# Compilation of Regional Input-Output Tables in Russia

***PhD., prof. Sayapova, Alsu; Slobodyanik, Svetlana****

*Lomonosov Moscow State University, Faculty of Economics*
*Address: Faculty of Economics, Lomonosov Moscow State University, GSP-1, Leninskie Gory, Moscow, 119991, Russian Federation, e-mail: tutov@econ.msu.ru*
*Phone: 84991671886, 84997477011.*
*E-mail: asajaf@mail.ru, slobodianik1986@mail.ru*

***Abstract***

In this paper we deal with the IO analysis. We focus on the issue of applying it to a separate-region economy. Actually, the paper concerns the IO analysis as a tool of territory planning. In fact the IO analysis was widely used under the planned economy framework in the USSR when regional and multiregional IO tables were compiled. However the period of transition economy accompanied with fundamental economic transformation resulted in poor interest in territory planning, and the IO analysis as well.

Unfortunately the work on compilation of regional IO tables is not provided by the National Statistics Office. Under the circumstances the authors have constructed (by own forces) regional IO tables for the Republic of Bashkortostan (Sayapova, 2004), which are based on the System of National Accounts and The United Nations Handbook of Input-Output Table Compilation and Analysis (1999). Thus, the Republic of Bashkortostan is nowadays the only Russian region where such a study has recommenced. The IO tables for the Republic of Bashkortostan are constructed in the dimension of 227 product groups for the year 1995 and in the dimension of 25 aggregate sectors for the year 2002. While compiling these tables the authors managed to solve methodical problems concerning the incompleteness of regional statistics in regional trade-flows, trade and transport margins. The regional IO tables permitted to reveal structural shifts, which are taking place in the transforming regional economy and can't be analyzed with the official statistical data.

The IO tables received were used to consider different scenarios of the regional development such as the well-balanced scenario, the inertia scenario, and the scenario of economic development followed by loading of idle capacities. Besides, we have analyzed a scenario of increasing consumption up to normative standards among population. For instance, it was ascertained that the attainment of rational consumption rate by population stimulates domestic demand. Price scenarios permitted to estimate the influence of price increasing in one sector on price movement in other sectors. The authors have calculated the scenario of gas price increase in the region up to the free-market level. All the simulations were made to estimate multiplicative effects caused by upsizing industries in the regional economy.

The IO analysis can also be applied to estimate ecological situation in a region varying the total output or final demand indices. The evaluation of the total investments required for nature protection activity is possible as well.

**Keywords**: regional IO tables, territory planning, forecasting and simulation.

## 1. Introduction

Russia is the largest country in the world so the necessity of territory planning is determined by the very largeness of the territory, the width of natural resources and differences in regional socio-economic development. All these factors make territory planning indispensable in government regulation. For the last few years there is an increasing number of executive and legislative acts in this field as well as scientific publications. So, the necessity of territory planning is realized and being broadly discussed. However, there is a poor interest in tools of territory planning in spite of the fact that it is the tool which is the first in the chain: tool – forecast – plan – regulation. It is widely assumed that the Input-Output method is one of the most effective tools for macroeconomic analysis.

Nowadays the IO method is broadly used in many countries. At the same time it is underestimated in Russia. 1) IO tables for the national economy are constructed in the dimension of 22 aggregate sectors (*e.g.* the level of detail comes up to almost 500 industries in the USA and Japan, 300 industries in Canada *etc*.). 2) The majority of information for compiling detailed IO tables comes from survey data. The main survey provided by the National Statistics Office is the Enterprise survey which covers most industries and permits to reveal the input structure throughout the economy. However the last survey refers to the year 1995 when a detailed IO table with a breakdown of 227 product groups was compiled. Still then the decision on the survey has not been made yet. Thus, all the aggregate IO tables are constructed on the base of input structure for the year 1995. According to the actual statistical practices the survey on input structure is provided every five years to get proper technological coefficients. Moreover, according to the European System of Accounts 1995 (ESA95) the demand is obligatory. 3) Regional IO tables on the survey-based method have not been compiled in Russia since the period of planned economy. Thus, the IO table we have compiled for the Republic of Bashkortostan is the only pattern in the transforming Russian economy made to appeal the necessity of compilation of regional IO tables in Russia.

