It is desirable to model problems that arise during the examination of processes occurring in the economy at a macrolevel so as to reveal laws which reflect economic reality and to forecast the behavior of the economy as an integral system bound by a multitude of varied links and mutual dependencies. Along with indicators such as GNP, price level, and volume of money supply and investments, employment level in the economy generally and in its individual industries, as well as unemployment level, are no less significant for their monitoring and forecasting.

The current tense situation in the labor market arose both because of the structural crisis and production slump, and because the government practically surrendered its regulatory role in job supply. The latter is connected, first and foremost, with sluggish investments. Lack of proper attention to employment prospects when drafting and implementing economic policy causes a regress in the employment structure. Today’s labor market has the following specific characteristics.

The employment situation is, paradoxical: since 1990, the volume of production dropped 50%, but the number of people employed has gone down by only 10 million. Aggregate statistics do not reflect the real situation in the different sectors and industries. Employment went down in two-thirds of the industries. The largest reduction took place in some branches of the fuel industry, engineering and metalworking, while the smallest occurred in food industry (Table 1). Meanwhile, in oil production, and oil refining employment has been rising.

The inadequate funding of scientific research and its servicing, education, culture, and art is perpetuating the trend toward lower employment in these spheres, which produces a higher supply of labor—an increase in the number of released people, some of whom find jobs in the private sector, and others join the ranks of the unemployed. Trade and banking have so far been unable to make up for the employment slump in production and science, and at present, this is even more unlikely. This makes it all the more important to support self-employment in trade and brokerage.

Russian unemployment has a predominantly structural form, in other words, is a result of the qualitative incompatibility between the demand for jobs and their supply in the new economic sectors. By our estimate, it accounts for 30–40% of total unemployment [1, 2]. According to the RF Ministry for Labor, the list of vacancies submitted to the employment services was usually confined to 20–25 occupations, most of them low-paid and unskilled. The financial and banking crisis aggravated the problem of structural unemployment, having caused a reduction of vacancies and an

Table 1. Rate of change in numbers of people employed in the individual industries of the Russian economy (% of year before)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Light industry</td>
<td>96.02</td>
<td>82.27</td>
<td>94.52</td>
<td>91.93</td>
<td>83.58</td>
<td>86.99</td>
<td>84.96</td>
<td>–57.61</td>
</tr>
<tr>
<td>Engineering and metalworking</td>
<td>96.49</td>
<td>92.22</td>
<td>93.47</td>
<td>84.73</td>
<td>90.00</td>
<td>92.11</td>
<td>90.40</td>
<td>–47.19</td>
</tr>
<tr>
<td>Forestry, timber industry, pulp-and-paper industry</td>
<td>98.59</td>
<td>101.13</td>
<td>93.96</td>
<td>91.53</td>
<td>90.34</td>
<td>92.05</td>
<td>87.98</td>
<td>–37.27</td>
</tr>
<tr>
<td>Coal industry</td>
<td>103.26</td>
<td>102.90</td>
<td>102.27</td>
<td>87.65</td>
<td>93.95</td>
<td>96.25</td>
<td>90.28</td>
<td>–22.24</td>
</tr>
<tr>
<td>Food industry</td>
<td>101.62</td>
<td>93.56</td>
<td>105.08</td>
<td>97.75</td>
<td>96.53</td>
<td>99.81</td>
<td>95.08</td>
<td>–10.54</td>
</tr>
<tr>
<td>Housing, utilities, and communal services</td>
<td>98.20</td>
<td>94.59</td>
<td>99.81</td>
<td>101.25</td>
<td>98.66</td>
<td>107.51</td>
<td>104.79</td>
<td>4.33</td>
</tr>
<tr>
<td>Oil refining</td>
<td>95.65</td>
<td>101.56</td>
<td>114.77</td>
<td>100.32</td>
<td>100.78</td>
<td>107.61</td>
<td>93.05</td>
<td>12.86</td>
</tr>
<tr>
<td>Electricity production</td>
<td>107.64</td>
<td>106.35</td>
<td>113.12</td>
<td>100.37</td>
<td>103.48</td>
<td>106.30</td>
<td>101.22</td>
<td>44.71</td>
</tr>
<tr>
<td>Oil production</td>
<td>113.63</td>
<td>107.60</td>
<td>116.50</td>
<td>100.56</td>
<td>106.02</td>
<td>115.60</td>
<td>91.91</td>
<td>+55.05</td>
</tr>
<tr>
<td>Gas production</td>
<td>106.24</td>
<td>102.18</td>
<td>109.31</td>
<td>103.22</td>
<td>114.97</td>
<td>108.48</td>
<td>113.04</td>
<td>72.68</td>
</tr>
</tbody>
</table>
inflow, apart from the usual contingent, of applicants from the financial sector.

