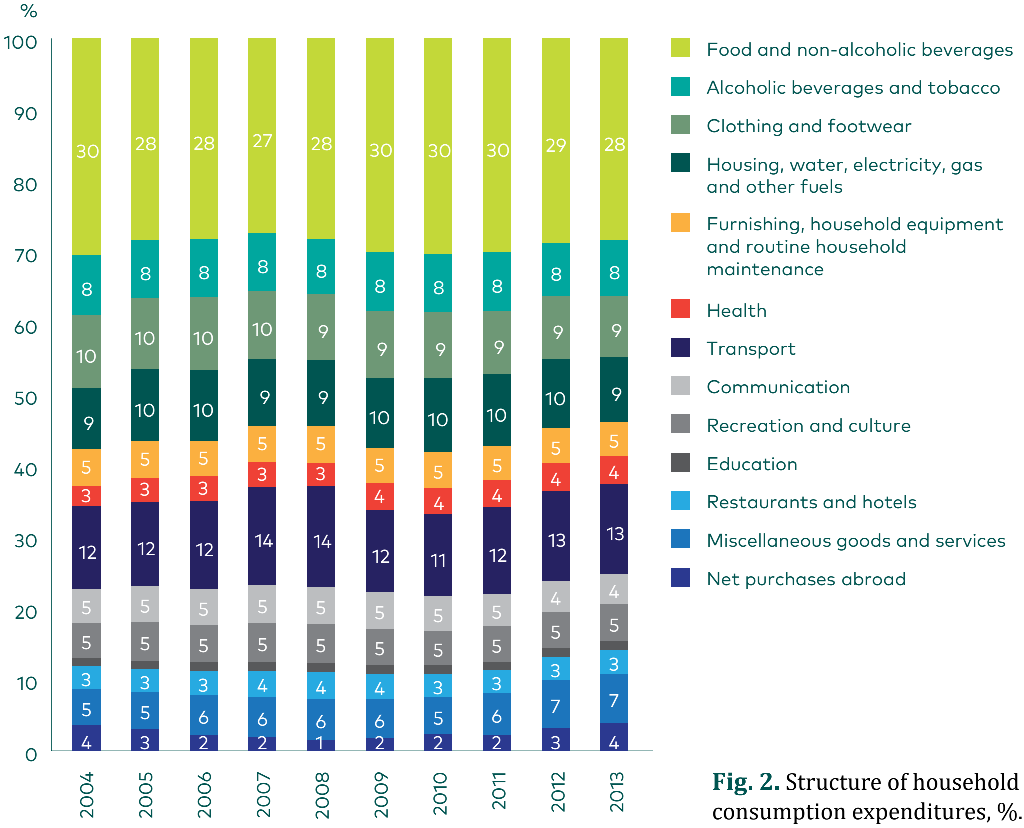

Fig. 2. Structure of household consumption expenditures, %.

The main feature of the structure of household consumption expenditures in Russia is its outstanding stability. Figure 2 splits household consumption into 12 top-level items of COICOP classification and net purchases abroad. The strongest shift of shares that these 13 positions took in 2004–2013 is attributed to net purchases abroad: 3 percentage points (in 2008–2013). The shifts of other items are only 2 percentage points or less. The situation is quite odd taking into account the growth of household consumption's volume by several times.

Another very odd feature of Russian household consumption structure is a very high and stable share of expenditures for food and non-alcoholic beverages: 27–30 % in 2004–2013. The share is enormous in comparison with countries that have approximately the same income and economic development level. In addition, the share of food expenditures seems to be invariant to income changes. There are two initial conjectures that might explain this food expenditures pattern. First, the relatively high price level for food in the country. Second, great wealth and income inequality, when demand for food is determined by the majority of people with relatively low income.

Another feature of the structure is low shares of expenditures on entertainment (recreation, culture, restaurants, and hotels). In part, it is explicable through high shares of food and non-alcoholic beverages and clothing and footwear.

The combination of rapid growth of household consumption expenditures' volume and its stable structure may lead to suggestion about allegedly equal growth of most of the consumption items. However, this is incorrect (Fig. 3). For instance, during 2004–2013 the volume of net purchases abroad increased by 5.4 times (this item is not displayed in Fig. 3 in order to improve readability of other items). The volume of household consumption expenditures in communication increased by 3.1 times, in miscellaneous goods and services – by 2.7 times, and in recreation and culture, health and transport – by 2.3–2.5 times. Consumption of food and non-alcoholic beverages grew at a slower rate: its volume increased by 1.7 times. The growth of expenditures on alcohol and tobacco was humbler: increasing only 1.5 times during 2004–2013.

By definition, maintenance of stable expenditures structure and varying growth rates of consumption volumes can coexist if price changes follow a determined pattern. The pattern suggests higher deflators for goods and services, volumes of which had been showing low growth rates, and vice versa.

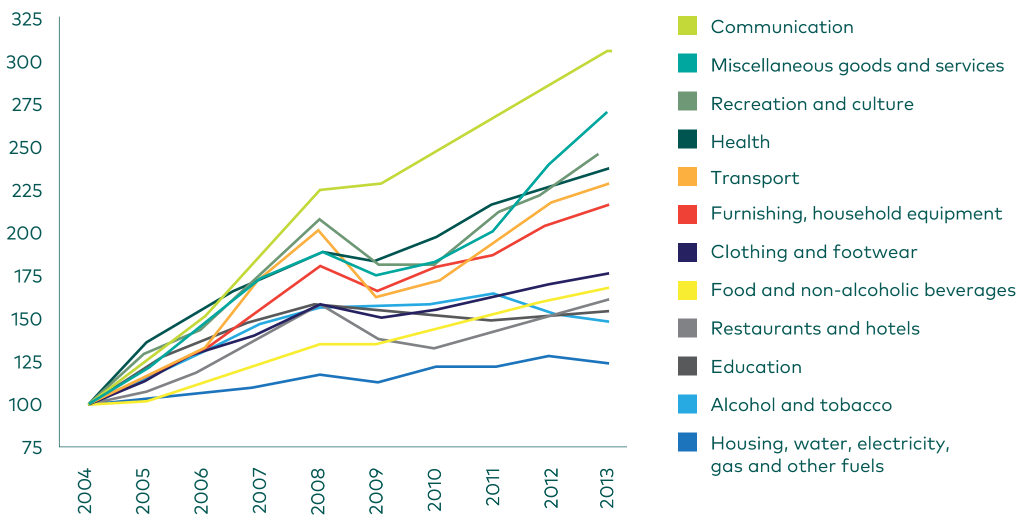

Fig. 3. Volumes of household consumption expenditures, 2004 = 100.

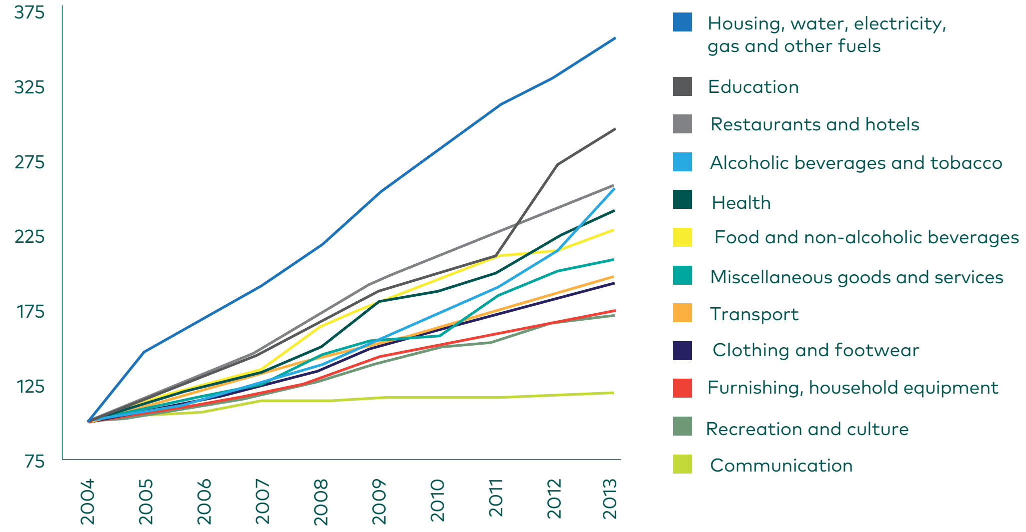

Fig. 4. Deflators of household consumption expenditures, 2004 = 100.

Net purchases abroad had the most significant volume increase, but simultaneously had a price decrease – their 2013 deflator is just 82 % of the 2004 level. The price level of household expenditures in communication increased only 1.2 times (Fig. 4), in recreation and culture –1.7 times, and in transport –2.0 times. The most substantial growth of price deflators – by 3.6 times – regards housing, water, electricity and other fuels, the same item that demonstrated the slowest increase of consumed volume.

3. Estimation of PADS for Russia

The most appropriate and correct mode of estimation of PADS equations is to launch a program specially written for solving the task in some programming environment. However, to apply the demand system for Russian data, we used a simplified procedure in Excel. Despite the simplicity of the procedure, the expected results have been obtained. Nevertheless, Excel is not conducive to many actions that can improve the quality of estimates.

The core of the estimation procedure is applying the Excel tool Solver. The tool enables optimizing the value of one cell depending on any range of cells within the limit of 200 modified variables and 100 constraints. The Solver can solve nonlinear tasks with the generalized gradient descent method. To give a task to the tool, one should set an optimized cell, a group of cells to be modified, and constraints. As a whole, the solving process is a black box: the user cannot see what happens, but only gives input and gets results.

The estimation of PADS with Solver implies the minimization of the sum of squared residuals of PADS equations by all years and goods and services. The cells, which have to be modified by the Solver optimization process, are constant terms (ai), time trends (bi), coefficients on real income (ci), coefficients on change of real income (di), lambdas (λ_i and λ_k), μ_G and ν_g.

Estimated PADS equations are written in (1):

$$x_i = (ai + bi \cdot t + ci \cdot \left(\frac{y}{P}\right) + di \cdot \Delta\left(\frac{y}{P}\right)) \cdot \left(\frac{p_i}{P}\right)^{-\lambda_i} \prod_{k=1}^{n} \left(\frac{p_i}{p_k}\right)^{-\lambda_k \cdot s_k} \left(\frac{p_i}{P_G}\right)^{-\mu_G} \left(\frac{p_i}{P_g}\right)^{-\nu_g} \qquad (1)$$

where

x_i – consumption per capita of item i in constant prices;

t – time;

y – nominal total expenditures (or income) per capita;

P, PG, Pg – overall, group and subgroup price indexes, respectively;

Δ – difference between *t* and *$t–1$* values;

p_k – price index for item *i* (in the base year = 1);

s_k – share of item *i* in the expenditures of the base year;

ai, bi, ci, di, λk, μG, νg – parameters to be estimated.

Specification of the PADS equations for Russia also included formation of 4 groups and 2 subgroups of homogenous goods and services (Table 1, columns G and S):

- Group 1 “Food”;
- Group 2 “Clothing and footwear”;
- Group 3 “Health”;
- Group 4 “Transport”;
- Subgroup 1 “Proteins” (within “Food” group);
- Subgroup 2 “Personal transport” (within “Transport” group).

While trying to estimate PADS for Russia, the decision to expel time trends from equations for each good and service was made. The decision is justified by a few combined causes: relatively short time series, rapid growth of real income, growth of consumption volumes for all product items, and low levels of consumption in the beginning of the estimation period. Due to these causes, simultaneous application of both real income and time trends in the estimated equation created issues with multicollinearity of the variables and gave hardly interpretable results. Presumably, variation of consumption volumes was not sufficient for revealing shifts in consumers’ tastes and habits, which had to be exposed by using time trends.

4. Results without constraints

Initial results were obtained without imposing any constraints on the estimated parameters (the results are presented in Table 1). The quality of the equation's fitting seemed to be appropriate for most of the items. The standard error of the estimate (as a % of 2010 value) exceeded 10 % only for 4 of 25 items. The residuals' autocorrelation coefficient was above 50 %, 40 %, and 20 % for 5, 10, and 16 items, respectively.

Table 1

Estimation Results (No Constraints)
Weighted Lambda L = 0.141, μ_1 = 0.22, μ_2 = 4.89, μ_3 = 0.30, μ_4 = 2.13, v_1 = −1.16, v_2 = −0.29

№	Title	G	S	Lamb	Share	IncEl	Dinc	PrEl	Err%	Rho
1	Bread and cereals	1		0.00	4.1	1.12	0.16	-0.34	3.2	-0.07
2	Meat	1	1	0.22	8.5	1.21	0.23	-0.01	3.7	0.06
3	Fish and seafood	1	1	0.67	1.6	0.96	-0.03	**0.03**	1.6	0.75
4	Milk, cheese and eggs	1	1	0.99	4.3	1.07	0.12	-0.43	4.3	0.48
5	Oils and fats	1		0.08	1.2	1.15	0.22	-0.44	1.5	0.45
6	Fruit and vegetables	1		0.04	5.6	1.15	0.11	-0.35	7.2	0.36
7	Food products n.e.c.	1		−0.07	2.7	0.97	−0.01	−0.28	2.0	0.06
8	Non-alcoholic beverages	1		−1.74	2.2	**−0.75**	**−1.74**	1.31	6.2	0.51
9	Alcoholic beverages			1.34	6.2	1.08	0.17	−1.32	8.6	0.46
10	Tobacco			0.10	1.9	0.96	0.00	−0.23	1.6	−0.14
11	Clothing	2		0.66	7.1	0.96	−0.02	−1.85	3.7	−0.01
12	Footwear	2		−2.74	2.2	1.44	0.47	−1.27	2.6	0.19
13	Housing, water, electricity, gas and other fuels			0.32	10.4	1.77	0.91	−0.40	14.4	0.26
14	Furnishing, household equipment and routine household maintenance			0.46	5.1	0.70	−0.29	−0.55	2.7	−0.23

№	Title	G	S	Lamb	Share	IncEl	Dinc	PrEl	Err%	Rho
15	Medical products, appliances and equipment	3		1.94	2.0	0.11	−0.89	**−2.14**	3.1	0.19
16	Outpatient and hospital services	3		−0.13	1.6	1.70	0.70	−0.18	2.5	0.44
17	Purchase of vehicles	4	2	−0.52	4.9	1.48	0.32	−0.77	15.0	0.24
18	Operation of personal transport equipment	4	2	−1.78	3.3	0.31	−0.69	**0.18**	7.2	0.89
19	Transport services	4		−2.06	3.3	2.40	1.48	**0.27**	9.7	0.19
20	Communication			0.32	4.8	**−0.32**	**−1.31**	−0.43	6.6	−0.05
21	Recreation and culture			0.75	4.8	0.83	−0.23	−0.82	5.2	0.19
22	Education			0.39	1.2	1.40	0.46	−0.52	1.6	0.35
23	Restaurants and hotels			0.25	3.3	1.62	0.57	−0.38	4.9	0.50
24	Miscellaneous goods and services			−0.44	5.3	0.69	−0.37	**0.25**	12.6	0.79
25	Net purchases abroad			2.17	2.3	**−0.65**	**−1.53**	−2.21	15.7	0.53

Notes: G – groups; S – subgroups; λ – lambda estimated; share – share of an item in 2010; IncEl – income elasticity in 2010; Dinc – ratio of coefficient on the change of income and income coefficient; PrEl – own price elasticity; Err – the standard error of estimate as % of 2010 value; Rho – residuals' autocorrelation coefficient; μ and ν – coefficients for groups and subgroups, respectively.

However, some of the estimated parameters seemed obviously logically incorrect or at least hardly explicable (these values are indicated as bold in Table 1). These inappropriate estimates can be split into several categories.

Negative income elasticities: non-alcoholic beverages, communication, and net purchases abroad.

Positive price elasticities: fish and seafood, non-alcoholic beverages, operation of personal transport equipment, transport services, and miscellaneous goods and services.

Ratio of coefficients on change of real income and on real income below –1: non-alcoholic beverages, communication, and net purchases abroad.

Other situations: a) very high negative value of own price elasticity for medical products, appliances and equipment that contradicts the suggestion about low price sensitivity of these vitally important goods; b) very high value of μ_2 coefficient for clothing and footwear.

5. Results with imposed constraints: tentative results

Results with imposed constraints are given in Table 2.

For improving the logical interpretability of the estimated parameters, a set of constraints was imposed on them, including the following:

- price elasticities must be negative for all items;
- price elasticity for medical products, appliances and equipment must be inside of interval (–1; 0);

Table 2

Results with Imposed Constraints

Weighted Lambda L = 0.256, μ_1 = 0.22, μ_2 = 2.00, μ_3 = 0.30, μ_4 = 2.13, v_1 = –1.16, v_2 = –0.29

№	Product group	λ	Share	IncEl	Dinc	PrEl	Err%	Rho
1	Bread and cereals	0.00	4.1	1.12	0.16	–0.45	3.4	0.04
2	Meat	0.22	8.5	1.21	0.23	–0.12	4.3	0.13
3	Fish and seafood	0.99	1.6	0.96	–0.03	–0.39	1.6	0.73
4	Milk, cheese and eggs	0.99	4.3	1.07	0.12	–0.54	4.6	0.52
5	Oils and fats	0.08	1.2	1.15	0.22	–0.55	1.6	0.40
6	Fruit and vegetables	0.04	5.6	1.15	0.11	–0.47	7.9	0.30
7	Food products n.e.c.	–0.07	2.7	0.97	–0.01	–0.40	2.4	0.13
8	Non-alcoholic beverages	–0.25	2.2	1.02		–0.23	9.7	0.92
9	Alcoholic beverages	1.34	6.2	1.08	0.17	–1.43	8.6	0.41
10	Tobacco	0.10	1.9	0.96	0.00	–0.35	1.7	0.03
11	Clothing	1.00	7.1	0.96	–0.02	–1.58	5.3	0.49
12	Footwear	–1.48	2.2	1.44	0.47	–0.37	2.0	0.21
13	Housing, water, electricity, gas and other fuels	0.32	10.4	1.77	0.91	–0.51	15.7	0.20

№	Product group	λ	Share	IncEl	Dinc	PrEl	Err%	Rho
14	Furnishing, household equipment and routine household maintenance	0.46	5.1	0.70	−0.29	−0.66	2.5	−0.31
15	Medical products, appliances and equipment	0.61	2.0	0.11	−0.89	−0.98	3.7	0.59
16	Outpatient and hospital services	−0.13	1.6	1.70	0.70	−0.30	2.6	0.48
17	Purchase of vehicles	−0.52	4.9	1.48	0.32	−0.88	14.9	0.25
18	Operation of personal transport equipment	−1.28	3.3	0.31	−0.69	−0.41	7.3	0.90
19	Transport services	−1.64	3.3	0.97		−0.24	4.4	0.56
20	Communication	0.32	4.8	1.02		−0.54	8.4	0.72
21	Recreation and culture	0.75	4.8	0.83	−0.23	−0.94	5.1	0.24
22	Education	0.39	1.2	1.40	0.46	−0.64	1.6	0.25
23	Restaurants and hotels	0.25	3.3	1.62	0.57	−0.49	5.2	0.50
24	Miscellaneous goods and services	−0.01	5.3	0.69	−0.37	−0.25	13.0	0.80
25	Net purchases abroad	2.17	2.3	1.23		−2.33	17.3	0.49

Notes: λ – lambda estimated; share – share of an item in 2010; IncEl – income elasticity in 2010; Dinc – ratio of coefficient on the change of income and income coefficient; PrEl – own price elasticity; Err – the standard error of estimate as % of 2010 value; Rho – residuals' autocorrelation coefficient; μ and ν – coefficients for groups and subgroups, respectively.

- coefficients on change of income must be removed for non-alcoholic beverages, transport services, communication, and net purchases abroad;
- value of μ_2 coefficient for clothing and footwear must be below 2.

After imposing the constraints, the quality of the estimation fitting necessarily worsened, but remained rather satisfactory. Figure 5 shows actual and forecast household consumptions expenditures per capita in constant prices for some of the considered COICOP items. The same picture is also typical for the rest of goods and services not displayed on the plots. Although volumes of consumption expenditures per capita differ in initial level, growth rates, presence of slumps and boosts, and the forecast curves are pretty close to the actual values.

Fig. 5. Actual and forecast volumes of household consumption expenditures by selected COICOP items, thousands of 2010 Russian rubles.

Due to consumer price theory, own price elasticities of all goods and services must be negative and relatively high in absolute magnitude in comparison with absolute values of cross price elasticities. With this, values of cross price elasticities must be positive for most of the items. If several items form a group or a subgroup of goods and services, then their cross price elasticities must be comparable in magnitude with own price elasticities, while their signs can be both positive and negative according to substitutability or complementarity of the items.

In general, the values of calculated cross price elasticities correspond to expectations determined by consumer price theory. In some cases, several cross price elasticities appear to be positive, which is incorrect, but their magnitudes are too low to seriously influence the results.

The highest values of income elasticities belong to housing, water, electricity, gas and other fuels (1.77), outpatient and hospital services (1.70), restaurants and hotels (1.62), and purchase of vehicles (1.48). Housing, water, electricity, gas and other fuels include expenditures on maintenance and repair of the dwelling that is believed to have determined such a high value of income elasticity. We can suggest that dwelling conditions are very important for Russians, and growth of income allows for housing repair. The importance of repair expenditures is underscored by a high share of old dwellings and the existence of additional countryside houses that belong to millions of urban inhabitants in the country. High income elasticity of outpatient and hospital services can be explained by overcrowding of public health offices and sometimes by doubts about the quality of public health services.

The lowest values of income elasticities belong to medical products and appliances and equipment (0.11), which is quite natural because of the vital necessity of some drugs, and operation of personal transport equipment (0.31).

The highest estimated own price elasticity belongs to net purchases abroad (2.33). It is an evident consequence of internet trade development throughout the world, which makes conditions for cheaper goods and faster deliveries. This item is followed by clothing, which has own price elasticity that equals –1.58.

Alcoholic beverages also have large negative price elasticities (–1.43). Stagnation in 2008–2011 and reduction in 2011–2013 of household consumption expenditures' volume of alcoholic beverages was accompanied by acceleration of their price growth since 2009 (Fig. 4). The changes of the variables have led to an initial conjecture about unusually high price sensitivity of alcohol consumption in Russia. Further, the conjecture can be modified or supplemented with other ones. For instance, stagnation and reduction of alcohol consumption may have been caused by increased government enforcement in the alcohol market and by generational shifts of behavioral patterns.

Further developments

The results presented in this paper are tentative and necessarily require further development. The development can touch new iterations for adjusting, cleaning and improving the estimates and getting better equation fitting and logically interpretable parameter values.

In addition, it would help to use a more appropriate programming environment for PADS estimation. Nevertheless, the simplified estimation procedure depicted in the paper has a very easy learning curve and can be used for rapid PADS calculations. Another important direction of further development is the construction of some bridge between Russian COICOP data in SNA2008 and SNA1993. Accomplishing this task will probably allow for inserting time trends into equations specification.

The application of PADS for Russian data should finally become a base for analysis of patterns and features of household consumption expenditures and one of the main parts of the Russian INFRORUM-type model RIM.

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POLICY ISSUES AND FORECASTS — 2

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GREAT AGAIN?
TAX REFORM AND THE PROSPECTS FOR U.S. GROWTH

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We will make America strong again.
We will make America proud again.
We will make America safe again.
And we will make America great again.

Donald Trump

The slogans above were repeated like a mantra in Donald Trump's 2016 campaign appearances. These, and oft heard shouts of "Build the wall![1]" and "Lock her up![2]" provided an easily recognizable brand to the campaign. But why did the phrase "make America great again" resonate so strongly with Trump voters? Wasn't the U.S. the world's largest economy, with the most powerful military, a good place to invest and do business, and a yardstick for productivity and efficiency? With an unemployment rate under 5 percent, a strong stock market, and an economic expansion entering its sixth year, wasn't America already great?

Despite the apparently strong macroeconomic reports, the economic situation was not good for many Americans. The low unemployment rate is consistent with two negative features of the U.S. labor market: 1) historically low labor force participation rates; and 2) several years of sub-par labor productivity growth. Many potential workers, especially males in their 40s to 60s, may be discouraged by lack of opportunity, and no longer in the labor force. Low productivity growth is one of the causes of slower growth of real wages. In fact, the growth of real median

[1] A border wall to keep out Mexicans and other Hispanic illegal immigrants.

[2] Referring to Secretary Clinton's inappropriate use of a private e-mail server for government business.

household income has been remarkably slow, compared to the growth of average real personal income, which includes the wealthy. GDP growth, while positive, has not been especially high. Average GDP growth since the end of the recession (2009) to 2016 has been just under 2.1 percent.

The U.S. has seen huge gains in globalization, and the size of the foreign-born population is at an all-time high. Not only do imports make up a larger share of domestic purchases, but there has been significant offshoring of formerly U.S. production activity. Many U.S. corporations now produce the majority of their output overseas. Perhaps due to perverse tax incentives, foreign earnings of U.S. owned firms are discouraged from being re-invested in the U.S. In cities and towns across the country, people see immigrants performing construction jobs, cleaning services, working in retail, driving taxis and working in fast food restaurants. It is not hard for unemployed Americans to conclude that foreigners have "stolen" their jobs, and that large multinational corporations have chosen to ship jobs overseas. There is a sense of economic malaise among many in the U.S. population.

In 2016, a group called Morning Consult conducted a survey of a sample that included both Democrats and Republicans, old people and young people. There was a clear demographic divide between Republicans and Democrats. When asked if life was better for people like them 50 years ago, 66 percent of Republicans answered yes. Among Trump voters, the share was 75 percent. Among Democrats, only 28 percent said it was better 50 years ago. The second most popular period for Republicans was the early 80s, in the first term of Ronald Reagan's presidency (Sanger-Katz, 2016)[3]. Clearly the standard of living and quality of life measured by numerous indicators has improved since 1967. How can so many people believe that former times were better?

1. The setting: America in 2016

Americans that have lived through the 60s and the 80s know that a lot has changed. To better understand the perception of America in 2016, let's do a direct comparison with economic and demographic descriptors of the U.S. about 50 years ago, in 1967.

Table 1 shows a sample of important economic and demographic facts about the U.S. in 1967 and in 2016. In 1967, real GDP had grown at an average annual rate of 5.1 percent in the previous 5 years. In 2016, the corresponding 5 year growth rate was only 2.1 percent. This slower

[3] By the way, Ronald Reagan had the campaign slogan "Let's make America great again" in 1980, but Trump claims to have been unaware of this!

growth can partly be explained by slower population and labor force growth, but also by a lengthy period of slow productivity growth after the Great Recession (Fig. 1). The U.S. economy had become much more open since 1967, but this openness is dominated by imports, which have grown from 4.6 percent of GDP to 14.7 percent by 2016. This has contributed to declining employment in goods-producing sectors, especially manufacturing. Employment in goods-producing sectors has fallen from 34.3 percent of total employment in 1967 to 11.5 percent in 2016. Many of the jobs that have been lost are traditionally male-dominated, and the male labor-force participation rate has declined significantly.

Table 1

The U.S. in 1967 and 2016

Economic and demographic facts	1967	2016
Average real GDP growth (last 5 years)	5.1 percent	2.1 percent
Average labor productivity growth (last 5 years)	3.0 percent	0.7 percent
Average population growth (last 5 years)	1.3 percent	0.7 percent
Imports to GDP (percent)	4.6 percent	14.7 percent
Share of employment in goods-producing industries	34.3 percent	11.5 percent
Federal debt per household (2016$)	25.5 thousand	111.6 thousand
Health care spending per capita (2016$)	$1,428	$10,448
Share of immigrants in the population	4.9 percent	13.7 percent
Gini Coefficient (measure of inequality)	0.36	0.46
Share of over 65 population	9.6 percent	14.9 percent
Labor force participation rate, men, 20–64	92.9 percent	82.7 percent

Inequality has gradually marched upward, with the Gini coefficient of 0.36 in 1967 rising to 0.46 in 2016[4]. Another reflection of this fact is that real median income has been growing much more slowly than average income. The burden of federal debt per household has increased from about $25 thousand dollars in 1967 to $112 thousand in 2016, in

[4] The Gini coefficient is larger when the distribution of income is more unequal.

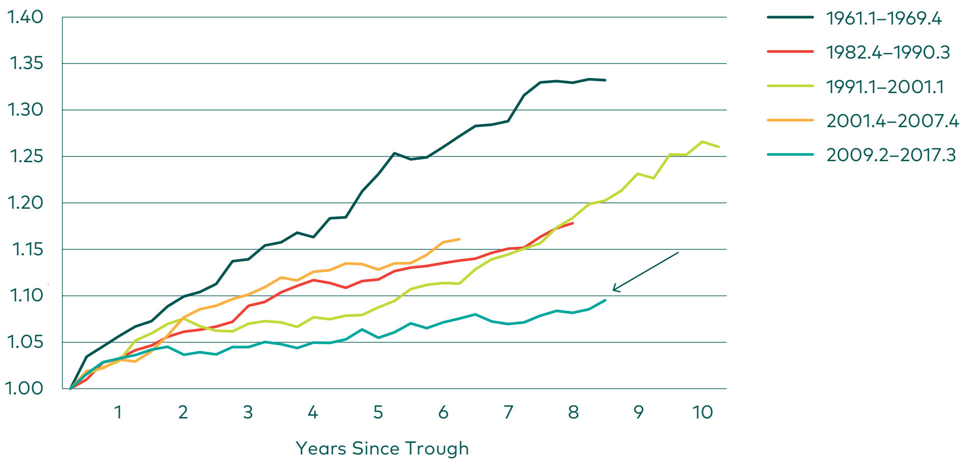

Fig. 1. Business sector productivity growth index in major postwar expansions.

real terms. The health care cost burden has increased even more in real (2016$) terms, from $1,482 per capita to $10,448.

Private fixed investment has also been growing more slowly since the end of the Great Recession, on track to be the lowest of all but one postwar expansion (Fig. 2).

Like many other OECD countries, the U.S. population has become older since 1967, with the share of the over 65 population growing from 9.6 percent to 14.9 percent. The population has also become more

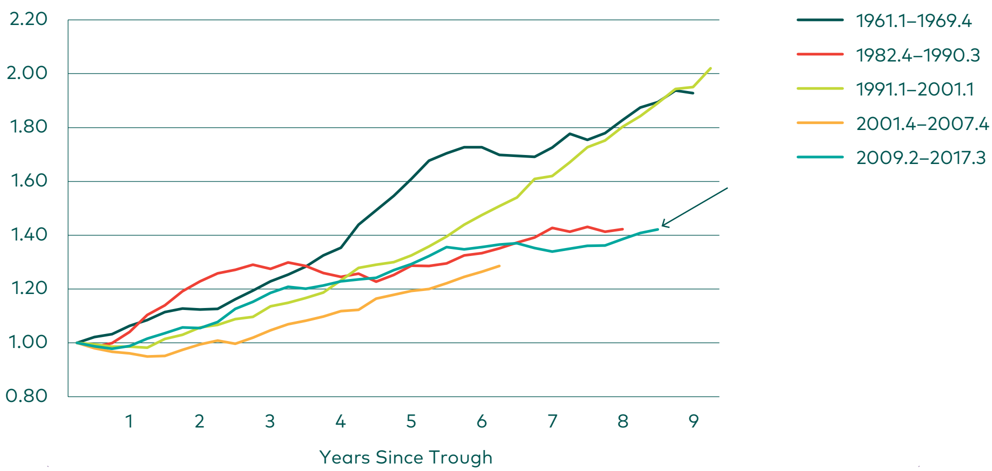

Fig. 2. Total private fixed investment growth index in major postwar expansions.

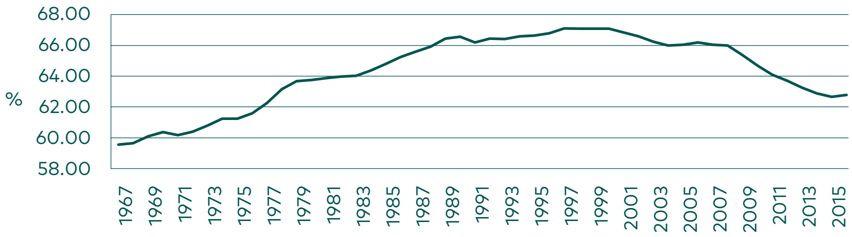

Fig. 3. U.S. Labor force participation, %.

diverse, with an increasing share of immigrants, rising from 4.9 percent in 1967 to 13.7 percent by 2016.

The overall labor force participation rate is actually slightly higher than in 1967, but has declined dramatically from its high point in 2000 (Fig. 3).

For a large segment of the population, namely white, native born, males, who worked in goods-producing industries, at about the median level of income, it is not hard to understand how they could look back longingly at a time such as 1967. For many, promises of change strike a chord. At the end of 2017, the possible change that would bring the economy "out of its doldrums" was tax reform.

2. Tax reform or tax cuts?

In 2016, before Donald Trump was elected, Republicans had already started to lay the groundwork for tax reform. Tax reform was primarily motivated by certain features of the existing tax system that were viewed as fundamentally flawed.

On the business side, the U.S. has one of the highest corporate tax rates in the world. This high corporate tax may be discouraging firms from locating in and earning profits in the U.S. A key tenet of the Republican tax reform was that this tax rate should be reduced, from a legislated rate of 35 percent down to as low as 20 percent. The taxation of profits earned abroad was also peculiar. Some countries work with a worldwide system, where profits are taxed immediately, wherever earned. Other countries use a territorial system, where profits earned in that country are taxed. The U.S. has a hybrid system, where profits are taxed when they return to the U.S. It is known that certain U.S. multinational firms have large pools of earnings sitting abroad that they hesitate to repatriate for this reason. It is argued that returning such funds to the U.S. would spur investment. Business taxation in the

U.S. also encourages debt finance, since interest payments are fully deductible. Depreciation schedules used to calculate profits are viewed as outdated, and favoring investment in certain classes of assets over others. Furthermore, the taxation of business profits has become riddled with special exceptions and favors for certain industries or types of activity, so that the taxation of business income is not a level playing field. Finally, individuals who receive their income from "pass-through" entities, such as partnerships, S-corporations and other proprietorships may pay taxes at the highest individual rate, and this is considered to be onerous for small businesses.

On the individual side, the marginal tax rates are complicated, with 7 different tax brackets. Unlike the VAT used in the EU and several other countries, which taxes consumption, the U.S. individual tax system primarily taxes income, and does not encourage saving. Furthermore, the individual tax system contains a labyrinth of special tax breaks, credits, phase-ins, phase-outs and "tax expenditures"[5].

Any student of the U.S. economy and government is surely aware that the U.S. tax system does not raise enough revenue to cover expenditures, so that the Federal Government is continually going deeper into debt. Tax reform was initially viewed as a way to simplify the individual tax system, modify the business tax system to be more fair, and to provide positive incentives and promote investment. Several provisions were proposed to make the repatriation of capital abroad less painful. In June 2016, the House released A Better Way, also known as the "House Blueprint" (Ryan, 2016). Although somewhat vague, the plan seemed to go far to suggest reforms that would improve incentives and fairness for business, while simplifying and rationalizing the tax system for individuals. It was also sold as being revenue neutral, due in large part to a border tax adjustment, that was designed to stimulate exports, reduce imports and raise revenue all in one fell swoop. Under certain heroic assumptions[6], the price effect of the tax would be neutral. However, if this assumption didn't hold, certain industries would be severely disadvantaged by the tax, while others would greatly benefit[7]. House leaders ultimately were not able to keep the border tax. Without this, the plan was a big revenue loser, and furthermore benefited the wealthy at the expense of the middle class.

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[5] These are special provisions of the tax code such as exclusions, deductions, deferrals, credits, and tax rates that benefit specific activities or groups of taxpayers.

[6] Including immediate and exact adjustment of the exchange rate by the percentage of the tax (20 percent).

[7] One industry that would see its costs rise and profits squeezed was the retail trade industry. The lobbying group The National Retail Federation spent a lot of money fighting this component of the plan.

By the summer of 2017, new ideas had replaced the House Blueprint, but several of the core features of the plan remained popular. The corporate tax cut was still a centerpiece of the discussions, as was some kind of simplification of individual tax rates. A reduction in tax rates on pass-through income was considered highly desirable. Republicans were also keen to do away with the estate tax and the Alternative Minimum Tax (AMT)[8]. To stimulate investment, full expensing was proposed, which would reduce the cost of capital, at least in the short-term. Rules for repatriating foreign income would be modified to be more favorable.

In autumn, the new ideas were still being presented as "tax reform", but more often as a "massive tax cut" especially as one that would help the middle class. Television viewers were subjected to dozens of advertisements paid for by corporate lobbyists, arguing that the time for tax reform was now, and promising healthy growth in jobs and income for the middle class if the tax reform was enacted. A version of the tax plan was passed in the House on November 16, and then the Senate went to work on their version. The "Tax Cut and Jobs Act" became reality by a narrow vote in the Senate in the early hours of Saturday morning, December 2. It was announced that day as a "momentous occasion for the Republican Party".

3. An outline of the Senate tax plan

At the time we performed the analysis of the tax plan, the most recently passed bill was the Senate version. At this time it must still go back to the House for reconciliation, then back to the Senate, and then to President Trump's desk. Table 2 summarizes the main components of the plan as it passed in the Senate.

Some of the components include the note "Sunset 12/31/25". This means that the provision is set to expire at the end of 2025. Due to certain procedural rules that allow the Republicans to pass this bill without any Democrat participation, it can have a 10 year static revenue loss of no more than $1.5 trillion. To reduce the projected revenue loss, some of the tax cuts on the individual side are not given during the last 2 years (2026–2027) of the 10 year period.

Under the individual income tax section of the table, the tax rates are the marginal rates for 7 brackets of income, which are different for single people and married couples. The individual AMT (Alternative Minimum Tax) is repealed, but will return in 2026. The current practice of

[8] The AMT was designed to ensure that extremely wealthy citizens pay at least some minimum tax, no matter how many exclusions or exceptions they may be due.

itemizing deductions (for mortgage interest, medical expenses, property taxes, charitable contributions, etc.) is being shifted to a simpler standard deduction.

One item in Table 2, the reduction of the ACA shared responsibility payment to zero, deserves a few words. The ACA, also known colloquially as "Obama Care", mandates that individuals obtain health insurance, or they must pay a fine. If they are judged too poor to afford

Table 2

Components of the Senate Tax Plan

Components	Description
Individual income tax	Tax rates: 10 %, 12 %, 22 %, 24 %, 32 %, 35 %, 38.5 % (Sunset 12/31/25).
	Individual AMT: Repealed (Sunset 12/31/25).
	Standard deduction: Increased to $12,000 for Single, $18,000 for head of household, and $24,000 for married filing jointly (Sunset 12/31/25).
	Interest, dividends and capital gains: Taxed at current rates.
	Itemized deductions: Eliminated all itemized deductions (including SALT) other than mortgage interest and charitable (Sunset 12/31/25).
	Personal exemptions: Repealed (Sunset 12/31/25).
	Modification of child credit to $2,000 not indexed (Sunset 12/31/25).
Corporate tax	Tax rate: Corporate tax rate 20 % effective 2019.
	Corporate AMT: Repealed.
	Business tax preferences: Repealed.
Pass-through entities	Tax rate: Deduct 17.4 % of qualified income (Sunset 12/31/25).
	Restrictions: If partnership or S-corporation, the percentage of total business income eligible is limited to 50 % of W-2 wages (Sunset 12/31/25).
	Disallow active pass-through losses in excess of $500,000 for joint filers, $250,000 for all others (Sunset 12/31/25).
Cost recovery provisions	Full and immediate expensing for 5 years then revert to accelerated depreciation (MACRS) in year 6.
Net interest deductibility	Limit deductions to 30 % of adjusted taxable income, carryforward of denied deduction.
Repatriation of foreign source income	U.S. businesses with international operations would be taxed on existing foreign profits at a tax rate of 10 %. If these repatriated earnings had been re-invested, the rate would be 5 %. Going forward, there would be a 50 % inclusion of foreign profits and a 12.5 % rate on U.S. income from overseas customers.
Affordable Care Act	Reduce ACA individual shared responsibility payment amount to zero.

Note: SALT (State and local taxes, which as of today, can be deducted on the Federal individual income tax return).

the health insurance, then the Federal government pays a subsidy to the insurance provider. The Republican tax plan is planning to reduce the revenue cost by repealing this mandated benefit and subsidy program, which is estimated to save a little over $300 billion for the 10 year period 2018 to 2027.

4. Modeling the plan: microsimulation and macrosimulation

The analysis in this paper quantifies likely impacts of the personal and corporate income tax cuts outlined above, introducing the feedback effects of additional rounds of spending from consumption and investment, but also incorporating supply constraints, and other pushbacks that may be expected from the macroeconomic environment.

The *Lift* model is a highly detailed and internally consistent interindustry macroeconomic model, with about 1,400 macroeconomic variables, and over 10,000 industry and commodity level variables that are forecast for each year. However, for tax analysis, it can be helped immensely by coupling with a microsimulation tax model. Such a model contains a database of tax records for firms and households that preserve the inherent diversity and differences in size of taxable incomes, as well as special characteristics of the agents that are relevant to the analysis. This type of model can compute the average tax rate changes implicit in a certain proposed rate bracket, while also considering the removal of special deductions and credits, or the additions of other. For this exercise we teamed with Quantria Strategies, which has microsimulation models for both individual taxes and corporate taxes, including a calculator that can estimate the impacts of corporate tax changes on the user cost of capital.

Quantria has run simulations with their micro model on these provisions, to determine 3 types of inputs that can then be incorporated as assumptions to the *Lift* model. These are:

1. reduction of the average federal personal income tax in the model from the baseline, over a forecast interval of 2018 to 2025, with these provisions expiring in 2026 and 2027;
2. reductions in the corporate tax rate for the same period;
3. changes in the cost of capital by sector, and their effects on fixed investment.

This exercise is intended to aid in understanding the full dynamics of the economy in response to the Senate tax plan, and to quantify the changes in important economic variables, such as employment, GDP, federal government revenue and expenditures, personal income and consumption and investment and trade.

The analysis is done using a scenario approach. This analysis starts with a baseline scenario developed for the INFORUM *Lift* model that is calibrated to be similar to the 2017 CBO 10 year baseline, from 2018 to 2027 (CBO, 2017). The baseline is modified to incorporate cuts in the personal income tax rates and the corporate tax rate. The tax cuts, which we implement in this study we assume to start in 2018, except for the corporate rate reduction which starts in 2019. We also model the impact of the cut in the corporate tax rate on the cost of capital and business investment.

We have made assumptions about changes in effective personal and corporate tax rates. These are different from the legislated rates (corporate) or a simplification of a complicated tax system (personal). Our approach has been to start with the proposed percentage reduction in the legislated rates, and then calculate the relevant percentage reduction in the effective tax rates.

Once these provisions were estimated, effective tax rates were calculated for individuals under both current law and the tax reform plan for different types of income, including: wages and salary, interest income, dividend income and the income of pass-through entities (i.e., sole proprietorships, partnerships and S-corporations). Table 3 below shows the assumptions provided by Quantria.

The *Lift* model generates components of personal income from several components of income for 66 private sector industries. Personal income is then used to derive the tax base for individual income taxes.

The model estimates personal income from several components of income by industry. For example, compensation of employees is

Table 3

Effective Tax Rates for Individuals, %

Effective tax rates	Current law	Tax reform
Wages & salaries	12.73	12.01
Interest income	22.27	20.69
Dividend income	17.44	16.80
Proprietors' income	15.10	13.38
Partnership income	29.40	26.02
S-corporations	31.60	28.92
Other proprietors' income	25.37	22.85

Table 4

Static Revenue Loss / Cash Flow Gain from Individual Tax Changes, Billions of Dollars

	Baseline	Tax cut scenario	Revenue loss / DI gain
2018	1 735	1 636	–100
2019	1 834	1 730	–103
2020	1 925	1 818	–107
2021	2 016	1 905	–111
2022	2 106	1 991	–15
2023	2 201	2 081	–119
2024	2 305	2 181	–124
2025	2 423	2 293	–129
2026	2 538	2 404	–134
2027	2 652	2 513	–140
Total			–1 182

calculated in the model for 71 private and government industries, dividend income is based on corporate profits after tax for 66 private-sector industries. Proprietors' income (pass-through income) is calculated for the same 66 private industries. The model calculates personal income in the projection period by building it up from the pieces. Therefore, the dynamic response of personal income to a cut in personal federal income tax hinges on the response of wage and salary disbursements, proprietor's income, dividends, transfer payments, etc.

For this study, the components of Proprietors' income in the National Income and Product Accounts (NIPA) were further disaggregated into the components shown in Table 3. For each taxable income component, tax rates and tax liability can be computed. Total personal tax liability for each year is the sum of the tax liability components.

We will first present some static calculations of revenue loss, where the economy does not respond positively to tax cuts. These are useful as an unrealistic upper bound to the revenue cost, and are comparable to estimates from other static models used for tax policy analysis. These are also helpful for comparing with the full impacts including macroeconomic feedback ("dynamic scoring") within the *Lift* model. After this presentation, we turn to an examination of the dynamic analysis.

Although the *Lift* model does not contain detail on households by income level, filing status, types of income received or age, such information is available in the Quantria model, and is used to calculate aggregate personal income tax rates for several categories of personal income, which are then applied in the model.

Corporate income tax in the *Lift* model is based on NIPA data on corporate profits before and after taxes. Although the legislated corporate tax rate in the U.S. is 35 percent, the effective tax rate is lower, and differs by industry. The overall rate has averaged between 18 and 38 percent since 2000, for the most part staying between 20 and 25 percent. The CBO projects the rate to rise gradually and then flatten in the baseline.