## 2. Historical Background

Nevertheless, the situation was quite different in the Soviet Union. First attempts to apply the balancing method to the national economy were already made for the year 1923/1924. The results were published in 1928. The pioneer of the IO method, W. Leontief pointed out some weaknesses of the first Soviet balance he studied closely and proposed a viable IO concept based on a symmetric IO scheme. The work on compilation of IO tables in the Soviet Union started in the late 1950's. First IO tables for the year 1959 were compiled by the Central Statistics Office for 83 industries in monetary form and for 157 commodities in physical form. Further, the IO table for the year 1966 was produced (110 industries and 237 commodities), and the one for the year 1972 (112 industries and 247 commodities). Later, the following tables were produced: the five-yearly IO tables for 1977, 1982, 1987. The detailed IO tables served as a base for annual IO tables with 18 aggregate sectors.

Since 1993 the National Statistics Office has accepted the System of National Accounts. The first IO table for the national economy under this framework was compiled for the year 1995. So far, the annual IO tables have been compiled on its basis. The latest IO table released for the year 2003 is compiled for 22 aggregate

sectors. The IO tables become available on average around 3 years after the reference period.

In fact, the compilation of regional and multiregional IO tables was a common practice under the planned economy. These tables were usually compiled by academic circles and provided a basis for macroeconomic analysis and forecasting. Particularly, the researches were conducted by Academy of Sciences for Bashkortostan, Buryatia, Daghestan, Karelia, Komi, Yakutia and other regions as well. The last IO table on the sub-national level was released for the year 1987. Since then the work on compilation of regional and multiregional IO tables has not been provided in an official way.

However, an increasing interest in territory planning involves, in its turn, the revival of spatial IO researches. So, the studies have recommenced for separate-regional economies (Miheeva, 2005, and Serebriakov, Uziakov & Yantovskii, 2002) and for multi-regional areas as well (Melnikova, 2007). The work on compilation of multiregional IO tables has been launched by the Committee on Productive Forces Studies, which makes scientific researches by governmental orders. Accepting the fact the development of regional IO tables is not provided by the National Statistics Office almost all the researches apply non-survey-based method. According to this approach an IO direct coefficient matrix derived from a symmetric IO table for the national economy is applied to a separate-region economy. In this case, there is an implicit assumption that technological coefficients at the national and regional levels are the same (*i.e.* that the economies use the same mix of inputs). However, in most cases national and regional production technologies differ. In order to approximate technological coefficients to a separate region the IO matrix is adjusted to the regional production process. Thus, the regional IO tables received provide a good basis for further analysis and forecasting.

However, the authors hold the opinion that the survey-based method is more accurate and provide proper input structure for a separate region. Under the circumstances the authors have constructed by own forces regional IO tables for the Republic of Bashkortostan (Sayapova, 2004). The tables are based on the System of National Accounts, and The United Nations Handbook of Input-Output Table Compilation and Analysis (1999). The IO tables for the Republic of Bashkortostan are constructed in the dimension of 227 commodities for the year 1995 and in the dimension of 25 aggregate sectors for the year 2002. The detailed IO table for the year 1995 was developed from a large-scale inter-industry regional study and served as a base for further compilation of the aggregate IO table. Thus, the Republic of Bashkortostan is nowadays the only Russian region where such a study has recommenced.

## 3. The Compilation Process: Methodical Problems and Table Balancing

While compiling the tables the adjustment of the SNA principles to a separate-region economy was needed. Besides, we had to fill up a gap in regional statistics and utilize indirect estimations where possible. Primarily we assessed the first quadrant of an aggregate 22-sector IO table (Sayapova & Sutiagin, 2001, and Sayapova, 2003). The latter was used to estimate technological coefficients which provided a basis for further simulations. However, the principal drawback of such an assessment was in potential imbalances: it was not possible to verify the coincidence of the supply and use flows. In order to balance the IO table all the components including the IO direct coefficient

matrix need corrections. Given the fact the balancing process can be applied only to disaggregate IO tables we had to compile a detailed IO table for the year 1995 in accordance with the national statistical classification on IO tables (*i.e.* in the dimension of 227 commodities).

To balance a symmetric IO table at purchases' prices information on taxes on products, trade and transport margins is required. However, there is no official data on the VAT and excise structure at the regional level. So, to allocate the total amount of VAT and excises (the information officially provided by the regional tax authority) we proposed to extend the VAT and excise structure typical for the national economy at the regional level. In other words, we calculated the VAT and excise-to-supply at purchasers' prices ratio by each product group for the national symmetric IO table. Then, we applied this ratio to the regional supply at purchasers' prices. Thus, we received the VAT and excise structure for the Republic of Bashkortostan in the dimension of 227 product groups.