There is also regional structural unemployment. The situation in the regional labor market evolved in such a way that the structure of vacancies incompatible with the structure of unemployment, given a stable trend toward longer duration of unemployment, has become a problem whose solution depends, first and foremost, on funding. If adequate measures are not taken, the result may be a rise of real and potential migration from the Russian Federation in the future.

The principal clients of the employment service are people who find it hard to find a job relying on their own resources, people with a low level of skills, insufficient experience, and those who are unable to cope with life changes and professional difficulties. Half of them stand in special need of social protection. The dominant place in the structure of registered unemployment still belongs to people (mainly women) who voluntarily gave up or lost permanent jobs more than a year ago.

Up to 1997, the increase in the number of unemployed people was mainly caused by high labor turnover. However, since the beginning of that year, the share of people dismissed by companies in the overall volume of registered unemployment began to rise (from 22.7% in 1996 to 26.4% in 1997). This can be explained both by the liquidation and reorganization of enterprises and industries and the introduction (since May 1996) of benefits for certain categories of released people into the new laws on employment. One-fifth of the registered unemployed lost a job due to staff reductions. And yet most unemployed have left their jobs of their own free will, although their share went down from 46.8% in 1996 to 42.2% in 1997.

The economic crisis, which came to a head in August–September 1998, had a negative effect on the employment sphere. Its consequences may, however, prove controversial. The crisis affected finances, banking, and trade and led to decrease in the number of newly and earlier advertised jobs, reduction of employment and, in consequences, higher unemployment. But, since banking and finances are a specific field of activity, it can be assumed that most dismissed people will not apply to the employment service but will try to find another job in the same field using informal contacts.

By the mid–1999, the number of unemployed, estimated by International Labor Organization methods, exceeded 14% of the able-bodied population; according to Goskomstat, it was approximately 10.5 million people. As for those officially registered as unemployed by the employment service, their number has recently been decreasing and is now approximately 1.8 million, or 2.5% of the able-bodied population.

Employment depends not only on the trends in production dynamic and structure but also, in a large measure, on the degree of government involvement in the regulation of employment and the labor markets (regional, sectoral, and professional) to minimize the social and economic costs that arise because of a clash of trends in modern Russian economic development. In the current tense labor market situation, comprehensive balanced actions aimed at maintaining employment and curbing unemployment are of special significance. Promising steps include: encouraging able-bodied unemployed to independently look for a job; creating incentives for people to find jobs in the countryside by giving the new arrivals land plots and removal grants; tightening control over the inflow of cheap labor from the near abroad; encouraging Russian citizens to seek temporary employment abroad; offering temporary employment while a permanent job is sought, so as to reduce social tensions in the labor market.

In this connection, the modeling of processes taking place in the economy is a promising research trend, because a detailed picture of current processes in individual industries makes it possible to adequately evaluate and forecast the state of employment and the overall situation in the Russian labor market. We shall take a look at the findings of our examination of the sectoral functions of employment.

At first sight, employment level and demand for labor are synonymous and interchangeable. Demand for labor may be defined as the amount of labor that a producer is prepared to pay for over a certain period of time at a certain wage rate. However, the demand for labor may not be identified with employment. Besides the factors that “monodirectionally” affect both demand and employment (e.g., ones associated with technological progress), there is a group of factors whose operation is not one-dimensional due to the faults in the use of capital and labor and the inefficiency of the labor market. The results of their operation include a deviation of real employment from demand for labor. The main thing here is the efficiency of the use of fixed productive capital, because at a fixed volume of production an industry’s demand for labor depends, above all, on available capital, which labor should set into motion.