In this analysis, we have reduced the legislated federal corporate from 35 % to 20 %. However, due to other provisions in the tax reform package we have modeled, the impact on the average rate is less than this, and the effective tax rate is different for each industry, based on calculations by Quantria.

The Quantria results provided effective corporate tax rates by industry, based on detailed calculations from the corporate microsimulation model. The statically calculated revenue loss is shown in Table 5.

Table 5
Static Revenue Loss / Cash Flow Gain from Corporate Tax Cut, Billions of Dollars

	Baseline	Tax cut scenario	Corporate tax cut
2018	410	349	–61
2019	415	353	–61
2020	412	351	–61
2021	430	365	–65
2022	454	386	–68
2023	474	403	–71
2024	493	420	–74
2025	521	444	–78
2026	544	463	–81
2027	570	485	–85
Total			–704

We have modeled the repeal of the Individual ACA mandate recommended in the Senate tax plan. Using figures from Joint Committee for Taxation, we have assumed the following static revenue gain. We have made the change in *Lift* simply by reducing the portion of government social benefits classified as Refundable tax credits. While the program is actually quite complicated, and the effects are really a combination of reductions in both penalties and benefits, we believe the revenue impact of this assumption is quite accurate. The year-by-year static assumptions are shown in Table 6.

Table 6

Static Spending Reduction Estimates of ACA Mandate Repeal, Billions of Dollars

	Baseline	Tax cut scenario	ACA mandate reduction
2018	135	135	0
2019	138	131	7
2020	141	131	10
2021	145	116	29
2022	150	112	38
2023	155	114	41
2024	160	116	44
2025	166	119	47
2026	172	122	50
2027	178	125	53
Total			318

5. Dynamic scoring using *Lift*

The revenue estimates shown above are static estimates, much like those done by CBO and other tax analysts. These estimates are useful for estimating an upper bound on the revenue loss. However, in the presence of tax cuts, consumers have additional disposable income. Increases in disposable income can be expected to stimulate personal consumption expenditures and personal savings, thereby increasing demand for consumer goods and services. Reductions in the corporate tax rate will increase corporate tax flow and reduce the cost of capital investment. This should increase the level of investment in both equipment, intellectual property and business structures, such as manufacturing plants and commercial office buildings. However, the dynamic analysis also imposes constraints. The model (and the economy) have difficulty operating above potential GDP, or tolerating low unemployment rates for extended periods of time. Potential GDP is a concept explaining the average trend real GDP that can be supported with the given labor force, labor productivity and hours worked, with a "full" employment rate. In this sense, to be above potential is to have an unemployment rate below full, and we leave the possibility open for the model to report a negative unemployment rate, even though this is impossible in the real economy. Obtaining a calculated negative unemployment rate is a sign that we are asking too much GDP to be generated for the given supply potential of the economy. This supply potential can be increased if labor force participation increases, or if labor productivity increases.

In the dynamic analysis, each change described above was implemented separately in a dynamic run of the *Lift* model. In the final results, all tax changes were applied together. This scenario incorporates the multiplier effects of consumption and investment, but also involves some "push back" from constraints in the labor market, and the effects on interest rates and prices.

The immediate effect of both personal and corporate tax cuts is stimulatory. Personal tax cuts result in higher disposable income. Disposable income is then divided into savings (modeled as determined by a flexible savings rate) and personal consumption. Unless consumers save all the additional personal disposable income, then personal consumption increases. Spending on personal consumption is divided into 83 categories of spending, which create demands for consumer goods industries directly, and for many other industries indirectly. The additional rounds of spending stimulate additional jobs and income, which allows for additional spending. This multiplier effect of a tax cut is well-known in the macroeconomic literature. Increases in investment occur in response to the better economy, but also in response to the reduction in the cost of capital. Investment in equipment and structures generates demand in the investment industries, which also create further jobs and income.

The majority of the tax cuts are projected to occur in 2018. The unemployment rate projected in the baseline for 2018 is 4.7 percent, and the baseline projection calls for an unemployment rate in the 4–5 percent range over the period 2018 to 2027. Additional consumer and investment spending is bumping into supply constraints, which can be understood as the level of production that the economy can produce without overheating (generating high inflation and interest rates). Some of the additional spending leaks out as imports. Both consumer and investment goods are partially imported from abroad. Sectoral prices and the GDP price level rise, as do wages, in response to the additional demand. This affects U.S. competitiveness, which implies that a higher share of demand will be imported, and less will be exported, generating a deterioration in the trade balance. Higher prices also raise the cost of government purchases. This, combined with personal and corporate tax cuts, are associated with an increase in the federal deficit.

As mentioned above, the *Lift* model has been designed to allow lower rates of unemployment than are historically observed, but this is often viewed as a signal that some constraint has not been adequately accounted for. Conversely, it may be possible that a constraint may be alleviated. Currently, the U.S. economy is operating with a historically low labor force participation rate, and slow rates of labor productivity growth. Many economists agree that stronger demand pressures in the economy, and the associated higher wages will tempt many workers back into the labor force. In addition, the increase in investment will result in a higher capital stock, which should stimulate labor productivity. As an illustration of these effects, we have increased the labor force participation rate and the growth rate of labor productivity to model these effects.

In order to explore other possible features of a consistent and feasible tax reform trajectory, we have explored using several additional assumptions and mechanisms in the analysis.

1. The labor force participation rate has been adjusted to rise back closer to the historical norm than the standard CBO projection. However, after 2022 it declines again, due to demographic composition.
2. We have modeled an increase in average labor productivity across industries in response to additional capital investment.
3. We have adjusted the long-run interest rates downward slightly, to reduce the average interest rate paid on the Federal Debt. This reduces the deficit, but also reduces personal income growth from what it would have been otherwise.

6. A review of the scenario results

The next several figures summarize some key results from the scenarios. In each graph, the baseline is in red (‘*x*’) and the tax cut scenario is in blue (squares).

Figure 4 shows graphs of the personal and corporate tax liabilities, and the federal deficit, showing the difference between the CBO baseline and the tax cut scenario. The blue line (squares) incorporates the dynamic

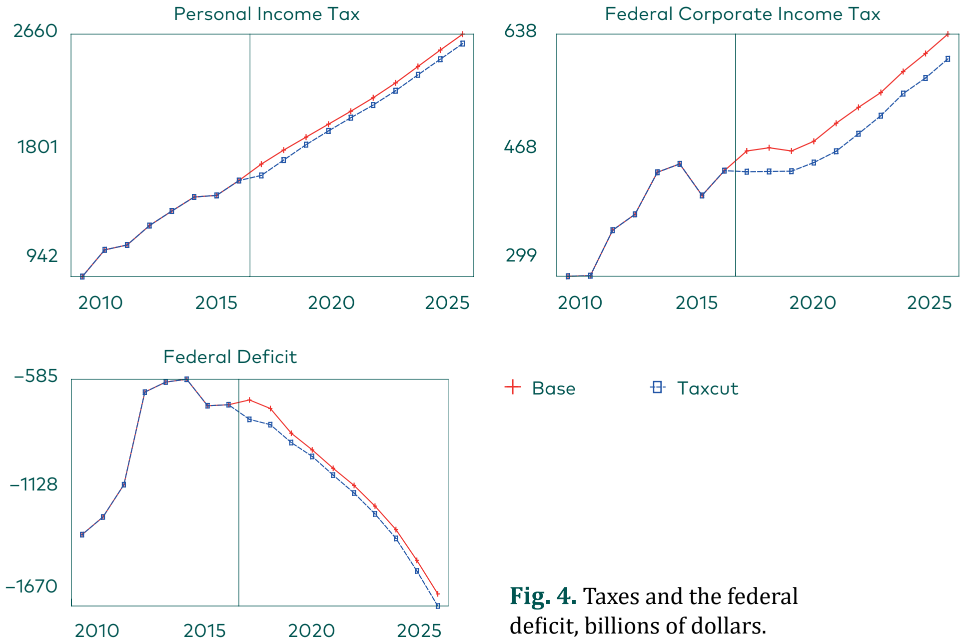

Fig. 4. Taxes and the federal deficit, billions of dollars.

response, in which the tax base is raised from the static scenario, due to increased output, wages and income. Statically calculated (using baseline income) 10 year tax revenue loss from personal taxes is estimated to be $1,182 billion. The *Lift* model's incorporation of dynamic response yields a total personal tax revenue loss of $534 billion, so that the dynamic

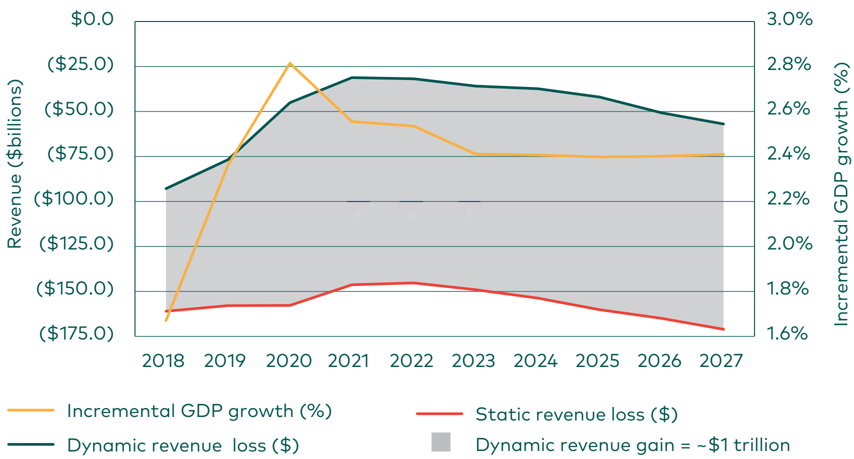

Fig. 5. Static and dynamic revenue loss.

Fig. 6. Consumption and income, billions of dollars.

response gains back about 55 percent of the static revenue loss. Statically calculated (using baseline profits) corporate profits tax liabilities imply a revenue loss of $704 billion. Dynamic calculations estimate a corporate tax revenue loss of $512, gaining back about 27 % of the static revenue loss.

Figure 5 shows the combined dynamic revenue gain, which is the difference between the statically calculated revenue loss and the revenue loss calculated by the *Lift* model. The federal deficit is worse than in the baseline, reaching a value of $1,670 billion by 2027, a difference of $57 billion. Total 10 year revenue loss is estimated to be $500 billion. The static calculations indicated a 10 year deficit increase of $1,567 billion.

Figure 6 shows the impact of the combined tax reform on real disposable income. Real disposable income has increased both because of an increase in personal income (see Table 10) and through the fact that

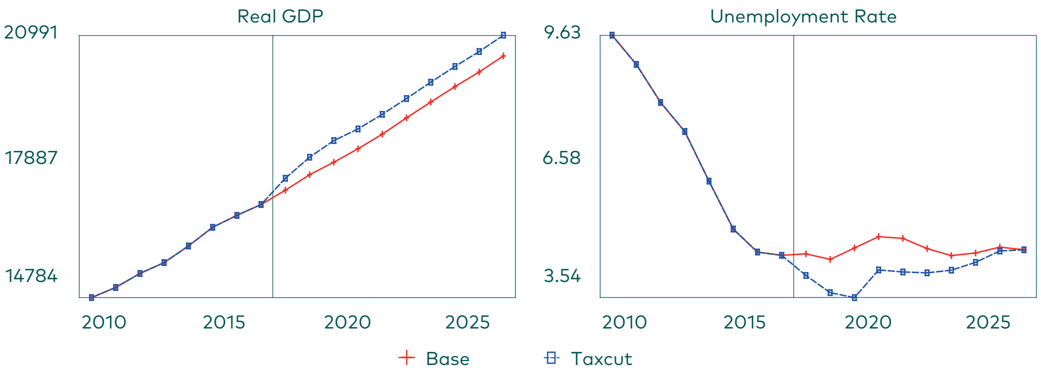

Fig. 7. Real GDP, billions of dollars, and unemployment rate, percent.

tax rates are lower. Personal consumption expenditures also increase in the tax cut scenario, generating increased demand for consumer goods and services, but also for additional imports.

Figure 7 shows that real GDP is higher by $494 billion by 2027, due partly to increased Personal consumption, but also due to higher real investment spending.

The unemployment rate drops sharply in 2018 and 2019, due to increases in real GDP and jobs. We assume that labor force participation and average labor productivity growth return to historical norms, thus increasing the available supply of labor. Eventually, this results in an unemployment rate about equal to that in the baseline by 2027. This pattern results largely from the combination of the increased labor force and productivity we have assumed, combined with a retraction of the personal tax cuts.

The trade deficit is worse in the tax cut scenario, mainly due to an increase in imports, as both consumption and investment goods have a significant import content.

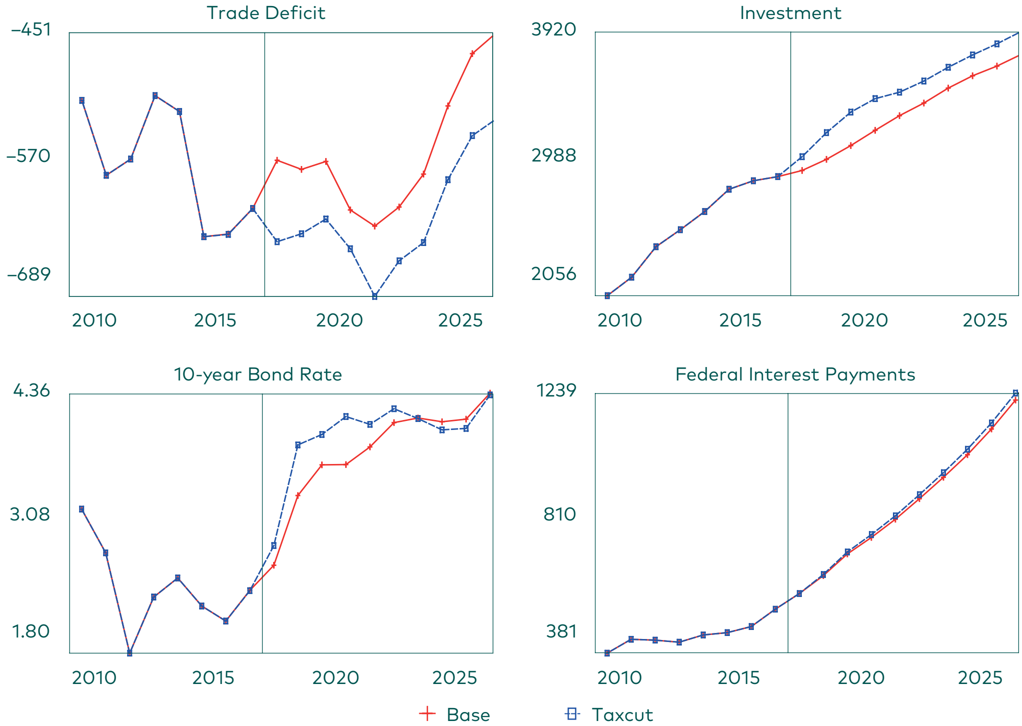

Fig. 8. Unemployment rate, trade deficit, investment, interest rate and interest payments.

Table 7

Macroeconomic Summary, Differences from Base

Titles of alternate runs Line 1: Baseline Line 2: Tax reform	Alternatives are shown in deviations from base values			
	2018	**2020**	**2025**	**2027**
Macro aggregates				
Gross Domestic Product (GDP)	20 386	21 677	26 327	28 505
	318	642	835	878
Real GDP	17 318	17 987	19 772	20 497
	289	506	474	494
Real exports	2 273	2 503	2 874	3 045
	10	21	–19	–26
Real imports	2 890	3 096	3 496	3 673
	76	82	98	113
Real personal consumption	12 096	12 553	13 858	14 404
	240	370	469	499
Gross private fixed investment	2 940	3 117	3 609	3 762
	98	236	149	158
Federal budget deficit	–685	–844	–1 305	–1 613
	–93	–45	–42	–57
Effective federal personal income tax rate	13.3	13.8	14.3	14.6
	–0.8	–0.8	–0.8	–0.8
Effective federal corporate tax rate	27.4	28.2	29.1	29.2
	–3.5	–3.6	–3.7	–3.7
Real disposable income	13 174	13 726	15 276	15 886
	280	507	526	521
Prices				
Personal consumption deflator	1.16	1.20	1.33	1.39
	0.00	0.00	0.01	0.00
GDP deflator	1.18	1.21	1.34	1.40
	0.00	0.00	0.01	0.01
Exports deflator	1.29	1.32	1.47	1.55
	0.00	0.00	0.03	0.03
Imports deflator	1.19	1.22	1.31	1.36
	0.00	0.00	0.00	0.00
Average wage	38.36	40.83	49.14	52.87
	0.04	0.49	1.16	1.32

Titles of alternate runs Line 1: Baseline Line 2: Tax reform	Alternatives are shown in deviations from base values			
	2018	**2020**	**2025**	**2027**
Employment				
Total household employment	154 329	155 746	159 766	161 012
	1 895	3 190	1 804	1 453
Unemployment rate	4.5	4.7	4.6	4.6
	−0.5	−1.1	−0.2	0.0
Taxes				
Federal personal income tax	1 738	1 929	2 431	2 660
	−80	−53	−59	−69
Federal corporate income tax	474	474	585	638
	−29	−28	−31	−35
Federal deficit	−685	−844	−1 305	−1 613
	−93	−45	−42	−57
Trade balance	−566	−568	−518	−451
	−73	−52	−66	−78

Investment increases significantly relative to the baseline, reaching its maximum difference in 2020, where it is $236 billion higher than the baseline in real terms, a difference of about 7.6 %. Due to additional borrowing requirements from the government and business sectors, the 10 year bond rate also increases relative to the base. (Note that this rate also helps determine the average rate paid on the federal debt, and so affects the interest payments portion of government expenditures.)

7. Whither tax reform?

This analysis has demonstrated how the Senate Tax Plan could ripple through the economy. The exercise used the INFORUM *Lift* model, in combination with the Quantria Strategies' microsimulation models of the household and the business sector. The *Lift* model embodies a full interindustry economic core, so that it includes the multiplier effects of personal consumption and investment expenditures to the domestic industries that supply these expenditures. It also embodies the generation of additional jobs and income in these industries that generate further demand. However, *Lift* is also an aggregative, or macro model. Jobs by industry sum to total employment, and the aggregate unemployment rate is an aggregate comparison of total household

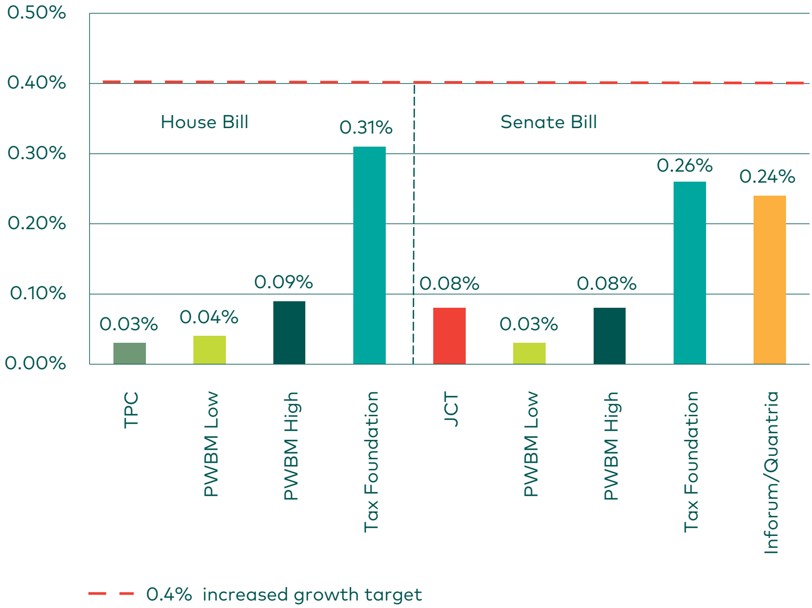

Fig. 9. Estimated impact of versions of the Tax Cuts and Jobs Act on annual GDP growth, %.

employment and the projected labor force. At some point, additional stimulus cannot permanently push the economy to a level of employment much below what is considered "full employment" (between 4 and 5.5 percent). We have modeled how increases in labor force participation and labor productivity may be brought about due to economic stimulus and increased investment, enabling higher potential GDP than would otherwise be available. We have made all assumptions explicit and the model incorporates the effects of these assumptions and their interactions in a fully consistent way.

Figure 9 compares increases in average annual real GDP growth in several studies that have been done on the Tax Cut and Jobs Act. The INFORUM / Quantria analysis is on the high side, though not the highest. Our study can be viewed as an exploration of the impacts of a strong labor force participation and labor productivity response to the increased demand, and the increased investment coming from the reductions in the cost of capital.

We have also assumed that the long term interest rates would not go up very much in response to the increase in the federal debt. Without these assumptions, our annual GDP growth increase would still be positive, but closer to 0.15 % per year.

Conclusions

In summary, here are a few of the key findings from the scenarios.

Individual taxes

- We have used information from Quantria on changes in tax rates on several sources of personal income. This results in a reduction in the average effective personal federal income rate from 13.8 % to 13.0 % by 2020, from 14.3 % to 13.5 % by 2025, and from 14.6 % to 13.8 % by 2027.
- We find that the reduction in the personal federal income tax rate raises real personal disposable income and personal consumption. Real personal disposable income per household is $3,883 higher in 2020 and $3,598 higher in 2027.
- Real personal consumption is $370 billion higher than the baseline in 2020 and $499 billion higher in 2027. On a household basis, these real personal consumption increases amount to $2,830 and $3,452, respectively.
- Statically calculated (using baseline income) 10 year tax revenue loss from personal taxes is estimated to be $1,182 billion.
- The *Lift* model's incorporation of dynamic response yields a total personal tax revenue loss of $534 billion, so that the dynamic response gains back about 55 percent of the static revenue loss through the personal tax side.
- We treated modifications to the Affordable Care Act (ACA) that were part of the Senate Tax Plan as reductions in government-provided social benefits.

Corporate / business

- Using detailed analysis on effective corporate tax rate by industry from Quantria, we obtain a reduction in the economy-wide average effective corporate income tax rate from 18.7 % to 16.8 % by 2027.[9]
- We find that fixed investment is stimulated both through increased economic activity (demand effect) and a reduction in the cost of capital (price effect). Total investment is higher by $236 billion in 2020 and $158 billion by 2027.

[9] These effective tax rates exclude the following sectors due to certain unresolvable data anomalies that arise from bridging two different data sets: Utilities, Other Real Estate, Federal Reserve Banks, Oil & Gas Extraction, Mining, and Mining Support Activities.

- Statically calculated (using baseline income) 10 year tax revenue loss from corporate taxes (baseline profits) is estimated to be $704 billion.
- Dynamic calculations estimate a corporate tax revenue loss of $512, gaining back about 27 % of the static revenue loss.

Macroeconomic

- We find that real GDP increases by $506 billion in 2020 and by $494 billion by 2027.
- We assume an increase in total labor force participation in response to stronger economic growth. By 2027, the labor force participation rate is 61.5 %, compared with 60.95 % in the baseline. In 2027, this represents about 1.5 million additional people in the labor force.
- We assume that average labor productivity increases in response to stronger investment. In 2027, productivity is 6 % higher than in the baseline.
- We find that total household employment increases by 3.2 million jobs by 2020, and by 1.5 million jobs in 2027.
- We find that the federal deficit increases by $45 billion by 2020, and by $57 billion by 2027.
- The total 10 year federal deficit is higher by $500 billion. The static calculations indicated a 10 year deficit increase of $1,567 billion.

Congress is now working to reconcile the two versions of the plan, vote on the reconciled version, and submit this bill to President Trump by Christmas. Although the final bill will certainly be different from the Senate version analyzed in this study, the main features of it will be similar. In addition to the macroeconomic impacts described above, there will certainly be distributional impacts. It is clear that the bulk of the tax cuts are coming from the reduction in the corporate tax rate, and reductions to the marginal tax rates paid by the highest income bracket. Other features, such as the repeal of the Alternative Minimum Tax and the estate tax, are primarily benefitting the wealthiest taxpayers.

Whether the tax reform will contribute to a feeling of “Great Again” for the average Trump voter remains to be seen. If we do see corporate cash return to be invested in the U.S.; if there is a revival of domestic manufacturing and construction activity; if discouraged older male workers are drawn back into the labor force; if labor productivity growth increases; if depressed areas of the country experience job and median income growth again, perhaps the voters' hopes will be partially fulfilled. However, many of the changes in the U.S. economy and demographics described in the first section will still be with us, and the federal debt per household will be worse due to the tax cuts. Economic scientists will be watching this experiment with a critical eye.

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ECONOMIC ASSESSMENT OF INTEREST RATE CAPPING ON THE SOUTH AFRICAN ECONOMY – AN INFORUM APPROACH

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Introduction

The National Credit Act (NCA, 2005) of South Africa was introduced to "promote and advance the social and economic welfare of South Africans; to promote a fair, transparent, competitive, sustainable, responsible, efficient, effective and accessible credit market and industry; and to protect consumers". Within this context, the Department of Trade and Industry (DTI) introduced the capping of fees and interest rates of different categories of credit in 2007. In 2015, the DTI proposed further changes to the capping of fees and interest rates, i.e. a decrease of 7.5 percentage points (from 32.7 % to 25.2 %) was proposed for unsecured lending, and a decrease of 2.5 percentage points (from 22.7 % to 20.2 %) for credit facilities. These proposed changes form the subject of this report.

The point of departure for the analysis undertaken in this study is that some customers will benefit from the proposed lower interest rates; however, others would henceforth be excluded from the formal lending market by virtue of the fact that financing institutions will no longer be able to supply unsecured credit to certain high-risk customers at these lower interest rates.

In practice, this implies that there will be a positive impact on the economy resulting from the fact that a category of customers will be paying a lower interest rate on credit, which means that such customers will have more money to spend on other goods and services. However, there is a conversely negative impact, in that there will be less credit available for consumer spending by a category of customers who no longer qualify for credit in the formal lending market. It is anticipated that some of these disqualified customers will turn to informal lenders for credit. The role of these informal lenders in catering for some of the credit rejected by the formal lending sector forms a critical element of this study, and it is assumed that informal lenders will charge substantially higher interest rates as compared to formal lenders.

The main output of the analysis undertaken in this study is the impact that the proposed interest rate changes for unsecured credit and credit facilities will have in terms of the gross domestic product (GDP), employment, household income, and government revenue.

1. The principle of capping – a brief literature overview

1.1. Arguments in favor of interest rate caps

According to a Harvard University study (Staten, 2008), "legislators have, for centuries, advocated caps on loan interest rates (rate ceilings) as a form of consumer protection in otherwise free market economies. More recently, restrictions on creditor collection practices and loan contract features have been added to the regulators' list of tools for protecting consumers from abusive lenders and credit."

In the South African context, legislators are of the opinion that over-indebtedness and financial exclusion are problems that tend to affect poorer consumers the most. Financially excluded consumers have been known to turn to high-cost categories of credit to finance relatively large single-product purchases, or even to finance some of their day-to-day living expenses.

Legislators tend to view interest rate caps or ceilings as a means of "saving consumers from themselves" (Staten, 2008) and as a means to limit over-indebtedness; and the extent to which consumers could face being blacklisted, prosecuted for bad debts, or declared insolvent – all of which are seen as having undesirable socio-economic effects.

1.2. Negative aspects of interest rate caps

Despite the seemingly laudable intentions of regulators, various studies have pointed out that interest rate caps may not have all of the benefits that regulators ascribe to them, whilst a number of unintended consequences may result from a rigid application of interest rate caps.

A 2013 University of Bristol study found that interest rate caps may result in a situation, where "lenders who do not exit the market may tighten their lending criteria and improve their risk assessment practices." This will restrict credit access for some types of consumers, particularly on low-income earners. In addition, "the diversity of short-term credit products that are available may reduce, resulting in less choice for consumers", and "access to credit may reduce particularly for low income or other vulnerable consumers".

A study conducted by the World Bank in 2014 (Maimbo & Claudia, 2014), reveals the following on interest rate capping.

- Caps on interest rates have been declining over the past several decades in most industrialized countries and a rising number of developing countries. The rationale for these changes is to make financial markets more accessible, and this has a positive impact on growth, productivity, and poverty reduction.
- Much of the evidence argues against the use of interest rate caps since they are an inefficient tool for lowering interest rates, especially in the long run. They also limit access to credit, reduce transparency, and decrease product diversity and competition. In addition, they could undercut the demand for formal credit and affect firms' productivity.
- Because interest rate caps distort the market and generate adverse selection, financial entities tend to lend to clients with higher collateral or better risk profiles. Consequently, financial institutions curtail their lending to those who need it most and who have little access to alternative sources of credit.
- Where interest rate ceilings or caps are set at unprofitable levels, financing institutions and microfinance institutions may withdraw from certain locales such as rural areas or from expensive market segments because they cannot cover their costs.
- Low-income customers with few options for borrowing in the formal market could turn to unlicensed moneylenders, probably at much higher interest rates and less protection.
- Evidence has shown that interest rate caps on credit discourage unlicensed (and hence unregulated) microfinance enterprises and other sources of finance for the poor from converting into licensed financial institutions.

The authors have to a large extent taken into consideration the views of the aforementioned study by the World Bank in calculating the economic impact of interest rate capping.

1.3. The determination of credit prices and consequences of capped interest rates

An often-held view by certain observers is that lenders will promote lending products with the largest profit potential, and that such products are short-term credit with high interest rates. However, each credit agreement category has specific characteristics relating to charges, origination and administration costs, repayment periods and conditions, and risk profiles. Specifically, with regard to risk, it is particularly difficult to compare secured credit products (such as mortgage credit) with unsecured credit products as the risks attached to these types of credit products are vastly different. Financing institutions have rather involved processes related to managing the gaps in terms of the maturities of their liabilities (deposits) and assets (credit) as this could have a crucial impact on aspects such as solvency and liquidity.

In view of the fact that the risk premium associated with the cost of a particular credit product will differ from customer to customer and from credit product type to credit product type, any reduction in the maximum interest rate that may be charged on a credit product will make a certain proportion of credit unaffordable from the lender's perspective. Consequently, a reduction in capped interest rates will lead to an increase in the number of credit applications that are declined, and customers who would previously have been able to secure credit at relatively higher interest rates will then not have access to finance in the formal, regulated market. Some portion of such customers may approach the unregulated market for assistance where they would be charged considerably higher rates of interest and be less protected.

2. Impact of the proposed changes to fees and interest rates on household income and expenditure

2.1. Introduction

Broadly speaking, the methodology employed to estimate the possible impact of changes in interest rate caps on unsecured credit and credit facilities[10] on the macro-economy, consists of two phases:

- the first phase calculates the likely impact on disposable income and consumption expenditure of the proposed interest rate changes on both unsecured credit and credit facilities, and
- the results of the first phase are then used in the second phase as an input to "shock" the South African INFORUM Model (SAFRIM).

Data utilized in the first phase of this study were sourced from the March 2015 Consumer Credit Market Report published by the National Credit Regulator (NCR), and the Banking Association of South Africa. Where data were not available, assumptions have been made that reflect a reasonable approximation of the magnitudes required by the modeling approach.

[10] Types of Credit Facilities include: credit and / or garage cards, bank overdrafts, store cards, services, and other facilities.

In calculating the impact on disposable income and consumption expenditures, the assumption is made that a segment of consumers seeking unsecured credit (between the current maximum interest rate of 32.65 % and the proposed cap of 25.2 %) will be unable to qualify for credit in the formal financial sector. The inability to source credit will negatively impact the spending ability of such households. It was further assumed that a segment of the non-qualifying customers in the formal financial sector will be accommodated in the informal financial sector at higher interest rates than those charged in the formal sector.

Since the short-term impact differs from the long-term impact, and to introduce a dynamic element to the analysis, the investigation has been undertaken over the 10-year period from 2015 to 2025. In addition, it was assumed that growth forecasts of real GDP (constant 2015 prices) as calculated by SAFRIM served as an adequate proxy of the projected growth in credit extended over the analysis period.

2.2. Impact on unsecured credit

The total debtors' book of credit extended to the household sector amounted to more than R1.6 trillion at the end of March 2015. Of this amount, R166.6 billion was in the category “unsecured loans”. In undertaking this study, it was assumed that 50 % of the value of the debtors’ book of unsecured credit is subject to interest rates above the new proposed cap of 25.2 %, but below the current cap of 32.65 %.

This study foresees that there will be a 32 % reduction in total unsecured credit by formally regulated financial institutions if interest rates were to be capped at the proposed new lower interest rate on unsecured credit. Furthermore, the assumption is made that 64 % of existing credit amounts that would normally have been rolled over after their current terms have ended will not be renewed by formally regulated financial institutions.

This study also foresees that some of the customers that do not qualify for credit from the formal financial sector will turn to the informal, unregulated financial sector, where interest rates are extremely difficult to regulate. The assumption is made that 50 % of the rejected loan applications in the formal sector will be serviced by the informal sector at an average annual interest rate of 60 %.

Together, these assumptions will affect household disposable income in the following ways:

- those households that are granted credit at the lower interest rate cap will experience an increase in disposable income;
- those households that no longer qualify for new credit will not be paying interest on credit anymore, which will increase their disposable income;

- the credit provided by the informal financial sector to customers that turn to this sector will have a positive effect on household disposable income; and
- the rejected credit in the formal financial sector, and a decision not to take up credit in the informal lending sector will have a negative effect on household disposable income.

The total impact on disposable income and household expenditure is thus the net sum of these impacts.

2.3. Impact on credit facilities

A similar type of analysis was performed to measure the impact of the proposed cap on interest rates on the credit facilities category, which represented 12.9 % of the total debtors' book at the end of the first quarter of 2015 as reported by the NCR. The major differences between assumptions made with regard to credit facilities and unsecured credit are the following.

- The terms of credit facilities' agreements differ from those of unsecured credit. The assumption is made that credit facilities have shorter term agreements as compared with unsecured credit.
- It is assumed that 40 % of credit facilities above the proposed cap of 20.2 % will be affected, whilst in the case of unsecured credit, the percentage is 50 %.

2.4. Impacts on consumer expenditure

Tables 1 and 2 below provide a summary of the impact of interest rate caps on unsecured credit and credit facilities.

The tables show that for both types of credit the impact of lower interest rate caps will be negative on consumption expenditure. This

Table 1

Unsecured Credit – Summary of Impacts on Consumer Expenditure
(R million, 2015 Prices)

	Net interest paid (negative value indicates positive impact on disposable income)	Net credit effect (credit from informal lending (positive) and rejected credit (negative))	Net effect on consumption expenditure
2016	400	–5 012	–4 612
2017	850	–5 644	–4 793
2018	1 429	–7 259	–5 829
2019	2 271	–10 551	–8 280

	Net interest paid (negative value indicates positive impact on disposable income)	Net credit effect (credit from informal lending (positive) and rejected credit (negative))	Net effect on consumption expenditure
2020	3 117	–10 595	–7 478
2021	3 377	–3 260	117
2022	3 491	–1 439	2 053
2023	3 610	–1 488	2 122
2024	3 733	–1 538	2 194
2025	3 860	–1 591	2 269

implies that the reduction in credit granted dominates the savings emanating from the lower interest rates. In the case of unsecured credit, this outcome lasts for 5 years. In the case of credit facilities, the negative effect lasts for the whole analysis period.

Table 2

Credit Facilities – Summary of Impacts on Consumer Expenditure
(R Million, 2015 Prices)

	Net interest paid (negative value reflects positive impact on disposable income	Net credit effect (credit from informal lending (positive) and rejected credit (negative))	Net effect on consumer expenditure
2016	59	–17 569	–17 629
2017	80	–6 094	–6 174
2018	101	–6 126	–6 227
2019	104	–1 013	–1 117
2020	108	–1 047	–1 155
2021	111	–1 083	–1 194
2022	115	–1 120	–1 235
2023	119	–1 158	–1 277
2024	123	–1 197	–1 320
2025	127	–1 238	–1 365

(Source: Conningarth Economists)

The impacts listed in Tables 1 and 2 form the inputs to the modeling system in order to calculate economy-wide impacts. The modeling system is "shocked" separately by the consumer expenditure effect of the two different types of credit. The reason for doing this is that the sectoral impacts of the two types of credit differ from one another.

3. Modeling the macroeconomic impacts of proposed changes in interest rate caps

3.1. Modeling System

In order to calculate the impact of the "Draft Regulations on Review of Limitations of Fees and Interest Rates" proposed by the DTI on the South African economy, the South African INFORUM Model (SAFRIM) has been employed. The SAFRIM is primarily based on the so-called INFORUM model developed by Clopper Almon of the University of Maryland in 1967, and has been adapted for South African conditions (Almon, 1991). Currently, the INFORUM Model is used by several countries for forecasting and macroeconomic impact studies, and is supported by a satellite of the International Input-Output Association called the INFORUM group.

The SAFRIM modeling system is macroeconomic, dynamic, and multi-sectoral, and is part of the family of general equilibrium models used around the world. It depicts the behavior of the economy in its dynamic sense, i.e. the workings of all of the major markets in their inter-related, dynamic existence are accommodated in the model.

The system is multi-sectoral and includes an input-output (I-O) table and national accounts that also depicts the magnitude and diversity of intermediate consumption (i.e. inputs into production processes) within the context of the current economic structure. This allows the system to integrate intermediate input prices with sectoral price formation that ultimately determines overall price levels in the economy. This is achieved through the use of behavioral equations for final demand that depend on prices and output; and functions for income that depend on production, employment, and other economic variables.

An important feature of this macroeconomic multi-sectoral model is its bottom-up approach in terms of which the model mimics the actual workings of the economy in that macroeconomic aggregates are built up from detailed activities at the industry or product level rather than first being estimated at the macroeconomic level, and then simply "distributed" across economic sectors.

3.2. Assumptions and methodology for activating the model

The macroeconomic impact of a specific policy intervention, as in the case of capping interest rates, is defined by the difference of the level of the economy before and after such intervention has occurred. As such, it is necessary to forecast the trajectory of the South African economy before the introduction of interest rate capping, which is then known as the baseline scenario.

Analysis has been undertaken over a period of ten years, using 2015 as the base year stretching up to 2025. The analysis has been undertaken in constant 2015 prices in order to provide an indication of the impact of capping interest rates in real / volume terms (i.e. without inflationary price distortions).

3.3. Forecasting the baseline scenario

It is important to note that, for the purpose of this study, the projection of the economy was done over a relatively long period, i.e. ten years. The assumptions that are usually applied to modeling, such as monetary variables (i.e. interest rates and money supply) and short term price fluctuations, which are normally imperative for short- and medium-term forecasting, are deemed not that important for this analysis. The long-term forecast is much more driven by expected structural developments in the South African economy, specifically regarding the potential of certain sectors to be able to export over the longer-term, i.e. the long-term sustainable exports of a wide array of basic commodities in various states of beneficiation (iron ore, magnetite, chrome, coal, metal products, motor cars, etc.).

Another assumption for forecasting purposes was that South Africa will play a much larger role in the economies of countries on the African continent, and will be less dependent on its traditional trading partners such as Europe and the United States of America. This assumption changes the structure of international trade, where South Africa will become more dependent on exports of manufactured goods and services, and less dependent on exports of primary and less-processed commodities. Furthermore, the diminishing role of gold and diamonds in the future development of the South African economy has also been taken into account; and a number of fundamental economic imperatives / rules have been built into the forecasting scenario, including that:

- there should be an acceptable current account balance in the balance of payments (not exceeding ±4 % of the GDP);
- no major obstructions will exist in obtaining foreign direct investment;
- positive growth of the world economy; and

- future South African population growth will be negatively affected by HIV / Aids.

It is important to note that, since the advent of democracy in 1994, the South African economy has only grown in the order of 3 % to 3.5 %, which is well below the medium growth target of ±4 %. Conningarth Economists produces medium- to long-term forecasts of the South African economy that reflect the demand for commodities on a detailed basis. The current forecasts for the next ten years are as follows:

- likely growth scenario: 3.3 %
- high growth scenario: 4.5 %
- low growth scenario: 2.5%

The likely growth scenario has been used as the base scenario for this study.

3.4. Methodology employed to activate the model

The model has been activated using the following final demand identity (constant prices):

$$fdc = pcec + invc + govc + exc - imc + fdrc + trcc + \Delta pcec \qquad (1)$$

where

fdc – total final demand;

pcec – private consumption expenditures;

invc – investment (investment excluding investment in the mitigation measures);

govc – government;

exc – exports;

imc – imports;

fdrc – residual;

trcc – transfer costs;

$\Delta pcec$ – change in private consumption expenditures – amount used to “shock” the model.

The change in private consumption expenditure results from the lowering of interest payments on credit, as well as changes to consumer spending due to reduced credit availability and higher interest payments on credit sourced through the informal unregulated lending sector not catered for by the formal financial sector.

The change in the magnitude of private consumption expenditure related to the capping of interest rates has been incorporated into the ∆pcec variable on an annual basis over the 2015–2025 period. The change in private consumption expenditure has been categorized into two groups, namely, unsecured credit and credit facilities. The latter was further differentiated into two elements, namely, increased private consumption expenditure due to lower interest rate payments; and lower private consumption expenditure resulting from a reduction in credit approvals. For an exposition of how these aspects were calculated, refer to the previous section.

A further requirement for activating the model is that the impact on private consumption expenditure calculated above is apportioned across the current spread of commodities that is representative of private consumption expenditure. This procedure is described further.

3.5. Methodology for estimating changes in spending patterns

The initial effect of capping interest rates is that consumers that receive credit from the formal financial sector will have more disposable income to spend. This money will probably be spent in accordance with current spending patterns on various commodities and services. Use was made of the RSA Social Accounting Matrix (SAM), where the SAM provides detailed spending patterns on various commodities of the different household income groups to determine current spending patterns. It was also assumed that the most affected households are mainly the lower to middle-income groups as opposed to the very low-income or very high-income groups; low-income households do not normally qualify for credit, whilst rich people do not require these types of credit – they are more active in the mortgage and secured credit groups.

Similarly, as in the previous case, SAM data were also used to estimate changes due to the unsecured credit, except that the information regarding unsecured credit was available in terms of level of income. In this case, the spending patterns on commodities of the various income groups were weighted by the value of the magnitude of credit given to each income group.

A similar approach was used to estimate changes related to credit facilities, except that the spending on certain commodities was excluded or curtailed in the spending patterns of the various groups. Examples of this include motor vehicles and furniture, where these are covered under secured credit, which is not profoundly impacted by the capping of interest rates.

3.6. Results of the macroeconomic impact of proposed interest rate and credit cost capping on GDP and labor

This section presents the macroeconomic impact of the proposed changes to interest rate caps. As already indicated, the impact on only two macroeconomic variables was modeled, i.e. gross domestic product (GDP) and employment.

The impact on GDP reflects the magnitude on value added in the economy, where value added is a measure of economic growth. Value added is made up of three elements, namely:

- remuneration of employees;
- gross operating surplus (which includes profit and depreciation); and
- net indirect taxes on production.

Labor is a key element of the production process. The study has determined the number of employment opportunities that will be lost or created by the proposed changes to interest rate caps by the financial sector. Whereas GDP is a reflection of economic growth, labor can be seen as a reflection of income distribution in the economy. The more people are employed, the more people take part in the economic production process.

The results of the macroeconomic impact analysis are presented for three scenarios. All three scenarios assume that both the formal and informal banking sectors will be affected by the proposed interest rate and credit cost capping in that a portion of customers (i.e. 35 %) will be redirected into the informal unregulated lending sector, where it is assumed that the interest rate charged to customers will be greater than the rate charged to customers in the formal sector, i.e:

- Scenario 1 assumes that the informal unregulated lending sector interest rate will be 60 % p. a.;
- Scenario 2 assumes that the informal unregulated lending sector interest rate will be 70 %; and
- Scenario 3 assumes that the informal unregulated lending sector interest rate will be 80 %.

3.7. Scenario 1 results

In considering Table 3, the following aspects are of importance.

- The net effect in terms of GDP and employment is negative, which means that the economy will lose out in terms of economic growth (GDP) and employment creation if interest rates on credit facilities and unsecured credit are capped at the proposed rates over the analysis period. Specifically, GDP will decrease by R 4 073 million, and about 40 601 potential jobs would be lost (see column 7). It is important to note that the GDP and potential job losses are average values / numbers over the period 2016–2025, i.e. potential job losses will amount to 40 601 on average per year over the programming period if interest rates are capped (see Table 4).
- The impact of capping the interest rate on unsecured credit on the economy is smaller than the impact of interest rate capping on credit facilities.

The only difference between Tables 3 and 4 is that the latter provides the same information on an annual basis. It is evident from

Table 3

Summarized Results of Scenario 1 of the Economic Impact. GDP (R Million, 2015 Constant Prices) and Employment (Numbers) for Unsecured Lending and Credit Facilities (Average Over the Period 2016 to 2025)

Scenario 1	Unsecured credit – Impact on consumption expenditures: Net interest paid	Unsecured credit – Impact on consumption expenditures: Change in credit	Total unsecured credit impact	Credit facilities – Impact on consumption expenditures: Net interest paid	Credit facilities – Impact on consumption expenditures: Change in credit	Total credit facilities impact	Net impact on unsecured credit and credit facilities
Column No.	1	2	3	4	5	6	7
GDP – total economy	2 307 241	2 301 928		2 305 463	2 302 722		
Baseline	2 305 357	2 305 357		2 305 357	2 305 357		
Difference	1 884	–3 429	–1 544	106	–2 635	–2 529	–4 073
Employment – total economy	15 155 220	15 106 900		15 138 941	15 110 196		
Baseline	15 137 965	15 137 965		15 137 965	15 137 965		
Difference	17 256	–31 064	–13 809	977	–27 769	–26 793	–40 601

Table 4 that the impact of capping is significantly negative for the first six years, thereafter, the impact turns positive. This initial negative effect should be attributed to the "bringing forward" of credit-affecting disposable income because the credit that would have been granted before capping will now not be granted. The positive effect starts in year 2019 due to the fact that people would, by then, benefit from lower credit repayments resulting from lower interest rates. This is in regards to paying less on credit, which is granted, as well as the fact that they don't have to pay interest on credit that was rejected by the formal sector.