As for export taxes and taxes on imports concerns, regional statistics is available only for 22 aggregate sectors. So we proposed to redistribute taxes in the detailed IO table proportionally to export and import volumes within each of aggregate product groups. In our case we resorted to this simple assumption because homogeneous products are usually taxed by the same rates.

The procedure of trade and transport margins estimation also differs for a separate region. In fact, the openness of the regional economy results in poor statistical registration of trade and transport margins. For instance, there are no official statistical data on railroad transportation in the Republic of Bashkortostan. Under the circumstances we experienced from the VAT and excise structure valuation, applying the same method to trade and transport margins.

As we have already mentioned in the paper the balancing technique implies that goods and services used for intermediate consumption, final consumption and gross capital formation are provided by supply domestically produced and imports (*i.e.* the use of goods and services equals the supply). However, information on the supply and the demand sides comes from different sources, consequently, imbalances may arise. This involves inauthenticity of primary data, underreporting, improper valuation of data or mis-classification. Also, the unofficial sector in the economy may cause discrepancies between the supply and the use flows[1]. In this case primary statistical reports for disaggregated industries should be carefully re-examined. Sometimes intimate knowledge can also be helpful.

While balancing the regional IO table we applied, step-by-step, a series of procedures and methods. At the first stage we analyzed commodity flows along the rows (*i.e.* in pattern of use). Then, we adjusted commodity flows within separate blocks of industries, each block comprising industries closely related in terms of input requirements[2]. At the third stage we performed a comparative analysis of structural parameters with the analogous ones for previous years. Thus, we managed to evaluate

[1]For instance, while balancing the IO table for the year 1995 we discovered that the supply of crude oil exceeded considerably its use. Latter, we found out that the discrepancy could be attributed to crude oil on give and take basis, which was not accounted in the regional economy.

[2] *see* The United Nations Handbook of Input-Output Table Compilation and Analysis (1999), pg. 186.

structural shifts in the regional economy over the 1982 to 1995 period. At the last stage we utilized the RAS-method to compute an adjusted matrix of intermediate demand.

So, the work on compilation of IO tables for the Republic of Bashkortostan resulted in the detailed IO table with a breakdown of 227 product groups for the year 1995, which further provided a basis for the aggregate 25-sector IO table for the year 2002[3]. Unfortunately, the latest IO table available under the planned economy framework refers to the year 1982, since the regional IO table for the year 1987 omitted because it was not compiled. Anyway, a time-series of IO tables for the years 1982, 1995 and 2002 permits to reveal structural shifts in the regional economy over a 20 year period.

## 4. Analysis of Structural Shifts in the Republic of Bashkortostan over the 1982 to 2002 period

In order to study trends on structural changes, it is necessary to have a time-series of IO tables with the same sector classification. However, the IO table for the year 1982 was compiled in the dimension of 110 industries, whereas the one for the year 1995 – in the dimension of 227 product groups. Consequently, since adjustment of nomenclatures required, the IO table for the year 1995 was aggregated up to the 110-industry working level.

Diagonal elements of the two IO matrices were thoroughly examined (*see* Figure 1). These ones are not distorted by price movement and reflect directly technological changes in intra-industry primary inputs. In our case, almost all the industries experienced negative changes in the depth of primary goods processing over the 1982 to 1995 period (this process is illustrated in figure 1 with diagonal elements decrease). For instance, high-technology production was rolled up in petrochemical industry (higher fatty alcohols, synthetic fatty acids *etc.*).

*<Figure 1>*

As for power generation concerns, intra-industry primary inputs increased 2.4 times between 1982 and 1995. Since power generation refers to basic economic sectors, an analysis of inter-industry flows was provided. Eventually, it was ascertained that energy and fuel intensity jumped in all the regional economy's key sectors. In our opinion, this may be argued for three major reasons. First, regional output reducing almost twice entailed additional costs to maintain idle capacities. Second, high energy consuming industries increased their share in the regional economy (*N.B.* oil refining industry of the Republic of Bashkortostan holds the first place in crude oil refining among the Russian regions). Third, and most important, the lack of energy-saving technologies resulted in energy and fuel consumption steady increase.