The wages/labor fund theory as the foundation of classical political economy, which considers relations between labor and capital formed in the process of production, asserts that the demand for labor is determined by the part of the capital that the employer uses to maintain production and preserve labor. According to Adam Smith, the demand for people who live by wages can rise only in proportion to the increase of the capital designated for the payment of wages. This capital can be of two kinds: first, excess of income over the size required to maintain the masters; second, excess of capital over the size required to give employment to the masters themselves. So the demand for people who live by wages necessarily increases with the rise of income and capital, and cannot increase in the absence of such a rise [3]. Meanwhile, in modern economic theory the demand for labor is determined by the cost of the man-
Production requires a certain amount of labor and capital (equipment): the available technology correlates these values. It follows that the forecasting value of demand for a product determines the required number of people employed in the economy. So, technology and the demand for product in theory directly determine the demand for labor and, correspondingly, the requisite employment level. To assess and forecast the economy’s demand for labor, we may represent the demand for a product by gross output, and technology, by fixed assets per worker.

Complex modeling of the sectoral dynamic of employment in the economy, which reflects multiple mutual links, is a multistage process of the model’s consecutive improvement and expansion on the basis of statistical analysis and verification of results. The original problem in the development of adequate tools for forecasting employment and its structure, is finding the theoretical functional interconnection between the variables concerned. This problem can be solved using the following approach. Territorial, sectoral, professional, qualification- and skill-based, educational, and other labor structures are formed largely under the impact of the movement of both jobs (creation, improvement, and abolition), which forms the production’s demand for labor, and the population and labor resources in its various forms. Thus a forecast of the employment structure should aim at coordinating the movement of jobs and the movement of the population and labor resources in terms of all their forms and all levels of the economy (country–region–industry/sector). At a federal or regional level, these processes can be described by autonomous sets of forecasting models united into two blocks, “labor demand forecast” and “labor supply forecast.” At the interface of these blocks, the expected demand for labor is tested for correspondence to its supply by analyzing the movement of population and labor resources, whose forecast is, in this case, exogenous (for details, see, e.g., [4, 5]).

This approach, especially as regards forecasts of labor demand, was applied through econometric models for estimating the expected demand for labor in Russia’s industries. Analysis of employment, its structures and dynamics is based on a broad range of demographic, economic, and social information, contained mainly in statistical reports, while the method of balances is the principal tool for recording and forecasting labor resources at a macrolevel.

A substantial part of information regarding employment in the base period will be found in reported summary balances of labor resources and accompanying estimates. Such materials are drafted for the Russian Federation as a whole, for the economic regions, republics, krais, oblasts, and the bigger cities. Balances of labor resources is the foundation for drafting forecasts for labor distribution among the industries and employment spheres.

We used the summary balances of labor resources in average annual terms to identify lasting trends in the evolution of employment and its sectoral structure in connection with the dynamics of the principal macroeconomic development indicators described in terms of the national accounts system and interindustry balance. To deal with this task, the available statistics had to be re-examined. In other words, it proved necessary to:

—make sure that the dynamics of employment indicators in the various industries are comparable throughout the entire period (1980–1997) taken as the base one in the study;

—estimate employment in terms of the balance of labor resources, mainly on the basis of data about the number of people employed in production in individual industries; and

—link up employment indicators in sectors and industries with the dynamics of production, capital, wage, etc.

This preliminary processing of initial statistics pertaining to the balances of labor resources ensured that our indicators were comparable with the population and work force dynamics.

Naturally enough, information about sectoral employment cannot provide answers to many concrete questions regarding the dynamic of the labor market and the use of labor resources: this task can be fulfilled by an analysis of a broad range of statistics belonging to a different category.

Classical econometric models of employment evaluation were built on the basis of functions inverse to traditional production ones; these were usually two-factor functions where the dynamics of gross output and fixed capital were present as explanatory variables.

A typical example of a sectoral labor force employment function is function $Y = f(F, L)$ derived from the production function. The $L$ factor is the expenditure of live labor and is usually measured as the number of people employed in a given industry. Occasionally, data about working hours or wages are used. In sectoral problems, independent variables $F$ and $L$ are often complemented by other factors, e.g., production level during the preceding period, the effect of scientific and technological advances, the fixed capital use index, the labor force skill index, the influence of production in related industries, import, and specific factors in individual industries (especially agriculture). So if $Y = f(F, L)$ is a production function, expressing $L$ as a dependent variable, we shall obtain the labor demand function: $L = g(Y, F)$—here, employment is a function of the end product and fixed capital.