Figure 1 indicates that the impact will mostly be on the services sector with nearly 40 %. The manufacturing sector will also be substantially negatively affected on average over the forecasting period.

Table 4

Annual Results of Scenario 1 of the Economic Impact: GDP (R Million, 2014 Constant Prices) and Employment (Numbers) for Unsecured Lending and Credit Facilities

Scenario 1	Unsecured credit		Total unsecured credit impact	Credit facilities		Total credit facilities impact	Net impact on unsecured credit and credit facilities
	Impact on consumption expenditures			Impact on consumption expenditures			
	Net interest paid	Change in credit		Net interest paid	Change in credit		
Column No.	1	2	3	4	5	6	7
				GDP			
2016	293	–3 561	–3 268	43	–12 693	–12 650	–15 918
2017	619	–3 986	–3 368	57	–4 367	–4 310	–7 678
2018	1 034	–5 094	–4 061	72	–4 350	–4 278	–8 338
2019	1 633	–7 363	–5 730	74	–692	–617	–6 347
2020	2 215	–7 334	–5 119	76	–703	–627	–5 747
2021	2 401	–2 238	163	78	–731	–653	–490
2022	2 548	–1 619	929	157	–675	–518	411
2023	2 695	–1 000	1 695	237	–620	–383	1 312
2024	2 664	–1 030	1 633	131	–749	–617	1 016
2025	2 744	–1 061	1 683	135	–770	–635	1 048
Average	1 884	–3 429	–1 544	106	–2 635	–2 529	–4 073
				Employment			
2016	2 959	–34 189	–31 231	424	–137 801	–137 377	–168 608
2017	6 126	–37 557	–31 431	559	–46 417	–45 858	–77 289
2018	10 055	–47 158	–37 103	695	–45 498	–44 803	–81 906
2019	15 611	–67 032	–51 421	704	–6 927	–6 223	–57 644
2020	20 849	–65 668	–44 819	711	–6 991	–6 281	–51 100
2021	22 177	–19 533	2 644	720	–7 149	–6 429	–3 785
2022	23 086	–13 939	9 147	1 369	–6 628	–5 259	3 888

Scenario 1	Unsecured credit		Total unsecured credit impact	Credit facilities		Total credit facilities impact	Net impact on unsecured credit and credit facilities
	Impact on consumption expenditures			Impact on consumption expenditures			
	Net interest paid	Change in credit		Net interest paid	Change in credit		
Column No.	1	2	3	4	5	6	7
2023	23 996	–8 345	15 650	2 018	–6 108	–4 090	11 561
2024	23 647	–8 523	15 123	1 288	–7 000	–5 712	9 411
2025	24 050	–8 699	15 351	1 278	–7 171	–5 892	9 459
Average	17 256	–31 064	–13 809	977	–27 769	–26 793	–40 601

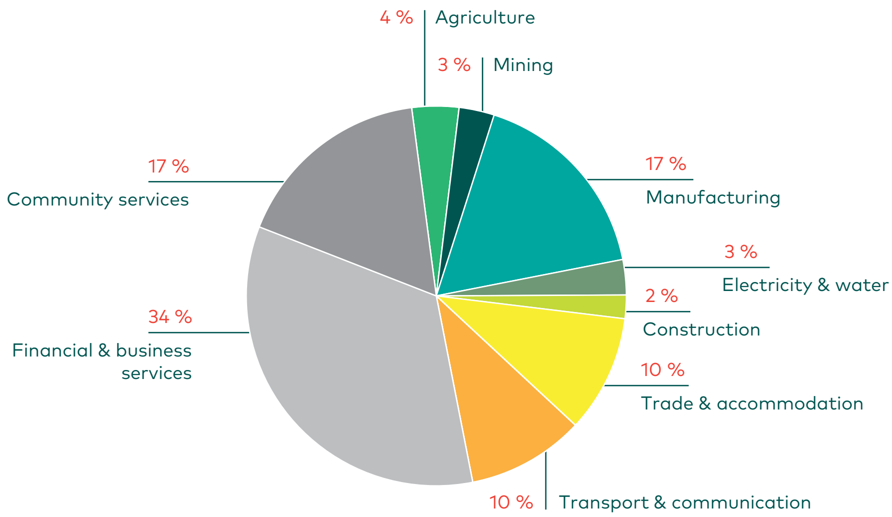

Fig. 1. Sectoral GDP impact of capping interest rates on unsecured lending and credit facilities, %.

3.8. Sensitivity analysis – results of Scenario 2 and Scenario 3

As indicated above, three levels of informal lending interest rates have been tested, namely 60 %, 70 %, and 80 % for Scenario 1, Scenario 2, and Scenario 3, respectively.

Table 5

Macroeconomic Impact of Different Interest Rate Levels in the Informal Lending Sector

	Scenario 1	Scenario 2	Scenario 3	Scenario 2 – Scenario 1 % change	Scenario 3 – Scenario 1 % change
Interest rate p.a.	60 %	70 %	80 %		
GDP (R million, 2014 prices)	–4 073	–7 927	–9 978	94.6 %	145.0 %
Employment (numbers)	–40 601	–76 031	–93 302	87.3 %	129.8 %

Currently, much higher rates are charged in the informal unregulated lending sector – there is overwhelming evidence that people are paying up to 20 % per month, which translates to a compounded interest rate of over 240 % per annum. However, it must be noted that the level of interest is inversely related to the volume of money that will be taken up in the informal lending sector. Further, it should also be noted that the additional customers in the informal lending sector are people that have been rejected by the formal lending sector where they were previously accommodated at interest rates in the range not higher than 33 %. They will therefore be reluctant to pay extreme interest rates that are common in the informal unregulated lending sector of 100 % plus per annum.

Table 5 presents the impact on GDP and employment for the different levels of interest rates charged in the informal lending sector, with the assumption that the same volume of credit would be taken up at the different interest rate levels. This assumption is only to a certain extent acceptable due to the fact that the assumed changes in levels are not that drastic. It is evident that there are major impact differences between the interest rate scenarios. For instance, the impact is more than doubled between Scenario 3 and Scenario 1, although the interest rate is only 20 percentage points higher.

The purpose of this exercise is to demonstrate that the impact given in the standard scenario (i.e. Scenario 1, 60 % interest rate charged in the informal lending sector) is not that unrealistic in view of the fact that currently up to 240 % per annum is charged for credit by the informal lending sector.

Conclusions and recommendations

The macroeconomic impact analysis of the proposed changes to the limitation of interest rates charged demonstrates very clearly that GDP and employment will be demonstrably negatively affected by the proposed changes. For example, on average over the period, GDP will decline by about R 4.1 billion, and employment losses will be 40 600 jobs over the 10-year analysis period. The main reason for this is that there is an inverse relationship between capping interest rates at lower levels and the willingness of financing institutions to accommodate credit resulting from the additional risks that financing institutions would carry at lower administered interest rates. The advantages of lower interest rates to customers are also to a great extent nullified by the fact that a certain number of customers who are rejected by the formal banking sector would be obtaining credit from the informal unregulated lending sector, but at significantly higher interest rate regimes.

It is of critical importance to note that only a portion of the customers that were in the past accommodated in the formal banking sector will be redirected into the informal lending sector – in the analysis undertaken, it has been assumed that, on average, 64 % of unsecured credit customers and 50 % of credit facilities customers that will not be serviced by the formal lending sector would be accommodated in the informal lending sector. The reason for this is that these groups of customers have always been accommodated in the formal lending sector at the maximum interest rates of 32.65 % for unsecured credit and 22.65 % for credit facilities. These rates are much lower than the rate currently charged by the informal unregulated lending sector, and it is foreseen that most of the customers that are declined in the formal banking sector will therefore not be willing to pay excessively high interest rates in the informal unregulated lending market, and rather refrain from further borrowing.

South Africa's lending sector is generally quite competitive and efficient, suggesting that major changes in the policy environment are not warranted. If lower interest rate caps were to be introduced, this should happen gradually with full cognizance of the consequences to the economy as a whole, as well as the potential unintended consequences. Any policy actions should not reduce the availability of credit in the economy.

Credit fees charged by formal financial institutions that have remained unchanged since 2007 are in need of adjustment. It is recommended that these fees (service and initiation fees) should be linked to an index such as the Consumer Price Index.

Where the regulation of fees and the implementation of changes to interest rate caps are deemed necessary by regulators, these should be implemented with caution and should, ideally, be phased in gradually. Interest rate caps should also be regularly reviewed to ensure that the negative effects associated with interest rate capping remain contained.

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THE ECONOMIC AND INDUSTRIAL FORECAST OF JAPAN 2013–2030 BY REVISED MODEL JIDEA9

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Introduction

23 years have passed since we started the construction of an INFORUM type model[11] JIDEA (Japan Inter-industry Dynamic Econometric Analysis). Year by year, we revised the model following the new I-O table published by the Japanese government. The government changes the base year of the I-O table every five years, then we construct a totally new model, re-organizing the industrial sectors and adding a new mechanism of calculation. The revision of 2016 demands a lot of work as the base year changed from 2005 to 2011[12] and the sector number increased from 73 to 85.

The model is based on observed data using I-O tables from 1995 to 2013. Estimates for future I-O tables from 2014 to 2030 are calculated using regression equations sector by sector. For both the final demand side (household consumption, private investment, exports and imports) and the value added side (wages, profits, depreciations, taxes and subsidies) we estimate each function sector by sector. All these components are summed up to macroeconomic variables. Through this model, input and output of each industry is calculated with perfect consistency, and we can analyze future economic situations from various aspects.

[11] The model structure is explained in ITI web page (http://www.iti.or.jp/jidea.model.pdf).

[12] The publishing of I-O table was delayed and the base year was 2011 instead of 2010.

In this report, we analyzed how the Japanese economy would develop from 2014 until 2030 based on Japanese historical data from 1995 to 2013 using the JIDEA9 model.

1. Shrinking Japanese economy and industries

1.1. Introduction and assumptions of the simulation

The revised model JIDEA9[13] is based on the observed data expressed in 2011 prices from 1995 to 2013, and we changed total sectors from 73 to 85. The number of manufacturing industry sectors increased from 44 to 51 and of service industry sectors from 29 to 34. The model is based on I-O tables published by the Japanese Statistical Office[14] and Japanese National Accounts.

The sectoral employment data are based on the attached table of the System of National Accounts (SNA) published in 2017, which contains 23 sectors. The 23 sectors are spread to 85 sectors using sectoral employment data attached to the basic I-O table which is published every 5 years. The labor input coefficients are extended by the assumption that the growth rate of the labor input coefficient from 2000 to 2015 is the same as from 2016 to 2030.

For the gross fixed capital formation of the I-O table, industries expressed as selling side industries of capital goods are converted to purchasing side industries by the fixed capital matrix of 2011 (available in the basic I-O table of the same year). The fixed capital matrix is only obtained once every 5 years, so in the JIDEA9 model, we converted the investment flow from the selling side to the purchasing side only by using the table of 2011.

The main sources of the I-O table are I-O linked tables made for 2000, 2005 and 2011 with the same definition and base year[15]. We have complemented the missing year tables by the extended I-O tables, which are prepared separately by the Ministry of Economy, Trade and Industry. The historical database itself contains the effect of the Lehman Brothers Bankruptcy, and the North East Japan Earthquake and its recovery process. The estimated I-O table for 2014 is adjusted by macroeconomic indicators of SNA. Accordingly, the results estimated by the model are from 2015.

Baseline assumptions of the JIDEA9 model.

[13] The basic software of this model is developed by INFORUM (http://www.inforum.umd.edu/)

[14] The details are shown in the data source Table A1 in the Appendix.

[15] Refer to Table A1 in the Appendix.

- Recent year (2014) simulation results are controlled by actual or provisional data of SNA.
- The additional government investment and consumption in 2014–2015 spent for the East Japan Earthquake is included.
- The planned increase of the consumer tax in 2014 (from 5 % to 8 %) and in October 2019 (from 8 % to 10 %) is included.
- The intermediate input coefficient matrix is extended by historical trend (1995–2013) until 2030.

The main exogenous variables.

- The population forecasted by the National Institute of Population and Social Securities Research on January 2012 with medium mortality assumption.
- The labor participation rate[16] and labor productivity are extended by historical growth rate.
- The exchange rate is fixed by the monthly average rate of 2016; 1 dollar=108.837 yen.
- The fossil fuel price is assumed to grow by 2 % annually from 2017 to 2030.
- World import demand from Japan and Japanese import price from the world are prepared by BTM[17].
- Government investment is extended by one year lagged value.

Considering the United Kingdom's exit from the EU, "America first" policy by the U.S. President Trump, and the economic stagnation of China, instability is increasing in the world economy and turning into a new stage. With OPEC's agreement to reduce oil production, world material prices are expected to spike, and with the instability of exchange rates and the stock market, the prospect of the world economy seems opaque. "Abenomics", which consists of three objects: bold monetary easing, flexible fiscal policy, and economic growth strategies to encourage private investment, started in 2013. It achieved limited results in financial and monetary aspects such as rising stock prices and weaker Yen. It has not shown evident recovery because of the delay of implementation of the policy to encourage growth.

In 2016, the Abe cabinet presented a new policy named the "Japan Revival Strategy" aiming to pull the size of Japanese GDP up to 600 trillion yen, but the detailed strategy was not announced. It is almost an abstract explanation without statistical data. On the other hand, the statistical office was planning the revision of the SNA statistical system and definitions. For example, private R & D payments are planned to be included as investment.

[16] The labor participation rate increases from 59.3 % in 2013 to 63.5 % in 2030. Labor participation rate is calculated as labor force divided by working age population.

[17] Bi-lateral Trade Model of INFORUM

Fig. 1. Population, 100 thousand.

As a result, the objective of increasing the size of GDP to 600 trillion yen was almost fulfilled. Nonetheless, Abe's strategy is not included in JIDEA9.

The special procurement of the Tokyo Olympic Games in 2020 may bring such effects as a result of construction of new game venues, game management costs, and travel expenditures of foreign visitors. The total amounts of these effects should be estimated outside the model. Therefore the effects of the Tokyo Olympic Games are difficult to estimate and not included in the model.

This model is intended to forecast the economy in real terms, so the fiscal or monetary policy such as significant monetary easing by Mr. Kuroda, the Governor of Bank of Japan, is not included in the model. Even though these fiscal and monetary policy effects are thought to be included in the historical data such as in 2014 and 2015 when "Abenomics" was implemented in the Japanese economy. It is assumed that the world economy grows gradually, though the exchange rate is fixed at 108.837 per US dollar of the 2016 level. The fuel price in 2016 is 41.6 US dollars per barrel, and after 2017, the fuel price is assumed to grow by 2 % annually until 2030.

In these assumptions, the most significant effect is caused by the shrinking population. The Japanese population reached its peak in 2005 and then began to shrink. The share of the population over 65 increases and the share of the population from 15 to 65, the working age population, decreases (Fig. 1). In 2025, the baby boom generation will reach the group of elderly people, and Japan will encounter the risk of rapid increase of Medicare costs. As this model does not include the financial or fiscal sub-model, it cannot estimate the budget deficit or bankruptcy of the pension fund.

1.2. Decreasing GDP and consumption

GDP in real terms decreases after the peak in 2016 (Table 1). From 2015 to 2030, consumption decreases, especially household consumption, which forms 60 % of GDP. Private investment peaks out in 2015, but government investment continues to increase, and accordingly total investment peaks in 2020–2021. Exports reach a peak

Table 1

Long-term Economic Forecasts of Japan, 2011 Prices, Trillion Yen, 100 Thousand*, %

Year	GDP	Consumption	Investment	Exports	Imports	Output	Wages	Inflation	Number of employees*	Growth rate GDP %
2013	471.1	385.2	101.3	72.1	87.4	934.9	255.3	0.53	633.8	0.67
2014	471.7	380.7	105.1	74.7	88.8	937.6	256.3	1.38	633.6	0.14
2015	476.6	375.7	112.8	76.8	88.8	953.6	260.6	0.26	634.6	1.02
2016	479.5	377.4	114.9	76.7	89.5	961.3	261.0	−0.87	635.0	0.61
2017	479.4	376.9	115.6	76.5	89.5	962.5	260.3	−0.05	635.0	−0.01
2018	479.3	376.6	116.0	76.2	89.6	963.4	259.4	−0.24	635.0	−0.03
2019	479.1	376.1	116.3	75.9	89.3	964.6	258.5	0.07	634.9	−0.04
2020	478.7	375.6	116.5	75.8	89.2	965.4	257.5	−0.13	634.9	−0.09
2021	478.2	375.2	116.5	75.7	89.1	966.2	256.5	−0.12	634.8	−0.10
2022	477.5	374.6	116.4	75.5	89.0	966.8	255.4	−0.09	634.8	−0.14
2023	476.8	374.0	116.2	75.5	88.9	967.4	254.3	−0.08	634.7	−0.15
2024	475.9	373.3	116.0	75.4	88.8	967.8	253.1	−0.06	634.6	−0.19
2025	474.9	372.6	115.7	75.3	88.6	968.2	251.9	−0.05	634.4	−0.20
2026	473.6	371.8	115.2	75.3	88.7	968.0	250.5	−0.02	634.3	−0.27
2027	472.2	370.9	114.6	75.2	88.6	967.5	249.2	0.01	634.1	−0.31
2028	470.6	370.0	114.0	75.1	88.5	967.0	247.8	0.03	633.8	−0.33
2029	468.9	368.9	113.4	75.1	88.5	966.4	246.4	0.05	633.6	−0.35
2030	467.1	367.8	112.7	75.0	88.4	965.7	244.9	0.07	633.4	−0.38
2013-2030 Average CAGR %	−0.05	−0.27	0.63	0.23	0.07	0.19	−0.24	n.a.	0.00	n.a.

Note: Figures are all in real terms except Wages; n.a. – no value.
(Source: Forecasted by JIDEA. Hereafter the source is the same except otherwise indicated.)

in 2015 followed by imports in 2018, and afterwards both gradually decrease.

Because of the transfer of the production base of Japan to overseas countries, exports decrease more rapidly than imports, and the foreign trade deficit gradually increases (Table 2).

The number of employees and wages per employee both decrease, and the total wages (which are calculated by multiplying these two indicators) decrease. As a result, disposable income, which is estimated from total wages and the profit of small business, decreases (Table 3).

Looking at this effect from the total population perspective, total wages per capita remain flat under the condition of decreased population, and disposable income per capita slightly increases (Fig. 2).

Table 2

GDP by Expenditure Approach, 2011 Prices, Trillion Yen

	Historical data				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
GDP	476.5	489.4	500.8	461.2	476.6	478.7	474.9	467.1	−0.18	−0.13
Total expenditure	364.5	383.2	393.6	370.4	375.7	375.6	372.6	367.8	−0.13	−0.14
Outside household	19.9	18.9	16.7	15.1	12.9	11.2	9.5	7.7	−2.49	−3.39
Household	271.0	281.2	283.5	276.3	275.8	278.6	278.3	276.5	−0.13	0.02
Government	73.6	83.1	93.4	79.0	87.0	85.8	84.8	83.6	0.31	−0.26
Total investment	137.2	127.3	116.3	96.8	112.8	116.5	115.7	112.7	−0.80	−0.01
Private sector	94.4	89.8	89.5	74.7	85.6	84.7	81.5	76.6	−0.32	−0.74
Government	40.9	37.6	25.1	21.1	27.9	32.4	34.8	36.7	−1.98	1.85
Inventory change	1.9	−0.2	1.7	1.1	−0.7	−0.7	−0.7	−0.7	10.4	0.0
Export	43.1	53.8	73.5	73.1	76.8	75.8	75.3	75.0	2.4	−0.2
Import	−68.3	−74.9	−82.5	−79.2	−88.8	−89.2	−88.6	−88.4	1.1	0.0
Trade Balance	−25.2	−21.1	−9.0	−6.1	−12.0	−13.5	−13.3	−13.4	n.a.	n.a.

Note: Forecasted figures of Inventory change are fixed at 2013 level. n.a. – no value.

Table 3

Disposable Income and Saving, 2011 Prices, Trillion Yen, 100 Thousand Yen*, %

	Historical					Forecast			2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Wages (in real terms)	269.4	271.2	258.8	243.0	248.5	245.5	238.7	230.4	−0.68	−0.50
Disposable income (in nominal terms)	301.7	300.7	290.0	287.5	304.0	303.1	300.9	297.3	−0.32	−0.15
Saving (in nominal terms)	32.5	20.7	4.2	5.7	15.0	17.5	14.6	10.4	–10.98	–2.41
Saving rate (%)	10.634	6.816	1.445	1.987	4.973	5.833	4.909	3.547	–10.58	–2.23
Household consumption (in nominal terms)	272.9	282.8	285.3	279.8	286.1	281.8	282.2	282.6	0.17	−0.08
Disposable income (in real terms)	300.9	296.9	287.4	288.9	289.2	296.8	293.8	288.0	−0.27	−0.03
Saving (in real terms)	32.4	20.4	4.1	5.7	14.2	17.1	14.2	10.1	–10.93	–2.29
Household consumption (in real terms)	271.0	281.2	283.5	276.3	275.8	278.6	278.3	276.5	0.13	0.02
Wages per employee* (in real terms)	21.3	21.2	20.1	19.0	19.6	19.8	19.8	19.8	−0.77	0.04
Disposable income per capita* (in real terms)	23.9	23.5	22.5	22.5	24.0	24.4	24.9	25.5	−0.41	0.40
Consumption per capita* (in real terms)	21.4	22.0	22.0	21.6	21.8	22.4	23.1	23.7	0.04	0.57

Note: Wages and wages per capita are converted in real terms by CPI.

Fig. 2. Income per capita and consumption, 2011 prices, 100 thousand Yen.

The decrease of total wages is caused by the increase of the number of non-full-time employees (or irregular employment) who are not paid the same as full-time employed workers, which leads to a labor share decrease in value added. The increase of the number of aged persons who do not work causes a decrease in income; however they withdraw savings, including pension funds, therefore household consumption holds at the same level. As a result, household consumption per capita increases slightly.

Household consumption decreases gradually from 2015 to 2030, and the decrease of tangible goods is more rapid than in services (Table 4). The consumption of chemical, petro, rubber and ceramic production goods increases because the high weighted pharmacy sector is included in the chemical sector and consumption of its products increases, but the consumption of petroleum refinery sector products, which also has a large weight, decreases. As a result, the total share of this sector slightly decreases. The transportation equipment sector in which the automobile sector occupies the largest part, is stagnant, however the weight of transportation equipment in total consumption holds almost the same.

Communication equipment, such as prevailing smart-phones, is rapidly enlarging the market. The emerging internet society causes the rapid increase of the consumption of communication and information services. On the contrary, the consumption of transportation services diminishes, though the total consumption of communication, information and transportation services holds almost at the same level. The increase of the aging population causes the expansion of consumption of medical and nursing services.

Table 4

Household Consumption, 2011 Prices, Trillion Yen

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**271.0**	**281.2**	**283.5**	**276.3**	**275.8**	**278.6**	**278.3**	**276.5**	**−0.13**	**0.02**
Agriculture, forestry, fishery and mining	4.1	3.7	3.7	3.7	3.0	2.8	2.7	2.6	−1.53	−0.93
Manufacturing total	**73.4**	**70.0**	**67.0**	**64.5**	**61.9**	**62.9**	**62.9**	**62.4**	**−0.82**	**0.06**
Food and beverage	31.9	29.9	28.0	26.4	23.9	23.4	22.6	21.7	−1.49	−0.63
Textile, pulp and wooden products	7.1	6.4	4.6	3.7	3.7	3.6	3.4	3.3	−3.52	−0.87
Petroleum, chemical, rubber and ceramic production	11.4	11.9	11.4	10.7	9.3	9.2	8.9	8.6	−1.62	−0.54
Ferrous, non-ferrous and metal production	0.9	0.6	0.5	0.4	0.4	0.4	0.4	0.4	−2.92	0.45
Machinery	4.2	4.5	5.4	6.8	7.0	8.5	9.6	10.6	3.01	2.80
Transport equipment	5.8	4.7	5.5	4.8	7.0	7.0	6.9	6.8	2.68	−0.16
Other manufacturing	3.9	3.3	2.9	2.2	2.3	2.6	2.7	2.8	−2.40	1.16
Construction and civil engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.a.	n.a.
Electricity, gas and water supply	8.1	8.8	8.7	9.4	8.3	8.3	8.3	8.3	−0.37	0.03
Service industries total	**193.6**	**207.5**	**212.9**	**208.1**	**211.0**	**212.8**	**212.7**	**211.5**	**0.11**	**0.02**
Commerce, finance and real estate	107.4	111.2	115.2	112.5	116.0	116.8	116.8	116.2	0.28	0.02
Transportation, communication and information services	19.3	22.8	23.9	26.7	25.1	25.6	25.7	25.6	0.65	0.13

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Administration, education and medical services	20.9	20.4	23.6	26.2	26.6	28.0	29.0	29.7	1.80	0.72
Business services	3.3	4.3	4.0	4.6	4.0	3.9	3.9	3.8	−0.48	−0.19
Personal services	42.7	48.9	46.1	38.0	39.3	38.5	37.4	36.1	−1.44	−0.57

Note: The model estimates 85 sectors, but here we aggregate them into 15 sectors.
The sectors Construction / Civil Engineering and Electricity / Gas / Water are included in Manufacturing.
n.a. – no value.

1.3. Output and employment; stagnation of labor productivity

In this model, the demand side is determined first, the components of GDP expenditure such as consumption, investment, and exports are estimated at the beginning, then the total of these demand items and the intermediate demand determine output and imports. The stagnation of output is caused by the decrease of household consumption, and finally the decrease of household consumption is caused by diminution of the population and the increase of the aged population. The decrease of output is apparent in the agriculture, forestry and fishery sector. The output of the total manufacturing industry decreases but slightly increases in services (Table 5). The reduction of the manufacturing industry may be caused by the transfer of production facilities[18] overseas. The augmentation of the service industries is explained by the immobility of service industries, that is to say, the services are produced and consumed at the same place and are difficult to transfer overseas.

Looking at the structure of the output, we can see that from 2015 to 2030 the share of manufacturing industries diminishes from 41.2 % to 39.0 % while the share of service industries increases from 57.5 % to 59.9 %. The shift towards the service industries continues. Rapidly increasing fields such as the Internet of Things, or Big Data analysis, the enterprises based on Internet society emerge one after another and the related industries or production are expected to increase significantly.

The employed population in this model is calculated by multiplying output by the labor input coefficient (=inverse of labor productivity

[18] In the 2013 fiscal year the overseas production rate in the manufacturing industry reached 22.9 %, higher than the preceding year by 2.6 percentage points and the highest level historically.

Table 5

Output by Sectors, 2011 Prices, Trillion Yen

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**936.8**	**940.9**	**972.7**	**900.0**	**953.6**	**965.4**	**968.2**	**965.7**	**0.09**	**0.08**
Agriculture, forestry, fishery and mining	16.3	15.4	14.2	14.0	12.2	12.0	11.6	11.0	–1.55	–0.64
Manufacturing total	**445.2**	**429.2**	**419.9**	**376.7**	**393.1**	**392.6**	**386.3**	**376.6**	**–0.58**	**–0.28**
Food and beverage	43.1	41.4	38.4	36.1	33.0	32.1	30.9	29.5	–1.51	–0.74
Textile, pulp and wooden products	35.6	30.2	25.0	19.9	19.4	17.9	16.5	15.2	–2.91	–1.62
Petroleum, chemical, rubber and ceramic production	74.6	76.0	74.6	69.9	69.8	70.7	70.5	69.9	–0.57	0.01
Ferrous, non-ferrous and metal production	64.1	57.2	57.2	51.8	53.1	50.9	48.2	45.2	–0.49	–1.07
Machinery	60.6	64.6	69.0	63.3	68.1	70.2	71.3	71.5	0.35	0.33
Transport equipment	40.5	41.0	54.0	51.1	50.4	49.3	48.3	47.1	1.39	–0.46
Other manufacturing	6.2	5.6	4.7	4.5	4.7	4.7	4.6	4.5	–1.22	–0.32
Construction and civil engineering	92.2	83.0	67.1	52.0	65.8	67.5	66.5	64.4	–1.54	–0.15
Electricity, gas and water supply	28.4	30.2	30.0	28.1	28.9	29.2	29.4	29.5	–0.30	0.13
Service industries total	**475.3**	**496.3**	**538.6**	**509.3**	**548.3**	**560.8**	**570.4**	**578.1**	**0.67**	**0.35**
Commerce, finance and real estate	189.1	186.5	203.6	193.3	200.4	203.2	204.6	205.0	0.48	0.15

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Transportation, communication and information services	72.8	75.2	82.1	83.5	88.0	91.5	94.2	96.7	1.05	0.64
Administration, education and medical services	104.9	115.5	130.8	119.5	130.9	132.4	133.5	134.1	0.84	0.16
Business services	45.0	50.1	58.1	58.6	71.5	78.5	85.2	92.2	2.39	1.71
Personal services	63.4	69.0	63.9	54.3	57.5	55.3	52.8	50.0	−1.21	−0.92

coefficient). The labor productivity coefficient is difficult to estimate. It is affected by the economic cycle and by the capital equipment rate per employee. It depends on whether the industry is labor intensive or capital intensive. The most influential factor for labor productivity is technical innovation, which does not occur consecutively and expectedly. Each industry is in a different level of development – some are stagnant, while others are rapidly confronting new technical innovations. The labor productivity of each industry reflects these stages of development. Accordingly, we tried many types of productivity equations to make it endogenous, but finally we assume that the labor productivity is determined by its growth rate of the past 15 years and continues at the same rate for 15 more years (Table 6). The amount of labor force required for each industry is calculated by multiplying the labor input coefficient and output estimated in the model. Labor productivity is then re-calculated using the result of the forecast and the original definition of labor productivity (=value added / employment) and graphs express the 34 sectors aggregated from 85 sectors of the model.

Comparing the increased rate of production, manufacturing grows slower than services but labor productivity growth in manufacturing is higher than in services (Table 6). This is because services are much more labor intensive than manufacturing, and also technical innovation tends to occur much easier in manufacturing than the service industries.

Looking at changes of labor productivity by comparing the values of the index in 2010 and 2030, we see that machinery, transportation

Table 6

Index of Labor Productivity (=Value Added/Number of Employees), 2015 = 100

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**		
Total	**97.4**	**102.5**	**105.1**	**98.3**	**100.0**	**99.9**	**99.9**	**99.8**	**−0.17**	**−0.01**
Agriculture, forestry and fishery	84.7	91.1	86.1	94.5	100.0	106.2	113.8	122.9	0.63	1.38
Mining	91.6	88.9	88.5	91.7	100.0	92.6	112.4	99.1	0.79	−0.06
Total manufacturing	**87.4**	**92.1**	**95.8**	**98.2**	**100.0**	**102.2**	**104.6**	**107.4**	**0.55**	**0.48**
Food and beverage	79.2	85.3	83.4	90.7	100.0	102.0	104.7	109.1	1.07	0.58
Textile	110.0	95.3	83.6	92.1	100.0	103.5	109.8	110.9	0.32	0.69
pulp and wooden products	106.1	107.4	108.7	111.5	100.0	97.9	94.8	92.8	−0.47	−0.50
Printing and book binding	102.8	103.6	103.2	106.2	100.0	102.2	102.9	104.7	−0.23	0.31
Chemical industry	101.4	104.5	120.0	111.7	100.0	102.5	99.2	106.9	−0.30	0.44
Pharmaceutical industry	68.3	77.7	82.7	97.1	100.0	103.1	131.3	132.5	1.69	1.89
Petroleum and coal products	64.2	85.1	83.8	98.7	100.0	105.4	109.0	111.8	1.08	0.75
Rubber and plastics	122.6	113.3	105.4	108.9	100.0	96.2	93.0	90.8	−0.83	−0.64
Glass, cement and ceramics	81.8	83.1	94.5	94.4	100.0	98.5	95.1	93.4	1.24	−0.45
Iron and steel	76.1	76.4	105.2	93.8	100.0	106.1	117.2	125.8	1.81	1.54
Non-ferrous metal products	81.6	106.6	108.2	121.2	100.0	94.9	88.4	84.4	−0.43	−1.12
Metal products	119.3	115.8	114.0	104.3	100.0	89.9	79.3	67.6	−0.97	−2.57
General and special machines	98.7	95.3	97.2	90.1	100.0	100.4	100.8	101.3	0.32	0.09
Office and service machines	90.6	103.6	113.4	94.9	100.0	108.7	117.3	124.1	−0.23	1.45
Electronic parts	126.3	157.8	117.6	91.4	100.0	108.3	117.0	133.1	−2.99	1.92
Heavy electric machinery	103.9	86.4	81.8	86.6	100.0	104.5	113.9	126.3	0.98	1.57

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Household electric appliances	97.9	92.5	93.1	104.9	100.0	97.7	99.5	99.6	0.52	−0.02
Computer and communication technologies	144.8	173.7	177.8	122.4	100.0	93.6	84.9	73.4	−3.62	−2.04
Transportation equipment	96.7	99.1	101.4	98.0	100.0	103.7	106.8	110.3	0.06	0.65
Automobile	104.1	98.3	99.3	93.7	100.0	105.0	109.5	113.4	0.12	0.84
Miscellaneous manufacturing	62.2	67.1	71.3	92.1	100.0	112.2	130.2	152.0	2.70	2.83
Construction and civil engineering	98.3	95.2	86.5	82.6	100.0	103.1	105.1	106.3	0.33	0.41
Electricity, gas and water supply	182.7	179.4	168.2	153.3	100.0	91.8	82.3	73.4	−3.82	−2.04
Total service industries	**103.3**	**107.6**	**110.4**	**99.1**	**100.0**	**99.1**	**98.3**	**97.5**	**−0.49**	**−0.17**
Commerce	113.3	112.1	120.2	101.8	100.0	93.3	87.1	80.9	−0.76	−1.40
Finance and insurance	82.4	90.4	104.8	87.3	100.0	110.8	123.2	139.0	0.67	2.22
Real estate and imputed rent	92.2	82.8	97.8	95.7	100.0	103.3	106.5	110.1	1.27	0.64
Transport services	110.2	105.0	112.6	101.7	100.0	97.5	96.2	95.5	−0.33	−0.31
Communication and information services	83.6	115.2	112.9	105.6	100.0	98.4	96.9	96.2	−0.94	−0.26
Public Administration	118.4	168.9	171.9	112.3	100.0	98.9	97.9	96.3	−3.43	−0.25
Education and research	114.5	125.0	125.1	108.6	100.0	96.3	92.7	89.7	−1.48	−0.72
Medical and nursery services	77.3	83.5	88.1	93.6	100.0	101.7	102.5	102.8	1.21	0.18
Business services	128.1	118.5	109.2	95.2	100.0	95.9	91.3	86.4	−1.13	−0.97
Personal services	106.0	112.2	109.6	98.4	100.0	100.7	102.3	104.6	−0.77	0.30
Not elsewhere classified	52.2	73.5	141.5	−39.6	100.0	103.8	135.3	152.6	2.08	2.86

Note: Value added figures are transformed in real terms by GDP deflator.
The 85 sector's result of estimation aggregated in 35 sectors.

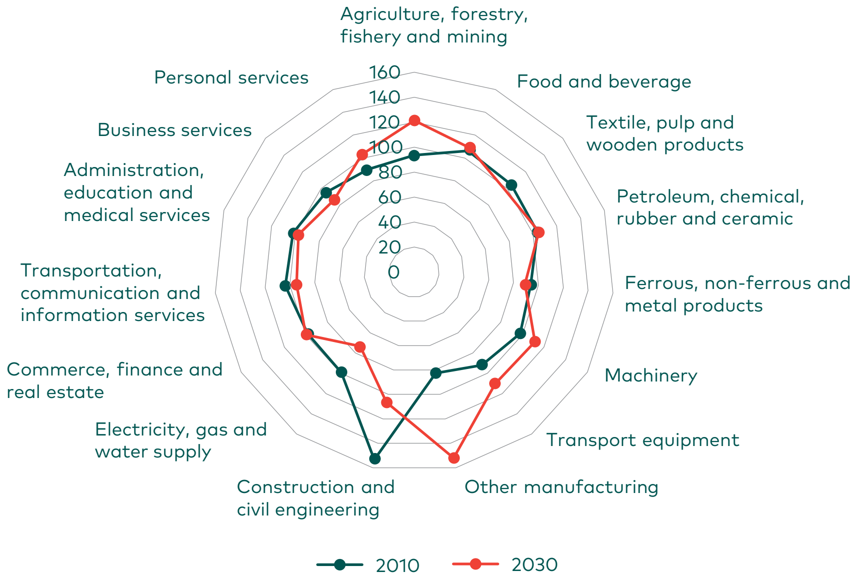

Fig. 3. Labor productivity index, 2015 = 100.

equipment and miscellaneous manufacturing show relatively high values in 2030, on the other hand, the electricity, water, gas and construction industries are stagnant and in some of the service industries the values of the index are decreasing (Fig. 3). The Japanese economy is driven by the high productivity of the large scale leading companies. However, we should not forget that relatively low level labor productivity sectors such as the service industries absorb the unemployed workers who lost

Table 7

Employed Population by Sectors, 100 Thousand

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**672.1**	**656.1**	**654.8**	**644.9**	**655.0**	**658.4**	**653.7**	**643.2**	**−0.01**	**−0.12**
Agriculture, forestry, fishery and mining	48.6	39.4	36.6	32.7	27.3	25.2	22.7	20.2	−2.42	−1.99
Manufacturing total	**224.3**	**204.3**	**185.8**	**169.2**	**170.1**	**168.5**	**163.5**	**156.5**	**−1.21**	**−0.55**
Food and beverage	16.6	16.0	15.6	14.7	12.8	12.4	11.9	11.2	−1.48	−0.89

	Historical				Forecast				2000–15 CAGR (%)	2015–30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Textile, pulp and wooden products	32.5	26.9	21.9	17.2	16.0	14.8	13.7	12.6	–3.40	–1.58
Petroleum, chemical, rubber and ceramic production	12.6	11.6	10.6	9.9	9.9	9.7	9.5	8.9	–1.05	–0.71
Ferrous, non-ferrous and metal production	17.0	15.1	14.0	13.4	14.1	14.1	13.7	13.1	–0.46	–0.49
Machinery	37.9	35.3	31.2	29.8	30.2	29.0	27.3	25.2	–1.03	–1.20
Transport equipment	11.3	10.5	11.8	12.3	12.6	12.2	11.8	11.3	1.22	–0.72
Other manufacturing	7.9	6.6	5.3	4.2	3.7	3.4	2.9	2.4	–3.78	–2.84
Construction and civil engineering	82.5	76.4	69.6	61.9	64.8	66.8	66.6	65.4	–1.09	0.06
Electricity, gas and water supply	5.8	5.9	5.7	5.9	6.0	6.1	6.2	6.2	0.11	0.22
Service industries total	**399.2**	**412.4**	**432.4**	**443.0**	**457.7**	**464.8**	**467.4**	**466.6**	**0.70**	**0.13**
Commerce, finance and real estate	148.5	142.4	146.4	146.3	147.5	147.4	146.2	144.1	0.23	–0.16
Transportation, communication and information services	49.6	50.8	53.2	55.6	55.4	57.6	58.9	59.5	0.58	0.48
Administration, education and medical services	86.8	93.2	99.8	103.4	109.4	112.7	115.6	118.0	1.07	0.51
Business services	37.3	46.9	54.7	58.5	65.8	69.1	71.5	73.4	2.28	0.73
Personal services	77.2	79.1	78.3	79.2	79.6	77.9	75.1	71.6	0.04	–0.70

their jobs at shrinking manufacturing industries. Also, the growth of the service economy in Japan tends to keep labor productivity low.

The labor participation rate depends not only on vital statistics but also on the social situation such as the school attendance rate, the retirement system, the labor participation of housewives and the economic growth rate or business cycle. Economic growth without a sufficient labor participation rate will cause a labor shortage, but in this model it does not happen because our model forecasts that the shrinking economy and increased labor productivity occur at the same time. If the economy grows faster than our projection, we fear a labor shortage will emerge. The workers are encouraged to work after the legal retirement age of 65 and the local governments are encouraged to make it easy for housewives to participate in the labor market by providing child care supports or expanding child nursing facilities.

Looking at the number of employees, it gradually increased from the low point in 2011 and reached its peak in 2016–2017 (Table 7). From 2015 to 2030, the number of employees in manufacturing will decrease. On the other hand, it will slightly increase in the service industries.

The capital intensive sectors are already so rationalized that it is difficult to reduce the labor any more. In the service sectors, except commerce, finance and real estate and personal services, the index will go up. The public sectors such as education and medical services will see a relatively high increase in the number of employees, except in public administration.

1.4. Private investment

Some researchers believe that Japan does not need economic growth[19]. The arrival of a high interest age means a decrease of investment demand and disappearance of a new economic frontier. As we cannot expect new enlargement of the market, the global capital market is confronting the crisis of continuous stagnation. Japan is now stepping into the stage of a matured economy keeping the highest position in the world from the environmental, health and securities viewpoints. The most important factor influencing the decrease of the population is how to increase labor productivity. To exploit the new demand, new technical innovations and aggressive investment is vital to increase productivity.

Under the shrinking working age population, increasing labor productivity is essential to enforce economic viability and international competitiveness.

To increase labor productivity, it is essential to increase private investment. However, with a shrinking population Japanese entrepreneurs cannot keep the willingness to invest. In the age of the globalization economy, if a business person is keeping old production systems, is not trying to expand market share and is refusing innovative changes, the

[19] Kazuo Mizuno, Eisuke Sakakibara(2015) “The End of Capitalism and the World After” (In Japanese), Sisousha-shinsho

Table 8

Private Investment by Purchasing Side, 2011 Prices, Trillion Yen

	Historical				Forecast				2000 –15 CAGR (%)	2015 –30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**94.593**	**89.919**	**89.711**	**74.852**	**85.600**	**84.724**	**81.513**	**76.631**	**−0.33**	**−0.74**
Agriculture, forestry, fishery and mining	2.011	1.851	2.072	1.674	1.701	1.777	1.755	1.661	−0.56	−0.16
Manufacturing total	**47.908**	**44.670**	**43.454**	**35.071**	**40.861**	**39.118**	**36.424**	**32.987**	**−0.59**	**−1.42**
Food and beverage	1.844	1.720	1.769	1.564	1.718	1.724	1.665	1.562	−0.01	−0.63
Textile, pulp and wooden products	1.659	1.619	1.687	1.462	1.637	1.687	1.677	1.625	0.07	−0.05
Petroleum, chemical, rubber and ceramic production	3.941	3.820	4.086	3.474	4.033	4.188	4.197	4.110	0.36	0.13
Ferrous, non-ferrous and metal production	2.273	2.151	2.169	1.846	2.135	2.183	2.148	2.055	−0.05	−0.25
Machinery	6.850	7.001	7.528	6.395	7.397	7.738	7.821	7.737	0.37	0.30
Transport equipment	2.822	2.778	2.989	2.376	2.811	2.876	2.822	2.684	0.08	−0.31
Other manufacturing	0.638	0.638	0.657	0.559	0.641	0.662	0.659	0.640	0.03	−0.01
Construction and civil engineering	22.018	19.739	18.073	12.934	15.532	13.034	10.406	7.609	−1.59	−4.65
Electricity, gas and water supply	5.862	5.204	4.497	4.460	4.957	5.027	5.029	4.966	−0.32	0.01
Service industries total	**44.674**	**43.399**	**44.187**	**38.106**	**43.038**	**43.829**	**43.335**	**41.983**	**−0.06**	**−0.17**
Commerce, finance and real estate	13.770	13.804	13.922	11.581	13.759	14.567	14.919	15.020	−0.02	0.59
Transportation, communication and information services	10.925	9.744	9.158	8.600	9.694	9.486	9.026	8.381	−0.03	−0.97

	Historical				Forecast				2000 –15 CAGR (%)	2015 –30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Administration, education and medical services	7.949	7.470	7.444	5.943	6.735	6.537	6.131	5.574	−0.69	−1.25
Business services	7.597	7.870	8.763	7.662	8.245	8.566	8.592	8.382	0.31	0.11
Personal services	4.435	4.510	4.901	4.319	4.605	4.672	4.667	4.626	0.14	0.03

market will be deprived immediately by the competitor. While expecting the effort of the private sector, the government should remove improper regulations or irrational systems of market control, which distort free market mechanisms and prevent investment so as to improve the efficiency of Japanese society as a whole.

Total private investment reached a low point in 2011 and gradually increased until 2015, but afterwards it gradually decreased (Table 8). From 2015 to 2030, investment in manufacturing will decrease much more than in services. We have not added any assumption such as "innovative industries invest much more than traditional ones" but only assume that the historical investment trend of each sector continues into the future. Therefore the sectors, which are expected to grow considerably do not increase so much. If the government does not implement new policy such as deregulation of economic activity or preferential treatment for new investments, the weak investment forecasted by this model will be realized.