Further, we evaluated structural changes in final demand. Here, a remarkable shift was revealed in the structure of households' consumption: the share of food industry dropped from 48.5% to 38.1% while the share of agriculture increased from

[3] The detailed IO table for the year 1995 is compiled by Sayapova, A.R., Mazitova, L.D., Gabdullin, A.R., Shamuratov, N.M., under the leadership of Sayapova, A.R. The aggregate IO table for the year 2002 is compiled by Sayapova, A.R., Abdrashitova, A.R., Ishbulatov, R.S. under the leadership of Sayapova, A.R.

15.0% to 22.7%. We have sufficient ground to assume that this shift was caused by economic recession, which provoked, in its turn, the revival of subsistence farming.

The diversity of the regional economy decreased, in particular, due to manufacturing sector. Indeed, the economy was represented in 97 of 110 industries in 1982 (*i.e.* 88% of the total amount) and only in 165 of 227 product groups in 1995 (*i.e.* 73% of the total amount). As for regional trade-flows concerns the share of regional imports[4] to total supply dropped from 23% in 1982 to 20% in 1995. Similarly, exports from the region[5] decreased from 42% to total output in 1982 to 25% in 1995.

In fact, the tendency in regional exports was examined in greater detail. The following structural shifts were revealed. First, the share of oil and gas industry in regional exports remained relatively constant between 1982 and 1995 at 50% (since its value in absolute terms reduced almost twice). Then, the share of chemical and petrochemical industry rose from 15.7% to 21.5% (regional export volume reduced by 25%). Finally, the share of machinery and equipment dropped from 12.1% to 7.5% (regional export volume reduced by 50%).

Further, we evaluated structural shifts in the regional economy over the 1995 to 2002 period. However, comparative analysis of IO tables for the years 1995 and 2002 at 1995 constant prices didn't show changes either in the regional output or in gross regional product structure (*see* Figure 2). Indeed, structural shifts did take place, particularly, due to price effects which played a major role during the period, and that could closely be followed through IO tables at current prices. For instance, price distortions caused stagnation in manufacturing and agriculture, whereas export-oriented regional sectors and trade gained. On the other hand, we followed positive structural shifts in households' consumption expenditures. It was ascertained that the share of food product expenditures dropped, that, probably, indicates a certain increase in living standards among population.

*<Figure 2>*

So, a time-series of IO tables for the years 1982, 1995 and 2002 at 1995 base prices provided a benchmark for comprehensive structural analysis. It should be noted that the IO table for the year 2002 further served as a basis to simulate different scenarios of regional economic development.

## 5. Study on Stability of IO Coefficients

This part of the paper concerns regional scenario-based studies applying a tool of IO modelling. With the aggregate IO table on hand for the Republic of Bashkortostan we could forecast regional economic development starting from the year 2002. However, we still had some hesitations if it was correctly to use IO coefficients for further medium-term simulations. These doubts arose from uncertainty in stability of technological coefficients in the aggregate IO table. Since IO modeling is based on this fundamental assumption we find it necessary to clear up the point why, after all, we decided to use the IO coefficient matrix for the year 2002 as a tool for medium-term macroeconomic analysis and forecasting.

[4] Regional imports are divided into imports from abroad and imports from other regions.
[5] Exports from the region are divided into exports of commodities abroad and exports of commodities to other regions in the country.

It is generally acknowledged that technological coefficients should be revised every five to ten years from large-scale enterprise surveys. In fact, there are two major factors which determine the stability of IO coefficients and can't be ignored. First, IO coefficients are influenced by new technologies which, usually, involve the most important changes in economic linkages. Second, price distortions cause changes in IO coefficients estimated at current prices. As for the Republic of Bashkortostan concerns, these factors influence the stability of IO coefficients in different ways. On the one hand, the lack of capital investment resulted in relatively constant technologies; on the other hand, asynchronous price changes provoked instability of IO coefficients in the regional economy. Price effects, however, can be eliminated by estimating IO tables at constant prices. Moreover, we assert that an IO coefficient matrix at constant prices can serve as a basis for total output or final demand simulations. Below we provide a mathematical proof.