Under economic crisis, when production efficiency drops, models of this type are not easy to build.
To raise the quality of econometric models, we attempted to use new factors adequate to current economic realities, for example, data about calculated (but not necessarily paid) wages. The economic experiments of the past few years have substantially changed the price proportions formed in the Soviet economy, including the price of labor. In 1980, the ratio of the size of the average calculated wage varied from 0.8 in the light industry to 1.6 in the coal industry. By 1996, this gap widened—from two to eight times; the light industry, as before, was an outsider, and the gas industry was the leader.

At present, all industries can be categorized into three groups by the dynamics of the work force size.

The first comprises industries where employment is increasing: fuel and energy (with the exception of the coal industry) and nonferrous metallurgy, where the employment level remains higher than in 1990, although the number of people employed is going down.

The second group includes ferrous metallurgy, the chemical and petrochemical industry, and the food industry. The reduction of the work force there is lower than on average in industry.

The third group includes industries where labor is released at a fast rate: the building materials industry, the timber industry, the pulp and paper industry, engineering, metalworking, and the light industry.

This categorization correlates with the indicator of the ratio of the average wage in individual industries and in industry generally. In the first group, it is 1.8–3.6 times; in the second, 0.9–1.3 times, and in the third, under 0.9. It became actually possible to use this factor in equations for electric power engineering, oil production, and the coal industry.

Let us introduce the main symbols and consider the correlations used at this stage of the study. Its basis was provided by the Cobbs–Douglas production function \( Y = aK^{\alpha}L^{\beta} \), \( \alpha > 0, \beta > 0 \), where \( Y \) is gross output, \( K \) is capital expenditure, and \( L \) is labor expenditure.

To estimate the volume of employment in industries \((LE_t)\), the natural logarithm of the volume of labor expenditure), the following explanatory variables were selected:

\( LC_t \) —natural logarithm of the volume of fixed capital;

\( LO_t \) —natural logarithm of gross output;

\( LW_t \) —natural logarithm of the ratio of average wages in the industries to the average wage in the economy;

\( T_t \) —trend variable presented by a natural series;

\( D_t \) —dummy variable determined in the following way:

\[
D_t = \begin{cases} 
1, & O_t/O_{t-1} < 1; \\
0, & O_t/O_{t-1} \geq 1,
\end{cases}
\]

where \( O_t \) is gross output in period \( t \).

\( DC_t = D_tLC_t, DO_t = D_tLO_t \) are variables which are products of the logarithms of fixed capital and gross output, and variable \( D_t \) respectively.

Variable \( LC \) reflects the influence of available capital in an industry upon the possibility of increasing employment in it or the need to decrease it; variable \( LO \) reflects the influence of the demand for an industry’s product upon employment in this industry.

Variable \( LW \) determines employees’ preferences as regards their employment in an industry with a wage ratio differing from that in the economy generally, because if its level is higher, it may affect the employee’s choice, for instance, compensating for hard labor conditions.

Variable \( T \) is used to identify the trend component in the gross output logarithm, the volume of fixed capital, and value \( LW \). These indicators are temporal serials, which means that both the explained and the explanatory variables may contain monodirectional upward- or downward-bound trends causing a false correlation between these parameters. So, a high coefficient \( R^2 \) need not reflect the genuine interdependence between the values concerned. This problem can be solved by the introduction, as an explanatory variable, of a determined trend component, which makes it possible to more adequately monitor the link between the level of employment, \( LE_t \), and the previously selected explanatory factors.

Fictitious variable \( D \) is built as a function of the rate of growth of gross output over the current period. So, the statistically significant variable \( D \), changing the value of the regression equation constant, reflects the following: a fall in output throughout the economy causes a change in employment in a given industry. Variable \( D \) explains the rise or decrease of employment in the industries that are especially sensitive to slump.

A decrease of gross output can also be regarded as a lower demand for the industry’s product, which in its turn should produce a reduction in the demand for labor and, in consequence, lower employment. Variable \( D \) relates changes in employment level to gross output both in the current and in the previous period, that is, this variable reflects also the lag between output and employment. Variable \( D \) can also be interpreted as economic agents’ transformed expectations regarding the evolution of the situation: production decline as compared to the previous period can shape both negative
and positive expectations regarding the economy’s further development, thus affecting economic activity.

Variables $DC$ and $DO$, which are obtained as the product of fictitious variable $D$ and variables $LC$ and $LO$, reflect the following: the very fact of the decrease of gross output in the economy from the previous period exerts an influence on the value of fixed capital and the output of goods and services itself, and this, in its turn, affects employment.