Looking at the changes in investment by sectors from 2015 to 2030, the forecast shows that the manufacturing sector will lose its share but the service sector enlarges its weight. Food and beverages, textile, and paper and furniture, keep their level, but the chemical, petroleum, rubber and ceramic, and machinery sectors will increase their weight. The iron, steel and non-ferrous metals, transport equipment and miscellaneous manufacturing sectors will increase slightly. Construction and civil engineering will experience an apparent decrease. In the service sector, commerce, finance and real estate will enlarge the share significantly, but on the contrary transportation, communication and information, public administration, education and medical service sectors will reduce their shares.

In summary, manufacturing industries, except food and beverages, keep their investment level from 2010 to 2030, but construction and civil engineering apparently will shrink, and in the service sectors total investment will be reduced, except in commerce, finance and real estate.

1.5. Exports and imports

The total real exports of Japan reached its peak in 2015 and are forecasted to gradually decrease (Table 9). The rate of decrease in services is much larger than in manufacturing. From 2015 to 2030, many sectors in the manufacturing industry will enlarge their export shares but only the transportation sector will reduce it. In the service sector, the export share of the commerce, finance and real estate sector, which is comparatively large, will gradually lose its weight.

Table 9

Export Value by Sectors, 2011 Prices, Trillion Yen

	Historical				Forecast					
	1995	2000	2005	2010	2015	2020	2025	2030	2000 –15 CAGR (%)	2015 –30 CAGR (%)
Total	**43.066**	**53.838**	**73.508**	**73.101**	**76.823**	**75.766**	**75.301**	**74.980**	**2.40**	**–0.16**
Agriculture, forestry, fishery and mining	0.038	0.065	0.080	0.107	0.101	0.106	0.110	0.118	2.98	1.04
Manufacturing total	**34.238**	**42.468**	**56.531**	**56.554**	**57.226**	**56.585**	**56.295**	**56.111**	**2.01**	**–0.13**
Food and beverage	0.199	0.231	0.310	0.336	0.483	0.524	0.559	0.602	5.04	1.48
Textile, pulp and wooden products	0.874	0.984	1.069	0.915	0.989	0.950	0.928	0.913	0.03	–0.53
Petroleum, chemical, rubber and ceramic production	5.347	6.349	9.587	10.255	10.704	11.080	11.247	11.400	3.54	0.42
Ferrous, non-ferrous and metal production	4.405	5.105	6.342	6.571	6.641	6.728	6.797	6.899	1.77	0.25
Machinery	13.897	17.765	22.396	22.707	22.967	22.660	22.560	22.413	1.73	–0.16
Transport equipment	8.945	11.325	16.003	14.758	14.943	14.187	13.772	13.476	1.87	–0.69
Other manufacturing	0.543	0.676	0.779	0.973	0.460	0.422	0.396	0.377	–2.53	–1.32
Construction and civil engineering	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	n.a.	n.a.
Electricity, gas and water supply	0.029	0.032	0.046	0.040	0.038	0.035	0.034	0.032	1.15	–1.14
Service industries total	**8.790**	**11.305**	**16.897**	**16.440**	**19.496**	**19.075**	**18.897**	**18.751**	**3.70**	**–0.26**

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Commerce, finance and real estate	3.358	5.120	9.672	9.213	9.917	9.322	8.946	8.614	4.51	–0.93
Transportation, communication and information services	4.375	5.042	5.584	4.892	7.057	7.203	7.356	7.507	2.27	0.41
Administration, education and medical services	0.066	0.067	0.063	0.399	0.125	0.129	0.133	0.137	4.25	0.61
Business services	0.548	0.637	0.600	1.038	1.498	1.492	1.498	1.497	5.87	0.00
Personal services	0.442	0.439	0.976	0.898	0.900	0.928	0.964	0.996	4.90	0.68

Note: n.a. – no value

From 2015 to 2030, total real imports will decrease slightly (Table 10). In the same period, the imports of the manufacturing industry will shrink a little but imports of services will keep almost the same level. Imports of agriculture, forestry and fishery, textile, paper and furniture (mainly classified as consumer goods) and imports of iron, steel and non-ferrous metals (classified as raw materials) will decrease. The decrease in imports of petroleum, coal and natural gas is very small. The imports of machinery (which includes electronics and communication equipment) will increase but the import of transportation equipment will decrease.

The import share of manufacturing goods and services will enlarge but the share of agriculture, forestry and fishery will decline.

Table 10

Import Value by Sectors, 2011 Prices, Trillion Yen

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**68.29**	**74.93**	**82.52**	**79.18**	**88.79**	**89.23**	**88.64**	**88.35**	**1.14**	**–0.03**
Agriculture, forestry, fishery and mining	27.87	27.86	27.93	26.16	26.84	26.50	25.91	25.25	–0.25	–0.40

	Historical				Forecast				2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Petroleum, coal, natural gas	21.36	21.06	21.59	20.28	21.21	21.13	20.82	20.40	0.05	–0.26
Manufacturing total	**31.15**	**37.20**	**44.18**	**42.96**	**51.33**	**51.90**	**51.82**	**52.03**	**2.17**	**0.09**
Food and beverage	5.80	6.64	6.71	5.41	5.97	5.72	5.42	5.17	–0.71	–0.95
Textile, pulp and wooden products	4.63	5.54	6.12	5.45	5.81	5.62	5.32	5.04	0.31	–0.94
Petroleum, chemical, rubber and ceramic production	8.04	9.35	9.75	9.88	12.04	12.14	12.20	12.42	1.70	0.21
Ferrous, non-ferrous and metal production	4.84	4.84	5.60	4.56	4.96	4.68	4.35	4.06	0.15	–1.31
Machinery	3.86	6.82	10.94	13.27	17.11	18.26	19.06	19.83	6.32	0.99
Transport equipment	1.99	1.95	2.63	2.29	2.89	2.74	2.60	2.48	2.67	–1.02
Other manufacturing	1.99	2.05	2.43	2.10	2.56	2.74	2.87	3.02	1.48	1.12
Construction and civil engineering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n.a.	n.a.
Electricity, gas and water supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–2.67	2.74
Service industries total	**9.27**	**9.87**	**10.41**	**10.06**	**10.63**	**10.83**	**10.91**	**11.07**	**0.50**	**0.27**
Commerce, finance and real estate	1.12	1.35	1.37	1.81	2.15	2.10	2.03	1.98	3.14	–0.56
Transportation, communication and information services	3.59	4.29	4.43	3.97	4.78	4.77	4.67	4.62	0.71	–0.22
Administration, education and medical services	0.07	0.12	0.13	0.75	0.26	0.28	0.30	0.31	5.38	1.23
Business services	1.05	1.24	0.92	1.15	2.39	2.68	2.98	3.29	4.45	2.17
Personal services	3.45	2.86	3.57	2.39	1.06	1.00	0.93	0.87	–6.43	–1.30

2. Changing input structure

2.1. Input structure

Looking at the Japanese input structure, the share of intermediate inputs gradually increases and that of value-added decreases (Table 11). Theoretically, sophistication of the industry means the increase in the share of value-added but in reality, Japanese value-added had a tendency of decrease from 1995 to 2010. The main cause of industrial sophistication or industrial complication is the increase in the procurements of other industries' products or services, that is to say, the increase of the external procurements. Industrial sophistication means a closely related inter-industry network. This tendency still continues, except in the epoch of reconstruction after the East Japan Great Earthquake disaster.

Concerning the details of the value added structure, the share of wages gradually decreases. This means that the labor share in value-added decreases, which will be explained in more detail later.

Table 11

The Structure of Inputs, %

	Historical				Forecast			
	1995	2000	2005	2010	2015	2020	2025	2030
Total Output	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Intermediate Input	46.1	44.6	46.7	47.9	50.5	49.2	49.5	49.8
Value added total (GDP)	**53.9**	**55.4**	**53.3**	**52.1**	**49.5**	**50.8**	**50.5**	**50.2**
Wages	29.1	29.4	26.9	27.3	26.6	27.2	26.7	26.2
Profit	10.6	10.0	11.2	10.3	9.2	9.4	9.5	9.6
Depreciation	8.6	10.7	10.3	9.2	8.7	9.1	9.2	9.3
Taxes	3.9	3.8	3.4	4.0	4.0	4.2	4.2	4.3
Outside household	2.1	2.0	1.7	1.7	1.4	1.3	1.2	1.1
Subsidy (deduction)	–0.5	–0.5	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4

2.2. Wages

The model calculates wages per employee first, and then multiplies it by the number of employees to get total wages. From 2015 to 2030, total wages are forecasted to gradually decrease, and the wages in services decrease much more than in manufacturing. In manufacturing such sectors as textile, pulp and wooden products, chemicals, petroleum, rubber and ceramics, and electricity, gas and water, the wages will decrease much more than in others.

Regarding wage structure, in the service sectors, the decrease of the share in the commerce, finance and real estate sector is apparent. The share in public administration and education decreases but expands in medical and nursing services (Table 12).

Since 2015, the labor share in value-added decreases. The labor share decrease may be due to the wage level per regular employees, which does not shrink. However, the number of non-regular employees whose

Table 12

The Structure of Wages by Sectors, %

	Historical				Forecast			
	1995	2000	2005	2010	2015	2020	2025	2030
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Agriculture, forestry, fishery and mining	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5
Manufacturing total	**31.7**	**30.1**	**28.4**	**26.3**	**28.8**	**29.4**	**29.7**	**29.7**
Food and beverage	1.9	1.8	1.8	1.9	1.9	1.9	1.9	1.9
Textile, pulp and wooden products	3.0	2.5	2.1	1.8	1.8	1.7	1.6	1.5
Petroleum, chemical, rubber and ceramic production	3.1	2.9	2.9	2.8	2.7	2.7	2.6	2.5
Ferrous, non-ferrous and metal production	2.8	2.6	2.6	2.4	2.5	2.5	2.5	2.5
Machinery	5.8	6.1	5.7	4.9	5.6	5.6	5.5	5.4
Transport equipment	2.2	2.3	2.5	2.6	3.0	3.0	3.0	3.0
Other manufacturing	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5
Construction and civil engineering	10.7	9.8	8.6	7.5	9.4	10.2	10.7	11.0
Electricity, gas and water supply	1.7	1.7	1.8	1.8	1.5	1.4	1.3	1.3
Service industries total	**67.6**	**69.3**	**71.0**	**73.1**	**70.6**	**70.0**	**69.8**	**69.8**
Commerce, finance and real estate	24.3	22.3	21.4	19.8	19.5	18.3	17.1	16.0
Transportation, communication and information services	9.6	10.3	10.6	10.9	9.3	9.4	9.6	9.9
Administration, education and medical services	21.5	23.3	24.9	27.8	26.8	27.3	28.0	28.8
Business services	6.3	6.9	7.9	8.7	9.3	9.4	9.4	9.3
Personal services	5.9	6.6	6.2	5.9	5.8	5.7	5.7	5.7

wage level is relatively lower will increase significantly[20]. The number of workers in the manufacturing sector will diminish and the workers in the service sector whose wage level is relatively low, will increase. This is also the cause of the shrinking of total labor share in value-added.

2.3. Profit

It is relatively difficult to forecast the profit. The deficit in profit is possible only in the short term and impossible in the long run for business to continue. However in reality, since 2011 in the observed data, a considerable number of sectors (mining, textile, furniture, petroleum and coal products, plastic, rubber, metal products, computer and communication equipment, heavy electric, motor vehicle parts, other transport equipment, electricity) have negative profits. When the last observed data in 2014 records a deficit, we assume that there will also be a deficit in the sector afterwards (Table 13). In the last forecasted year 2030, there are 15 sectors with negative profits and the total amount of these sectors' output accounts for 7 % of the total.

In spite of the long term deficit, the reason why business can continue could be explained as follows. The deficit of the head office may be covered by the overseas surplus. As the model is based on the I-O table, the data are constructed by the GDP concept and the profit data do not include the transfers from the overseas profits.

From 2015 to 2030, the total profit will continue at the same level, while in services it will grow by 0.13 % and in manufacturing fall by 1.28 % (Table 13). Since the disaster of the East Japan Earthquake, electricity production fell into a big deficit and it will continue until 2030.

The share of the manufacturing sector, which accounted for 26.5 % of total profits in 1995, decreased significantly to 8.4 % in 2015. On the contrary, the share of services increased from 68.1 % to 88.7 % in the same period. The share decreased in many sectors but in the machinery sector it increased. In services the profit share of commerce, finance and real estate and public administration, education and medical sectors significantly increased.

Conclusions

With these forecasts, we can clarify how the service economy of Japan affects employment and wages. As an implication of these changes we can glimpse the future of the Japanese economy in 2030.

[20] The variable of non-regular employees is not endogenous in this model, though.

Table 13

Profit by Sectors, 2011 Prices, Trillion of Yen

	Historical					Forecast			2000 ~15 CAGR (%)	2015 ~30 CAGR (%)
	1995	2000	2005	2010	2015	2020	2025	2030		
Total	**99.7**	**94.7**	**108.5**	**92.0**	**89.9**	**89.5**	**89.7**	**89.9**	**–0.35**	**0.00**
Agriculture, forestry, fishery and mining	5.4	4.3	3.3	3.5	2.6	2.5	2.4	2.3	–3.26	–0.83
Manufacturing total	**26.4**	**20.9**	**16.1**	**15.7**	**7.5**	**7.0**	**6.6**	**6.2**	**–6.58**	**–1.28**
Food and beverage	2.8	4.2	4.1	4.4	3.1	3.2	3.2	3.3	–1.94	0.33
Textile, pulp and wooden products	3.0	2.2	1.7	1.3	0.3	0.2	0.1	0.0	–12.98	n.a.
Petroleum, chemical, rubber and ceramic production	4.2	3.0	2.5	2.5	1.4	1.3	1.2	1.0	–4.79	–2.13
Ferrous, non-ferrous and metal production	2.4	2.1	2.8	1.6	2.8	2.5	2.2	2.0	1.84	–2.27
Machinery	5.6	4.0	1.3	1.9	0.6	0.8	1.0	1.2	–11.67	4.48
Transport equipment	1.2	–0.1	0.7	1.0	0.3	0.3	0.3	0.3	n.a.	0.54
Other manufacturing	0.5	0.4	0.3	0.2	0.0	0.0	0.0	0.0	n.a.	n.a.
Construction and civil engineering	3.1	2.5	1.8	0.6	1.7	1.6	1.5	1.4	–2.85	–1.17
Electricity, gas and water supply	3.6	2.5	1.0	2.3	–2.6	–2.7	–2.8	–3.0	n.a.	n.a.
Service industries total	**67.9**	**69.5**	**89.1**	**72.7**	**79.8**	**80.0**	**80.6**	**81.3**	**0.92**	**0.13**
Commerce, finance and real estate	45.7	46.2	61.1	51.8	54.4	55.5	56.8	58.2	1.10	0.44
Transportation, communication and information services	5.3	6.8	9.6	6.7	9.8	9.6	9.4	9.3	2.47	–0.39
Administration, education and medical services	2.4	1.4	2.6	3.1	3.0	3.1	3.2	3.3	5.11	0.49
Business services	5.2	6.7	7.5	5.6	5.9	5.8	5.6	5.5	–0.84	–0.46
Personal services	9.4	8.3	8.3	5.4	6.5	6.0	5.5	5.1	–1.62	–1.60

Note: The profits are converted in real terms by GDP deflator.
n.a. – no value.

The labor shortage becomes more and more evident, and measures to avoid the shortage are urgently needed. The main measure might be to raise labor productivity. In this model, future labor productivity is assumed to grow by the same rate as in the past 15 years. Accordingly, it requires attention that the several industrial sectors' productivity is so low that a severe labor shortage appears for these sectors.

Labor productivity is the integrated result of the economic situation, such as economic cycles, technical innovations, and capital investment. To raise labor productivity in Japan, it is necessary to increase the efficiency of the whole economy, that is to say, to promote business activities by improving the institutional system or deregulation of outdated business controls. Especially now the spread of network society caused by IT and communication technologies creates new industries and new services, which should be actively integrated within the future Japanese industries. To promote technical innovation, measures to enrich the support of fundamental research and applied research should be taken. Adding to these direct measures, indirect measures such as increasing sophisticated human resources are also needed for raising labor productivity in the long run.

In the process of forecasts, we found several tasks to improve the model: to endogenize labor productivity, to improve the profit equation, and to add the compact finance and budget system in the model. Also, following the advancement of Japanese globalization, the Japanese economy expressed by the GDP concept does not cover the incomes from abroad. We should find measures to integrate income from abroad in the domestic economy, that is, to use the Gross National Income approach.

APPENDIX

Table A1

The Original Sources of I-O Tables Used by JIDEA9

	Basic Table	2000 Linked Table	2005 Linked Table	2011 Linked Table	Exteded Table		Extended Table by ITI	
	Sectors	Sectors	Sectors	Sectors	Base year	Sectors	Base year	Sectors
1995	519×402	498×399	514×401		1990	526×413		
1996					1995	517×401		
1997					1995	517×401		
1998					1995	517×401		
1999					1995	517×401		
2000	517×405	498×399	514×401	510×389			1995	517×403
2001							1995	517×403
2002							1995	517×403
2003							2000	517×403
2004					2000	515×403		
2005	520×407		514×401	510×389	2000	515×403		
2006					2000	515×403		
2007					2000	515×403		
2008					2005	520×407		
2009					2005	520×407		
2010					2005	520×407		
2011	518×397			510×389	2005	520×407		
2012					2010	516×395		
2013					2010	516×396		

Note: METI did not publish the full scale extended table from 2000 to 2003.

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MODELING THE INFLUENCE OF SELECTED ECONOMIC PROCESSES ON THE LONG-TERM DEVELOPMENT OF THE POLISH ECONOMY[21]

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Introduction

Over the past 15 years the Polish economy has experienced strong fluctuations in economic growth. After the slowdown in 2002–2003, Poland's accession to the European Union contributed to a significant acceleration. However, as a result of the global economic crisis, the dynamics of development slowed down substantially. Yet, it did not lead to such a recession as in other EU countries and in the USA. The Polish economy continued to develop, being the only "green island" among the EU countries. Will this optimistic picture change in the longer term? This paper does not aim at answering this question, but it tries to estimate the potential influence of selected (considered as crucial) processes occurring in the first decades of the 21st century on the perspectives of the further development of the Polish economy.

The purpose of the paper is to analyze basic mechanisms and processes that emerged in the Polish economy in the 21st century. Identification of these phenomena through empirical verification is complemented by scenario analyses to quantify their possible impact on Poland's future economic development. These phenomena and processes are as follows.

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- Demographic phenomena, including changes in the population size and population structure by age, with particular focus on forecasts for the increase in the number of retirees. The analysis does not take into account migration.
- Changes in the intensity and structure of Polish foreign trade related to the deepening of the globalization process, which means the increase of Poland's involvement in the phenomenon of fragmentation of production processes.
- Technological progress and growth of knowledge capital in the economy, which plays an important role in the process of long-term growth. Knowledge capital can be identified with human capital, innovation and the ability to acquire knowledge from abroad.

It should be stressed that the intention of the authors was not to create any projection of the most likely development of the Polish economy. If the simulations presented in this paper were to be considered as forecasts, they would certainly be judged as imperfect, and some of them unquestionably unrealistic. The variety of phenomena and processes occurring in the modern world undermines the reasonableness of predicting the future based on the belief that we are able to take into account all, or at least the "most important" factors affecting economic development.

The structure of the paper is as follows. First, we present the model. Then the assumptions for three scenarios are given, each of the scenarios concerns the particular phenomena listed above. Results are shown for 4 scenarios; the additional one is a combination of the three. The results are followed by conclusions.

1. The model

The model consists of a three-element core and satellite models (see Fig. 1). The core (or central model) is an input-output model, based on tables excluding imports. The source of data is the set of such tables for 2010, published by the Polish Statistical Office (Input-Output Table at Basic Prices in 2010, 2014). These tables show the economy aggregated into 77 branches. The input-output model is supplemented with a sequence of national accounts by institutional sectors as an identity centered model derived from the methodology proposed by Almon (Almon, 1995, 2011). The third, original element of the central model is the flow of funds model, based on the philosophy of the input-output model, with disaggregation of accounts by institutional sector and type of financial instrument (see, e.g. Tsujimura & Mizoshita, 2003;

Tomaszewicz & Trebska, 2013). It allows decomposition of money demand and supply of financial instruments on individual financial markets to be treated as one of the investment determinants.

Satellite models are used to develop simulation scenarios and include a set of equations describing the consumption of households, number of employees, number of retirees and pension transactions, R & D outlays and labor productivity, exports, and import intensity.

Although the authors were strongly inspired by the INFORUM modeling philosophy, the model does not follow it fully. The main difference is the lack of loops (or feedbacks) in the sequence of equations. The model is strictly recursive. No price submodel is present, the assumption is made that prices do not change over the whole analyzed period.

The sequence of national accounts starts from an input-output table, showing accounts of products and income generation for the entire economy. On the basis of this part, the output and value added are determined by final demand.

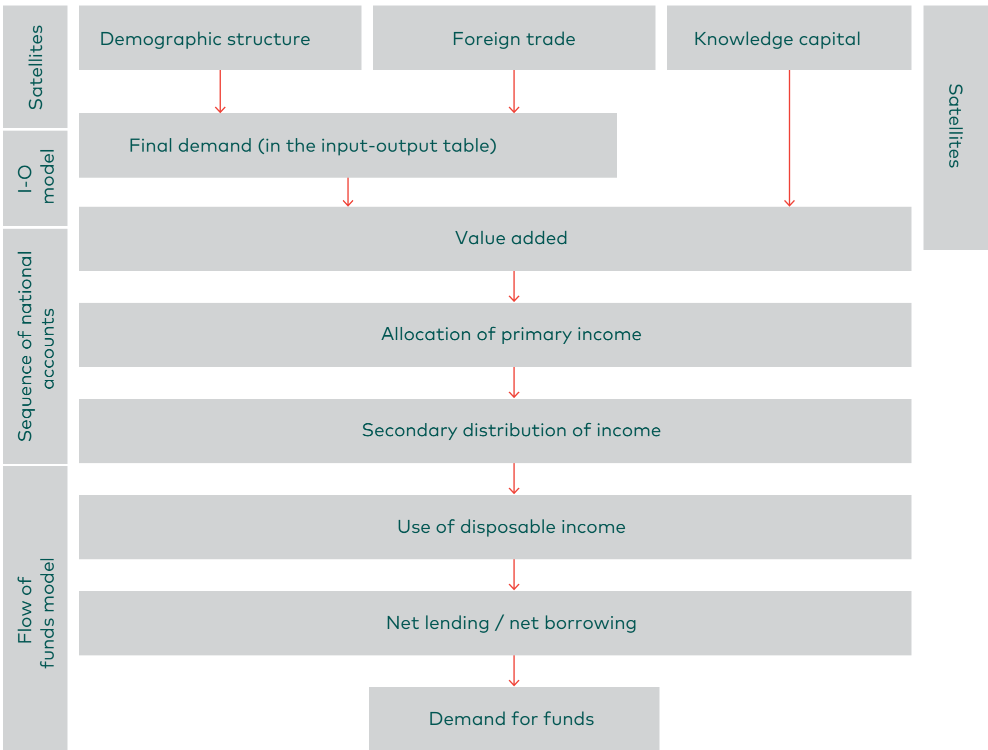

Fig. 1. Scheme of the model.

Then, using tables of cross-classification of activity (industry) and sector, value added data by NACE are transformed into value added by institutional sectors. Value added for the total economy is decomposed into compensation of employees – costs incurred by employers from each institutional sector, which are the primary income of households presented on allocation of primary income account; taxes less subsidies on production that are the general government's primary income and operating surplus of all institutional sectors.

Subsequent equations refer to the transactions recorded on the secondary distribution of income account, which determine gross disposable income as the sum of primary incomes and net of current transfers. On the expenditure side of the use of the disposable income account is consumption, whereas the balancing item is gross savings, determined as a residual in this model. Gross savings are the revenues on capital account, which together with the net of capital transfers and net borrowing constitutes the sources of the accumulation financing. The balancing item of the capital account is net lending – in the national accounts recorded as a positive value (when the net acquisition of financial assets exceeds the net incurrence of liabilities) or net borrowing (the opposite situation).

The identity centered model based on the sequence of national accounts is followed by the model describing the supply of financial instruments and the demand for them.

2. Assumptions

As mentioned above, the three analyzed scenarios assume isolated changes, so all exogenous variables (except for the chosen ones) remain at the level of 2010. This also concerns prices, which are kept constant. Scenario 4 was created as a combination of Scenarios 1–3.

Scenario 1

In the first scenario it is assumed that the consumption of households results from the changes in the population size of different age groups (the proportion of retired and non-retired persons) – see Fig. 2. The population size was taken from the forecasts of the Polish Central Statistical Office (Population Projection 2014–2050, 2014). This forecast does not consider migration.

A diminishing population, together with constant unemployment and labor activity ratios obviously lead to a reduction in the number of employees. As can be seen in Fig. 3, this assumption seems unrealistic.

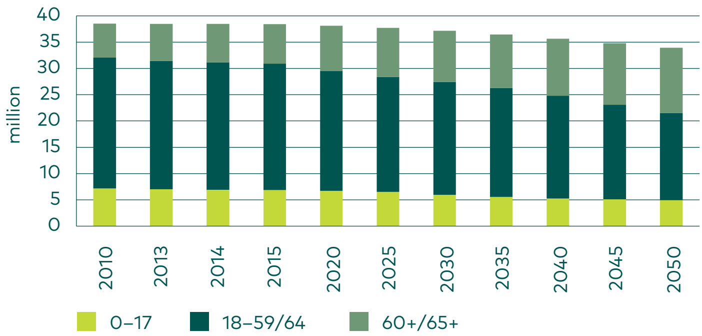

Fig. 2. Population size by age group, million. (Source: Polish Central Statistical Office)

In the economy, adjustment processes are launched that counteract the effects of demographic change.

Consumption per capita of various age groups as well as their propensity to consume, income and other factors do not change. This, of course, implies a reduction in household consumption proportionally to the size of the population. Other elements of final demand remain constant. Total final demand falls, but not as much as the employment.

The average annual increase in labor productivity, needed to produce final production in accordance with the adopted assumptions is relatively low, moreover, it is lower than the growth rate of accumulation of fixed capital (which translates into an increase in the capital / labor ratio), see Fig. 4. It should be considered as achievable.

Although Scenario 1 seems quite unlikely to happen, it is possible from a theoretical point of view. Analysis of its assumptions does not lead to any contradiction or impossibilities.

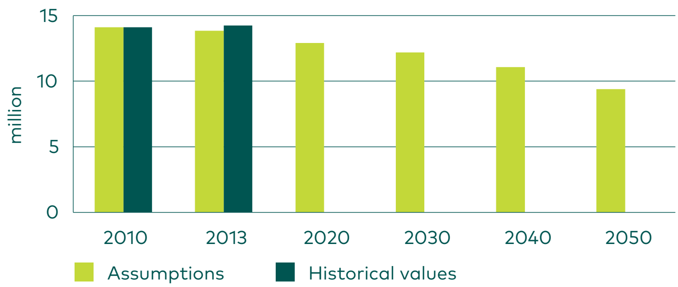

Fig. 3. Number of employed persons, million. (Source: Own calculations, Polish Central Statistical Office)

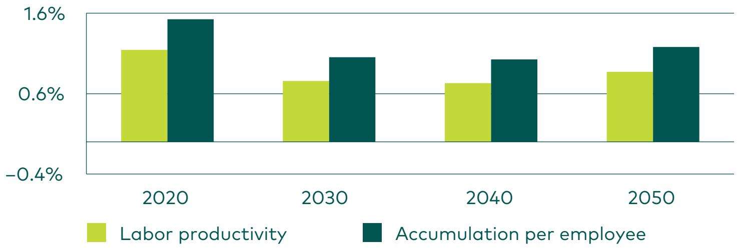

Fig. 4. Labor productivity and accumulation of fixed capital per employee (annual growth rates, %). (Source: Own calculations)

Scenario 2

The second scenario aims at estimating the influence of trends in trade patterns. Changes in imports result from import intensity coefficients, which are projected by log-logistic trend; exports increase due to observed trends for various products. The increase in the intensity of trade that took place in Poland after 1990 was primarily the result of the transition and the process of Poland's accession to the EU. At the same time, becoming a country with an open market economy, Poland joined the processes of globalization, such as increased involvement in international fragmentation of production. These processes led to changes in the product structure of foreign trade. In a situation where political transformation has already been completed and the process of integration with the EU has long passed its main

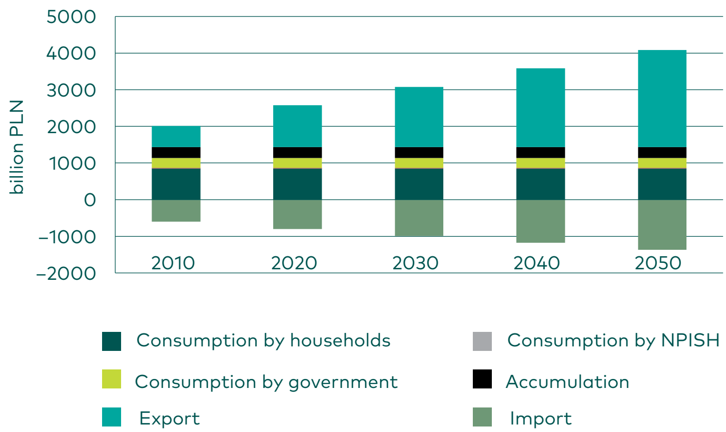

Fig. 5. Final demand and import, billion PLN. (Source: Own calculations, Polish Central Statistical Office)

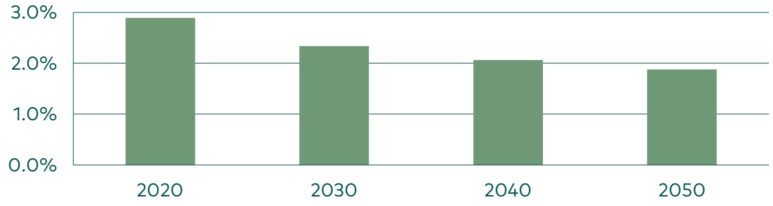

Fig. 6. Labor productivity (annual growth rates, %). (Source: Own calculations.)

phase, the future development of Polish foreign trade depends on factors characteristic for modern, open economies. The projections based on trends show a significantly higher growth rate of exports than imports, which causes an increase of the balance of trade. The macroeconomic sum of sectoral projections is presented in Fig. 5.

In this scenario the number of employees is kept constant at the level of 2010. To allow for increment in the balance of trade, a suitable growth in labor productivity is necessary (see Fig. 6).

The highest growth of labor productivity is needed at the beginning of the analyzed period. Around 2040 the growth rate drops to about 2 %.

Scenario 3

In the third scenario, the impact of domestic R & D expenditures on the changes in labor productivity and, consequently, changes in the number of employees was analyzed. It is assumed that labor productivity is a function of capital-to-labor ratio and total factor productivity (TFP). TFP is a function of domestic and foreign knowledge stock, measured by the amount of accumulated R & D expenditure (domestic and foreign (Coe, Helpman, & Hoffmaister, 1997; Coe, Helpman, & Hoffmaister, 2009). The effects of diffusion of knowledge among sectors (industries) in the Polish economy are also taken into account. In the case of domestic knowledge stock, it is assumed that the process of diffusion of knowledge takes place through the flows of goods and services used as intermediate goods in the production process. In the case of diffusion of knowledge from abroad, it is assumed that transfer of this kind of knowledge takes place through imports, foreign direct investments and in a disembodied form.

This, of course, required the estimation of parameters of TFP functions at the level of industries. Subsequently, it is assumed that changes in labor productivity in the branches of the Polish economy are only the result of changes in the domestic knowledge stock. The values of all other variables included in the model (capital to labor ratio, foreign knowledge stock, etc.) are set at the level observed in 2010.

In order to estimate the amount of accumulated R & D expenditure in the perspective up to 2050, the growing share of these expenditures in relation to GDP is assumed. Part of the assumptions (until 2030) is consistent with the provisions from the long-term strategy for Polish economic development. The share of R & D expenditure in GDP is projected to increase to 1.7 % in 2020, 3 % in 2030, 4 % in 2040, and 5 % in 2050. To obtain the level of value added, the potential levels of labor productivity in individual branches of the Polish economy were multiplied by the number of employees observed in 2010.

Scenario 4

The last scenario puts all three scenarios together in a way that the value added that begins the sequence of national accounts equations results from the cumulated changes in the value added due to changes in the population size of different age groups (causing the changes in consumption of households), the changes in the foreign trade structure and the changes in domestic stock of knowledge.

The assumptions that concern final demand in all of four scenarios are showed in Fig. 7.

As a result of the projected changes in the demographic structure that are reflected by Scenario 1, the total final demand will decrease in

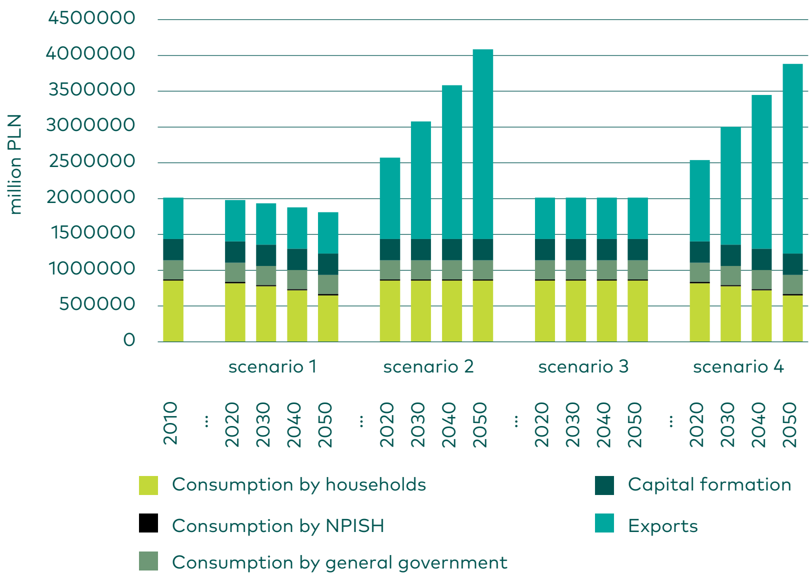

Fig. 7. Final demand – simulation assumptions, million PLN. (Source: Own calculations.)

2050 by 10.1 % because of the 24 % decrease in household consumption. The biggest changes in final demand result from the growth in exports of 359 % that is estimated according to observed trends in the period 2010–2050. This will increase total final demand by 103 %. Assumptions concerning the domestic stock of knowledge do not take into consideration final demand. The cumulated changes in final demand assumed in the fourth scenario form a 93 % increase in 2050 (compared to 2010).

Results – value added by institutional sectors and income circulation

As was mentioned before, in Scenarios 1 and 2 value added is determined using the input-output model with assumed final demand values. Whereas in Scenario 3 value added results from the changes in labor productivity, which in turn result from the increase in domestic R & D activity.

The decrease in final demand (consumption of households), assumed in the first scenario, causes value added to decline by 9.7 % (in total) in 2050 compared to 2010 (see Fig. 8). In turn, Scenario 2 assumes the increase in final demand resulted from the increase in exports, which causes the 96.4 % increase in value added in 2050. Growing domestic R & D activity increases value added by 20.3 % (in 2050 compared to

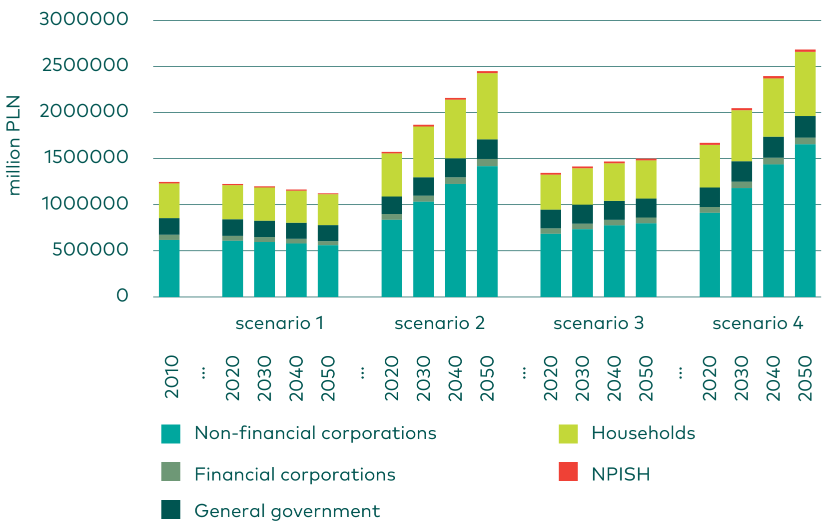

Fig. 8. Value added by institutional sectors, million PLN. (Source: Own calculations.)

2010). In Scenario 4, which puts all three scenarios together, the value added gradually grows by 34.1 % in 2020, 64.2 % in 2030, 92.1 % in 2040, and 115.2 % in 2050 compared to 2010. The biggest increase concerns non-financial corporations as a sector that is most involved in the process of value added generation.

As a consequence of the allocation of primary income, compensation of employees (reported in the system of national accounts on the uses side of the generation of income account of all institutional sectors) becomes the resource of households (as well as for the rest of the world sector), whereas taxes on production and imports, paid by all sectors, are then obtained by general government (and the rest of the world). The balance of primary income (see Fig. 9) results from the operating surplus generated by all sectors, the balance of property incomes and the transactions in the field of compensation of employees and taxes mentioned above. It is obvious that changes in primary incomes are proportional to changes in value added in individual scenarios. However, changes in primary incomes are characterized by reduced differentiation between sectors. In Scenario 4 the balance of primary income of all domestic institutional sectors increases by 109.3 % in 2050 compared to 2010, which is less than the increase in value added

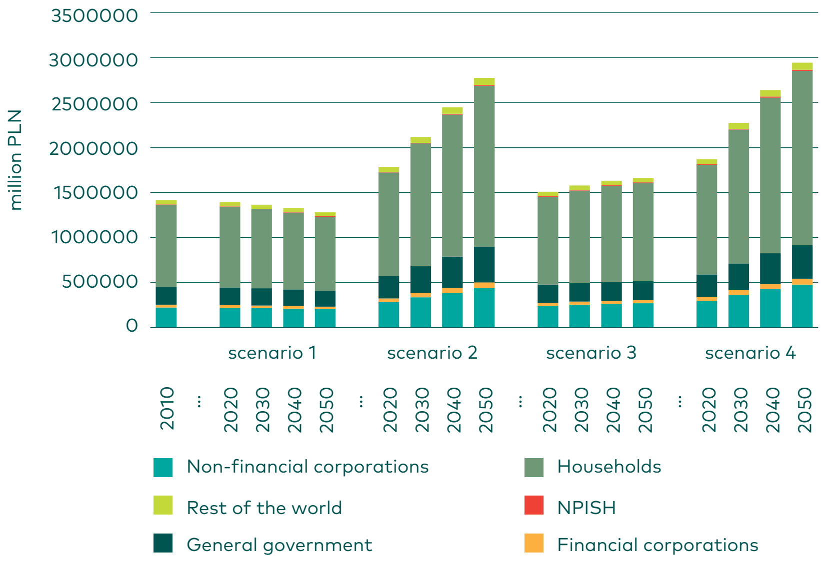

Fig. 9. Primary incomes of institutional sectors, millions PLN. (Source: Own calculations)

because of the circulation of primary income between domestic sectors and the rest of the world (in favor of the latter).

The evaluation of the changes in the process of secondary distribution of income is focused on the most important transactions such as income taxes, social contributions and social benefits. Both taxes and social contributions (assuming a constant rate of fiscal burdens) change in proportion to the changes in primary incomes. The simulation of social benefits increases results from the changes in demographic structure, which are introduced to the pension sub-model (Trebska, 2015). Social benefits depend on the number of pensioners (resulting from the number of elderly and the propensity to retire) and the average amount of pension as well as the number of other kinds of beneficiares and the average amount of social payments (survivors and disability pensions).

On the basis of demographic projections, the number of beneficiaries is estimated, assuming a fixed (as in 2010) propensity to retire at retirement age (0.85), the share of disability and survivors pensioners in the working age population (respectively 5.9 % and 3.9 %). Therefore, an increase in the number of retirees and a slight decrease in the number of people receiving disability pensions and survivors pensions are expected. Moreover, assuming that the average amount of old-age and other pensions will not decrease, a 49 % increase in the amount of social benefits is expected in 2050 compared to 2010 (in all scenarios the percentage change of social benefits is the same). The tendencies in

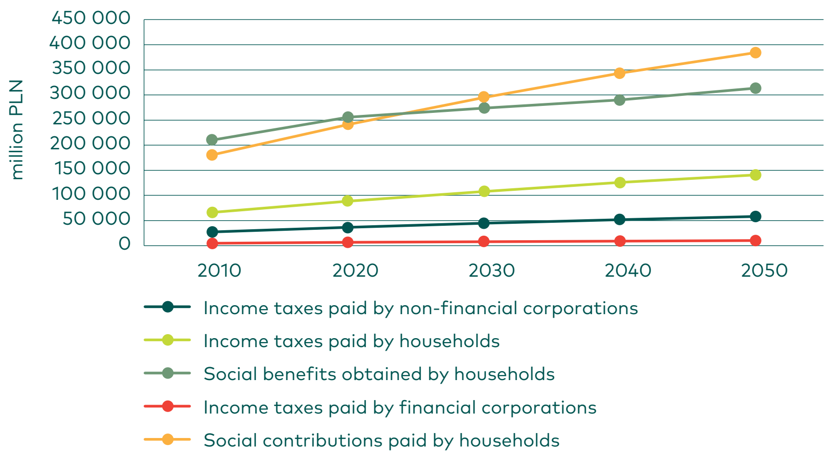

Fig. 10. Transactions of income redistribution, million PLN. (Source: Own calculations)

redistribution of incomes broken down by instruments are presented in Fig. 10.

The changes in primary incomes and current transfers are reflected in the changes in disposable income of individual institutional sectors. In the first scenario only disposable income of households slightly increases (by 1 % in 2050 compared to 2010) as a consequence of a significant increase in social benefits that are obtained by this sector, see Fig. 11. These transfers are paid by general government, so disposable income of this sector decreases to the greatest extent (by 57.2 % in 2050 compared to 2010) in this scenario. The assumed decline in household consumption with the simulated increase in this sector's disposable income contributes to the growth of its gross savings.

In Scenario 2, the disposable income of domestic sectors (in total) increases by 98.5 % in 2050 compared to 2010 with marginal growth of nonresidents' income. The biggest growth concerns general government mainly due to the secondary distribution of income – current transfers (connected with foreign trade) from the rest of the world to general government.

Growing domestic R & D activity causes the increase in disposable income of all domestic institutional sectors (18 % in 2050 compared to 2010) and a slight decrease in the case of the rest of the world.

In Scenario 4, as a result of the three described scenarios, disposable income of all institutional sectors grows by 103.7 % (in total) in 2050 compared to 2010, with the largest increase in the general

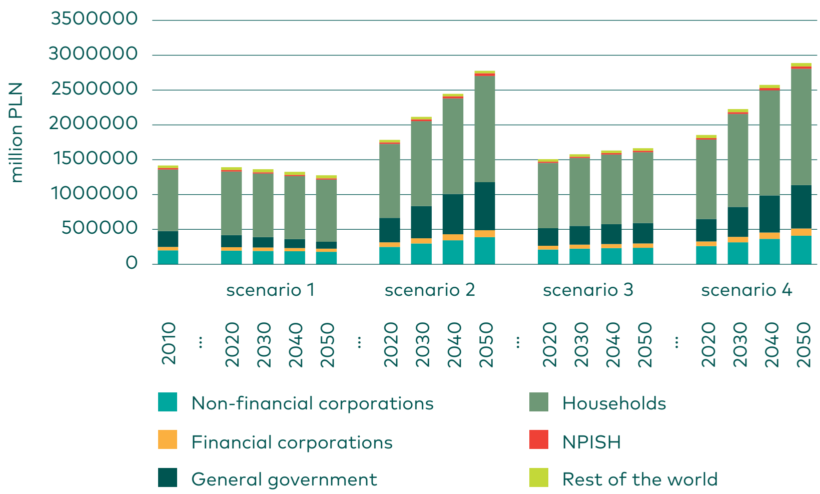

Fig. 11. Disposable income, million PLN. (Source: Own calculations)

government (although the decline of this sector's income is due to the changes in demographic structure).

The complete sequence of national accounts allows us to follow the financial consequences of the changes assumed in individual scenarios. The ending item of the sequence of non-financial accounts, i.e. net lending (positive value) or net borrowing (negative value) can be interpreted from two points of view. On the one hand, as previously stated, this is the difference between the net acquisition of financial assets and the net incurrence of liabilities (balance of intersectoral transactions being the flows of financial instruments). On the other hand, taking into consideration the real sphere of the economy, it is the difference between revenues and expenditures of institutional sectors, both current and capital. The chart below (see Fig. 12) presents the final effects, measured by the excess (or deficit) of income over expenses, putting all three scenarios together.