Let $Y$, $Y^k$ be the column vectors of final demand at base prices and at *k*-year prices, correspondingly;

$X$, $X^k$ - the column vectors for industry total output at base prices and at *k*-year prices;

$A$, $\tilde{A}$ - the IO direct coefficient matrices at base prices and at *k*-year prices;

$B$, $\tilde{B}$ - the Leontief inverse matrices or total requirements at base prices and at *k*-year prices;

$I_1,..., I_n$ - prices at the year *k* relating to base year prices, or price indices in sectors 1 through *n*;

Notice, that *k* denotes a year for which a forecast is provided.

We affirm, that final demand at the year *k* can be calculated through IO coefficients and total output revalued at *k*-year prices, or equally through final demand at base prices (thus, calculated through IO coefficients at base year) weighted with price indices.

Indeed, the IO coefficient matrix at *k*-year prices can be written as follows: $\tilde{A} = IAI^{-1}$ ; or in terms of input-output coefficients: $\tilde{a}_{ij} = a_{ij}\frac{I_i}{I_j}$, where $I$ – is a diagonal matrix version of price indices $I_i$.

Then,

$$Y_i^k = x_i I_i - \tilde{a}_{i1}x_1 I_1 - ... - \tilde{a}_{in}x_n I_n = x_i I_i - a_{i1}\frac{I_i}{I_1}x_1 I_1 - ... - a_{in}\frac{I_i}{I_n}x_n I_n =$$

$$= (x_i - a_{i1}x_1 - ... - a_{in}x_n)I_i = Y_i I_i, \quad i = 1,..., n.$$

Accordingly, $\tilde{B}$ - the total requirements matrix at *k*-year prices can be written as follows:

$$\tilde{B}=(E-\tilde{A})^{-1}=(E-IAI^{-1})^{-1}=(IEI^{-1}-IAI^{-1})^{-1}=(I(E-A)I^{-1})^{-1}=I(E-A)^{-1}I^{-1}=IBI^{-1}$$

(it is known that for non-singular matrices $(ABC)^{-1}=C^{-1}B^{-1}A^{-1}$).

Hence, $\tilde{B}=IBI^{-1}\Rightarrow\tilde{b}_{ij}=b_{ij}\frac{I_i}{I_j}$.

Consequently,

$$X_i^k=\tilde{b}_{i1}y_1I_1+...+\tilde{b}_{in}y_nI_n=(b_{i1}y_1+...+b_{in}y_n)I_i=$$

$$=(\sum_{j=1}^{n}b_{ij}y_j)I_i=X_iI_i,\quad i=1,...,n.$$

Thus, the vector of total output at the year *k* can, also, be calculated through total requirements matrix at base year with further recalculation of total output at base prices in *k*-year prices. Moreover, if forecasts are specified at growth rates there is no need to use price indices. The aforesaid gives grounds to make medium-term forecasts directly from the IO coefficient matrix at base year.

**6. IO scenario-based approach to the regional economic development**

Scenario-based IO modeling assumes varying the total output or final demand indices on the principle "what happens, if…". In our studies on the regional economic development we dealt with a number of scenarios, but in this paper we would like to focus on a few ones, which are the most interesting in our opinion.

The first scenario released for the Republic of Bashkortostan is normative or target-oriented. In 2002 regional per capita consumption of food products was below the national average. Moreover, there was a decrease in the regional per capita consumption of food products in physical units from the early 1990$^{th}$. So, we proposed to analyze a scenario of increasing consumption up to normative standards[6] among population. It was ascertained that the attainment of rational consumption rates by population stimulates regional output for sugar – by 35%, confectionery – by 100%, meat and meat products – by 30%, milk and dairy products – by 50%, assuming regional import flows being fixed. On the whole, regional output in crop production and livestock farming rises by 10% and 14% correspondingly. Since other industries are closely involved in economic linkages, a new total output in food industry requires regional output increases in power generation – by 5%, oil refining industry – by 1.5%. As a result, GRP grows at 4.7%, while regional total output – at 5.4%, comprising two-percentage increase due to multiplicative effect.

IO analysis can be used to estimate economic effects caused by changes in unit costs. According to expert estimates energy and fuel intensity can be reduced in the region by 10%, material intensity – by 8%. However, there is no official statistical data for most of unit costs. To be more precise, information is available merely on energy and fuel intensity. Under the circumstances, IO coefficients fill a gap in regional

[6] The standards are fixed by Academy of Medical Sciences.

statistics providing valuable information on unit costs. Applying the tool of IO modeling we ascertained that energy and fuel intensity decrease by 10% results in GRP increase by 3.5%, while material intensity decrease by 8% involves GRP increase by 9%.