Unlike variable $D$, which changes the regressive equation constant, variables $DC$ and $DO$ in the case of $D = 1$, that is, a decline of gross output, change the coefficients with, correspondingly, variables $LC$ and $LO$.

The estimated relationship can be presented in a general form:

$$LE_t = \beta_0 + \beta_1 LC_t + \beta_2 LO_t + \beta_3 LW_t + \beta_4 T_t + \beta_5 D_t + \beta_6 DC_t + \beta_7 DO_t + \epsilon_t,$$

or

$$LE_t(D = 0) = \beta_0 + \beta_1 LC_t + \beta_2 LO_t + \beta_3 LW_t + \beta_4 T_t + \epsilon_t,$$

$$LE_t(D = 1) = (\beta_0 + \beta_2 + \beta_3) + \beta_1 + \beta_0) LC_t + \beta_5 D_t + \beta_6 DC_t + \beta_7 DO_t + \epsilon_t,$$

where $\epsilon_t \sim N(0, \sigma^2)$.

The sought-for regressions were not evaluated in the form of (1), which is only an illustration of the dependence of employment on the selected set of factors and the influence of variables $D$, $DC$ and $DO$ on the form of the equation we evaluated.

Regressive equations were evaluated using the method of least squares for 25 industries on the basis of annual data for 1980–1997. The equations obtained were marked by high $R^2$ values (for two-thirds of the equations, they were over 0.9) and significant coefficients, with explanatory variables at 95% fiducial probability. Employment estimates which made use of obtained equations for the 1980–1997 base revealed a good smoothing capacity of the revealed regressive dependencies. Figure 1 shows a chart of the actual and estimated dynamic of the number of people employed in engineering and metalworking in the Russian Federation developed with the use of explanatory variables, $LO$, $D$, $T$.

At the same time, negative coefficients at the variables $LC$ and $LO$ in a number of industries presented a difficulty in building the sought-for dependences (Table 2). One way to deal with this problem is to expand employment equations, using fictitious variables.

Employment in the first three industries is a function of fixed capital, correlation of the wages by individual industries and in the economy generally, and the temporal trend. Fixed capital in short- and medium-term models is relatively stable and inelastic. It may form part of the employment equation either with a plus or with a minus sign depending on the prevalent effect. If the complementary effect prevails, the growth of fixed capital causes a simultaneous increase of employment; if it is the substitution effect, the expansion of fixed capital may substitute the growth of employment. This is probably the situation which is observed in the three above-mentioned industries, in which labor and capital are not so much complementary as substituting factors. Hence the minus sign before the relevant variable in the equations obtained.

In the two latter equations, there are also minuses at variables $LC$ and $LO$. At first sight, this situation is not typical. At the same time, according to expansion (2) and (3), each of these equations falls into two for different general economic situations, that is, for the recession period and for the non-recession period ($D = 1$ and $D = 0$, respectively):

- for agriculture and forestry
  at $D = 1$: $LE_t = -3.1159 + 0.8274 LC_t$,
  at $D = 1$: $LE_t = -10.82476 - 0.1062 LC_t$;
- for circulation, including commerce
  at $D = 1$: $LE_t = -8.10152 + 0.051773 LO_t + 0.0343 T_t$,
  at $D = 0$: $LE_t = -20.14182 - 0.8557 LO_t + 0.0343 T_t$.

In this form, the equations no longer present a problem as regards the interpretation of their substance and adequately describe the current economic situation.

In the sphere of circulation, during a recession a rise of gross output increases employment. Indeed, in a situation of uncertainty, when there are opportunities to derive high profits in relatively simple and painless ways, a rise of output in an industry (an indicator of its “prosperity”) attracts increasing numbers of people to it. Where there is economic growth, the situation in the sphere of circulation is transparent enough: the opportunities for getting superprofits sharply diminish. In this case, the dependence between an industry’s gross output and labor expenditure would be negative, because here, labor and fixed capital are substituting factors.
EMPLOYMENT IN THE RUSSIAN FEDERATION BY INDUSTRY: AN ESTIMATE

Table 2. Parameters of “problem” employment equations for some industries of the Russian economy