After determining disposable income from the identity centered model and assuming the values of particular elements of the final demand in individual scenarios, gross savings and net lending / net borrowing are determined as a residual. Since we have made assumptions of a decrease in household consumption, an increase in net exports and a constant value of investments, the simulated increase in disposable income of all domestic institutional sectors causes growing savings and net lending of the Polish economy (growing net borrowing of

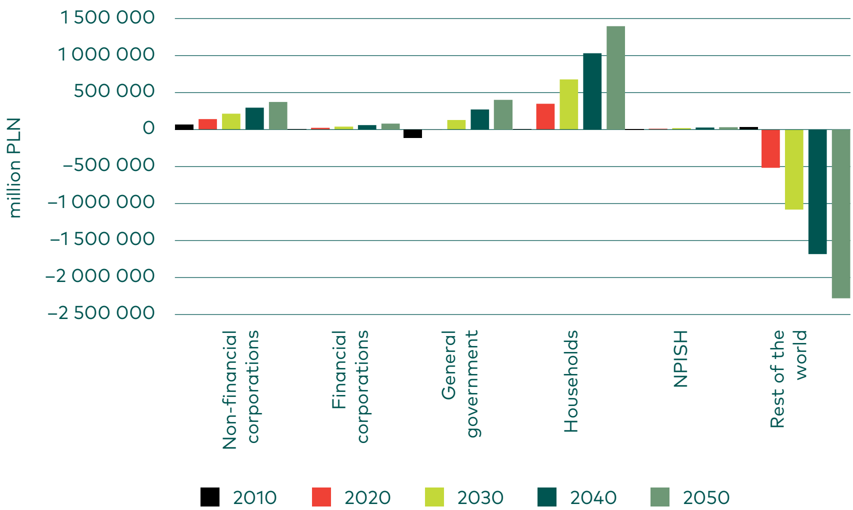

Fig. 12. Net lending / net borrowing simulated in Scenario 4, million PLN. (Source: Own calculations)

the rest of the world). This situation is a consequence of the development trends in the field of foreign trade, which themselves contribute to significant foreign borrowing and the accumulation of net lending of domestic sectors. The household sector seems to be the biggest beneficiary of the changes assumed in the analyzed scenarios. Financial benefits for general government are also worth attention.

Conclusions

The paper presents the results of research carried out as part of a research project on the role of selected determinants of the development of the Polish economy in the 21st century. The system of economic models allows for simulations and forecasts of the development of the Polish economy in the medium and long term. Its advantage is the sectoral level of investigation, both in the sense of the activities and institutional sectors. The system is transparent and enables us to follow economic mechanisms. It is also flexible, which means that it is easy to implement different scenarios. Its very important feature is balancing, which ensures consistency of the obtained results and allows for logic control at every stage of the calculations.

The use of an input-output model in the research (as the central model) allowed us to show the relationship between final demand (and its individual categories) and value added, i.e. the primary income of production factors. The sequence of national accounts describes the primary and secondary distribution of income, specifying the disposable income, which in turn is a decisive factor in the size of final demand. In the central model, the feedback between income and demand was interrupted by exogenizing final demand. The introduction of changes in this economic category results in adjustments in the sequence of national accounts.

The results of simulation analyses presented herein concerned the isolated effects of three processes observed in the Polish economy (changes in the demographic structure, increase in foreign trade intensity and growing activity of the national R & D sphere) and their cumulative impact on the circulation of income in the economy.

Simulation analyses based on the constructed model system indicate that the effects of demographic structure changes will be visible in the structure of revenues and expenditures of individual institutional sectors, in particular on the household and government accounts. Maintaining the current living standard of the population, measured by per capita consumption (assuming a secondary distribution structure of income from 2010), would require a gradual increase in government debt from 8 % of GDP in 2010 to 14 % in 2030, and 19 % in 2050. However, further changes in the mechanisms of secondary distribution of income, which will transfer the debt of government to other institutional sectors, are expected. The historical data up to 2015 confirm that.

The reduction of the Polish economy's debt in recent years was supported by growing exports, especially exports of services. Maintaining this trend would require a high rate of labor productivity growth (on average by 1.9 % year on year), it would also lead to a growing net lending of domestic sectors relative to the rest of the world to 113 % of GDP in 2050 (from 3 % in 2015) – assuming stability of other model coefficients and variables.

The increase in domestic R & D expenditures combined with greater activity of the enterprise sector in their financing leads ceteris paribus to the increase in labor productivity, and consequently (with the unchanged employment) to an increase in value added by about 20 % in 2050. These conclusions were formulated based on satellite models for individual sectors (understood as groups of branches) of the Polish economy. They also enabled us to determine the role of particular factors related to the broadly understood knowledge capital for TFP growth, and the increase in labor productivity in the Polish economy. An important contribution to value added growth will still be made by traditional sectors of activity, i.e. industrial processing, agriculture and energy sector.

The outcomes of Scenario 4, which put the results of the three analyzed processes together, are the foundations for the following final remarks for the labor market and pension system: firstly, achieving production that meets the assumed final demand will require an average increase of labor productivity by 2.4 % per year (with constant employment). Maintaining constant employment would require an increase in the employment rate to an unrealistic level of 90 % in 2050 against the projection of the decline in the working age population by 39 %. The alternative is inflow of foreign labor. Secondly, the application of the pension sub-model points out that the assumption of a fixed average pension will mean a nearly 2.5-fold decrease in the replacement rate at retirement (which is close to EC-EPC projections (The 2015 Ageing Report, 2015)).

Already during the project implementation, we have witnessed events that may have a significant impact on the trajectory of economic growth in the world's regions. The Russian-Ukrainian conflict, the refugee problem and the related radicalization of European and other societies, Brexit, the uncertain fate of the Transatlantic Trade and Investment Partnership (TTIP) are problems on the international scale directly affecting the future of Poland. During this time, the hopes for a rapid economic development of Poland, which was to take place due to the exploitation of shale gas deposits, disappeared. Much will depend on the internal policy of the state, which also reveals the features of unpredictability. This problem appeared, for example, during the simulation of the impact of demographic changes on lending (borrowing) of institutional sectors, in the form of a change in the retirement age. 2050 is still far away and many surprising turns likely await us.

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NEW MODEL DEVELOPMENTS AND DATA ISSUES — 3

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DEVELOPMENT OF THE LATVIAN MACROECONOMIC MODEL IN THE CONTEXT OF COMPETITIVENESS[22]

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Introduction

Competitiveness is very important for the development of any company, industry or country. It is even more significant in small open economies like Latvia, where local companies compete with foreign ones in the domestic market, and where exports are the major driving force of economic development due to the small domestic market. Therefore governments tend to find ways to help exporters and thus stimulate the economic growth of the country. However, the question arises as to whether any successful company can be supported, or should support be focused only on companies in particular industries or companies exporting to particular countries? It is important to note that within the European Union, according to the legislation the member states are allowed to support national companies only in special cases, as all the companies compete in the common market.

A similar question can be posed by banks, which make decisions regarding loans to particular companies, investment organizations, and other interested parties. Moreover, the question is relevant not only in present terms, but also in regards to the future. Therefore it is important to determine which indicators illustrate competitiveness and how they can be incorporated in the macroeconomic model.

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The aim of the study is to distinguish which competitiveness indicators can be incorporated into the Latvian macroeconomic model to evaluate sectoral competitiveness.

1. Theoretical and practical aspects of the competitiveness studies

The concept of competitiveness has been widely discussed in many publications resulting in a wide range of definitions of competitiveness. These definitions differ depending on particular issues, which have been investigated in particular research projects. Thus there is not one single, common definition of this concept. It is also clear that there are differences when applying the concept of competitiveness to different objects of interest – regions, countries, industries and organizations. Therefore it is obvious that there are similar and distinct aspects that have to be taken into account at different levels of competitiveness analysis. The summary of the thoughts of several authors (Sirikrai & Tang, 2006) even stresses that the divergent nature of competitiveness implies that competitiveness has to be analyzed from different aspects and using different theories to better appreciate its complexity.

There are many studies of competitiveness at a national level. Some researchers (Bellak, Leibrecht, & Damijan, 2009; Egger & Raff, 2015; Hristu-Varsakelis, Karagianni, & Saraidaris, 2011) analyze the competitiveness of countries in the context of the investment attraction. The study on the global competitiveness of Latvia in the post-crisis period (since 2011) focuses also on labor productivity and economic growth as major indicators (Auzina-Emsina, 2014). Other studies (Kancs, 2011; Kutasi, 2005) concentrate more on labor migration. Technological advancement usually means a higher level of competitiveness, therefore it is crucial for developing countries to increase the fixed capital formation (Özçelik & Taymaz, 2004). Also, the industrial perspective is found to be very important and sometimes even crucial to ensure sustainable development of countries. Industrial policy can enhance economic efficiency and increase the national output, however, there has to be a balancing policy to ensure income equality, for example, by means of progressive household income tax (Field & Wongwatanasin, 2007). Another interesting focus of the studies are the relations among competitiveness at various levels. For example, about the ways strong development of the competitive industries can help in the regional development of the country (Chico, Sánchez, & García, 2014). One conclusion is that only the actions producing uniform increases in regional productivities, such as infrastructures and human capital, should be the focus of the regional development policies (Esteban, 2000).

There are many indicators, which can be used in analysis as measures of competitiveness. There are some indicators, which can give an insight into trends of competitiveness. However, it is more common to analyze competitiveness with respect to the competitors, that is, by looking at the market shares or other relative indicators. One example in this case is the Revealed Comparative Advantage Indexes (Laursen, 2015; Silgoner, Steiner, Wörz, & Schitter, 2015). There are also several complex competitiveness indexes as well, like the Global Competitiveness Index (GCI), which helps to rank the countries focusing on different aspects of the competition in a certain year. GCI can be used to compare the performance of countries in a certain time period and reveal general relative dynamics. However, as the number of countries included in GCI annual reports varies, it has to be done with caution.

There are several indicators, which are used in competitiveness analysis by industries (Auziņa-Emsiņa & Ozoliņa, 2014; Keiko, Junko, & Asia, 2013; Özçelik & Taymaz, 2004; Ozolina & Auzina-Emsina, 2013). Some of the competitiveness indicators are exports of goods and services (as a percentage of GDP), the real export growth rate (%), gross labor productivity (employment here can be measured as the number of employees, hours worked or as a full-time equivalent of the number of employees), the ratio of value added to compensation of employees, the ratio of value added to unit spent on labor, the labor input coefficient, the ratio of value added to output, export dependency, and the speed of structural change (adjustment of the export specialization towards the higher value added). Unit labor costs and nominal effective exchange rates are used in the context of technology transfer. Additionally, foreign direct investment (flow and stock), R & D expenditures, capital productivity, imports of technology, and innovations can be attributed to export growth as factors related to competitiveness. International competitive advantages from the sectoral perspective can be analyzed by using specialization expressed as exports in a given sector over total exports of a country, and competitiveness as a share of exports of a given country in a given sector over total exports of all countries in the same sector standardized by population (Guerrieri & Meliciani, 2005). Inter-industry linkages are also stated as important facilitators of competitiveness (Evangelista, Lucchese, & Meliciani, 2015).

The choice of appropriate competitiveness indicators is quite wide, however, it is usually limited by data availability and approaches (including tools) used in research. Therefore it is necessary to determine which indicators can be used in the context of macroeconomic modeling in order to cover all industries and, at the same time compute and analyze structural, inter-industry, and macroeconomic effects. It should be stressed that the analysis and modeling of competitiveness of an individual industry or economic activity can be more sophisticated and detailed (special indicators, even technical indicators, etc.), but in most cases the specific indicators used for one certain industry cannot be applied to all other industries due to technological, data availability, and logical reasons, etc.

Analysis and predictions of competitiveness by industries can be computed in several ways. Moreover, disaggregated calculations tend to be more precise than aggregated ones (Lee, 1997). One of the best ways to do that is using an INFORUM (Interindustry Forecasting at the University of Maryland) type model, which can be characterized as an I-O (input-output) Econometric model. The core of such a model consists of multi-sectoral quantity and price relationships based on I-O representation of the economy. Thus many important variables are calculated by industry, taking into account the inter-industry relationships, and are later added up as the macroeconomic aggregates (by bottom-up approach), including GDP (Almon, 1991; Bockermann, Meyer, Omann, & Spangenberg, 2005; Grassini, 2001; Meade, 2014; Su, Yang, Huang, Lin, & Chang, 2015). Using this kind of model, it is possible not only to analyze trends of competitiveness by industry, but also the influence of changes in competitiveness on the development of other industries and the whole economy.

Analysis of main relationships of the inter-industry macroeconomic models provides information on competitiveness indicators, which can be calculated in the majority of the models. However, each model is individual, and thus it depends on the structure of a particular model and whether all the necessary data are included. On the other hand, it is possible to introduce additional data and relationships into the model and thus enable the model user to obtain more information on competitiveness by industry.

One of the central equations of the INFORUM models is the I-O solution relating output to intermediate and final consumption. Thus the output and demand components by industry are included in the model. The second central component of the INFORUM models is the I-O price solution relating the unit price vector to the unit material cost and the unit value added cost. Value added components – wages, depreciation expenses, operating profits and indirect taxes – are calculated as well together with labor productivity and labor demand. This allows using a wide range of indicators in competitiveness studies as well.

On the other hand, input-output data are not published as frequently as other statistics, therefore other types of models such as econometric models have to be considered. Such models can also incorporate some industry structure and thus be used as the tools for competitiveness analysis by industry (Ozolina & Pocs, 2013).

Competitiveness indicators can be incorporated in the models in two ways: 1) as exogenous indicators, which show the assumptions of scenarios regarding the possible development of competitiveness; and 2) as endogenous indicators showing the results of activities towards higher competitiveness, or consequences of changes in the economic environment. In both cases it is possible to get important insights into the competitiveness issue.

2. Competitiveness indicators

Within the research several competitiveness indicators are chosen for analysis, which might be incorporated in the Latvian macroeconomic model. As competitiveness demands complex studies, there is a need for several competitiveness indicators in the model, each of them capturing different aspects of competitiveness. Seven indicators are used in this study in order to reveal competitiveness trends by industry in Latvia. The selected indicators are as follows:

1. specialization;
2. export dependency;
3. value added per unit of output;
4. real labor productivity;
5. value added per employee;
6. value added per unit spent on labor; and
7. unit labor costs.

Additionally, the real growth rate of the exports and the ratio of the nominal exports to GDP are calculated in order to reveal the overall trend of export-orientation of Latvia.

Analysis of the specialization indicator (1) or the export structure shows which industries are dominating exports at present and which industries could become the export leaders in the future. Increase of the value of the specialization indicator shows that the export value of a particular industry grows comparatively faster than in other industries. However, it shows not only the result of the changes in competitiveness, but also the changes in the demand, prices and other factors.

$$\exp\_spec_{i,t} = \frac{\exp_{i,t}}{\sum \exp_{i,t}} 100\% \qquad (1)$$

where $exp_{i,t}$ is the nominal exports of goods and services of the industry i in the time period t. If only total exports are calculated in the model, this indicator can be used as an exogenous variable, otherwise it will be endogenous.

The export dependency ratio (2) shows the fraction of the output, which is exported in each industry. In other words, it shows the dependency of a certain industry on the economic activity abroad.

$$\exp\_dep_{i,t} = \frac{\exp_{i,t}}{out_{i,t}} \tag{2}$$

where $out_{i,t}$ is the nominal output in industry *i* in time period *t*. This indicator is endogenous in the model.

The ratio of value added to output is calculated using Equation (3). This indicator helps to distinguish the actual higher-, medium-, and lower-value added industries in the economy.

$$r\_v_{i,t} = \frac{r\_va_{i,t}}{r\_out_{i,t}} \tag{3}$$

where $r\_va_{i,t}$ is the value added in industry *i* in time period *t*, and $r\_out_{i,t}$ is the real output in industry *i* in time period *t*. This indicator can be exogenous or endogenous, if the elements of the value added are calculated within the models.

Real labor productivity (4) shows the volume of output produced per one unit of labor. The usual choice of the labor indicator is between the hours worked and the number of full-time equivalent employees, although sometimes also the number of employees as such is used.

$$r\_p_{i,t} = \frac{r\_out_{i,t}}{empl_{i,t}} \tag{4}$$

where $empl_{i,t}$ is the number of employees in full-time equivalent. This indicator can be exogenous or endogenous, calculated with the formula or depending on other factors.

Value added per employee (in full-time equivalent) as computed in Equation (5) is sometimes associated with labor productivity. It also shows to what extent employees in each industry facilitate economic activity. This indicator is endogenous in the model.

$$r\_pvu_{i,t} = \frac{r\_va_{i,t}}{empl_{i,t}} \tag{5}$$

The ratio of value added to the unit spent on labour (6) is a significant indicator as it shows how much value added is generated per one unit spent on labor. The higher the values, the greater positive impact each industry has on the whole economy.

$$pvu\_lc_{i,t} = \frac{va_{i,t}}{lc_{i,t}} \tag{6}$$

where $lc_{i,t}$ are the labor costs in industry *i* in time period *t*. This indicator is endogenous in the model.

Unit labor costs (per full-time equivalent employee) are calculated using Equation (7).

$$ulc_{i,t} = \frac{lc_{i,t}}{empl_{i,t}} \tag{7}$$

Unit labour costs capture one of the aspects of cost competitiveness. This indicator is endogenous in the model.

The main sources of data for this study are the database of the Central Statistical Bureau (CSB) of the Republic of Latvia (CSB, 2017) and the Eurostat database (Eurostat, 2017a). In the research, more attention is paid to high-technology industries (according to NACE classification Rev.2. codes of industries: 21 and 26), medium-high-technology industries (20 and 27 to 30) and medium-low-technology industries (19, 22 to 25 and 33). The data for 2005–2016 are mainly analyzed, however, in some cases the data were missing, thus a shorter period is used.

3. Data analysis

Analysis shows that exports is one of the drivers of Latvian economic development (see Fig. 1). During the crisis there was also a fall in export volumes, but it lasted for only one year (GDP fell 3 years in a row) and afterwards presented considerable positive annual growth rates (9.8–13.4 %). In 2013, the export growth rate was comparatively low due to the export sanctions of Russia (this market accounted for 11 % of Latvia's exports of goods in 2012) and the weak demand in other countries.

There are two dominating industries in exports – manufacturing and trade. It is understandable as goods can be exported directly and

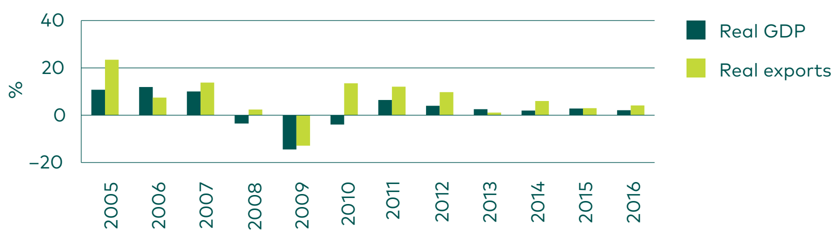

Fig. 1. Real GDP and exports of goods and services growth rate, %. (Source: Authors' calculations based on the CSB database)

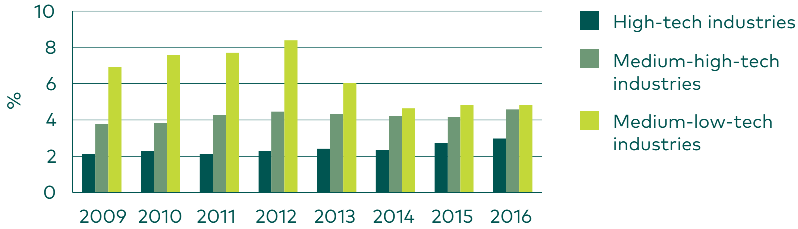

Fig. 2. Specialization indicators in manufacturing in Latvia, %. (Source: Authors' calculations based on the CSB database)

indirectly – via distributers and other third parties, which are mainly related to the trade sector. The main commodity groups (CN) associated with the trade sector in 2009 and in 2016 are machinery and mechanical appliances (XVI), vegetable products (II), products of the chemical and allied industries (VI), base metals (XV), wood and articles of wood (IX), mineral products (V), prepared foodstuffs (IV) and transport vehicles (XVII). The total share of manufacturing in total exports of goods has decreased from 43.8 % in 2009 to 37.5 % in 2014, but since has slightly increased to 40.6 %. About 30 % of the manufacturing exports are associated with the manufacture of wood and wood products. The share of trade has increased from 38.0 % in 2009 to 46.7 % in 2017 and is mainly related to wholesale trade.

Analysis of the specialization indicators by groups of industries (Fig. 2) shows that the shares of exports of high-tech and medium-high tech industries (the grouping of industries performed on the Eurostat methodology basis (Eurostat, 2017b)) are stable or slightly increasing, however, the share of medium-low-tech industries falls dramatically in 2013–2014. As these data are in nominal terms, it can indicate both the fall of export volumes as well as the decrease in prices of the products.

The importance of exports in Latvia has increased substantially during the global financial crisis – from about 40 % of GDP in 2005–2009 to more than 60 % in 2012–2016. This means that during the crisis, the Latvian economy became more export-oriented.

Higher export-orientation leads to higher export dependency. In Latvia, the ratio of exports to output has increased from an average of 20.3 % in 2005–2009 to 30.6 % in 2012–2016. Export dependency ratios by industry are slightly imprecise as 4.0–9.7 % of the total exports of goods are not distributed by industry. However, it is clear that high-tech industries, as expected, are highly export-dependent (see Fig. 3). The overall export dependency of medium-high-tech industries is more than

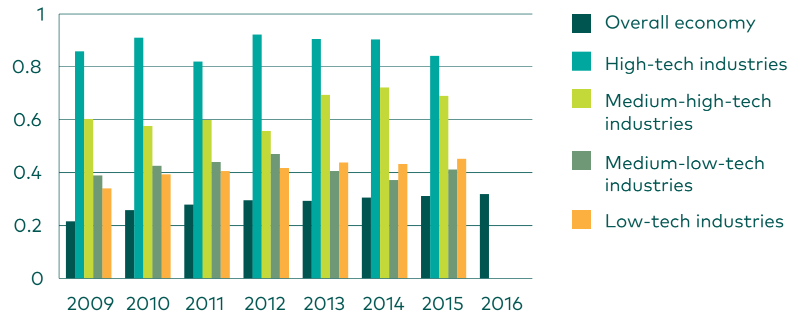

Fig. 3. Export dependency ratios in manufacturing industries in Latvia. (Source: Authors' calculations based on the CSB and Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2016 are not available.

50–60 %, but the overall export dependency of medium-low-tech and low-tech industries fluctuates around 40 %. Thus the competitiveness in export markets is crucial in these industries.

The Latvian economy generates on average 0.42–0.45 units of value added per unit of output (see Fig. 4). The values of the ratio are comparatively higher in high-tech industries, but lower in medium- and low-tech industries. It is interesting to note that value added per unit of output in medium-high-tech industries was comparatively high in 2005–2007, but sharply decreased in 2008, when the global financial crisis began.

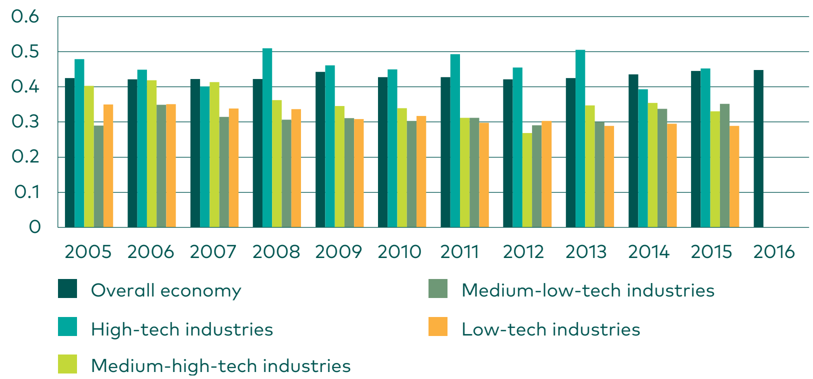

Fig. 4. Real value added per unit of output in manufacturing industries in Latvia. (Source: Authors' calculations based on the Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2016 are not available.

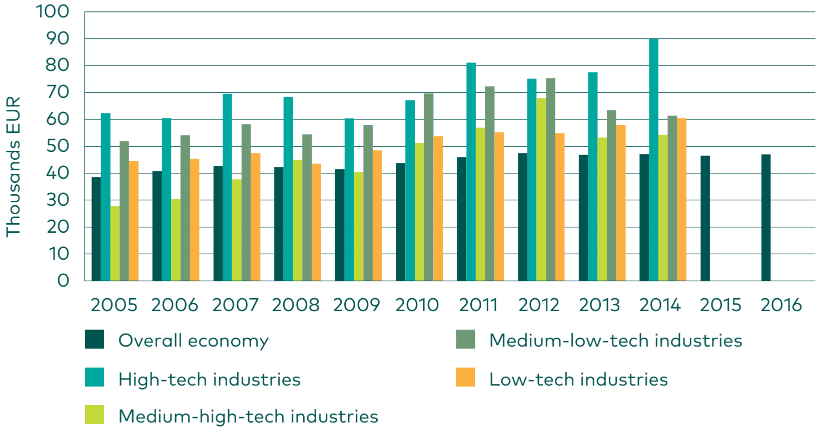

Fig. 5. Labor productivity in high- and medium-tech industries in Latvia, thsd EUR per person. (Source: Authors' calculations based on the Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2015 and 2016 are not available.

Contrary to value added per unit of output, productivity has increased considerably during the crisis, especially in medium-high-tech industries, although this trend did not continue in 2013–2014 (see Fig. 5). The productivity indicator is calculated using the data on number

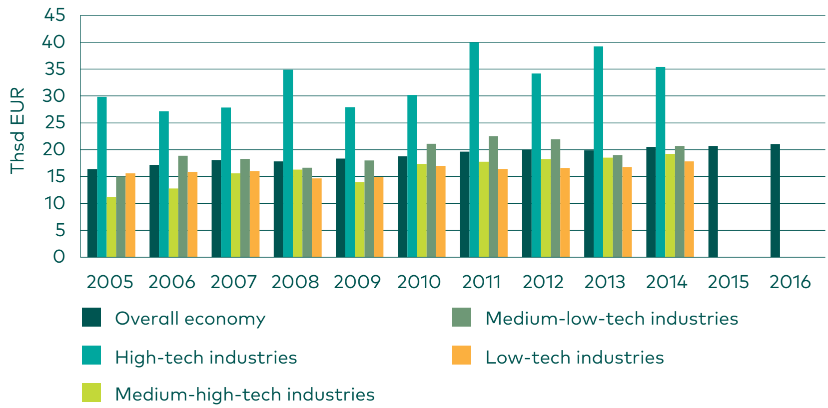

Fig. 6. Real value added per employee (full-time equivalent), thsd EUR per person. (Source: Authors' calculations based on the Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2015 and 2016 are not available.

of employees as the labor indicator, however, the general trend in manufacturing is similar as the number of hours worked is used instead. It is important to note that productivity in all the industry groups of manufacturing is higher than the average in the economy.

Real value added per employee is considerably higher in high-tech industries, as expected (see Fig. 6). However, the difference between the medium-high- and medium-low-tech industries is not that large. Moreover, real value added per employee is higher in medium-low-tech industries.

Value added per unit spent on labor is generally considerably higher than in the economy as a whole (see Fig. 7). However, for medium-low-tech industries the values were higher only in 2006 and 2010–2011. It is interesting to note that this value was very high for low-tech industries in 2005–2007, but then it began to decrease, reaching a value only slightly higher than in medium-tech industries.

There is a general increasing trend in unit labor costs in Latvia with a decrease during the crisis (see Fig. 8). The unit labor costs in high-tech industries are considerably higher than on average, but only slightly higher in medium-tech industries. One possible reason might be that the number of specialists needed in high-tech industries is very limited and companies must pay higher wages to keep their high-skilled employees. Unit labor costs are lower in low-tech industries.

In summary, high-tech industries stand out in most aspects of competitiveness except value added per unit of output, when compared with the overall economy. Analysis of manufacturing sectors also shows that competitiveness patterns are different among industries, thus a detailed macroeconomic model is needed for competitiveness analysis.

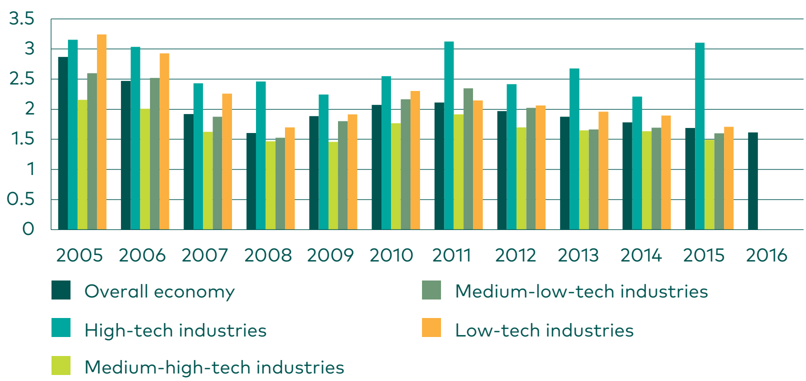

Fig. 7. Value added per unit spent on labour. (Source: Authors' calculations based on the Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2016 are not available.

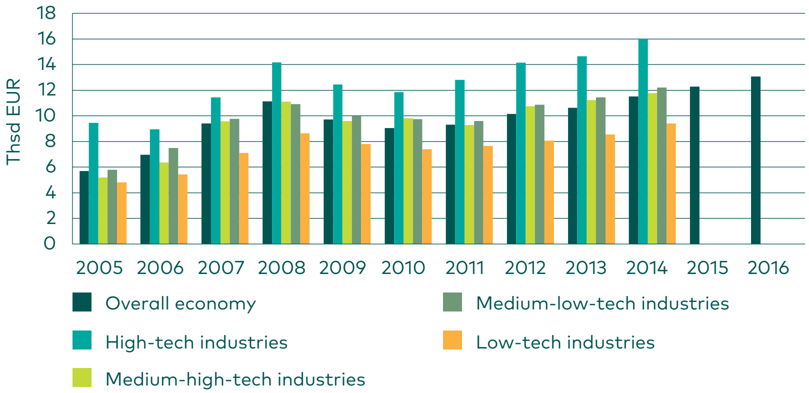

Fig. 8. Unit labor costs, thsd EUR. (Source: Authors' calculations based on the Eurostat database)
Note: Disaggregated data in NACE classification Rev. 2. for 2015 and 2016 are not available.

4. Current state of the Latvian macroeconomic model

As mentioned above, macroeconomic models, which combine input-output and econometric equations, are very useful for economic analysis by industry. On the other hand, if reliable input-output data are not available, macro-econometric models are the second best choice. However, such models cannot incorporate highly detailed data. Therefore at present, competitiveness indicators are incorporated in the Latvian macro-econometric model with 10 industries disaggregation. The next step is to incorporate input-output relationships and add more detail, including distinction among high-tech, medium-high-tech and low-tech industries.

The current stage of the model incorporates only a part of the selected competitiveness indicators by industry. The ratio of real value added to output ($r\_v_{i,t}$) and real labor productivity ($r\_p_{i,t}$) are used as the exogenous indicators by industries, while real value added per employee ($r\_pvu_{i,t}$) is endogenous. It is assumed that, if the ratio of value added per unit of output increases due to higher competitiveness, real labor productivity should increase as well. Export orientation, unit labor costs and the ratio of value added to labor costs is calculated only at the aggregate level for the whole economy.

Conclusions

There are many competitiveness indicators, some of which can be used also at the industry level, but data availability issues limit the options to incorporate all of them in the model. Therefore there is a need for further research on how to adapt valuable competitiveness indicators or estimate the lacking data in order to cover all the necessary aspects of competitiveness.

Inter-industry linkages are important in competitiveness studies by industry, therefore input-output econometric models are appropriate instruments for competitiveness analysis. When adequately formulated, such a model can provide an outlook in competitiveness positions of industries in the future.

The high-tech industries are high-value added industries in Latvia, however, labor costs are higher in these industries. The medium-low-tech industries are more developed than the medium-high-tech industries, indicating the potential of development in medium-high-tech industries. Thus the requirements for such development have to be analyzed in more detail, using appropriate macroeconomic models.

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RESEARCH ON DIVISION OF LABOR OF CHINA'S DOMESTIC VALUE CHAIN FROM THE GLOBAL VALUE CHAIN PERSPECTIVE

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Introduction

With the development of infrastructure and information and communication technology, the global division of labor has deepened. It developed gradually from the separation of production and consumption to inter-industry and intra-industry, and further to the current intra-product division of labor or the division of production. From the early division within a smaller region to the present division among different countries, more and more enterprises have been engaged in investment, production, and trade activities on a global scale. At present, about 80 % of global trade is transnational trade (UNCTAD, 2013).

At the same time, with the development of regional integration and the continuation of all-around "opening up", the economic ties between different regions within a country and between domestic regions and foreign countries are becoming closer and closer. From 1987 to 2007, the average inter-provincial trade dependence in the domestic provinces increased by nearly 20 percentage points, and the economic and trade links between the provinces were continuously strengthened (Zhang, 2013). What's more, the export proportion of the central and western regions in total in the country rose from 6.7 % in 2002 to more than 13 % in 2016 from January to August. The economic development of any region within a country depends not only on its own domestic environment, but even more so on its role and status in the entire global production network. So, we need to understand regional economic development from the perspective of the global value chain. There is a high degree of heterogeneity between regions in China, so research in the regional level has a stronger practical significance to promote the transformation of China's economy.

In recent years, the gradual emergence of trade in value-added measurement and decomposition methods based on the input-output model is providing a new set of theoretical systems for the study of the global value chain. It is also changing people's understanding of economic ties between countries based on traditional balance of payments and trade statistics. Based on this theoretical background, this paper attempts to construct the fusion analysis framework of the domestic value chain and the global value chain by embedding the domestic regional input-output table in the global input-output table. This is based on the value-added trade calculation and decomposition framework proposed by Wang, Wei, & Zhu (2015) in order to solve the current problem of fracture analysis for the domestic value chain and the global value chain. The specific research arrangements in this paper are as follows: in the second section, we will comb the current literature on the domestic value chain based on the input-output model and find out the shortcomings of the current research; in the third section we introduce the methods and analysis framework adopted in this study; the fourth section will analyze the trade pattern, value chain participation, and industry competitiveness; and finally, we end with the corresponding research conclusions.

1. Literature

At present, there have been many studies about research methods for the value chain division of labor and global value chain, such as (Yi, 2003), KWW method (Koopman, Wang, & Wei, 2010; 2014), WWZ method (Wang, Wei, & Zhu, 2015); the related literature has also been reviewed quite a lot, such as (Pan & Li, 2014). For the purposes of this paper, we will focus on combing the literature about domestic value chain based on input-output model.

For a long time, due to the lack of data on economic ties inside each province and between provinces, the study of the domestic value chain division of labor relied mainly on national or single region input-output tables. For example Chai & Yang (2011) proposed a new framework for analyzing the interrelationship between the domestic value chain and the global value chain of high-tech industries based on the non-competitive input-output model. Using the input-output tables and industry-level data of Guangdong Province and Jiangsu Province in 1997, 2002 and 2007, Zhang & Li (2013) established a simultaneous equation model and found that there is a negative correlation between the domestic value chain and the global value chain, and that the domestic value chain has not successfully joined the global value chain.

As Wang, Wei, & Zhu (2015) proposed the global value chain research method based on input-output tables, some scholars began to apply this approach to the study of the domestic value chain. Meng, Wang, & Koopman (2013) embedded the domestic input and output table of eight districts into the global input-output table, studied the global division of labor and the links among different domestic regions on the basis of the KWW method, and analyzed how value added is distributed between domestic and international. Su (2016) considered the domestic value chain on the basis of the global value chain and decomposed the export value added of domestic regions. He had three major findings: 1) the level of economic development and the local share of the value added and the international vertical and professional share have respectively strong negative correlation and positive correlation; 2) the low local value-added ratio of China's exports is mainly due to the low ratio of value added export in gross value export of the manufacturing sector in the coastal provinces; and 3) the degree of export specialization measured by the value added export is lower than that measured by the gross value export. Based on China's interregional input-output tables, Li & Pan (2016) carried out the value-added decomposition of domestic interregional trade from the perspective of value added flow, and explored patterns of the Chinese regions embedded in the global value chain from three dimensions – vertical professional production, value added supply preferences, and the regional re-outflow. The study shows that the production of domestic regions is gradually turning from internal vertical specialization to external vertical specialization in 1997 to 2007. There is an obvious preference adjacent to the "polarity" value added supply in the inland area, and the pure repetition ratio of value added in China's regions expectedly rose after joining the WTO.

Although there are current studies on provincial value added and inter-provincial value added trade, the existing research is either the decomposition of the value added export in each province (Su, 2016), or the decomposition of inter-provincial trade value added and domestic vertical division of labor (Li & Pan, 2016). There is not any study combining these two aspects. This paper attempts to embed China's regional (provincial) input-output tables into the global input-output table and build a global input-output model containing China's inter-provincial input-output modules, which makes it convenient for us to analyze the domestic value chain from the global value chain perspective. Using this model, we start the analysis of different regions involved in the global division of labor and domestic division of labor from the perspective of the global value chain and the domestic value chain.

2. Methodology, data source and decomposition examples

This paper will follow the WWZ approach (Wang, Wei, & Zhu, 2015). In order to analyze the domestic value chain, this study expands it in two aspects, which is also the biggest difference between this study and the current decomposition methods of domestic provincial export value and domestic interregional trade value.

2.1. Constructing a global input-output table embedded with China's domestic input-output tables

Figure 1 shows the way to build and form a global input-output table embedded with China's domestic inter-provincial input-output tables. Specifically, a multiregional input-output table containing 30 provinces (cities, districts) in China is grafted together with a global input-output table containing China and other countries and regions. Domestic

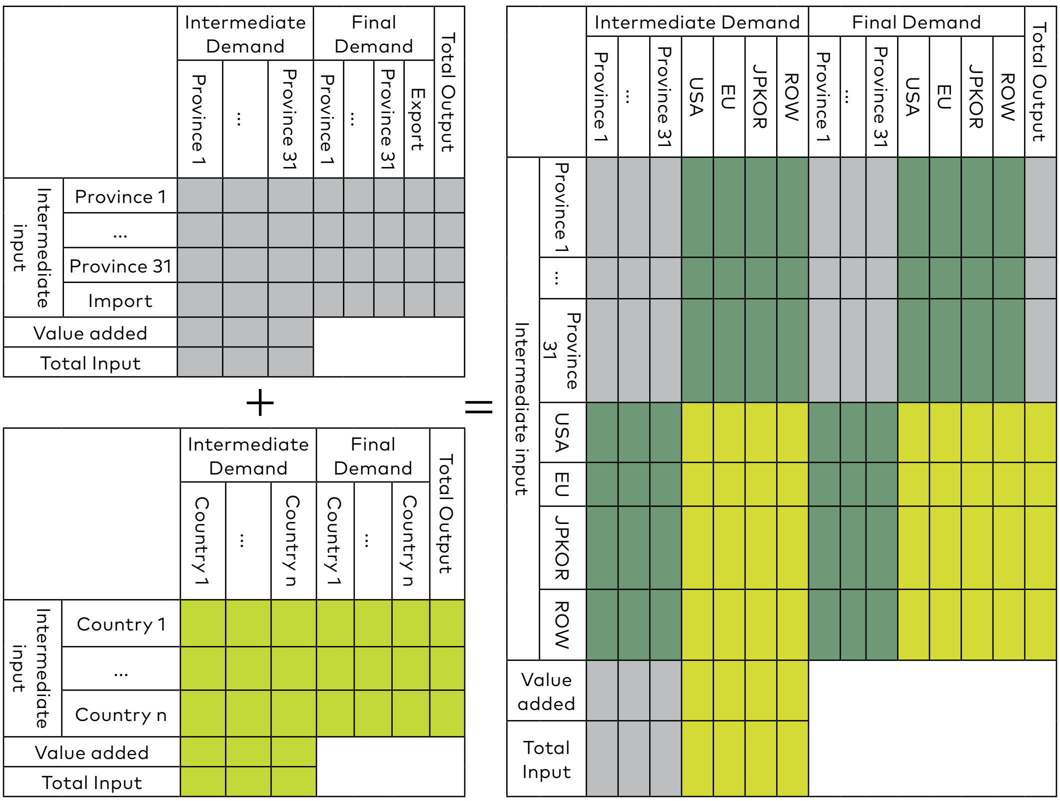

Fig. 1. The Global input-output table embedded with China's domestic inter-provincial input-output tables.

provinces and international countries and regions are all seen as a separate area. The resulting global input-output table contains both economic ties among provinces and economic ties among countries, as well as economic links between different provinces and different countries and regions.

This method of grafting is based on the initial global input-output table as a control to adjust the domestic multiregional input-output table, making the industry output and import and export in the domestic multiregional input-output table consistent with China-related data in the global input-output table. See Meng, Wang, & Koopman (2013) for specific practices.

We will mainly use three types of data – the 2007 multiregional input-output table constructed by the State Council Development Research Center and the National Bureau of Statistics, the 2007 global input-output table from WIOD, and the import and export data of each province of China with different trade objects.

For the sake of analysis, this paper merges the 43 regions of WIOD's global input-output table into five countries and regions, namely, China, the United States, the European Union, Japan-South Korea (including Japan and Korea) and other countries and regions. At the same time, in order to make China's input-output table correspond to the WIOD industry, this article will merge their respective industries into 14 departments, including agriculture, extractive industries, food, textile and garment, petrochemical, building materials, metal smelting and products industry, equipment manufacturing, electrical and electronic and instrumentation, other manufacturing, electrical water, construction, production and distribution services and other services.

2.2. Constructing a unified framework of value added decomposition of foreign trade of the domestic provinces from global perspective

WWZ approach (Wang, Wei, & Zhu, 2015) divides exports into four parts (the domestic value added absorbed abroad, the domestic value added first exported then returned home, the foreign value added, and the purely double-counting term) and 16 items, as follows :

$$E^{sr} = A^{sr}X^{r} + Y^{sr} =$$

$$= (V^{s}B^{ss})' \# Y^{sr} + \quad (1.1)$$

$$+ (V^{s}L^{ss})' \# (A^{sr}B^{rr}Y^{rr}) + \quad (1.2)$$

$$+ (V^{s}L^{ss})' \# (A^{sr}B^{rt}Y^{tt}) + \quad (1.3)$$

$$+ (V^s L^{ss})' \#(A^{sr} B^{rr} Y^{rt}) + \quad (1.4)$$

$$+ (V^s L^{ss})' \#(A^{sr} B^{rt} Y^{tr}) + \quad (1.5)$$

$$+ (V^s L^{ss})' \#(A^{sr} B^{rr} Y^{rs}) + \quad (1.6)$$

$$+ (V^s L^{ss})' \#(A^{sr} B^{rt} Y^{ts}) + \quad (1.7)$$

$$+ (V^s L^{ss})' \#(A^{sr} B^{rs} Y^{ss}) + \quad (1.8)$$

$$+ (V^s L^{ss})' \#[A^{sr} B^{rs} (Y^{sr} + Y^{st})] + \quad (1.9)$$

$$+ (V^s B^{ss} - V^s L^{ss})' \#(A^{sr} X^r) + \quad (1.10)$$

$$+ (V^r B^{rs})' \# Y^{sr} + \quad (1.11)$$

$$+ (V^r B^{rs})' \#(A^{sr} L^{rr} Y^{rr}) + \quad (1.12)$$

$$+ (V^r B^{rs})' \#(A^{sr} L^{rr} E^r) + \quad (1.13)$$

$$+ (V^t B^{ts})' \# Y^{sr} + \quad (1.14)$$

$$+ (V^t B^{ts})' \#(A^{sr} L^{rr} Y^{rr}) + \quad (1.15)$$

$$+ (V^t B^{ts})' \#(A^{sr} L^{rr} E^r) \quad (1.16)$$

where E^{sr} is the vector of Country *s'* gross exports to country *r*; V^s is the vector of direct value-added coefficients of Country s; *A* is the input-output coefficient matrix; and *B* denotes the Leontief (global) inverse matrix; *X* is the gross output vector; Y^{sr} is the vector of final goods produced in s and consumed in *r*; *L* is the local Leontief inverse matrix, and E^s is the vector of total gross exports by Country *s*.

Based on the previously constructed global input-output table, this study expands the WWZ approach (see Fig. 2). When we treat China as a whole, the trade objects can only be foreign countries and regions, and at the same time third parties can also be only foreign countries and regions. However, when we treat provinces as research objects, the trade objects can either be foreign countries and regions (international export) or other domestic provinces (inter-provincial export). Additionally, the relevant third parties include not only other countries and regions abroad, but also other domestic provinces.