Price scenarios for the regional economy were considered as well. It is known that $\Delta p_i = \frac{b_{ji}}{b_{jj}} \Delta p_j$, where $\Delta p_i$ - change of price index in industry *i*, $\Delta p_j$ - change of price index in industry *j*, $b_{ij}$ - total requirements coefficients. Consequently, we could estimate the influence of price increasing in one sector on price movement in other sectors. Here we provide the most important results.

Since the regional economy is heavily dependent on natural gas supplies, we calculated the scenario of gas price increase in the region up to the free-market level. We ascertained that each percentage of gas price increase contributes 0.08% to the regional inflation rate. As it was expected, the most significant price changes occur in power generation, chemistry and utilities (*see* Figure 3).

*<Figure 3>*

Similarly, when the price of electricity goes up by 1%, the price in utilities increases by 0.02%, in transport – by 0.17%, a general increase in the prices equals 0.18% for the region.

IO analysis can also be helpful to estimate multiplicative effects caused by upsizing industries in the regional economy. In our case we turned to a large-scale capital investment project in chemical industry, which is one of the key regional sectors. The project concerns the expansion of manufacturing capacities at the regional giant "JSC Polief" by launching a new export-oriented production line. As a result, the sum of output increases in basic chemical products (code 023[7]), artificial fibers and filaments (code 024), and synthetic dyes (code 030) is planned at the level of 70%.

The investment project should contribute 3.3% to the GRP growth and 3.5% to the regional total output increase (1.9% falls on multiplicative effect). Moreover, if price conjuncture for chemical products on world markets is favorable, GRP rises by 5.4%, and regional output – by 6% (multiplicative effect contributing 3.8%). While realizing the scenario we had to examine carefully the use of production capacities through industries. So, we discovered that almost all the industries have idle capacities and, consequently, can easily meet increased domestic demand. The latter gives grounds to assert the attainability of economic effects argued for in the scenario.

Indeed, many different scenarios can be considered with a tool of IO modeling depending on the purposes of research. For instance, IO tables for the Republic of Bashkortostan can be applied to estimate ecological situation in the region and to evaluate the total amount of investments required for nature protection activity.

[7] The items are given according to Russian classification on 227 product groups. This one may differ from other countries' classifications.

## Conclusion

Summing up aforesaid, we find it necessary to underline that the tool of IO modeling can be successfully applied to regional researches. It provides basis for comprehensive macroeconomic analysis and forecasting. Unfortunately, the work on compilation of regional and multiregional IO tables is not provided by the National Statistics Office. Nowadays there are some private developers of regional and multiregional input-output tables. Almost all the researchers apply an IO direct coefficient matrix derived from a symmetric IO table for the national economy to a separate-region economy. In this case, however, improper technological coefficients can be received, because the regional input structure differs from the national one. Under the circumstances, the authors compiled the symmetric IO table for the Republic of Bashkortostan from a large-scale regional Enterprise survey for the year 1995. The adjustment of the SNA methods was needed to bridge the gap between the available statistical data and the data required. We managed to solve methodical problems concerning the incompleteness of regional statistics in regional trade flows, taxes, and trade and transport margins.

After all, we argue that compilation of regional IO tables is necessary for purposes of territory planning. With IO tables at one’s disposal studies on regional economic development can be done. Structural analysis is possible as well if IO tables are compiled for a separate-region economy on regular basis. However, adequate statistical data base is required, as well as large-scale enterprise surveys on sub-national level to provide a snapshot of the national economy.

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## Figures:

**Figure 1: IO diagonal coefficients for the Republic of Bashkortostan: 1982 and 1995**

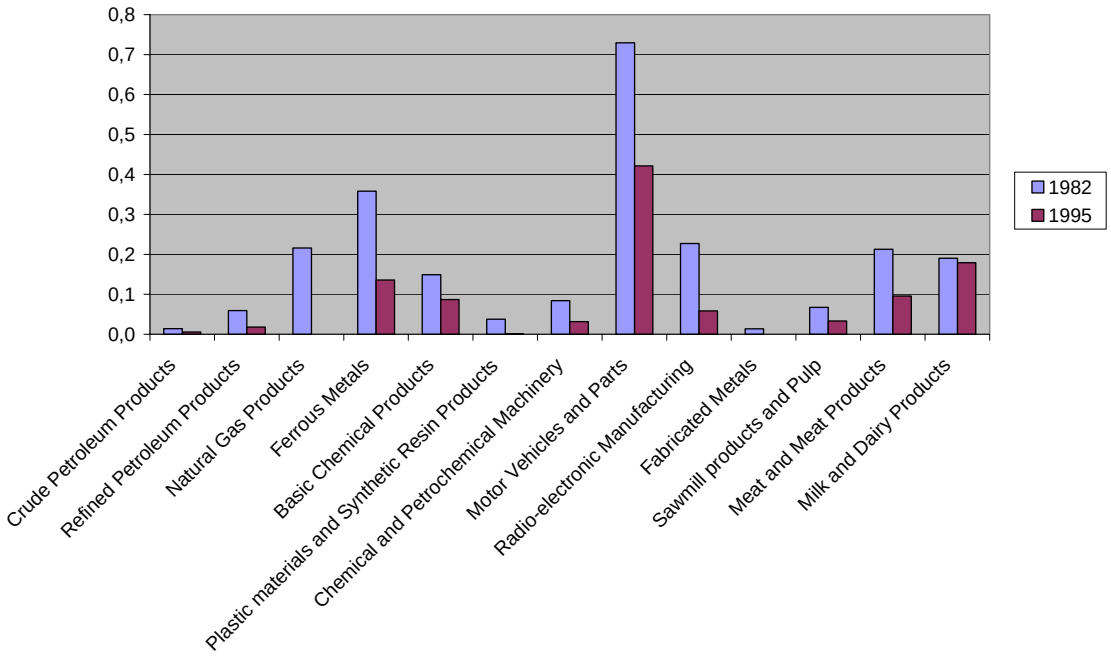


**Figure 2: The GRP structure in the Republic of Bashkortostan for the years 1995 and 2002 at 1995 constant prices**

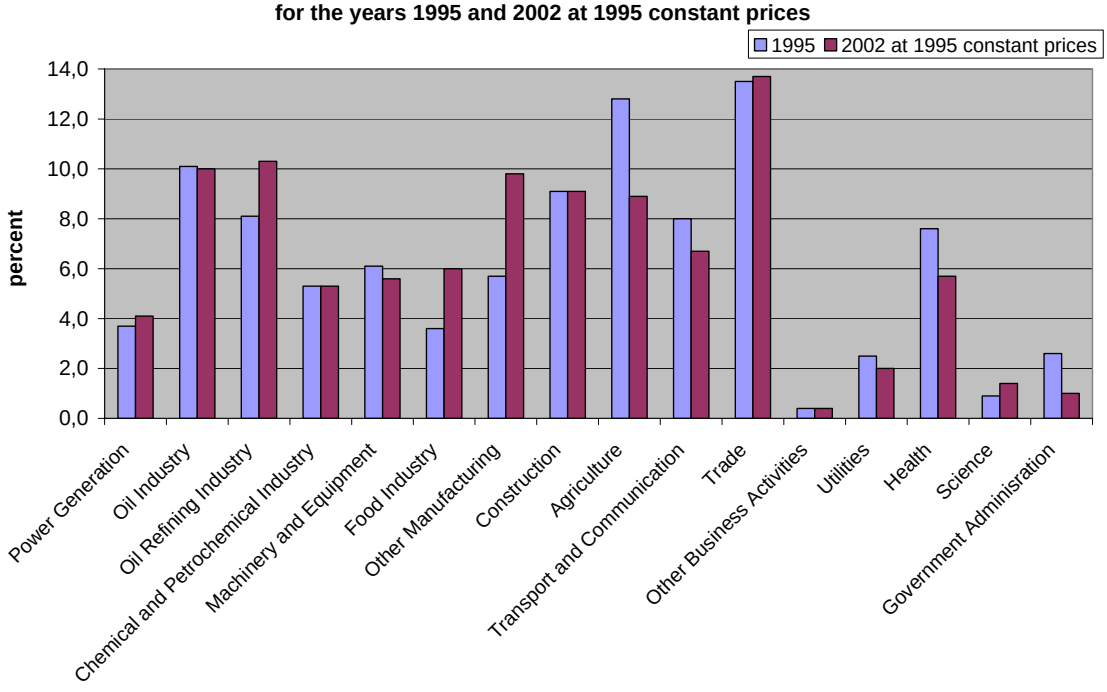

**Figure 3: Price changes in response to each percentage gas price increase**