<table>
<thead>
<tr>
<th>Industry</th>
<th>const</th>
<th>LC</th>
<th>LO</th>
<th>LW</th>
<th>D</th>
<th>T</th>
<th>DC</th>
<th>DO</th>
<th>$R^2$</th>
<th>DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity production</td>
<td>16</td>
<td>-0.758</td>
<td>0.046</td>
<td>0.058</td>
<td>0.99</td>
<td>1.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t$-statistics</td>
<td>18.3</td>
<td>-6.18</td>
<td>2.3</td>
<td>9.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil production</td>
<td>9.567</td>
<td>-0.41</td>
<td>0.052</td>
<td>0.08</td>
<td>0.996</td>
<td>2.36</td>
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<td>$t$-statistics</td>
<td>19</td>
<td>-9.6</td>
<td>6.3</td>
<td>16.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas production</td>
<td>8.403</td>
<td>-0.49</td>
<td>0.084</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.23</td>
<td></td>
</tr>
<tr>
<td>$t$-statistics</td>
<td>10.9</td>
<td>-6.9</td>
<td>12.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>10.82</td>
<td>-0.106</td>
<td>-13.94</td>
<td>0.934</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.885</td>
<td>2</td>
</tr>
<tr>
<td>$t$-statistics</td>
<td>27.2</td>
<td>-3.9</td>
<td>-6.3</td>
<td>6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td>20.14</td>
<td>-0.856</td>
<td>-12.04</td>
<td>0.034</td>
<td>0.868</td>
<td>2.7</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$t$-statistics</td>
<td>7.3</td>
<td>-4.1</td>
<td>-2.8</td>
<td>3.9</td>
<td>0.85</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The processes that determined employment in the sphere of circulation during the Soviet period differ from those currently shaping the demand for labor in this sphere. This assumption can be illustrated by charts (Fig. 2), which show actual employment in the sphere of circulation and the expansion of the sectoral employment equation in different general economic situations we have described. The equation for $D = 0$, that is, for the growth period, adequately describes real employment before 1990 inclusive, while the equation for $D = 1$, that is, for recession, describes employment in the following period.

Figure 2 shows that the relevant equations before and after 1990 significantly deviate from real employment in the circulation sphere. This means that the fictitious variable used here can be seen as delimiting not only economic upturns and recessions, but also the mechanisms that generate them.

The employment equation in agriculture and forestry can be interpreted as follows: at the phase of recession, there is a relative increase in the use of fixed capital in the context of a more noticeable decline of employment; such relative increase of capital is possible when labor and capital are mutually substituting factors. As for the use of capital during economic recession, it would rather cause a rise in employment, because the use of new machinery and equipment would require a significant expenditure of labor. It is also important that the industry under consideration has features that set it aside from the others. Production in agriculture and forestry is seasonal and largely depends on the weather, climatic, and some other conditions, which are objects of special forecasting; this means that output and labor expenditure are unevenly distributed over the year. Consequently, the employment equation presented above may contain inaccuracies, which it was not our objective to evaluate and describe.

While remaining statistically significant, the expansion of the sectoral employment equation into two components makes a poor distinction between the periods of economic growth and recession. At $D = 0$, the equation component adequately describes the employment observed between 1980 and 1995, while at $D = 1$, that is, the recession period, it adequately reflects reality starting with 1990 (Fig. 3).

![Fig. 2. Expansion of the employment equation in the sphere of circulation at $D = 0$ and $D = 1$.](image1)

![Fig. 3. Expansion of the employment equation in agriculture and forestry at $D = 0$ and $D = 1$.](image2)
Another difficulty when building sectoral employment equations is autocorrelation of residues: some values of the Darbin-Watson d-statistics lie in the uncertainty zone and some even in the zone of certainty of decision-making regarding the existence of autocorrelation of residues.

The value of d-statistics calculated from the formula
\[ d = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2} \], where \( e_t \) is regression residue at a given moment of time, is close to value 2(1–\( p(1) \)), where \( p(1) \) is the selective autocorrelational function of first-order residues. Correspondingly, the ideal value of d-statistics equals 2 (autocorrelation is absent). Lower values correspond to positive autocorrelation of residues, and higher, to negative. The distribution of these statistics depends on the form of evaluated regression. However, one can build two boundary distributions, with the distribution of d-statistics “squeezed” in between. The so-called uncertainty zone lies between these two values. When a concrete value of Darbin-Watson statistics finds itself in this zone, one cannot say definitely whether or not first-order autocorrelation is present in the equation. Uncertainty zones are located symmetrically with reference to 2, therefore, when d-statistics find themselves left of the bottom uncertainty zone and right of the top one, one may assume the presence of positive or, correspondingly, negatively autocorrelation. This situation distorts estimates of regressive coefficients and hampers forecasting.