Therefore, this study will decompose the foreign trade of each province (including international export and inter-provincial export) into four parts, namely, the value added of one province, the value added in other provinces, the foreign value added, and the repeated calculation part. Specifically, the third party in the WWZ method is divided into the domestic third party and the foreign third party. Based on this division, the 16 items of decomposition in the WWZ method can be further extended to 20 items. According to the trade object, we divide the eleventh item and the twelfth item into the value added in other provinces and the foreign value added; according to the third party, we

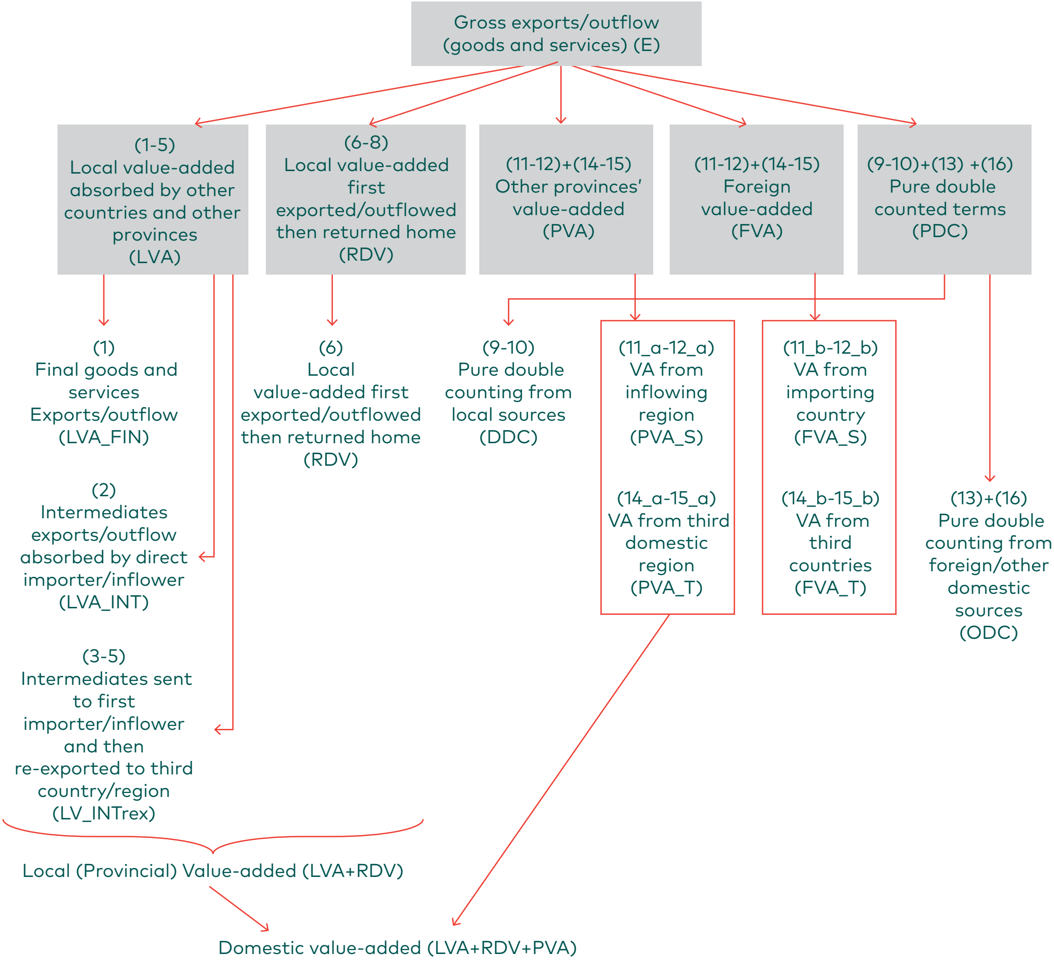

Fig. 2. Decomposition of international export / inter-provincial outflow of domestic provinces. (Source: Adjusted based on Wang, Wei, & Zhu (2015))

divide the fourteenth item and the fifteenth item into other provinces in the country value added and foreign value added:

$$E^{sr} = (V^s B^{ss})' \# Y^{sr} = \tag{2.1}$$

$$+ (V^s L^{ss})' \# (A^{sr} B^{rr} Y^{rr}) + \tag{2.2}$$

$$+ (V^s L^{ss})' \# (A^{sr} B^{rt} Y^{tt}) + \tag{2.3}$$

$$+ (V^s L^{ss})' \# (A^{sr} B^{rr} Y^{rt}) + \tag{2.4}$$

$$+ (V^s L^{ss})' \# (A^{sr} B^{rt} Y^{tr}) + \tag{2.5}$$

$$+ (V^s L^{ss})' \# (A^{sr} B^{rr} Y^{rs}) + \tag{2.6}$$

$$+(V^s L^{ss})' \# (A^{sr} B^{rt} Y^{ts}) + \quad (2.7)$$

$$+(V^s L^{ss})' \# (A^{sr} B^{rs} Y^{ss}) + \quad (2.8)$$

$$+(V^s L^{ss})' \# [A^{sr} B^{rs} (Y^{sr} + Y^{st})] + \quad (2.9)$$

$$+(V^s B^{ss} - V^s L^{ss})' \# (A^{sr} X^r) + \quad (2.10)$$

$$+(V^r B^{rs})' \# Y^{sr} + \quad \text{(2.11\_}a\text{) if } r \text{ is other domestic province}$$

$$+(V^r B^{rs})' \# Y^{sr} + \quad \text{(2.11\_}b\text{) if } r \text{ is other country}$$

$$+(V^r B^{rs})' \# (A^{sr} L^{rr} Y^{rr}) + \quad \text{(2.12\_}a\text{) if } r \text{ is other domestic province}$$

$$+(V^r B^{rs})' \# (A^{sr} L^{rr} Y^{rr}) + \quad \text{(2.12\_}b\text{) if } r \text{ is other country}$$

$$+(V^r B^{rs})' \# (A^{sr} L^{rr} E^r) + \quad (2.13)$$

$$+(\sum_{t \in D} V^t B^{ts})' \# Y^{sr} + \quad \text{(2.14\_}a\text{) D includes all other domestic provinces}$$

$$+(\sum_{t \in F} V^t B^{ts})' \# Y^{sr} + \quad \text{(2.14\_}b\text{) F includes all other countries}$$

$$+(\sum_{t \in D} V^t B^{ts})' \# (A^{sr} L^{rr} Y^{rr}) + \quad \text{(2.15\_}a\text{) D includes all other domestic provinces}$$

$$+(\sum_{t \in F} V^t B^{ts})' \# (A^{sr} L^{rr} Y^{rr}) + \quad \text{(2.15\_}b\text{) F includes all other countries}$$

$$+(V^t B^{ts})' \# (A^{sr} L^{rr} E^r) \quad (2.16)$$

What needs to be pointed out here is that E^{sr} can not only indicate the international export of one province to other countries, but also indicate the inter-provincial outflow between provinces within China. In addition, (2.11_a), (2.11_b), (2.12_a) and (2.12_b) do not appear in the decomposition of the four terms simultaneously. When r refers to other countries, only (2.11_b) and (2.12_b) will appear in the decomposition formula; when r refers to other province in China, only (2.11_a) and (2.12_a) will appear in the above formula.

On the basis of the previous decomposition, we follow the method of vertical specialization index proposed by Hummels et al. (1998; 2001). To reflect the degree of each domestic region participating in the global value chain and the domestic value chain, we respectively design *VS_GVC* index and *VS_DVC* index. The *VS_GVC* measures the import value implied in exports of each province; the *VS_DVC* measures the inter-provincial import value implied in inter-provincial exports of each province. The specific formulas are as follows:

$$VS\_GVC = \frac{FVA+PDC}{E}; \quad (3)$$

$$VS\_DVC = \frac{PVA+PDC}{DE}. \quad (4)$$

Hereinto, *FVA* and *PDC*, respectively, mean the foreign value added contained in exports of one province and the repeated calculation part due to the intermediate trade. *PVA* represents the value added of other domestic provinces included in inter-provincial exports.

2.3. A decomposition example based on the new decomposition framework

In order to better demonstrate this new method of decomposition, we first take the decomposition for Guangdong's export of electrical, electronic, and instrumental goods to the US as an example of the method of value chain decomposition and the calculation of the vertical specialization index.

Figure 3 shows the decomposition for Guangdong's exports of the electric, electronics, and instrument industry to the United States. There are three parts in this figure. First, the middle portion shows the main content of decomposition. The export of Guangdong's electrical &

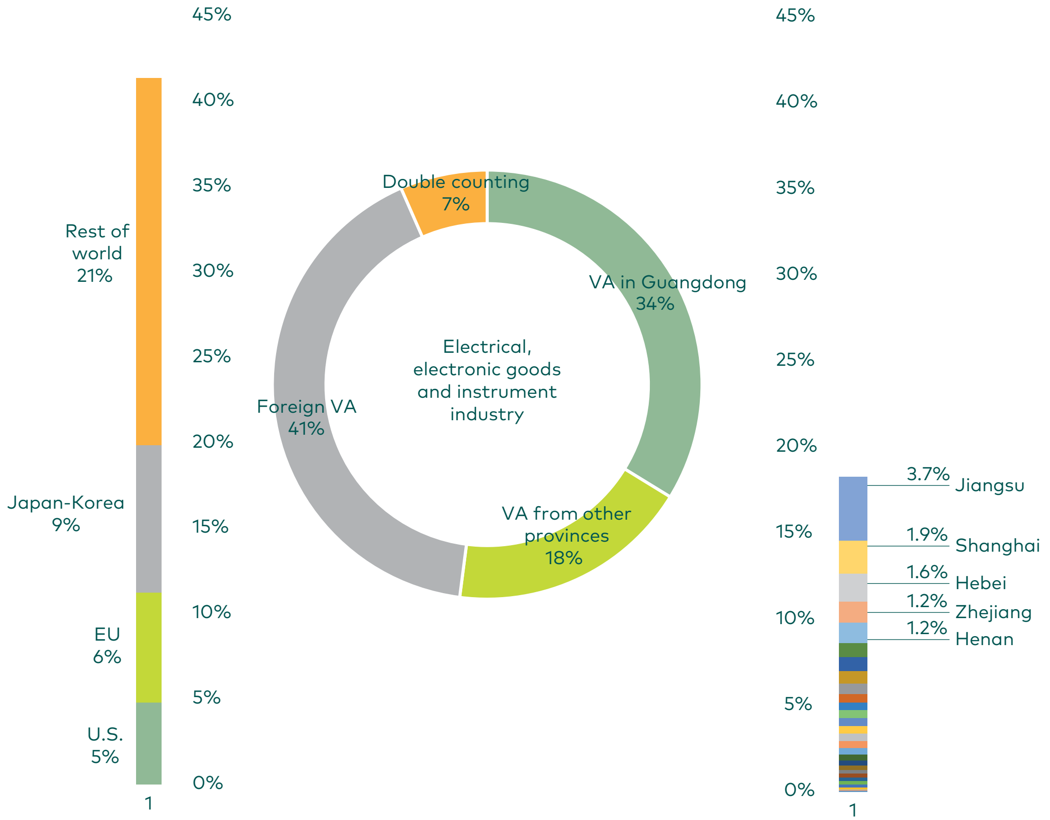

Fig. 3. GVC decomposition for Guangdong electrical & electronic goods exported to the U.S., %.

electronic goods is divided into four components: local value added (in Guangdong), foreign value added (international value added), value added from other provinces (domestic value added, excl. Guangdong), and double counting. Looking at the decomposition results, the largest component in Guangdong's export is foreign value added, accounting for 41 % of total exports; the second largest component is value added of Guangdong itself, accounting for 34 % of total exports; other domestic provinces get 18 % of value added from Guangdong's export; the remaining 7 % is double counting. According to the calculation, Guangdong's vertical specialization index in the electrical & electronic industry (export to the U.S.) reaches 48 %.

Secondly, the left portion shows the detail of the international value added in Guangdong's export. The EU, Japan-South Korea, and the United States account for half of the total Guangdong's export value added, and other countries and regions get the remaining half. Japan and South Korea account for 9 % of value added in the total of Guangdong's exports, which is related to a large number of Sino-Japanese and Sino-Korean intermediate trade. The EU and USA get 6 % and 5 % of value added in the total Guangdong's exports, respectively.

Finally, the right portion shows the value added of other provinces of the country. This shows that the proportion of the Yangtze River Delta region is the highest. More than 1/3 of the domestic value added is obtained by the Yangtze River Delta region. As for each province, the largest beneficiary is Jiangsu, which accounts for 1/5 of all domestic value added of other provinces.

3. Main results

3.1. The participation degree of each province in the global value chain

Figure 4 shows the vertical specialization indices of each province participating in the global value chain. From the space point of view, the main features are as follows.

(1) The degree of coastal and border provinces participating in the global value chain is significantly higher than that of the inland provinces.

From Fig. 4, both the developed southeastern coastal areas, and the northeast and northwest regions have higher vertical specialization indices of export than inland provinces. On average, the vertical specialization indices of the coastal and border areas are about 10 percentage points higher than those of the inland provinces in international trade. To a certain extent, this proves the importance of location advantages in international trade. This also explains why the world economy has concentrated in coastal port areas for a long time. However, there are significant differences within the coastal provinces, for example Shandong's vertical specialization index is lower than of other coastal provinces.

(2) The vertical specialization index of three growth poles of the global value chain in the national leading level.

From the results of the calculation, the vertical specialization indices of the three growth poles – the Pearl River Delta, the Yangtze River Delta and Beijing-Tianjin-Hebei are significantly higher than those in other regions in the global value chain. The vertical specialization index of the Pearl River Delta is the most prominent. Further, Guangdong Province owns the highest vertical professional index, reaching 21.6 %. The second is the Yangtze River Delta region that has an average index of about 15 % and in which Shanghai has the highest index, close to 20 %. Zhejiang has the lowest index, which has something to do with its industrial structure. The third is the Beijing-Tianjin-Hebei region that has an average index of about 14 % in which Hebei has the lowest index.

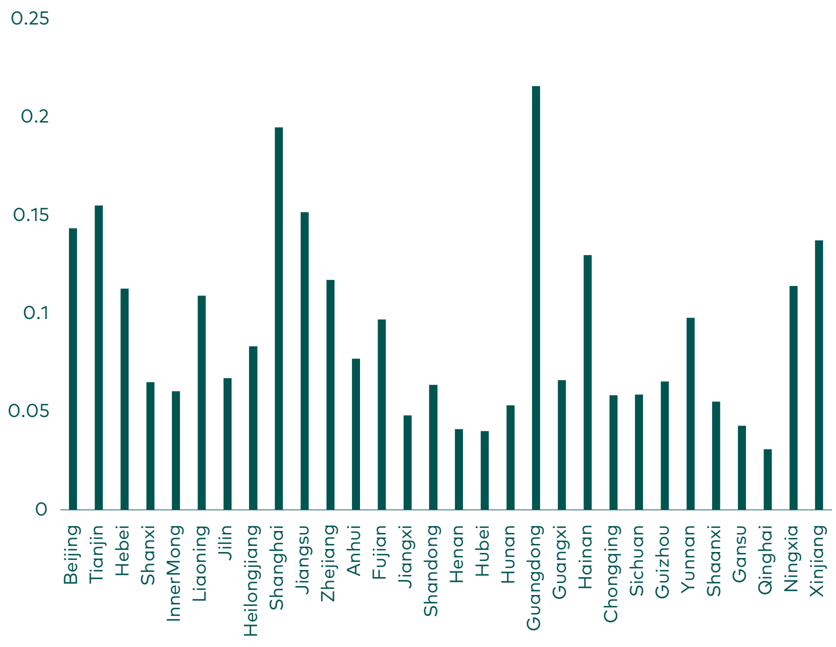

Fig. 4. Vertical specialization indices of each provinces in the global value chain.

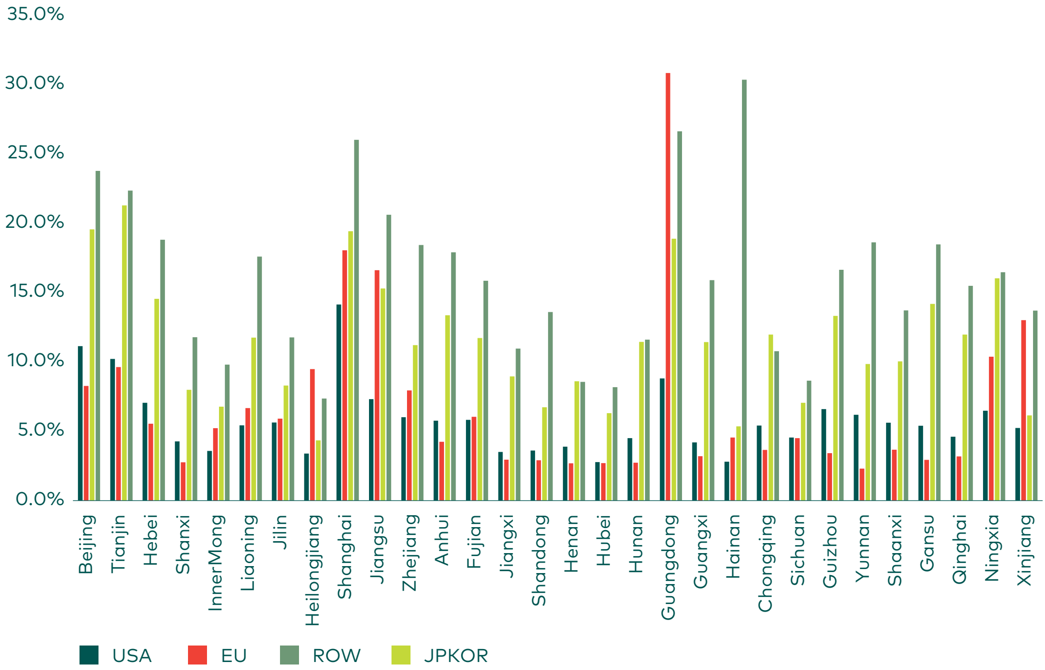

Fig. 5. VS indices of each province with different export objects, %.

(3) The vertical specialization index of areas close to coastal provinces is higher than the one of areas far away from the coastal areas in the global value chain.

In terms of calculation results, the participation degree of inland provinces bordering the coastal provinces in the global value chain is significantly lower than that of coastal provinces, but slightly higher than of other provinces that are closer to the interior. For example vertical specialization indices of Anhui, Jiangxi's are higher than Hubei. This, to some extent, is relevant to the fact that the change in comparative advantage of the factor cost leads to the transfer of part of industries from the coastal area to the inland provinces.

(4) For most provinces, the vertical specialization index of trade with Japan-South Korea is significantly higher than it is with Europe and the United States.

Figure 5 shows the vertical specialization (VS) indices of trade between each province and different trade objects (including EU, JPKOR, USA, and ROW). From the comparison of different trade objects, the VS value of each province is generally shown as USA < EU < JPKOR < ROW, that is, the more developed the country, the lower is the participation degree of China in its value chain. This is related to the trade structure between China and these trade objects, as well as the division of labor network. The fact that the VS index of trade between China and Japan-South Korea is significantly higher than Europe and the U.S., reflects that the division of labor network of the intermediate input product value chain in East Asia is very developed.

3.2. Analysis of the participation degree of each province in the domestic value chain

Figure 6 shows the vertical specialization indices of each province participating in the domestic value chain. From the calculation results, the main features are as follows.

(1) The vast majority of eastern coastal provinces are more involved in the domestic value chain.

Similar to the global value chain, the vast majority of the eastern coastal provinces are more involved in the domestic value chain. On average, the vertical specialization index of the eastern coastal areas in the domestic value chain is about 8 to 10 percentage points higher than of other regions.

(2) The participation degree of three growth poles and their surrounding areas in the domestic value chain is relatively high.

From the calculation results, another significant feature of the space is that the three major growth poles – the Pearl River Delta, the Yangtze

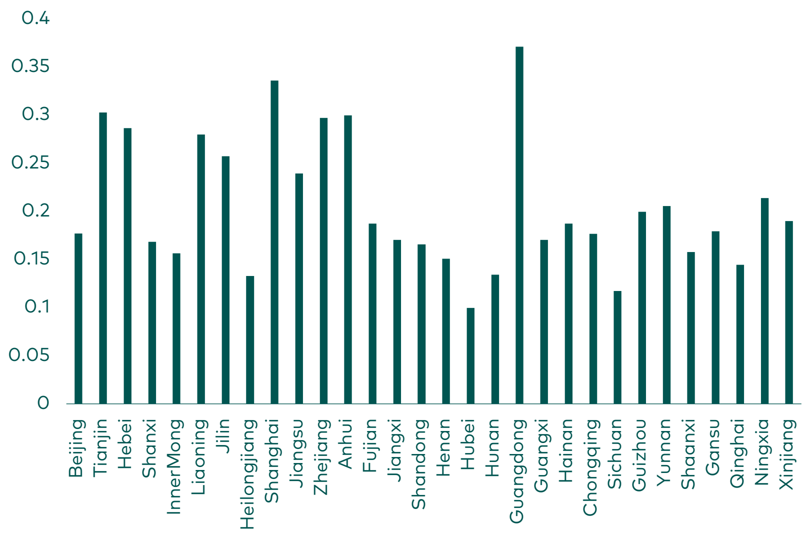

Fig. 6. Participation degree of each province in the domestic value chain.

River Delta and Beijing-Tianjin-Hebei and their surrounding areas in the domestic value chain have relatively high vertical specialization indices. The vertical specialization indices of Shanghai, Jiangsu, Zhejiang in Yangtze River Delta and its surrounding Anhui are relatively high. In particular, the vertical specialization index of Anhui has been basically the same with the Yangtze River Delta; the vertical specialization indices of the Pearl River Delta and its surrounding provinces, Guangxi, Jiangxi and other places are also relatively high. At the same time, the vertical specialization indices of Beijing-Tianjin-Hebei and its surrounding provinces in northern China are also relatively high, especially Tianjin and Hebei, reaching about 30 %. This phenomenon shows that the radiation and driving function of the three growth poles in the domestic economy has been revealed.

(3) The participation degree of the Northeast in the domestic value chain is also very high.

On the map, there is a more prominent area – Northeast China. Except Heilongjiang in Northeast China, the vertical specialization indices of Jilin and Liaoning in the domestic value chain are very high, reaching about 30 %.

This has a lot to do with its industrial structure. Northeast China is the old industrial base. Its equipment manufacturing industry has a higher proportion in the manufacturing industry, and the VS indices of these downstream industries are higher than the upstream industries. So, the overall VS of Northeast China is relatively high. This also explains why the vertical specialization index in Heilongjiang is not high, mainly because agriculture-related industries and oil-related industries own a higher proportion in Heilongjiang.

3.3 Comparison between GVC vertical specialization index and DVC vertical specialization index

By comparing *GVC* and *DVC*, it can be seen that the *DVC* value of each province is higher than that of the *GVC*, which indicates that the participation degree of each province in the domestic value chain is higher than in the global value chain. In order to more intuitively reflect the relationship between the global value chain and the domestic value chain, Fig. 7 shows the scatter plot and the fitting curve. It can be seen from the figure that China's domestic value chain and global value chain have a strong positive correlation, and the fitting degree is relatively high. However, different provinces also show different characteristics. Specifically, Guangdong, Shanghai and Tianjin have a relatively high participation degree both in the domestic value chain and the global value chain; Sichuan, Hunan, Inner Mongolia, Shanxi and other central and western regions have

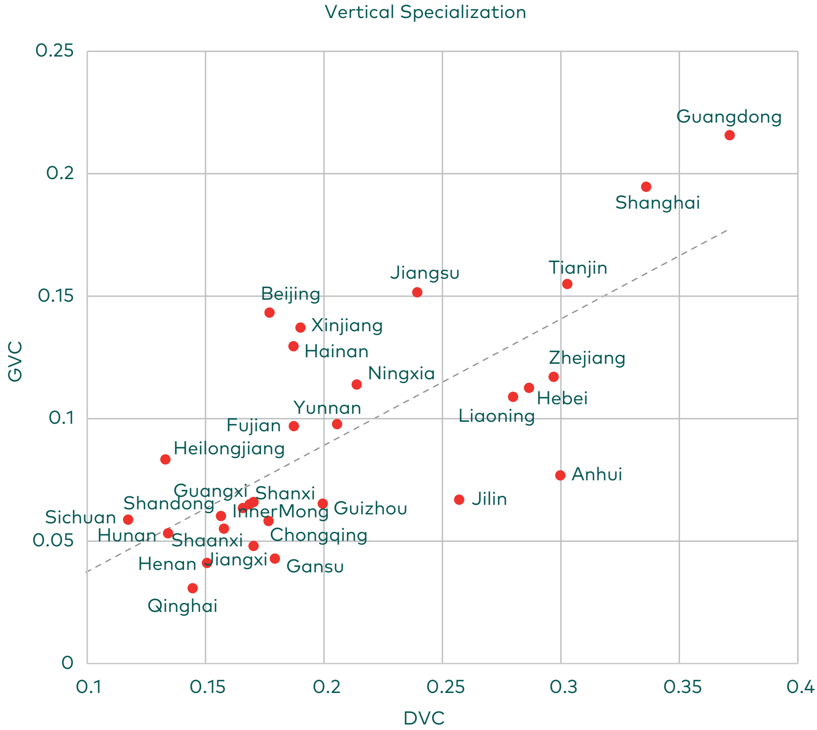

Fig. 7. Relationship between GVC and DVC.

relatively high participation both in the global value chain and the domestic value chain; and Beijing, Xinjiang, Hainan and Jiangsu have a relatively high participation degree in the global value chain but a low participation degree in the domestic value chain. Otherwise, Gansu, Anhui and Jilin have a relatively high participation degree in the domestic value chain but low participation degree in the global value chain.

3.4. The domestic and international comparison of vertical specialization index

In order to explore the possible law of value chain division of labor, we compare the vertical specialization index of domestic regions participating in the value chain and that of other countries and regions. Because there are no vertical specialization indices of different regions within a foreign country, we can only compare vertical specialization indices of domestic provinces participating in the global value chain and those of other countries or economies. Figure 8 shows the scatter plot of vertical

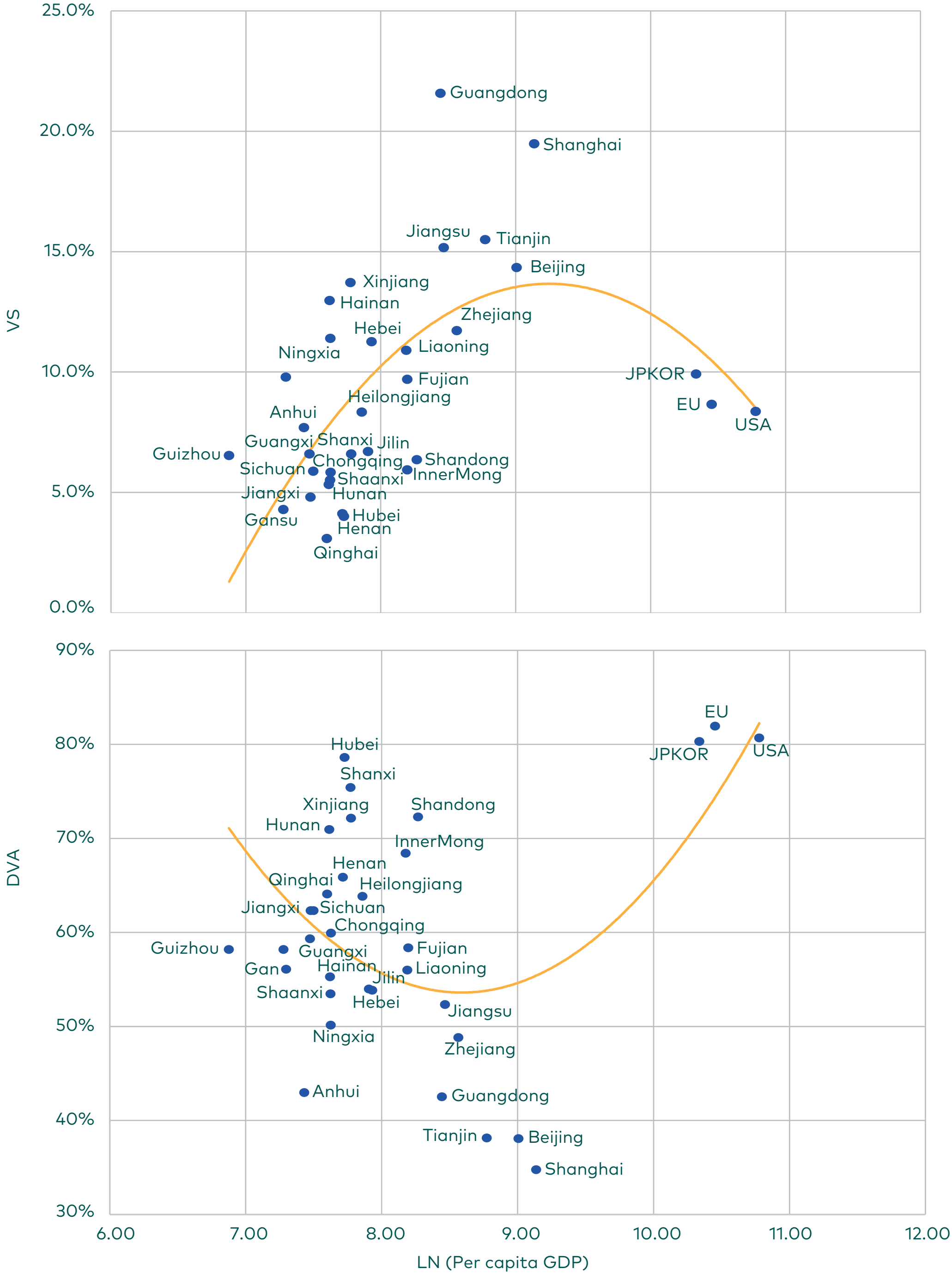

Fig. 8. Relationship between per capita GDP and VS/LVA index.

specialization indices of domestic provinces and the EU, Japan-South Korea and the United States participating in the global value chain and the level of development. By contrast, the following stylized facts can be observed.

(1) There is an "inverted U" type relationship between the vertical specialization index and the level of development.

The explanation for this phenomenon is that countries with low levels of economic development usually export agricultural products, minerals, and primary products that do not require too much processing and therefore do not require imports of intermediate inputs. Thus, its vertical specialization index is relatively low, but its exports own a high proportion of its value added. With the advancement of the industrialization process, the industry needs to be upgraded, and the economy needs to participate more and more in the global division of labor to better organize their own production activities and better play the role of economies of scale. Thus, with continuous improvement at the developmental level, the vertical specialization index in the global value chain is also rising. With the increasing capacity of division of labor in the industrial chain, it will gradually upgrade to the high-end value chain and high-end links of the value chain. Because these parts have strong monopoly characteristics and share more value in the value chain, the share of intermediate input in the cost shows a significant decline. Its industry value-added rate continues to increase, and thus the vertical specialization index begins to decline again.

(2) There is a positive correlation between the level of economic development of different regions in China and the vertical specialization index in the global value chain.

Comparing the vertical specialization indices of different provinces in the country participating in the global value chain, we find that the higher the participation degree in the global value chain, the higher is the level of economic development; and the lower the level of economic development, the lower is the vertical specialization index.

(3) The vertical specialization indices of many central and western provinces participating in the global value chain are significantly lower than the current level of developed countries.

As can be seen from the figure, the vertical specialization indices of many current central and western provinces to participate in the global value chain are significantly lower than the current level of developed countries. For these regions, there is significant room for improvement of the participation degree in the global division of labor, both compared to the developed countries and domestic developed regions.

(4) The vertical specialization indices of part of the eastern provinces participating in the global value chain have been far higher than those of the developed countries.

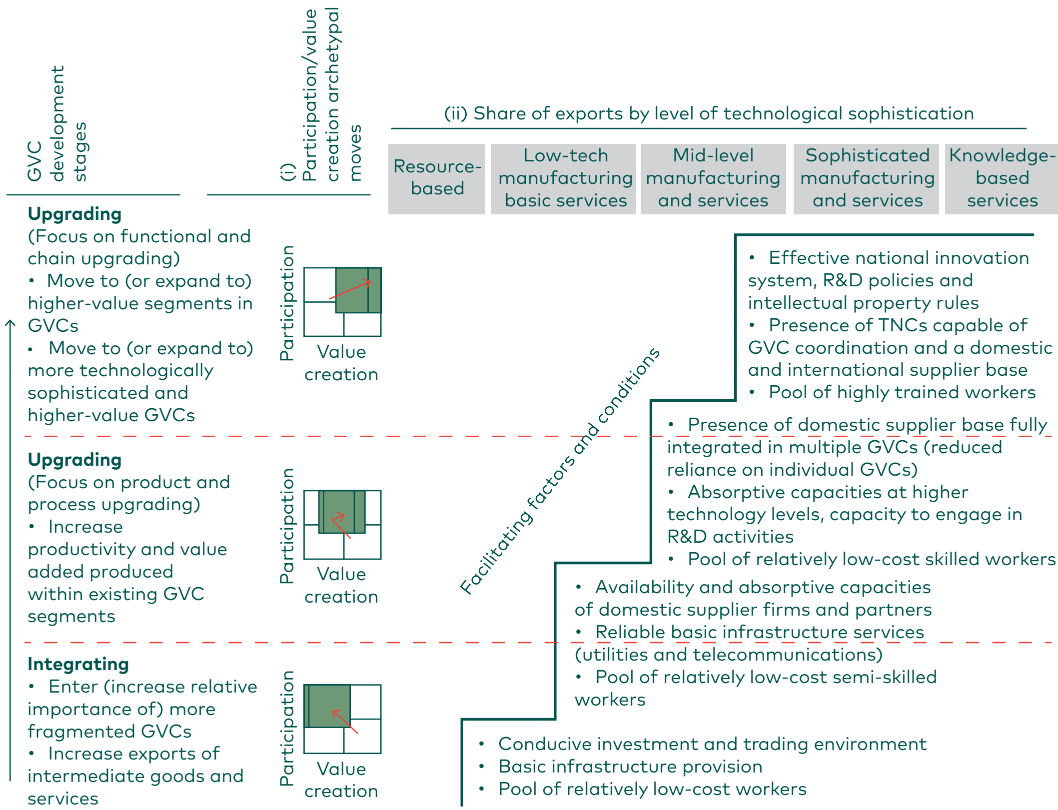

Fig. 9. Channels of value chain upgrading. (Source: UNCTAD analysis)

From the data shown in the figure, the vertical specialization indices of part of the eastern provinces have been much higher than of the EU, the United States, and Japan-South Korea. This, to some extent, indicates that these areas are different from the central and western provinces, and should transit towards the developed countries and increase the proportion of value added in the global value chain exports.

These stylized facts are consistent with the direction of the industry chain that the United Nations Conference on Trade and Development (UNCTAD) has raised for different levels of development (see Fig. 9). According to the study of UNCTAD (UNCTAD, 2013), for backward areas, its main task is to increase the participation degree in the value chain but not the proportion of value added. However, for areas with a relatively high participation degree, the main task is to upgrade the production process and work towards a more complex value chain.

Conclusions and implications

By constructing an international input-output model, which includes the domestic inter-provincial input-output model, and using methods of value-added trade calculation, this paper analyzes the status of different regions participating in the global value chain and domestic value chain. It summarizes the relevant stylized facts by comparing the domestic and international vertical specialization indices. According to these analyses, we get the following conclusions and inspirations.

(1) Since the reform and opening up, China's regional division of labor has formed a pattern similar to "dumbbell-shaped". In the process of participating in the global value chain, regional factor endowments and location conditions have led to a "dumbbell-shaped" docking model in which both the East and the West have a higher degree of participation. On the one hand, the eastern coastal areas develop foreign trade (especially processing trade) and import a large number of foreign intermediate inputs, and directly connect the domestic value chain to the global value chain. The vertical specialization indices of the eastern coastal areas participating in the global value chain are significantly higher than of the inland areas. On the other hand, the inland western regions own abundant energy and raw materials and provide these at low cost for the processing trade of the eastern regions.

(2) The radiation and driving function of three growth poles on the surrounding areas is very obvious. The spatial characteristics of the domestic value chain participation show that the degree of neighboring provinces of the Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin-Hebei participating in the domestic value chain is significantly higher than of other provinces. In the future, it is necessary to further enhance the inter-provincial connectivity, radiation, and driving function of the three growth poles.

(3) The relationship between vertical specialization index and the level of development is the "inverted U" type. Regions with relatively backward economic development are also less involved in *GVC*. With the vertical specialization index continually rising, its level of development is also continually rising. However, with the increasing level of development, the vertical specialization index shows a downward trend. The enlightenment of the evolution mechanism to China's regional economic development is that the less developed areas need to enhance participation

of the value chain. Additionally, those areas with a higher participation degree need to pay more attention to production technology and process upgrading, in hopes of upgrading to more complex value chain, rather than continuing to focus on the participation degree.

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CONSTRUCTION OF THE DYNAMIC INPUT-OUTPUT MODEL OF THE RUSSIAN ECONOMY WITH A HUMAN CAPITAL BLOCK

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Introduction

This paper provides a brief description of the extended dynamic input-output model with a human capital block, based on the input-output model from the KAMIN system (the System of Integrated Analyses of Interindustrial Information) developed at the Institute of Economics and Industrial Engineering of the Siberian Branch of the Academy of Sciences of the Russian Federation and at the Novosibirsk State University. The paper also presents some calculations and analysis of the derived results. The obtained results are the base for future calculations with the extended dynamic input-output model to forecast the Russian economy's economic development more efficiently.

1. The model used

The basic DIOM (the dynamic input-output model), which was extended by including a human capital block, was first described by Pavlov & Baranov (1994). Later it has been developed in several directions including a version of the model with fuzzy parameters (Baranov, Pavlov, & Pavlov, 2009). Full description of the extended model is presented in (Baranov, Pavlov, & Slepenkova, 2017).

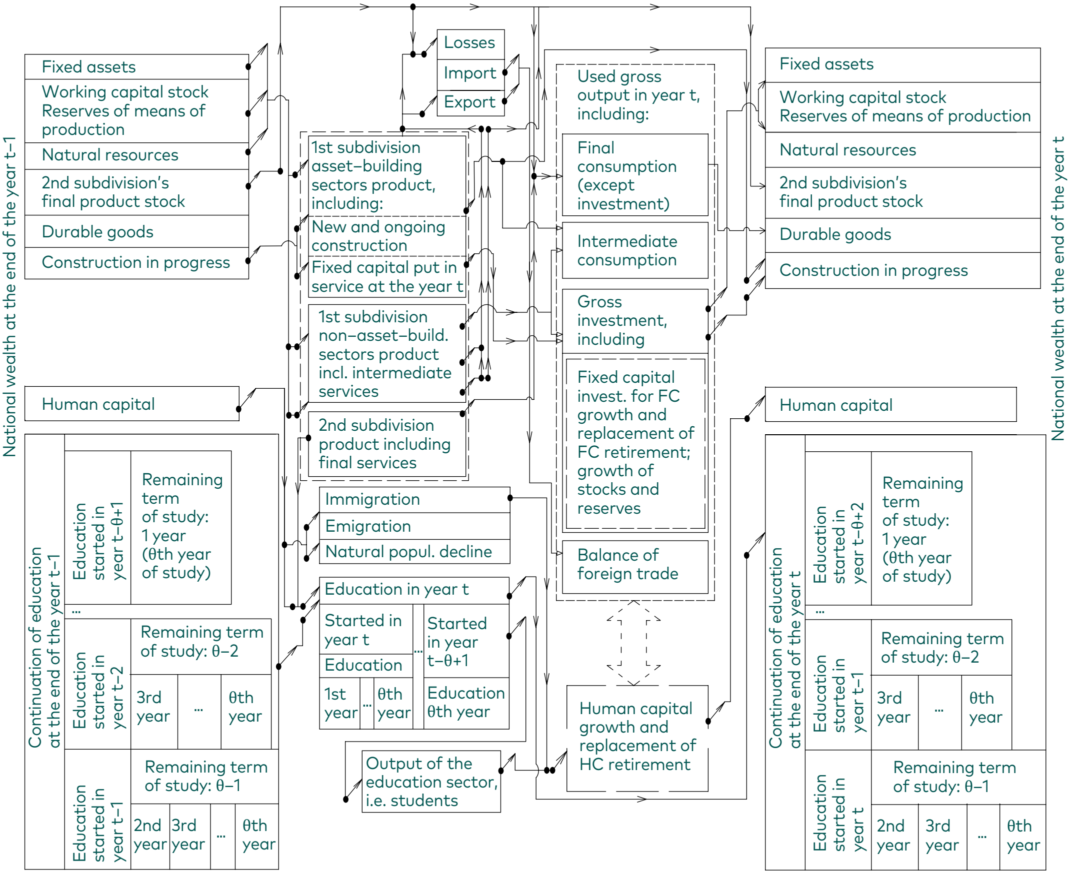

Fig. 1. National wealth reproduction.

The model is based on the theoretical scheme of the national wealth formation taking into account the reproduction of human capital. The scheme (Fig. 1) is developed by the authors in (Baranov, Pavlov, & Slepenkova, 2017).

The model includes n sectors. Among them $1 \le j \le k$ can be defined as asset-building sectors, $k < j \le (\tilde{\imath} + k)$ as sectors, which produce human capital, $(\tilde{\imath} + k) < j \le m$ as non-asset-building sectors in the first subdivision, and $m < j \le n$ as non-asset-building sectors in the second subdivision.

The extended model uses the following parameters:

m – the number of sectors in the first subdivision ($m < n$);

k – the number of asset-building sectors;

$\tilde{\imath}$ – the number of human capital investment types;

T – years of the forecast period.

Along with the parameters of the basic model, the extended DIOM requires the following parameters:

$h_{ij}(t)$ – human capital-output ratio, with human capital of type i (according to the investment type) and total output in sector j;

$\tilde{\theta}_{ij}$ – lag of type i human capital formation in sector j;

τ_{ij} – a year within the education or medical treatment process of human capital in sector j, so that $0 \leq \tau \leq \tilde{\theta}_{ij}$;

$\tilde{k}_{ij}(t)$ – replacement rate of human capital of type i in sector j at time t;

$BH_{ij}(t)$ – output of the education sector, i.e. students with i level of education who get a job at time t. They are included in new human capital of type i in sector j;

$H_{ij}(t,t + \tau)$ – human capital investment (of type i in sector j at time t) into the output of students for time $t + \tau$;

$H_{ij}(t)$ – human capital investment of type i in sector j at time t;

$HC_{ij}(t)$ – amount of human capital of type i in sector j by the end of time period t;

$NH_{ij}(t)$ – human capital (of type i in sector j) remaining in the education process (including "cultural education" and receiving medical services) by the end of time period t.

The basic model is extended with the additional equations that allow modeling human capital reproduction.

Output of students with i level of education is $BH_{ij}(t)$ determined by the human capital investment of type i in sector j:

$$BH_{ij}(t) = \sum_{\tau=0}^{\tilde{\theta}_{ij}-1} H_{ij}(t-\tau,\boldsymbol{t}) = \sum_{\tau=0}^{\tilde{\theta}_{ij}-1} \tilde{\eta}_{ij}(\tau) \cdot H_{ij}(t-\tau),$$

$$i = k+1, \dots, \tilde{l}; j = 1, \dots, n \tag{1}$$

where $H_{ij}(t - \tau,t)$ is a total amount of human capital investment of type i deposited in $t - \tau$ time period and provided for type i human capital at time t in sector j; $\tilde{\eta}$ is the share of the previous years $(t - \tau)$ investment in operation of the human capital of the same type in sector j in t time period with the following conditions:

$\tilde{\eta}_{ij} \in [0,1]$ for any τ;

$$\sum_{\tau=0}^{\tilde{\theta}_{ij}-1} \tilde{\eta}_{ij}(\tau) = 1.$$

$H_{ij}(t - \tau)$ is human capital investment deposited in $t - \tau$ time period and $\tau \geq 0$, as it allows to take into account some short educational programs (less than a year, e. g. qualification courses) and a shorter investment lag in case of medical treatment.

The necessary amount of human capital investment for human capital output in $t + \tau$ time period is defined as follows:

$$H_{ij}(t, \boldsymbol{t} + \boldsymbol{\tau}) = \sum_{\tau=0}^{\tilde{\theta}_{ij}-1} \tilde{\mu}_{ij}(\tau) \cdot BH_{ij}(t+\tau),$$
$$i = k+1, \dots, \tilde{l}; \;\; j = 1, \dots, n \qquad (2)$$

where t is a year of investment and $(t + \tau)$ is a year of students output, as well as “output” of people who underwent a course of medical treatment and can return to work, i.e. $(t + \tau)$ is a year of human capital output.

$\tilde{\mu}_{ij}(\tau)$ stands for a ratio showing a share of human capital output in sector j in time period $(t + \tau)$ formed due to investment of type i in time period t so that

$\tilde{\mu}_{ij}(\tau) \in [0,1]$ for any τ;

$$\sum_{\tau=0}^{\tilde{\theta}_{ij}-1} \tilde{\mu}_{ij}(\tau) = 1.$$

Construction-in-progress human capital of type i in sector j (i. e. people remaining in the education process or medical treatment process) $NH_{ij}(t)$ can be calculated as follows:

$$NH_{ij}(t) = NH_{ij}(t-1) - \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} H_{ij}(t-\tau, \boldsymbol{t}) + \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} H_{ij}(t, \boldsymbol{t}+\boldsymbol{\tau})$$
$$= NH_{ij}(t-1) - \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} \tilde{\eta}_{ij}(\tau) H_{ij}(t-\tau) +$$
$$+ \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} \tilde{\mu}_{ij}(\tau) BH_{ij}(t+\tau), \quad i = k+1, \dots, \tilde{l}; \; j = 1, \dots, n \qquad (3)$$

The total amount of human capital of type i in sector j by the end of time period t is determined as follows:

$$HC_{ij}(t) = BH_{ij}(t) + HC_i(t-1)\left(1 - \tilde{k}_{ij}(t)\right),$$
$$i = k+1, \dots, \tilde{l}; \;\; j = 1, \dots, n \qquad (4)$$

Labor resources limits are defined by the system of inequalities:

$$\sum_{j=1}^{n} c_{kj}(t) x_j(t) \le L_k(t), \qquad k = 1, \dots, l; \;\; j = 1, \dots, n \qquad (5)$$

where $c_{kj}(t) = G(HC_{ij}(t))$ depends on the size of the human capital, $c_{kj}(t)$ is the labor intensiveness ratio of sector j for type k of labor resources in time period t.

Along with the basic constraints and equations described above, an additional constraint for human capital should be added:

$$\sum_{j=1}^{n} h_{ij}(t)x_j(t) \leq HC_i(t)\,, \qquad i = k+1, \dots, \tilde{l};\; j = 1, \dots, n \tag{6}$$

where $x_j(t)$ is the domestic output in sector j at time t.

The same way as in the basic model, Ω defines a trajectory of the economic system development $x_j(t)$ under all basic constraints of the model as well as human capital restrictions in (1)–(5) described above. Defining the trajectory Ω with given parameters (e. g. amount of human capital, human capital-output ratio, etc.) for each moment from the [1; T] time period allows to get the system of economic development parameters (output, human capital investment, human capital output, etc.).

The optimization problem can be described as follows:

$$\sum_{t=1}^{T}\sum_{j=1}^{n} f_j(t)\,x_j(t) \Rightarrow max, \qquad x \in \Omega$$

with constraints described above and $f_j(t)$, which stands for weight coefficients of the production in sector j in the target function of the economic system.

2. Calculations and results

It is necessary to prepare and calculate some data including human capital investment, output of human capital in value terms, amount of human capital, and others for use in the extended model.

Human capital (HC) investment in value terms is treated as a sum of government and private expenditures on education, healthcare and culture.

Government and private expenses used for calculations were taken from the Federal State Statistics Service (www.gks.ru), Ministry of Finance of the Russian Federation (Brief information on execution of the consolidated budget of the Russian Federation), and The Federal Treasury (the information on execution of budgets of budgetary system of the Russian Federation) databases. The analyzed time period is from 1992 to 2015. As the data are given in current values, we used a price

Table 1

Human Capital Investment (Prices of 2015), bln. Rubles

Year	Education expenses		Healthcare expenses		Culture expenses		HC investment
	Government	Private	Government	Private	Government	Private	
1992	11 722.8	177.7	3 467.2	243.6	1306.3	121.6	17039.2
1993	4 950.4	106.3	1 514.4	104.1	452.9	42.8	7170.9
1994	2 945.9	92.6	1 398.1	145.9	366.5	42.2	4991.1
1995	1 983.1	97.0	1 130.9	191.9	420.7	54.8	3878.3
1996	1 954.6	140.5	1 128.6	218.8	383.7	71.2	3897.4
1997	2 143.6	221.0	1 280.5	270.1	432.6	93.8	4441.6
1998	1 604.6	275.8	875.9	280.5	243.5	70.8	3351.0
1999	1 772.5	339.9	998.2	318.2	288.2	82.3	3799.3
2000	1 928.4	373.0	1 201.5	341.4	356.5	88.0	4288.7
2001	1 822.6	367.4	1 159.8	362.8	311.9	101.6	4126.0
2002	1 972.5	351.1	1 241.1	375.8	336.5	111.4	4388.,5
2003	1 874.2	376.1	1 192.5	386.3	341.0	137.5	4307.5
2004	1 986.2	408.7	1 290.2	426.6	335.1	154.0	4600.8
2005	2 217.8	422.3	2 339.4	462.8	448.1	155.1	6045.5
2006	2 518.0	468.2	2 486.0	493.1	475.3	157.1	6597.7
2007	2 878.9	518.0	3 133.9	513.5	541.9	129.0	7715.1
2008	3 077.3	531.8	3 015.9	523.5	591.8	126.9	7867.4
2009	2 955.1	514.0	2 830.6	519.3	555.4	129.2	7503.6
2010	2 903.9	500.0	2 699.5	527.1	557.2	129.2	7316,9
2011	3 147.6	489.9	3 010.2	547.7	574.9	126.8	7897.1
2012	3 363.4	498.2	3 266.4	583.7	593.5	128.3	8433.5
2013	3 516.1	546.8	3 078.2	659.2	582.9	138.3	8521.5
2014	3 347.1	536.2	3 095.6	689.2	565.3	137.8	8371.3
2015	3 034.6	539.7	3 115.9	701.1	521.3	138.9	8051.5

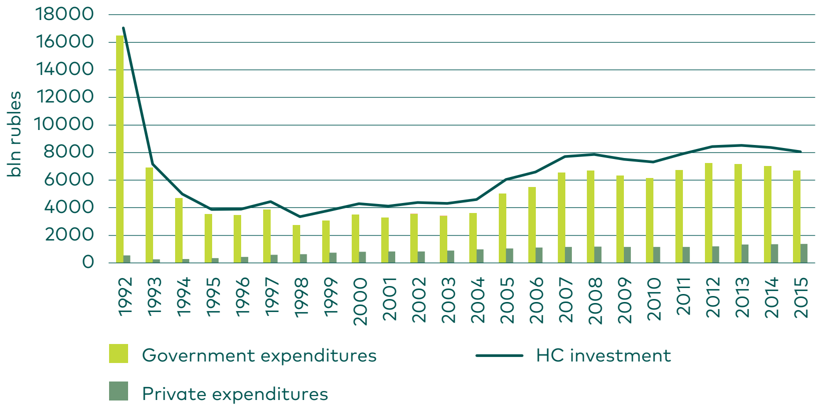

Fig. 2. Human capital investment (prices of 2015), bln rubles.

index for services, a price index for paid services of cultural institutions, and a price index for healthcare services to get the investment in constant prices.

Table 1 shows human capital investment by type in constant prices. The share of government expenditures on culture were stable enough and averaged 9 % of total government expenditure. Government expenditure on education and healthcare showed a similar trend up to 2005. From 1992 to 2005, the share of government healthcare expenses averaged 55 % of government education expenses, but in 2005 the amount of healthcare expenses became almost the same as the amount of government expenditures on education.

Figure 2 describes the dynamics of human capital investment, including the government and private components. The share of private expenses in the total amount of expenditures averaged 15 %. The maximum share runs up to 22 % in 2004. From 1992 to 1995 human capital investment fell dramatically, mostly because of the serious shrinkage in government expenditures on HC. Despite the upward trend after 1995 and significant economic and technological development, more than 20 years later the top level of investment, 17 trillion ruble in constant prices, has not been reached.

As Fig. 3 shows, there was a significant decrease of private expenses from 1992 to 1993 that is likely the result of the crisis in the 1990s in the Russian economy. However, afterwards, the steady positive trajectory in private investment in HC can be seen. The greatest increase takes place in healthcare investment: from 1993 to 2015 it increased 6.7 times. Education expenses increased 5 times and culture expenses increased more than 3 times.

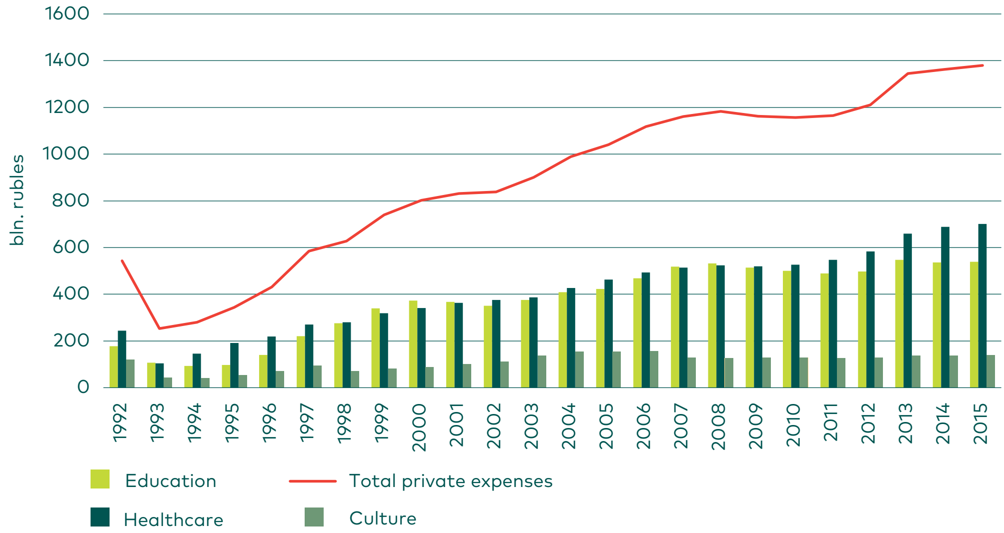

Fig. 3. Private human capital expenses (prices of 2015), bln rubles.

To calculate the output of human capital in value terms, we can either use the DIOM extended by the authors (using the equations described above), or calculate average costs of output per capita and multiply the result by the output of students.

It is not hard to calculate the output in the education sector, but it is difficult to define output for the healthcare sector, because even a minor ailment, which requires medical treatment, can seriously influence the labor productivity level. It significantly influences the medical treatment time as well, hence the HC investment lags in the healthcare sector can vary a lot.

The culture sector is also tricky, as one cannot measure the exact influence of cultural development on people, though it definitely influences their mentality and therefore labor productivity. In addition, lags in the culture sector can be enormous; the cultural development effects can be accumulated by decades. However, we can definitely consider that healthcare and culture expenditures do influence the output of the education sector, as it provides the socio-cultural environment for the education process.

To calculate the output of students in value terms, the 4-year lag was defined. It was chosen mostly because of the 4-year bachelor's degree programs, as the output mostly consists of the bachelors graduated. The average expenses for one student (h_t) are defined as follows:

$$h_t = \frac{\sum_{\tau=t-\tilde{\theta}+1}^{t} H(\tau) \big/ t}{\sum_{\tau=t-\tilde{\theta}+1}^{t} BB^H(\tau) \big/ t} = \frac{\sum_{\tau=t-\tilde{\theta}+1}^{t} H(\tau)}{\sum_{\tau=t-\tilde{\theta}+1}^{t} BB^H(\tau)} \quad (7)$$

where $H(\tau)$ is human capital investment in year t in billlion rubles, and $BB^H(\tau)$ is the output of students (number of persons, in thousands). HC investment includes education, healthcare and culture expenses; output of students includes graduates with vocational and higher education. The way we calculate the average expenses for one student allows us to take into account the previous years' investments, which influence the final students' output.

To calculate students' output in value terms it is necessary to multiply the average expenses by the number of graduates:

$$BH(t) = h_t \cdot BB^H(t) \quad (8)$$

where $BH(t)$ is the output of human capital in value terms, $BB^H(t)$ is the number of students, and h_t are the average expenses for one graduate.

The results are presented in Table 2.

To calculate the accumulated human capital amount, we are using the perpetual inventory method. Human capital by the end of the year t ($HC(t)$) is defined as follows:

$$HC(t) = BH(t) + HC(t-1)(1-\tilde{k}) \quad (9)$$

where $\tilde{k}$ is a replacement rate of human capital. The average time of work of a person is defined as 30 years, which gives a replacement rate of 3 %. The first year human capital amount is calculated as follows:

$$HC(1) = BH(1)\frac{1+g_{BH}}{g_{HC}+\tilde{k}} \quad (10)$$

where g_{HC} is the growth rate of the volume of human capital, and g_{BH} is the growth rate of human capital output. We assume the growth rate of human capital volume to be the same as the growth rate of human capital investment. We also use the average growth rate to make the calculations presented in Table 3 and Fig. 4.

It can be seen that from 1996 to 2015 HC investment doubled, HC output increased 1.7 times, but the total amount of accumulated human capital raised no more than 1.4 times. While the growth rate of HC output averaged 3 %, the growth rate of human capital amount is 1.7 %. The output does not cover HC retirement efficiently, that means we need more HC investment to increase the accumulation of human capital, as it is an important factor of economic growth and development.

To show the influence of HC on productivity level, the regression equation was estimated with an index of labor productivity growth (*Productiv*) as a dependent variable and an increase in investment in human capital (*Inv_HC*) and its first lag (*HC1*) as explanatory variables:

Table 2

Output of Human Capital in Value Terms (Prices of 2015)

Year	Output of students, number of persons, in thousands	Human capital investment (education, healthcare and culture), bln. rubles	Average expenses for one graduate (education, healthcare and culture), thousand rubles	Output of human capital, bln. rubles
1992	1 932.60	17 039.23		
1993	1 869.10	7 170.89		
1994	1 819.50	4 991.15		
1995	1 717.80	3 878.34	4 507.37	7 742.77
1996	1 745.90	3 897.42	2 787.61	4 866.88
1997	1 799.50	4 441.61	2 429.66	4 372.17
1998	1 834.60	3 350.96	2 193.40	4 024.02
1999	1 894.10	3 799.33	2 129.38	4 033.26
2000	1 977.20	4 288.73	2 115.89	4 183.55
2001	2 087.40	4 126.04	1 997.24	4 169.03
2002	2 255.40	4 388.46	2 021.23	4 558.67
2003	2 399.25	4 307.48	1 962.41	4 708.30
2004	2 487.30	4 600.79	1 887.76	4 695.42
2005	2 538.60	6 045.51	1 998.05	5 072.25
2006	2 634.20	6 597.65	2 142.43	5 643.58
2007	2 690.00	7 715.09	2 411.48	6 486.88
2008	2 634.30	7 867.37	2 688.90	7 083.36
2009	2 610.80	7 503.61	2 808.48	7 332.39
2010	2 620.50	7 316.88	2 880.27	7 547.74
2011	2 477.60	7 897.14	2 957.01	7 326.30
2012	2 367.00	8 433.50	3 091.65	7 317.93
2013	2 166.00	8 521.50	3 340.12	7 234.70
2014	2 080.20	8 371.26	3 654.62	7 602.33
2015	2 114.50	8 051.46	3 824.34	8 086.57

Table 3

Accumulated Human Capital Calculation

Year	Human capital investment, bln. rubles	Output of human capital, bln. rubles	Growth rate of human capital investment	Growth rate of human capital output	Human capital, bln. rubles	Growth rate of human capital
Average	5 980.96	5 817.27	0.015	0.03		0.017
1993	7 170.89		–0.58			
1994	4 991.15		–0.30			
1995	3 878.34		–0.22			
1996	3 897.42	4 866.88	0.00		103 108.92	
1997	4 441.61	4 372.17	0.14	–0.10	104 044.12	0.01
1998	3 350.96	4 024.02	–0.25	–0.08	104 600.00	0.01
1999	3 799.33	4 033.26	0.13	0.00	105 146.59	0.01
2000	4 288.73	4 183.55	0.13	0.04	105 825.25	0.01
2001	4 126.04	4 169.03	–0.04	–0.00	106 466.77	0.01
2002	4 388.46	4 558.67	0.06	0.09	107 476.56	0.01
2003	4 307.48	4 708.30	–0.02	0.03	108 602.31	0.01
2004	4 600.79	4 695.42	0.07	–0.00	109 677.65	0.01
2005	6 045.51	5 072.25	0.31	0.08	111 093.98	0.01
2006	6 597.65	5 643.58	0.09	0.11	113 034.43	0.02
2007	7 715.09	6 486.88	0.17	0.15	115 753.49	0.02
2008	7 867.37	7 083.36	0.02	0.09	118 978.40	0.03
2009	7 503.61	7 332.39	–0.05	0.04	122 344.85	0.03
2010	7 316.88	7 547.74	–0.02	0.03	125 814.43	0.03
2011	7 897.14	7 326.30	0.08	–0.03	128 946.91	0.02
2012	8 433.50	7 317.93	0.07	–0.00	131 966.61	0.02
2013	8 521.50	7 234.70	0.01	–0.01	134 802.42	0.02
2014	8 371.26	7 602.33	–0.02	0.05	137 911.34	0.02
2015	8 051.46	8 086.57	–0.04	0.06	141 400.87	0.03

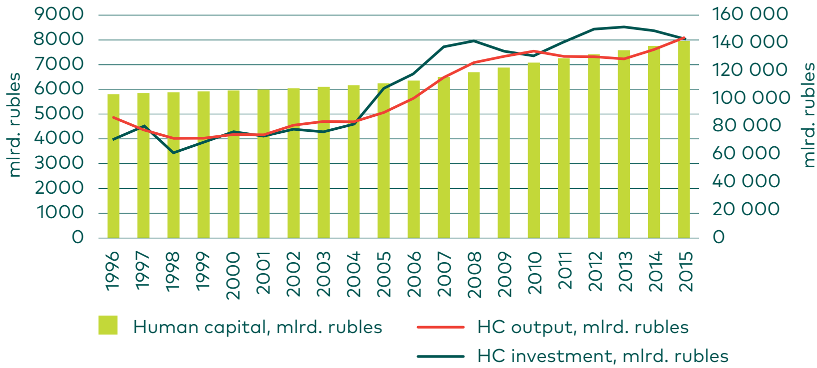

Fig. 4. Human capital, mlrd rubles.

Table 4

Labor Productivity and Human Capital Investment

Year	Index of labor productivity growth	Growth rate of human capital investment
1993	–7.2564	–57.9154
1994	–10.1449	–30.3971
1995	–13.8484	–22.2956
1996	–2.9369	0.4918
1997	3.3510	13.9630
1998	–3.8438	–24.5554
1999	5.6358	13.3803
2000	9.3587	12.8814
2001	4.3424	–3.7936
2002	3.7953	6.3603
2003	6.5248	–1.8453
2004	6.4855	6.8092
2005	5.7639	31.4016
2006	7.5377	9.1331
2007	7.1865	16.9370
2008	4.5495	1.9737
2009	–6.2736	–4.6237
2010	4.1352	–2.4885
2011	10.9756	7.9304
2012	3.1497	6.7918
2013	1.3512	1.0435
2014	4.0702	–1.7631
2015	–3.6904	–3.8202

$$Productiv = c0 + c1 \cdot Inv\_HC + c2 \cdot HC1. \quad (11)$$

Other lags were not significant at the 5 % level. The data used are presented in Table 4.

The results of estimation of the regression equation showed that all of the explanatory factors are significant. Some tests of the model had proved the significance of the model as well. The estimated equation is shown as follows:

$$Productiv = 2.1 + 0.22 \cdot Inv\_HC + 0.13 \cdot HC1. \quad (12)$$

It indicates the direct interdependence of labor productivity level and human capital investment.

Conclusions

Some of the calculations made show an important influence of human capital and human capital investment on economic growth and development. At the same time, the calculations are showing some problems we have, including lack of necessary investment and slow growth rates of important economic activities. Our future research and calculations with the extended dynamic input-output model will give more detailed information, including inter-industry information of human capital reproduction. Finally, all the information will be included in the model to forecast Russian economic development and to estimate necessary levels of investment and human capital to reach the target growth rate of the economy.

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MACROECONOMIC IMPACT OF NUCLEAR POWER PLANT PROJECTS

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Introduction

The article describes the main approaches to assessing multiplier effects from implementation of major international projects. A conventional example considers the distribution of effects between the supplying country and receiving country.

Macroeconomic models have gained widespread acceptance in estimating multipliers for the whole economy in general (Beetsma, 2008; Christiano, 2011). Methods based on the input-output approach are typically applied for estimating effects at the industry level. Among these calculations, it is possible to distinguish three main types, which are as follows:

(1) calculations within general equilibrium models with integrated input-output tables (Burfisher, 2017);
(2) calculations within a static input-output model (Miller, 2009);
(3) calculations within a modified input-output model using econometric dependences for modeling the impact of additional income on total consumption (Ghosh, 2011; West, 1995).

1. Impact analysis of investment projects using an input-output model

The input-output model is one of the most convenient tools for determining multiplier effects from implementation of nuclear power plant (NPP) projects. Hereinafter the “multiplier effect” refers to an increase in one of the macroeconomic indicators (gross output, GDP, budget revenues, etc.) caused by the extension of the initial increase in the output in one of the sectors over the inter-industry relationships[23].

This study deals with the following three types of multiplier effects:

- the output multiplier effect (caused by increase in operating expenses);
- the investment multiplier effect (caused by increase in capital expenditures);
- the value added multiplier effect (caused by increase in value added).

1.1. The methodology of the output multiplier effect assessment

We should first consider the multiplier effect of increasing operating expenses, which is caused by the initial increase in output.[24] To describe the mechanism of this effect formation, an iterative logic can be used. First of all, the increase in the output of industry k predetermines an increase in its operating expenses (other things being equal), which causes an increase in output of the related industries that provide industry k with production resources. Further, the increase in output of the supplying industries results in additional demand for the necessary intermediate consumption resources from these industries. This demand is satisfied by an output increase in the related industries, which causes an increase in intermediate demand and gross output at the following iterations.

The process of the multiplier effect formation can be formalized within the static input-output model. In the case of nonzero imports, the equation of the Leontief static model appears as follows:

$$\vec{X} = (I - A^*)^{-1} \cdot \vec{Y}^* \tag{1}$$

where $\vec{X}$ is a vector of output by industries; $\vec{Y}^*$ is a vector of final demand for domestic products; I is an identity matrix; A^* is an adjusted technical coefficient matrix in which imports were excluded from intermediate consumption as follows:

$$A^* = \begin{pmatrix} a_{11} \cdot (1 - imp_{11}) & a_{12} \cdot (1 - imp_{12}) & \dots & a_{1n} \cdot (1 - imp_{1n}) \\ a_{21} \cdot (1 - imp_{21}) & a_{22} \cdot (1 - imp_{22}) & \dots & a_{2n} \cdot (1 - imp_{2n}) \\ \dots & \dots & \dots & \dots \\ a_{n1} \cdot (1 - imp_{n1}) & a_{n2} \cdot (1 - imp_{n2}) & \dots & a_{nn} \cdot (1 - imp_{nn}) \end{pmatrix}; \tag{2}$$

$$a_{ij} = {}^{X_{ij}}\!/_{X_j}, \tag{3}$$

[23] It is necessary to distinguish the initial output increase in the industry from the resulting gross output increase that includes indirect effects.

[24] In general, this multiplier effect can occur not only because of an output increase, but as a result of a decrease in any industry's material intensity (in other words, due to an increase in its intermediate consumption).

where imp_{ij} is an import share in the intermediate consumption by industry j of industry i products (in flow X_{ij}); and X_j is the output of industry j.

Under the assumption that technical coefficients do not change, and the initial increase in output is caused by an increase in final demand (e.g. by an increase in exports), the resulting increase in output can be estimated as follows:

$$\Delta\vec{X} = (I - A^*)^{-1} \cdot \Delta Y^* = (I - A^*)^{-1} \cdot \Delta\vec{X}^0 = \left(E - A\right)^{-1} \cdot \begin{pmatrix} 0 \\ 0 \\ \dots \\ \Delta X_k^0 \\ \dots \\ 0 \end{pmatrix} = \begin{pmatrix} b_{1k} \cdot \Delta X_k^0 \\ b_{2k} \cdot \Delta X_k^0 \\ \dots \\ b_{kk} \cdot \Delta X_k^0 \\ \dots \\ b_{nk} \cdot \Delta X_k^0 \end{pmatrix} \tag{4}$$

where ΔX^0 is a vector of initial increase in output (assuming that the entire increase is concentrated in industry k); ΔX_k^0 is the initial output increase in industry k; and b_{ik} are column components of the matrix $B^* = \left(E - A^*\right)^{-1}$.

In this case the output multiplier for industry k can be calculated as a sum of the k-th column components of matrix B^*:

$$\mu_k^{prod} = \frac{\Delta X}{\Delta X_k^0} = \frac{\sum_{i=1}^{n}\left(b_{ik}^* \cdot \Delta X_k^0\right)}{\Delta X_k^0} = \sum_{i=1}^{n} b_{ik}^* . \tag{5}$$

In addition, a few important observations should be made.

First, the use of an iterative logic for the description of the output multiplier effect formation does not mean that this effect is a long-drawn-out process. An increase in the output (i.e. an output multiplier effect) can occur only if provided with all the necessary resources. In fact, this means that stocks (formed by *pre*-production in supplying industries or imports) are used. This remark is valid not only with respect to material resources, but also with respect to other inputs (under-utilized facilities, labor). Subsequently, for the initial impulse to be transferred to the next iterations, the stocks are to be recharged by means of additional production and/or imports. Otherwise (if stocks are maintained at a new, lower level), the main part of the multiplier effect is essentially “left” in retrospect, whereas in the reporting period the value of the estimated multiplier effect corresponds only to the initial impulse – the output increase in industry k. Hereinafter it is assumed that stocks are maintained at the same level (i.e. the hypothesis of zero change in stocks is accepted).

Secondly, we should emphasize the dual role of imports. On the one hand, imports that compete with domestic production can be considered as a factor, which reduces the multiplier effect value. On the other hand, complementary imports can fill the shortage of production resources required for an output increase to occur.

1.2. The methodology of the investment multiplier effect assessment

The investment multiplier effect (excluding the output increase effect caused by the creation and loading of new facilities) arises in the *construction phase* due to the increase in output of machinery industries (fund-creating industries). The increase in output of fund-creating industries results in increasing operating expenses of these industries and, consequently, the increase in output of industries that supply the required intermediate consumption resources. Further, the formation of this effect is similar to the one described above for the output multiplier effect.

Thus, an increase in gross output at the first iteration is the increase in output of fund-creating industries, which corresponds to the increase in final demand for *domestic investment products*. This increase in final demand can be determined through the structure of capital expenditures within the given project.

If the detailed information on capital expenditures in the given project is unavailable, the vector of increase in final demand for domestic products can be obtained using a matrix of the fixed capital formation technological structure *T*. Its columns are vectors that reflect the typical structure of capital expenditures within investment projects in various industries. In this case, the vector of increase in final demand both for domestic and imported investment products is defined as follows:

$$\Delta\vec{Y} = T \cdot \overrightarrow{inv} = \begin{pmatrix} t_{11} & t_{12} & \dots & t_{1k} & \dots & t_{1n} \\ t_{21} & t_{22} & \dots & t_{2k} & \dots & t_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ t_{k1} & t_{k2} & \dots & t_{kk} & \dots & t_{kn} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ t_{n1} & t_{n2} & \dots & t_{nk} & \dots & t_{nn} \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 0 \\ \dots \\ inv_k \\ \dots \\ 0 \end{pmatrix} = \begin{pmatrix} t_{1k} \cdot inv_k \\ t_{2k} \cdot inv_k \\ \dots \\ t_{kk} \cdot inv_k \\ \dots \\ t_{nk} \cdot inv_k \end{pmatrix} \quad (6)$$

where $\overrightarrow{inv}$ is a vector of investments by industries[25]; and t_{ik} is a share of industry *i* in capital expenditures of industry *k*.

[25] When considering the project, the investments are concentrated in the relevant industry. But it is also possible to consider several related investment projects in different industries. In this case, the vector of investments has several non-zero components.

The vector of the increase in final demand for domestic investment products is determined by multiplying the components of vector by the share of domestic production in the corresponding investment consumption flows:

$$\Delta\vec{X}^1 = \Delta\vec{Y}^* = \begin{pmatrix} t_{1k} \cdot inv_k \cdot (1 - imp_{T\,1}) \\ t_{2k} \cdot inv_k \cdot (1 - imp_{T\,2}) \\ \dots \\ t_{nk} \cdot inv_k \cdot (1 - imp_{T\,n}) \end{pmatrix}. \quad (7)$$

At the second iteration, the increase in gross output is caused by the increase in intermediate consumption in fund-creating industries.

$$\Delta\vec{X}^2 = A^* \cdot \Delta\vec{X}^1 = A^* \cdot \Delta Y^*. \quad (8)$$

The output increases at the following iterations are determined by analogy with the previously considered output multiplier effect. By results of all iterations, the increase in gross output is expressed as follows:

$$\Delta\vec{X} = \Delta\vec{X}^1 + \Delta\vec{X}^2 + \Delta\vec{X}^3 + \dots = (E + A^* + (A^*)^2 + \dots) \cdot \Delta Y^* = \\ = (E - A^*)^{-1} \cdot \Delta Y^*; \quad (9)$$

$$\Delta\vec{X} = (E - A^*)^{-1} \cdot \begin{pmatrix} t_{1k} \cdot inv_k \cdot (1 - imp_{T\,1}) \\ t_{2k} \cdot inv_k \cdot (1 - imp_{T\,2}) \\ \dots \\ t_{nk} \cdot inv_k \cdot (1 - imp_{T\,n}) \end{pmatrix} =$$

$$= \begin{pmatrix} \sum_{j=1}^{n} [b^*_{1j} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \\ \sum_{j=1}^{n} [b^*_{2j} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \\ \dots \\ \sum_{j=1}^{n} [b^*_{nj} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \end{pmatrix}. \quad (10)$$

It is easy to see that the investment multiplier of industry *k*, which shows how much gross output increases due to capital expenditures in industry *k*, is calculated as a sum of the output multipliers of various industries weighted by the capital expenditures structure within the given project (excluding consumption of imported investment products):

$$\mu_k^{инв} = \frac{\Delta X}{inv_k} = \sum_{j=1}^{n} \left(\mu_j^{prod} \cdot t_{jk} \left(1 - imp_{T\,j}\right) \right) = \sum_{j=1}^{n} \left(\left(\sum_{i=1}^{n} b^*_{ij} \right) t_{jk} \left(1 - imp_{T\,j}\right) \right). \quad (11)$$

The investment multiplier formula underlines the fact that the mechanisms of formation of the output multiplier effect and the investment multiplier effect are similar. The only difference is that in the case of the output multiplier the initial impulse is an increase in the output of any industry, whereas in the case of the investment multiplier the initial impulse is an increase in the output of fund-creating industries (weighted by the capital expenditures structure within the given project). Therefore, the impact on the investment multiplier estimates of such indicators as intermediate demand coefficients or shares of imports is similar to their impact on the output multiplier estimates.

1.3. The methodology of the value added multiplier effect assessment

This effect is formed in the case of additional income for various subjects of the economy (households, government, business) and further increase in spending. This additional final demand predetermines production expansion across a wide range of industries of the national economy. It leads to an increase in operating expenses, which generates the indirect effects described above.

The approach to assess the income multiplier effect uses methodology similar to the one described for the investment multiplier effect. There are two stages of calculations. In the first stage, we should assess the increase in final demand for domestic products due to additional income in the economy (using average ratios between value added and output for different industries, average shares of wages and taxes in value added for different industries, average income elasticities of final consumption by households, by government and by companies). In the second stage, we can use the equation $\Delta\vec{X} = (E - A^*)^{-1} \cdot \Delta Y^*$ to determine the resulting increase in gross output.

We should note that this gross output increase should once again lead to an increase in value added. This additional income can also be spent, which will create another income multiplier effect (at the second iteration of spending). Whether it is appropriate to take into account the effects that arise in the next iterations is a rather complicated question. The fact is that each new iteration of spending implies a management decision to invest or to consume more. In other words, each new iteration is a consequence of the income multiplier effect at the previous iteration. Since an iteration takes a certain amount of time to pass through, only a few iterations occur in a year. In addition, each subsequent income multiplier effect turns out to be smaller than the previous one because the amount of additional value added decreases with a new iteration (since the ratio of value added to output is less than 100 %). Thus, accounting for the first few iterations allows to estimate the resulting gross output increase quite accurately.

The income (value added) multiplier of industry *k* shows how much gross output increases (at the first iteration of spending) due to the increase in value added in industry *k*. It can be determined by analogy with the investment multiplier – as a sum of output multipliers of various industries weighted by the structure of the increase in final demand for domestic products:

$$\mu_k^{\partial c} = \frac{\Delta X}{\Delta va_k^0} = \sum_{j=1}^{n}\left(\mu_j^{prod}\delta_j\right) = \sum_{j=1}^{n}\left(\left(\sum_{i=1}^{n} b_{ij}^*\right)\delta_j\right) \qquad (12)$$

were δ_i *is* the share of industry *i* in the increase in final demand for domestic products:

$$\delta_i = \left(w_k + tr\cdot tax_k\right)\cdot c\cdot\alpha_i\left(1-imp_{c\,i}\right) + tax_k\cdot gc\cdot\beta_i\left(1-imp_{gc\,i}\right) +$$
$$+\left(1-imp_{T\,i}\right)\sum_{j=1}^{n} t_{ij}\left[tax_k\left(1-gc-tr\right)\gamma_j + \left(1-tax_k-w_k\right)binv_k\right]. \qquad (13)$$

1.4. Methodology of the integrated multiplier effect assessment

The combination of the described multiplier effects arising due to the project implementation can be illustrated by the conceptual scheme presented in Fig. 1.

In the construction phase, an investment multiplier effect occurs due to the capital expenditures within the project. The gross output increase caused by this effect predetermines the increase in value added. It leads to a rise of the income multiplier effect. In the phase of production (in the case of an appropriate demand), the output multiplier effect arises, which is also supplemented by the income multiplier effect. The integrated multiplier effect of the given investment project is determined by summing out the indicated “single” effects.

The integral output increase can be represented in the following way:

$$\Delta\vec{X}^{\text{ total}} = B^*\cdot\Delta\vec{Y}_{inv}^* + B^*\cdot\Delta\vec{Y}_{va\,(inv)}^* + B^*\cdot\Delta\vec{X}_{prod}^0 + B^*\cdot\Delta\vec{Y}_{va\,(prod)}^* =$$
$$= (E-A^*)^{-1}\left(\Delta\vec{Y}_{inv}^* + \Delta\vec{Y}_{va\,(inv)}^* + \Delta\vec{X}_{prod}^0 + \Delta\vec{Y}_{va\,(prod)}^*\right) \qquad (14)$$

where $\Delta\vec{Y}_{inv}^*$ and $\Delta\vec{Y}_{va\,(inv)}^*$ are the vectors of the increase in final demand for domestic products due to capital expenditures within the NPP project and due to spending of additional income in the investment phase of the project; $\Delta\vec{X}_{prod}^0$ is the vector of the direct increase in output within the NPP project; and $\Delta\vec{Y}_{va\,(prod)}^*$ is the vector of the increase in final demand for domestic products due to spending of additional income in the production phase.

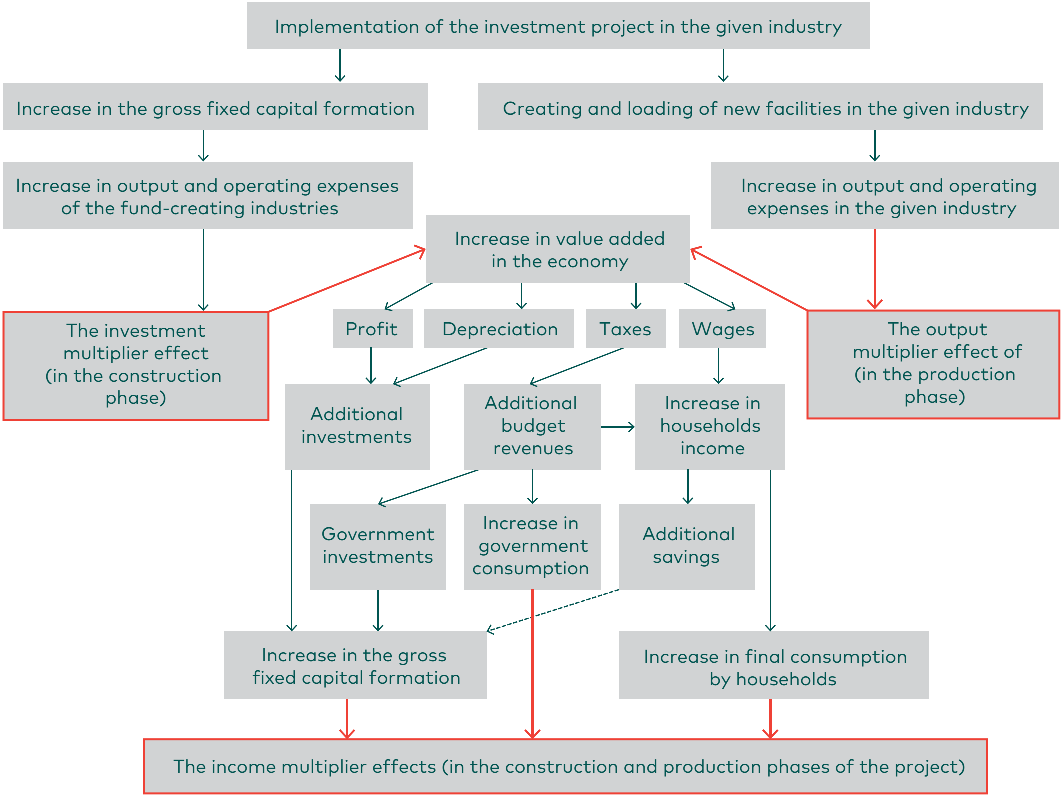

Fig. 1. Formation of multiplier effects during the investment project implementation.

The initial increase in output in the production phase (in industry k where the NPP project is implemented) can be obtained from the feasibility study of the project or expressed through the capital intensity q_k in industry k:

$$\Delta \vec{X}^{0}_{prod} = \begin{pmatrix} 0 \\ 0 \\ \dots \\ \Delta X^{0}_{k} \\ \dots \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \dots \\ \dfrac{inv_k}{q_k} \\ \dots \\ 0 \end{pmatrix}. \tag{15}$$

1.5. The procedure for dynamizing calculations

The investment projects in the nuclear power industry have long terms of implementation. During this time, the key parameters involved in the assessment of multiplier effects (in particular, the structure of production costs in the economy, the share of imports and other structural parameters) change significantly. This is a rigid constraint for using the static input-output model within the assessment of the investment project's economic consequences. This constraint is taken off by "splitting" the overall effect during the entire period of the investment project implementation. It lets us consider these effects in specific periods, each of which is characterized by its own structural parameters, corrected in accordance with the trends of scientific and technological development and increases in production efficiency, and the changing of geological and technical characteristics in mining, etc. The methodology described above is used within a year.

An increase of some indicators (output, value added) is understood not as the increase to the previous year level, but an increase to the level within the scenario in which the referred project is not implemented (other things being equal). The assessment of multiplier effects during various years can be carried out in constant prices or with discounting of cash flows (taking into account the time value of money). The splitting of the project implementation period into certain years also facilitates forming a set of input parameters for the calculation, since the data on the annual amounts and structure of capital expenditures and output within the project are traditionally given in the feasibility study.

In order to take into account the long-term changes in structural parameters, we should adjust matrix A by multiplying its elements by the index of productivity for the selected year (it indicates changes in the efficiency of using primary resources in comparison with the basis of 2013). The import matrix is adjusted by multiplying its coefficients by the import substitution index, indicating changes of the share of imports in domestic consumption.

The use of the static input-output model for assessing the multiplier effects is associated with the adoption of several simplifying assumptions, which narrow the field of the correct application of the described methodology in practice. The use of the static model implies that the parameters of calculations (intermediate demand coefficients, the structure of final demand, the structure of value added distribution, etc.) remain unchanged in the year under review. Thus, we assume in the hypothesis that the cumulative effect of the given investment project is incomparable with the scale of the entire economy and therefore does not have a significant impact on its key structural parameters. This means that the additional demand for goods and services, formed due to the implementation of the project, can be covered by loading idle capacities, imports expansion or using stocks (i.e. does not create the shortage in commodity markets and an increase in prices). A similar assumption should be made regarding the impact of the given project on the situation in labor markets and debt capital.

2. Assessment of macroeconomic effects of international NPP projects

2.1. Multiplier effects for the country supplying NPP

In this study the following international NPP project macroeconomic effects for the supplying country are considered:

- the increase of external demand for investment products (corresponding to the share of the country in capital expenditure within the project) and the effects of the output increase in fund-creating industries (the investment multiplier effect with subsequent spending of additional income due to the value added increase);

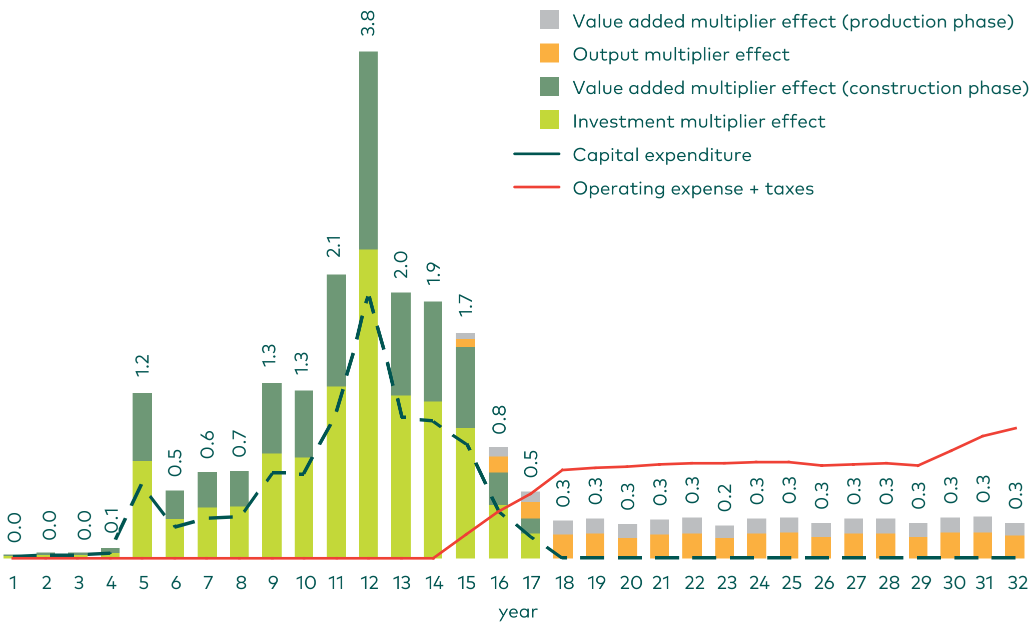

Fig. 2. Estimates of the multiplier effects on gross output of the supplying country by years, billion constant 2013 US dollars. (Source: IEF RAS)

- the increase of external demand for intermediate consumption resources in the production phase (the output multiplier effect with subsequent spending of additional income due to the value added increase).

In principle, the methodology for assessing the international NPP project effects does not differ from the general methodology described above. One of the few differences is the accounting for the direct output increase and value added within the NPP project. Since the project is external to the supplying country, the increases in output and value added within the project do not affect gross output and GDP of the supplying country. Also, we should note that the impact of the project on the supplying country exports is likely underestimated because direct contacts between the supplying country and the country receiving NPP are only considered (although, for example, exports of metals or fuels can increase, required to produce equipment for NPP in any other country).

The main challenge here is to accurately assess the extent of the supplying country's participation in the project (i.e. its shares in the supply of investment and intermediate consumption resources).

Illustrative calculations were carried out based on the real project data to demonstrate the capabilities of the methodology for assessing multiplier effects.

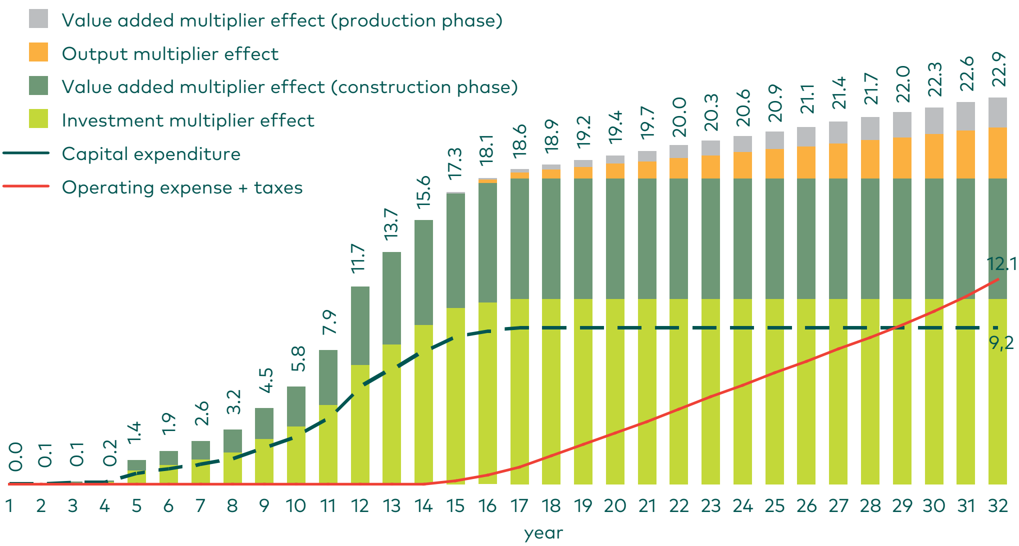

Fig. 3. Estimates of the cumulative multiplier effects on gross output of the supplying country, billion constant 2013 US dollars. (Source: IEF RAS)

In these calculations, the input-output table developed by IEF RAS (for 2013) was applied. The estimates were obtained in constant 2013 US dollars, and discounting was not carried out. The results are shown in Figs. 2 and 3.

It is assumed that Russia is helping to build a nuclear plant in one country. Power station has 2 units, each 1,200 MW, construction period (including preconstruction stage) – 14 years, payback period – 15 years , operation period – 60 years, investment volume – $ 9.2 bln.

According to the results of the calculations, the supplying country receives the largest multiplier effect in the construction phase. The estimates of multiplier effects are strongly correlated with capital expenditure and output within the NPP. The multipliers' estimates decrease (see Fig. 4) due to the increasing efficiency of the primary resources used in the economy. In the construction phase, the investment multiplier (i.e. the ratio of the gross output increase to the amount of annual investment) for the supplying country decreases from 1.37 to 1.12 (without the value added multiplier effect) and from 2.38 to 1.18 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the gross output increase

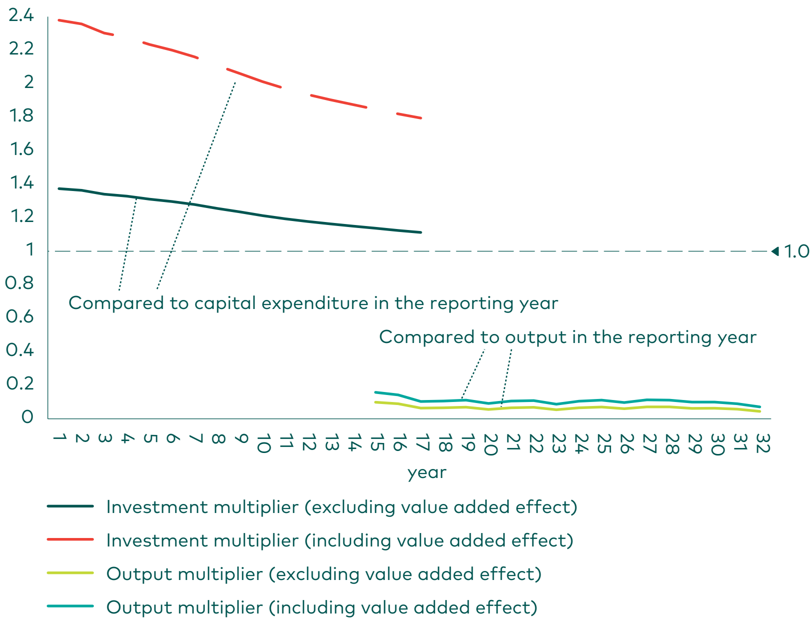

Fig. 4. Multiplier estimates (of gross output) for the supplying country. (Source: IEF RAS)

to the amount of total investment within the project) for the supplying country lowers from 0.10 to 0.04 (without the value added multiplier effect) and from 0.16 to 0.07 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative gross output increases during the considered period to the amount of total investment) is 2.48.

Figure 5 presents the structure of gross output increase for the supplying country in the construction phase (for example, in year 12). The largest output increase is expected in manufacture of machinery and equipment.

Also, we can use the proposed methodology to assess multiplier effects on GDP. In the construction phase, the investment multiplier (i.e. the ratio of the GDP increase to the amount of annual investment) for the supplying country decreases from 0.67 to 0.55 (without the value added multiplier effect) and from 1.17 to 0.88 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the GDP increase to the amount of total investment within the project) for the supplying country decreases from 0.05 to 0.02 (without the value added multiplier effect) and 1.08 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative GDP increase during the considered period to the amount of total investment) is 1.22.

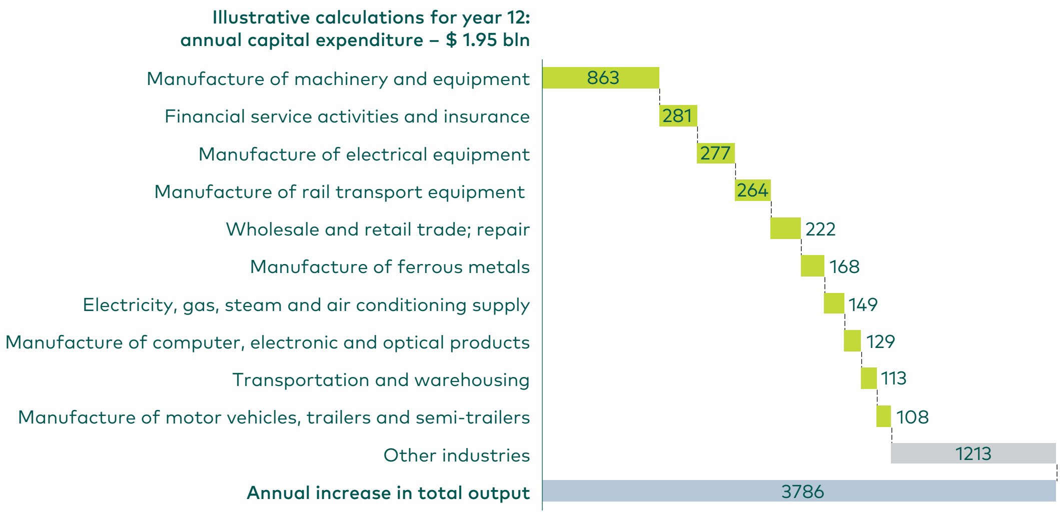

Fig. 5. The structure of gross output increase for the supplying country in the construction phase, billion constant 2013 US dollars. (Source: IEF RAS)

2.2. Multiplier effects for the country receiving NPP

In this study the following international NPP project macroeconomic effects for the receiving country are considered:

- the increase of domestic demand for investment products (corresponding to the share of the country in capital expenditure within the project) and the effects of the output increase in fund-creating industries (the investment multiplier effect with subsequent spending of additional income due to the value added increase);
- the increase of domestic demand for intermediate consumption resources in the production phase (the output multiplier effect with subsequent spending of additional income due to the value added increase).

For the receiving country, the methodology for assessing the international NPP project effects is fully in line with the general methodology (including the impact of investment and intermediate consumption resources imports). The most complex issue is accounting for net profits within the project (or, more precisely, its spending). Since such projects are usually funded mainly by external loans and equity of the supplying company, the net profit goes for payback and depreciation.

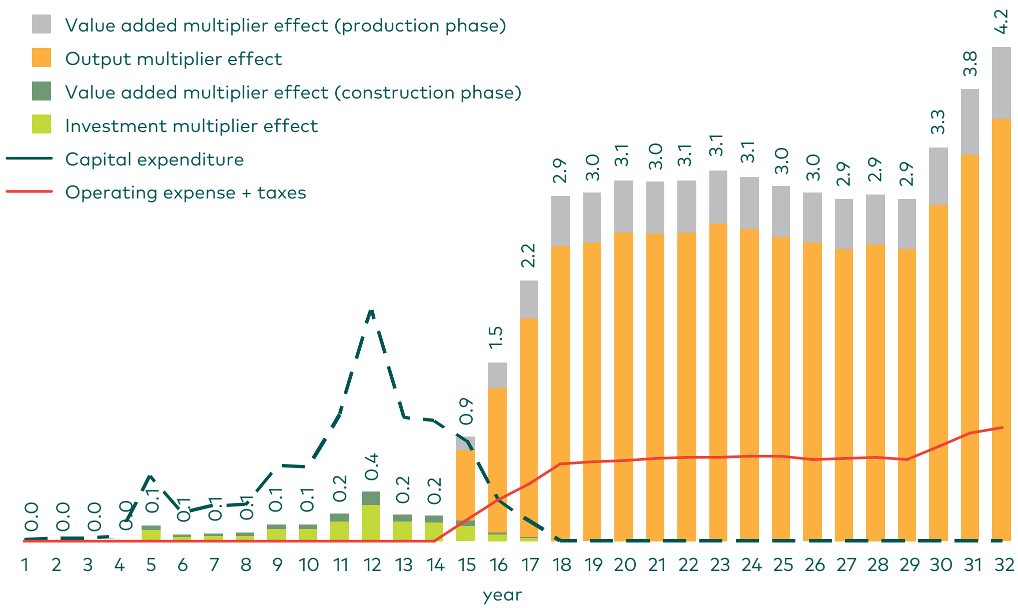

Fig. 6. Estimates of the multiplier effects on gross output of the receiving country by years, billion constant 2013 US dollars. (Source: IEF RAS)

Therefore, these additional revenues should not be taken into account when determining the value added multiplier effect for the receiving country.

The results of assessing macroeconomic effects of the considered NPP project for the receiving country are presented in Figs. 6 and 7.

The largest multiplier effect occurs in the production phase. At the same time, the gross output increase (without the value added multiplier effect) coincides with the increase in electricity production within the project, i.e. the indirect effect of increase in operating expenses is almost zero. It is due to a low share of the receiving country in the supply of intermediate consumption resources for NPP.

The estimates of multiplier effects are correlated with capital expenditure and output within the NPP as in the case with the supplying country. The decrease of multipliers' estimates (see Fig. 8) due to the increasing efficiency of the primary resources used in the economy. In the construction phase, the investment multiplier for the receiving country decreases from 0.18 to 0.15 (without the value added multiplier effect) and from 0.25 to 0.20 (including the value added multiplier effect). In the production phase, the output multiplier for the receiving

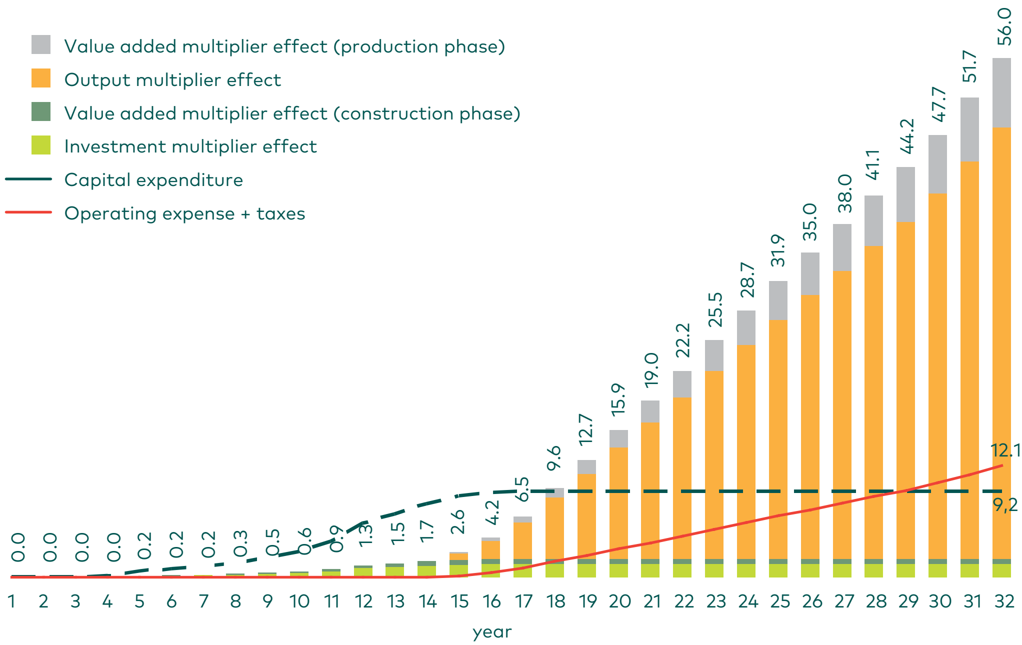

Fig. 7. Estimates of the cumulative multiplier effects on gross output of the receiving country, billion constant 2013 US dollars. (Source: IEF RAS)

country does not change significantly and equals 1.0 (without the value added multiplier effect) and about 1.16–1.17 (including the value added multiplier effect). The integrated investment multiplier (i.e. the ratio of the cumulative gross output increases during the considered period to the amount of total investment) is 6.1.

Figure 9 represents the structure of gross output increase for the receiving country in the construction phase (for example, in year 12). The largest output increase is expected in construction and engineering.

Regarding the multiplier effects on GDP for the receiving country, in the construction phase, the investment multiplier (i.e. the ratio of the GDP increase to the amount of annual investment) for the receiving country is equal to 0.08 (without the value added multiplier effect) and 0.11 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the GDP increase to the amount of total investment within the project) for the receiving country is equal to 0.95 (without the value added multiplier effect) and 1.05 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative GDP increase during the considered period to the amount of total investment) is 4.8.

We should note that in the production phase, the estimates of multiplier effects on gross output and on GDP for the receiving country

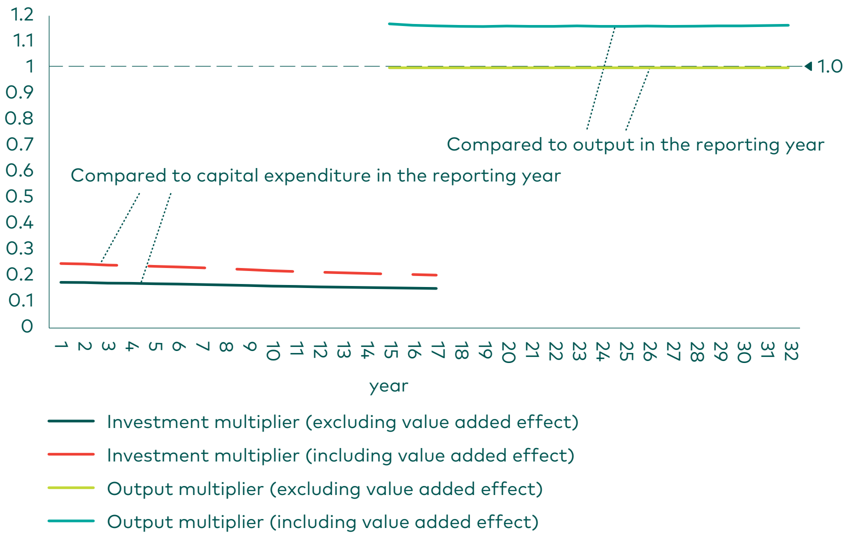

Fig. 8. Multipliers estimates (on gross output) for the receiving country. (Source: IEF RAS)

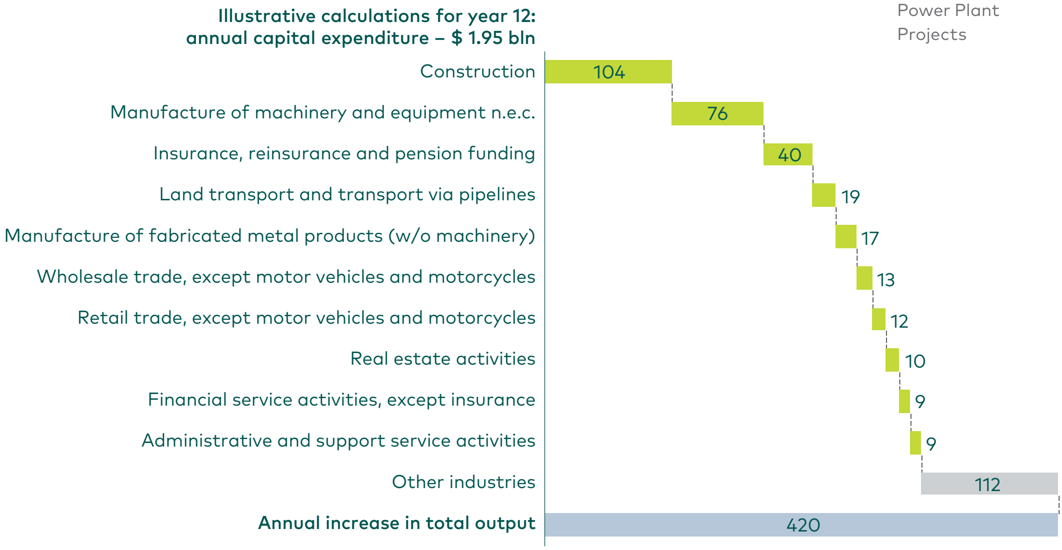

Fig. 9. The structure of gross output increase for the receiving country in the construction phase, billion constant 2013 US dollars. (Source: IEF RAS)
Note: Excluding direct effect of the project on total output in the partner country

are close because of a low share of domestic production in the supply of intermediate consumption resources for NPP, and, therefore, there are small differences between the output and value added in the project (including profit, depreciation, taxes and wages).

Conclusions

The input-output approach is one of the most convenient tools for determining multiplier effects from the development of Nuclear Power Plant (NPP) projects.

In order to take into account the long-term changes in structural parameters of the NPP project period, we should adjust the direct cost coefficient matrix A by multiplying its elements by the index of productivity for the selected year (it indicates changes in the efficiency of using primary resources in comparison with the basis of 2013).

During the construction and operation of the NPP, there are two basic types of effects: investment and operational. In international NPP projects macroeconomic effects are divided between the supplying country (the equipment producer) and the receiving country (where the project is implemented). As a rule, in the case of implementing international projects for the construction of nuclear power plants, the main effects for the country supplying of machinery and equipment are observed at the investment stage, and for the country implementing the project on its territory at the operation stage.

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ANALYZING THE EFFECTS OF EXOGENOUS PRICE ADJUSTMENTS IN ENERGY MARKETS USING AN INPUT-OUTPUT MODEL: THE CASE OF TURKEY

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Introduction

Energy commodities play a key role in all economies not only because of their absolute volume but also because of their backward and forward linkages to other sectors of the economy. Accordingly, prices of all other sectors depend on price changes in the main energy goods. The I-O model provides an appropriate tool to analyze the results of these interactions both in the form of volume and price changes in all sectors of the economy.

Total energy consumption in Turkey has increased from 74 Mtoe in 2002 to 131.3 Mtoe in 2015, growing at 4.1 percent annually. Nearly 90 percent of the total energy supply in Turkey is provided by the three primary energy sources: natural gas (30.7 %), coal (29 %), and petrol (28.1 %). The remaining 10 percent come from renewable energy sources, mainly from hydroelectric power stations. Moreover, in 2016, 99.5 percent of natural gas, 89 percent of petrol, 60 percent of lignite, and 97 percent of hard coal were imported (BOTAS, 2016). As a result, nearly 78 percent of the total energy supply is met by imports. Clearly, on the supply side the Turkish economy is heavily dependent on foreign resources. It is also expected that this energy problem will not change significantly in the foreseeable future (OME, 2014). This situation implies that Turkey has very limited bargaining power in the pricing process administered mainly by the suppliers operating in non-competitive international market structures such as oligopolies, cartels, or a few dominant state-owned companies. Natural gas mainly comes from Russia, Iran, Azerbaijan, Algeria, and Nigeria. Petrol is imported mainly from Iraq, Iran, and Russia (BOTAS, 2017).

Domestic prices paid by final consumers and manufacturing companies are set by another chain of oligopoly firms. The Energy Market Regulatory Board (EMRB, EPDK) sits at the top of the pyramid of the domestic distribution process and regulates the market. Using the standard I-O price model, this paper analyzes a one-time effect of an exogenous price increase in imported energy commodities on domestic production sectors.

The study is based on the 64-sector 2012 I-O table published by TurkStat. It is used within the I-O modeling framework and two scenarios are designed for computations: a low inflation scenario and a high inflation scenario. In each scenario import data are grouped into three categories: crude petroleum and natural gas imports, imports of refined petroleum products, and all other imports.

1. Data Sources

The data for this study come mainly from two sources. The first one is the TurkStat sources. Towards the end of 2016 TurkStat published a set of I-O tables for the year 2012, three of which constitute the basic data structure of this paper. These are the Domestic Input-Output Table, the Import Input-Output Table, and the [Total] Input-Output Table. As will be explained in Section 2, in order to apply the I-O price model, the domestic I-O table is used. The data in the import matrix are then aggregated into three rows and added to the primary input block of the domestic table. An abridged version of the I-O table is presented in the Appendix (Table A1).

For the purpose of price analysis, along with the other primary inputs or value added rows, import data are grouped into three following categories:

- imports of crude petroleum and natural gas;
- imports of refined petroleum products;
- all other imports.

These three lines are appended into the value added block of the domestic I-O table. All the values are expressed in millions of TRY in current prices.

The second set of data is related to the domestic energy price formation process. These data were obtained from the regular annual reports of EPDK. Since the analysis in this paper is related to only one-year price change in energy products, the data obtained from the 2016 Annual Report were sufficient (EPDK, 2017).

2. Methodology

2.1. The I-O production model

The standard I-O production model is given by

$$q = Aq + f \tag{1}$$

where q is output column vector; A is matrix of input coefficients; and f is final demand column vector.

The solution to Equation (1) is

$$q = (I - A)^{-1}f = Lf \tag{2}$$

where $L = (I - A)^{-1}$ is called the Leontief inverse.

The I-O production model given in Equations (1) and (2) is known as the demand-driven I-O model. In this model the fixed technical coefficient matrix A, output levels of each industry depend entirely on the exogenously determined final demand vector f.

To explore the I-O production model further, three new coefficient matrices should be defined. These are given in Table 1.

Here the A matrix is obtained in the usual way by dividing each element of the interindustry flow matrix by the column totals or output levels in each industry. Matrix C is defined by dividing each element of primary input rows by their column (output) totals. In Table A1 (see Appendix) six primary inputs are included. Three of them show imported inputs into domestic production and the remaining three are for value added rows in the form of net indirect taxes, wages, and gross profits. Matrix B shows the sectoral input composition of final demand vectors obtained by dividing column elements of the final demand block in

Table 1

Tableau of Direct Input Coefficients (Schematic)

A	B
C	D

In Table 1 the four coefficient matrices are:

A – input-output coefficient matrix as in Equation (1);

B – final demand coefficient matrix;

C – primary input coefficient matrix;

D – coefficient matrix defined for primary inputs into final demand categories.

Table A1 (see Appendix) into their respective column totals. In the original form of the I-O table five final demand categories are defined: private household consumption, government consumption, gross fixed capital formation, changes in stocks, and exports. Finally, matrix *D* is obtained by dividing primary input components of final demand vectors into their total as in matrix *B.* From these definitions it can be shown that the column totals of *A* and *C*, and the column totals of *B* and *D,* respectively add up to unity.

For a full description of the I-O production model a set of the balancing equations should be defined using the four coefficient matrices. The first one is related to the total income for six primary input categories given in Equation (3).

Let y denote the column vector of total incomes of primary inputs:

$$y = Cq + \mathrm{h} \tag{3}$$

where *h* is a column vector of direct uses of the primary inputs by the final demand categories. Inserting *q* from Equation (2) into the first component of *y* in Equation (3) the following equation can be obtained:

$$Cq = C(I - A)^{-1}f. \tag{4}$$

Equation (4) ties the income of primary input categories or payments sector to exogenously determined final demand vector *f*.

Now, let *g* denote the sum of column elements of all final demand categories expressed in the form of a column vector. Then, with the help of matrix *B* the row sums of the final demand categories in the I-O table (Table A1, see Appendix) gives column vector *f* as in Equation (5):

$$f = Bg. \tag{5}$$

Finally, direct use of the primary inputs by the final demand vectors can be expressed as in Equation (6):

$$h = Dg. \tag{6}$$

From the last three Equations (4)–(6) the vector of primary input income categories can be expressed as in Equation (7):

$$y = C(I - A)^{-1}Bg + Dg \tag{7}$$

or as in Equation (8):

$$y = [C(I - A)^{-1}B + D]g \tag{8}$$

Now a new matrix can be defined as in Table 2.

This new matrix is known as the tableau of cumulative I-O coefficients (Heesterman, 1979). In the I-O production model the Leontief inverse $(I - A)^{-1}$ plays a crucial role. The elements of $(I - A)^{-1}$ are very useful and important numbers. Each captures, in a single number, the direct and indirect effects of a change in the final demand vectors (Miller & Blair, 2009). Accordingly, the solution to the production model given in Equation (4) for any sector i can be expressed as in Equation (9):

$$q_i = l_{i1}f_1 + \cdots + l_{ij}f_j + \cdots + l_{in}f_n. \tag{9}$$

Table 2

Tableau of Cumulative I-O Coefficients (Schematic)

$(I-A)^{-1}$	$(I-A)^{-1}B$
$C(I-A)^{-1}$	$C(I-A)^{-1}B + D$

It is easy to show that l_{ij} is the partial derivative of q_i with respect to f_j, that is $\partial q_i / \partial f_j = l_{ij}$. Therefore, it measures the direct and indirect effects of one unit increase in the final demand of sector *j* on the output of sector ***i***.

2.2. The I-O price model

The I-O price model states that the unit price of any sector is equal to the sum of the unit cost of physical inputs evaluated in their respective prices plus value added per unit produced in that sector. Accordingly, the basic I-O price model can be expressed as in Equation (10). In this model it is useful to place a row vector to the left of a matrix:

$$p = pA + rC + p^* \qquad (10)$$

where

p – sectoral price index vector in row form;
A – domestic inputs coefficient matrix;
r – price index vector for primary inputs in row form;
C – coefficient matrix of primary inputs (including imports);
p^* – excess (arbitrary) price increases in some sectors, if any.

When we assume that both A and C matrices are constant, then the increase in the domestic output price in each sector depends on the increase in prices of intermediate inputs plus the increase in prices of primary inputs. In Equation (10) the first component on the right hand side, vector pA, captures the total intermediate cost of one unit of output in each sector expressed in monetary units. The second component, vector rC, captures the total cost of the primary inputs (imports and factors of production) of one unit of output in each sector. For that reason the price model is also called the I-O costing model. In any specific sector there may be some arbitrary price increase. This last component is shown in the row vector p^*, which does not depend directly on any structural matrix in the I-O framework.

If each row of the primary inputs coefficient matrix C is treated as a row vector, and taking the sum of these vectors – a process which makes sense if all the rows are measured in monetary values in the prices of the year of the table – row vector v of value-added per unit of output can be obtained (Almon, 2016). Omitting p^* for simplicity, at least for the base year (2012 in the present model), Equation (10) can be expressed as follows:

$$p = pA + v. \tag{11}$$

In Equation (11) it is implicit that vector rC is replaced by vector v. This final equation can answer the question of how prices p would change if v changes while A remains constant. To answer these types of questions in a broader context, three rows of imported energy items are included in matrix C.

The solution to Equation (10) is given in Equation (12):

$$p = rC(I - A)^{-1} + p^*(I - A)^{-1}. \tag{12}$$

In the present model, p is a row vector of 64 elements.

2.3 Deflator computations

The deflator d is defined as the price index numbers for all final demand categories. Given the assumption of fixed coefficients for all elements of B and D, as for A and C, d is given by:

$$d = pB + rD \tag{13}$$

where d is deflator, a row vector in the form of index numbers; B and D are defined in Section 2.1; and p is computed in Equation (12).

The first component on the right side of Equation (13), pB, measures the unit cost of domestic sector outputs consumed by final demand categories. The second component, rD, measures the unit cost of primary inputs in the form of imports or factor payments going directly into the final demand sectors.

Substituting the solution to the output price vector p from Equation (12) into Equation (13), we obtain the solution to domestic deflators as follows:

$$d = r[C(I - A)^{-1}B + D] + p^*(I - A)^{-1}B. \tag{14}$$

It is now clear that the cumulative I-O coefficients presented in Table 2 are fully utilised in the computational process of the deflators for final demand categories. The next section will demonstrate the model applications with actual I-O data for the Turkish economy.

3. Application

The I-O price model is not as widely known as the production model, though it was also formulated by Leontief as early as in 1947. Using the 1939 I-O table of the US, in 1947 and 1951 Leontief himself calculated the effects of a 10 percent increase in (the price of) indirect taxes and wages on the prices of all sectors of the economy (Leontief, 1986). Similar computations were performed for the Norwegian economy by (Bjerkholt, 1983). For 1980, Bjerkholt calculated that a 10 percent increase in the price of imports resulted in a 2.9 percent inflation in consumer price index, CPI.

Using Equation (11) as stated above, a more comprehensive approach has been adopted in the INFORUM modeling systems for a long time. However, the INFORUM modeling group does not calculate the Leontief inverse very often in their applications. Instead, in the Interdyme modeling software applied by the INFORUM group, vector p is calculated in a dynamic process for many years without calculating the Leontief inverse. This method is called the Gauss-Seidel algorithm for the production model and the PSeidel algorithm for the price model (Almon, 2016; Meade, 2010). In this paper, since it is a comparative static analysis for one year (2012), the Leontief inverse is calculated and all other matrix computations are done in Excel.

3.1 Price Formation in Domestic Energy Markets

Before moving to the model calculations with actual data, the price formation process in the domestic markets needs to be explained. The prices of energy items in Turkey are determined and administered by the Energy Market Regulatory Board (EMRB or EPDK as its Turkish acronym). After receiving imported energy items at CIF prices, the Board follows a mark-up procedure to determine the actual market prices that consumers and enterprises pay. Table 8 shows the price composition and changes in the fuel markets in Istanbul from January 2016 to January 2017.

The first item in Table 3, "product price", shows the CIF price determined in the world market, generally in Europe. Over the course of the last 12 months the share of this basic price in the final market price increased to 30.1 percent from 22.1 percent. This high rise was mainly caused by the depreciation of the Turkish lira against the US dollar. The main component of the final fuel price is the total tax. It was 66.4 percent in January 2016 but fell to about 60 percent in January 2017. The main reason for this decline is the fact that the original import price of oil increased by more than 70 percent. As a result, the overall price increase was about 25 percent in one year, from January 2016 to January 2017.

Figure 1 shows the total energy import value of Turkey in billions of dollars from 2002 to 2016. There has been a sustained growth in the total cost of energy imports from 2002 to 2012, except for 2009 and 2010. After 2012, it started to fall mainly because of the

Table 3

Unleaded Fuel Price Formation in Istanbul, TRY Per Liter

Price components	Jan 2016	%	Nov 2016	%	Jan 2017	%	y/y, %
Product price	0.94	22.1	1.18	24.4	1.60	30.1	70.2
Wholesale margin	0.05	1.2	0.06	1.2	0.06	1.1	20.0
Income contribution	0.00	0.1	0.00	0.1	0.00	0.1	4.1
Distributor margin	0.44	10.3	0.47	9.7	0.47	8.8	6.8
Total tax	2.83	66.4	3.12	64.6	3.19	59.9	12.7
Sale price	4.26	100.0	4.83	100.0	5.32	100.0	24.9
Price increase (%)		10-month: 13.4		2-month: 10.1		12-month: 24.9	

(Source: Own elaboration based on EPDK (2017))

falling petrol prices. A further point to note in Fig. 1 is that the share of imported energy in GDP has followed a similar path as shown on the second y-axis.

An international comparison of relative energy prices reveals that Turkish consumers pay the eighth highest relative price for petrol in the world. In this comparison the relative price is defined as the ratio of the average daily wage to the nominal (absolute) price of a gallon of petrol expressed in percentage terms. Using this definition of relative price, Table 4 shows the 10 least affordable countries for oil consumption in 2015. India ranks as the most expensive country in the world in terms of the relative price of oil. Indian consumers pay nearly 80 % of their average daily wage to buy a gallon of petrol. Among these 10 countries Turkish consumers pay the highest price ($ 5.8) for a gallon of petrol. However, the average daily wage in Turkey is also the highest among these countries ($ 26.1). Accordingly, Turkish consumers pay only 22.1 % of their average daily wage to buy a gallon of petrol. In this regard they are also better off than consumers in Nigeria, which is a major oil producer in the world. Nigerians pay the lowest prices ($ 1.94) but coupled with an $ 8 average daily wage Nigeria's gas becomes the sixth least affordable in the world.

The statistics presented thus far emphasize the high cost of imported energy items and the importance of the price formation process in this sector for the Turkish economy.

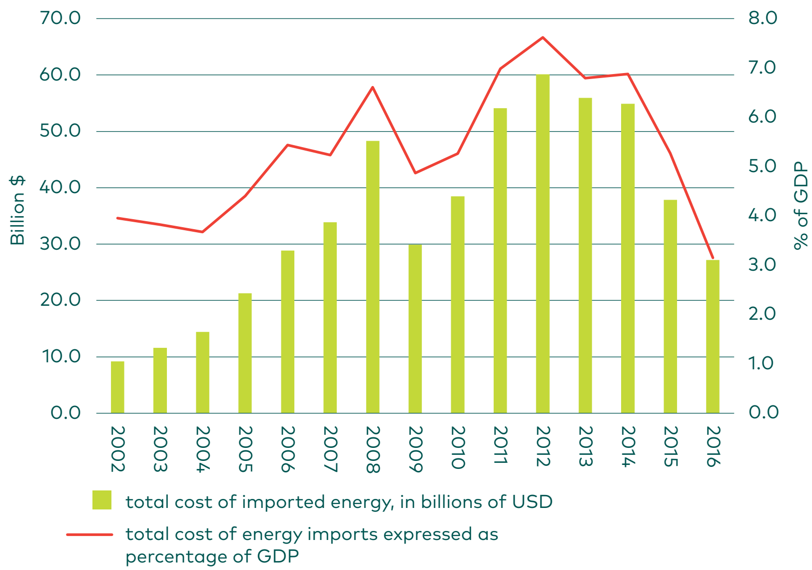

Fig. 1. Total energy import value, in billions of USD, and as percentage of GDP. (Source: Own elaboration based on BOTAS (2017))
Note: The values of 2016 are for nine months only.

Table 4

Least Affordable 10 Countries for Oil Consumption, 2015

		Price per gallon, $	Average daily wage, $	Wage paid for a gallon of petrol, %
1	India	3.75	4.77	78.62
2	Pakistan	2.32	3.97	58.44
3	Philippines	3.17	8.14	38.94
4	Egypt	2.66	10.25	25.95
5	South Africa	3.19	13.03	24.48
6	Nigeria	1.94	8.00	24.25
7	Indonesia	2.23	9.89	22.55
8	Turkey	5.77	26.13	22.08
9	Bulgaria	4.05	18.93	21.39
10	Thailand	3.44	16.23	21.20

(Source: www.oilprice.com (2017))

3.2. Price increase scenarios

Equations (12) and (14) together are used in calculations of the I-O price model. If it can be assumed that there is no increase in the profit margin along with an increase in the price of imported energy items, the final term in these two equations will disappear, i.e. the v^* vector will be zero. Under this assumption sectoral price indexes will depend only on an initial increase in the price of import items, wage rates, or profit rates. As will be clear from the calculations below, even if there is an increase in the profit margin in any sector, its effect on the other sectors will be negligible. Therefore, only two scenarios are included in this paper. The first one is the low price increase scenario called Scenario A, and the second one is the high price increase scenario called Scenario B.

Scenario A: Low price increase scenario

In this scenario, relatively low initial price increases are assumed for three import rows in the C matrix. In this matrix, the first row shows imports in the mining and quarrying sector, as a share of total domestic output in each sector. By definition, among all other mining products this sector also covers the imports of crude petroleum and natural gas. The second row shows coke and refined petroleum products expressed as a percentage of total domestic output of all sectors. Finally, row 3 contains imports from all other 62 sectors expressed as percentages of total domestic output of each sector.

Based on the information given in Table 3, an overall price increase of imported crude oil and natural gas by 25 percent can be assumed a “normal” or “relatively low” rate. Besides the demand and supply conditions, in international practice natural gas prices follow the path of the petroleum prices. For that reason in this scenario natural gas prices are allowed to increase by the same rate as in Table 3, which is 25 percent. Refined petroleum prices are assumed to grow only by 15 percent, as prices of domestically produced refined petroleum products usually increase less than the price of raw materials (petrol and natural gas). Finally, prices of all other imports are allowed to increase by 20 percent, which is a simple arithmetic mean of the previously mentioned price increase rates. The reason for this is the fact that the increase in prices of petroleum products and natural gas depends to a large extent on the appreciation of the US dollar against the Turkish lira. As a result of the exchange rate depreciation of Turkish lira it is normal to assume that the domestic prices of all other imports should go up.

Table 5 shows these three price changes. Since the present model considers only one-step price effects of energy prices, there are no

Table 5

Initial Price Increase in Energy Import Items: Scenario A

	Primary inputs, vector r	New index	Increase, %
1	Crude petroleum and natural gas imports	1.25	25.0
2	Refined petroleum products imports	1.15	15.0
3	Other imports	1.20	20.0
4	Net indirect taxes	1.0	0.0
5	Wages	1.0	0.0
6	Capital income	1.0	0.0

changes in the prices of the other three primary inputs – taxes, wages, and profits. To reflect this fact, the last three items in vector r are presented with index number 1.

As stated at the beginning of this section, in the low price increase scenario it is assumed that all the elements of vector p^* are zeros. Thus the last term in Equation (12) cancels out, and the solution to the price model becomes as in Equation (15):

$$p = rC(I - A)^{-1}. \tag{15}$$

Now, a new price vector p is obtained by premultiplying the bottom left block of the cumulative I-O table by the new level of vector r. After this computation the top 10 sectors showing the highest price rises are given in Table 6.

Table 6 shows that the highest price increase occurs in coke and refined petroleum products (by 17.4 percent). This rate is only 2.4 percentage points higher than the initial increase in the price of refined petroleum imports but much lower than the increase in the price of crude petroleum and natural gas imports. The second highest increase is seen in the electricity and gas utility sector with a relatively low rate of 11.4 percent. Inflation rates in all other sectors are much smaller than the initial increase in the prices of imported energy items and all other imports.

The deflators in the I-O price model are summary measures. They can reflect the economy-wide price changes in a few numbers instead of 64 sectors. With the assumption of zero exogenous domestic price increase (or without an additional profit margin) in any sector of the economy, i.e. when p^* is a zero vector, the deflators are calculated as in Equation (16):

$$d = r[C(I - A)^{-1}B + D]. \tag{16}$$

Equation (16) makes use of all the coefficient matrices in the I-O coefficients table, which are collected in the bottom-right corner of

Table 6

Top 10 Highest Price Changes: Scenario A

	I-O No.	Sector	Price index	Price increase, %
1	10	Coke and refined petroleum products	1.174	17.4
2	24	Electricity, gas, steam and air conditioning	1.114	11.4
3	15	Basic metals	1.094	9.4
4	20	Motor vehicles, trailers and semi-trailers	1.089	8.9
5	11	Chemicals and chemical products	1.087	8.7
6	13	Rubber and plastic products	1.083	8.3
7	18	Electrical equipment	1.081	8.1
8	8	Paper and paper products	1.076	7.6
9	17	Computer, electronic and optical products	1.070	7.0
10	19	Machinery and equipment n.e.c.	1.069	6.9

the tableau of the cumulative I-O coefficients (Table 2). The resulting d vector is given in Table 7.

Table 7 shows that even though a 15 percent increase is assumed for the price of imported commodities, the overall general price increase reflected in the GDP deflator is only 4.5 percent. In Table 7 the GDP deflator is a weighted arithmetic mean of the five deflators of the final demand categories. The highest increase is observed in the exports of goods and services at a rate of 6.8 percent. The second highest number

Table 7

Deflators in Scenario A

	Deflator	Index number	Increase, %
1	C: Household consumption of final goods	1.036	3.6
2	G: Government final consumption	1.022	2.2
3	I: Gross fixed capital formation	1.060	6.0
4	dS: Changes in stocks	1.049	4.9
5	X: Exports of goods and services	1.068	6.8
	GDP: Gross domestic product (GDP deflator)	1.045	4.5

Note: GDP deflator is computed as weighted arithmetic mean of the five components.

is 6 percent, which is observed in gross fixed investment. The increase in prices of private household consumer goods is 3.6 percent. The reason for the relatively low level of price increase in consumer goods is the relatively lower rate of direct import content in their composition, which is reflected in matrix D. In matrix D the highest rate is 0.134, which belongs to the investment column and in the row of the other imports.

Scenario B: High price increase scenario

Scenario B is the same as the low price increase scenario but with an extra price increase in the land transportation and transportation via pipeline sector. The second assumption implies that the last item on the right side of Equation (12) is not zero. Whenever the Turkish lira depreciates against the dollar and other major currencies at a significant rate coupled with a rise in the prices of imported energy items, business associations in the transportation sector claim an immediate price increase for their services. When the Turkish lira depreciates against the US dollar by about 10 percent, the next day petrol prices at gas stations may go up by about 20 percent, and taxi drivers in Istanbul or Ankara can shock their customers showing the new rate at their meters, which can be about 25 percent higher than the day before. This practice is reflected in the last item in Equation (12), with $p^*_{31} = 0.25$. Here the index number 31 is the sector number of land transportation and transportation via pipelines in the I-O table. Therefore, in the high price increase scenario, the I-O price model is fully applicable.

With all these assumptions vector r will look like the one given in Table 5. However, the last item will be placed in a different vector called *p**, which has 0.25 for its 31st element and zeros for all of the other 63 elements.

Upon applying Equation (12) with all its components, the price indices and rates of increases are computed for all 64 sectors of the economy. The top ten sectors showing the highest price increases are listed in Table 8.

Table 8 shows that the highest price increase is in land transport services and transport services via pipelines. This sector shows a 33.3 percent price increase rate of which 25 percent comes from the initial price rise defined in Scenario B. The remaining 8.3 percentage points come from the indirect effects of the increase in imported energy prices due to the I-O relations. The second highest increase is seen in the coke and refined petroleum products sector with a relatively lower rate (18 percent). As in Scenario A, price rises in all the other sectors are much smaller than the initial price increases in imported energy items and all other imports.

Table 8

Top 10 Highest Price Changes: Scenario B

	I-O No.	Sector	Price index	Price increase, %
1	31	Land transportation services, transportation services via pipelines	1.333	33.3
2	10	Coke and refined petroleum products	1.180	18.0
3	24	Electricity, gas, steam and air conditioning	1.117	11.7
4	15	Basic metals	1.112	11.2
5	20	Motor vehicles, trailers and semi-trailers	1.106	10.6
6	11	Chemicals and chemical products	1.099	9.9
7	18	Electrical equipment	1.098	9.8
8	13	Rubber and plastic products	1.096	9.6
9	8	Paper and paper products	1.093	9.3
10	19	Machinery and equipment n.e.c.	1.086	8.6

With the assumption of the exogenously determined price rise in land transportation and transportation via pipelines, Equation (14) is fully applicable for the computation of deflators in Scenario B. The resulting deflators in Scenario B are given in Table 9.

Table 9 shows that even though at least a 15 percent increase is allowed in the price of import items and an additional increase in the price of land transportation and transportation via pipelines sector (31), the overall general price increase reflected in the GDP deflator is only 5.8 percent. As in Scenario A, the highest price increase is observed in the exports of goods and services at a rate of 8.3 percent. The second highest number – 6.4 percent – is observed in the gross fixed investment column. The increase in the prices of private household consumer goods is only 5.5 percent.

A final comment regarding the deflators is related to two numbers taken from the TurkStat and the UN Statistical Division websites (TurkStat, 2017b; United Nations, 2017). For 2012, in the former the consumer price index is 1.062, and in the latter the GDP deflator is 1.069. Thus, somewhat hypothetical model solutions in the high inflation scenario presented in this paper produced almost identical indices for both indicators: 1.055 and 1.058, respectively.

However, compared with a 9.2 percent increase in the actual CPI for 2016 (TurkStat, 2017b) the model solution underestimates this result. The difference then can only be attributed to other determinants, such as changes in monetary variables, wages, profits, or demand conditions.

Table 9

Deflators in Scenario B

	Deflator	Index number	Increase, %
1	C: Household consumption of final goods	1.055	5.5
2	G: Government final consumption	1.023	2.3
3	I: Gross fixed capital formation	1.064	6.4
4	dS: Changes in stocks	1.049	4.9
5	X: Exports of goods and services	1.083	8.3
	GDP: Gross domestic product (GDP deflator)	1.058	5.8

Note: GDP deflator is computed as weighted arithmetic mean of the five components.

Summary and conclusions

Traditional price index methods cannot answer the question: what happens to the consumer price index if the price of imported oil increases exogenously, say, by 10 percent. In this regard, the standard I-O price model is a powerful tool with a strong theoretical base. The model presented in this paper has produced not only six deflators for all final demand categories but also inflation rates for all 64 domestic production sectors. Accordingly, the decision makers in regulatory government authorities in energy markets would be able to test the effects of their pricing policy on individual sectors of the domestic economy using the I-O price model.

The Turkish economy is heavily dependent on imports of all the types of energy items – crude oil, refined petroleum products, and natural gas. The present form of the international energy market structure makes Turkey a price taker. That is, Turkey has limited bargaining power in energy markets. Therefore, to reduce the degree of its dependence of the supply of basic fuel items on foreign players, Turkey should boost investment activities in domestic renewable and clean energy sources.

In the process of the domestic price formation, after an increase in the price of imported energy items, additional arbitrary and unjustified price increases in domestically produced goods and services should be avoided.

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APPENDIX

Table A1

Domestic I-O Table of Turkey, 2012, Current Prices, in Millions of TRY (Abridged)

		1	5	6	10	1	2	3	
		Agricul.	Food, beverage, tobacco	Textile	Coke and refined petrol	Consum. (h/holds and gov.)	Gross invest. (inc. stock changes)	Exports	Total q
1	Agriculture	28 934	47 390	4 384		61 781	14 511	9 099	170 616
5	Food, beverage, tobacco	6 067	19 064	471	8	95 192	630	31 452	173 280
6	Textile	76	249	47 312	3	38 882	–2 361	60 774	152 189
10	Coke and refined petrol	2 065	315	190	433	1 958	89	12 169	43 695
31	Land transport	2 295	6 684	2 729	635	77 173	5 946	22 420	198 182
44	Real estate activities	42	669	2 195	100	125 992		695	172 460
55	Public services	10	34	12	2	89 038			91 379
56	Education		38	12	6	68 618		207	72 260

		1	5	6	10	1	2	3	
		Agricul.	Food, beverage, tobacco	Textile	Coke and refined petrol	Consum. (h/holds and gov.)	Gross invest. (inc. stock changes)	Exports	Total q
57	Health			2		61 894		1 318	67 703
64	Paid household services					782			782
	Other sectors	12 081	28 704	23 735	4 562	503 909	347 907	211 574	1 881 920
	Total intermediate input	51 569	103 146	81 041	5 749	1 063 324	366 723	348 391	2 956 762
1	Crude petroleum and natural gas imports	3	559	975	29 268	3 614	1 471	362	76 127
2	Refined petroleum imports	2 210	341	204	464	5 872	27	72	37 425
3	Other imports	6 569	17 283	17 341	80	47 218	57 324	20 096	335 027
4	Net indirect taxes	–532	1 465	2 564	5 347	82 441	18 737	2 580	189 146

		1	5	6	10	1	2	3	
		Agricul.	Food, beverage, tobacco	Textile	Coke and refined petrol	Consum. (h/ holds and gov.)	Gross invest. (inc. stock changes)	Exports	Total q
5	Labor income	2 490	13 409	19 660	490				438 578
6	Gross capital income	108 308	37 076	30 403	2 297				941 948
	Total primary inputs	119 048	70 134	71 148	37 946	139 146	77 559	23 109	2 018 252
	Total output q	170 616	173 280	152 189	43 695	1 202 470	444 282	371 500	

(Source: Own elaboration based on TurkStat (2017a))