In view of this, an attempt was made to correct the autocorrelation obtained and improve the statistical characteristics of these equations within the framework of the following scheme [6].

Let us assume that \( \varepsilon_t = \rho \varepsilon_{t-1} + \nu_t \), where \( \nu_t \sim N(0, \sigma^2) \) is the character of the revealed autocorrelation dependence. Different estimates of \( \hat{\rho} \), autocorrelation coefficient, were built; then new variables \( LE_t^* = LE_t - \hat{\rho} LE_{t-1}; LC_t^* = LC_t - \hat{\rho} LC_{t-1}; \) etc. were built. The first point of each series was built with the Praise–Winston correction in the form: \( LE_t^* = \sqrt{1 - \hat{\rho}} LE_t; LC_t^* = \sqrt{1 - \hat{\rho}} LC_t; \) etc. On the basis of these variables, the regression was estimated in the form

\[ LE_t^* = A + \beta_1^* LC_t^* + \beta_2^* LO_t^* + \beta_3^* LW_t^* + \beta_4^* T_t^* + \beta_5^* D_t^* + \beta_6^* DC_t^* + \beta_7^* DO_t^* + \nu_t \]  

(4)

with the assumptions analogous to equation (1).

The reversal to corrected regression coefficients was accomplished in the following way: \( \hat{\beta}_0 = \frac{\hat{A}_0}{1 - \hat{\rho}}, \hat{\beta}_1 = \hat{\beta}_1^*, \ldots, \hat{\beta}_7 = \hat{\beta}_7^*, \) etc.

Our analysis showed that the most sensible way was to use the estimate of autocorrelation coefficient \( \hat{\rho} \), which takes account of the size of the sample: \( \hat{\rho} = \frac{n^2 (1 - d/2) + (k + 1)^2}{n^2 - (k + 1)^2} \), where \( n \) is the number of observations; \( d \) are the Durbin–Watson statistics; and \( k \) is the number of explanatory factors of the regression.

For instance, for the building materials industry there one of the lowest values of Durbin–Watson statistics was obtained which equalled 0.98 with the uncertainty interval of [1.046; 1.535]. Thus, there exists a positive autocorrelation of residues in this equation. This conclusion is also confirmed by a statistically significant trend of the form: \( e_t = 0.4980 e_{t-1} \) with a positive coefficient at \( e_{t-1} \). t-statistics was 2.305, \( R^2 = 0.248 \), \( d = 1.286 \) with the uncertainty interval of [1.158; 1.391].

Then we applied to the considered equation the above-described autocorrelation correction scheme. As a result we obtained a new equation of employment for the building materials industry:

\[ LE_t = 0.0912 + 0.6026 LC_t - 0.0354 T_t, \]

\[ t\text{-statistics} \quad (0.972) \quad (98.456) \quad (–13.263) \]

\[ R^2 = 0.999 \]

\[ d = 1.339. \]

As an illustration, below we present an equation of the demand for labor before the correction of autocorrelation and a figure showing the genuine and forecast equations of the volume of demand for labor.

\[ LE_t = –0.4515 + 0.6434 LC_t – 0.0347 T_t, \]

\[ t\text{-statistics} \quad (–0.461) \quad (7.851) \quad (–14.628) \]

\[ R^2 = 0.9498 \]

\[ d = 0.98. \]

Despite insignificant distinctions between the regression equations of the corrected and the original equations, coefficient \( R^2 \) increased, as did the value of d-statistics. The new value of this coefficient was added to the upper limit of the uncertainty interval, which is a consequence of an improved initial regression.

On the whole, the application of this method made it possible to improve the statistical characteristics of the problem equations of sectoral employment.

In conclusion, let us consider the results of the evaluation of the forecast quality obtained on the basis of the equation of employment in the country’s industries built at this stage of the study. To do this, we evaluated the dependencies of the quantity of the labor used upon the explanatory variables for 1980–1997 identified at the previous stage. We obtained adequate equations on the basis of which we built, using known data, a retrospective forecast of employment in industries for 1994–1997.
As a result, as shown in Table 3, the period’s highest average relative errors of the employment forecast were 26.48% in the coal industry and 26.18% in management, finances, crediting, and insurance, and the lowest were 0.05% in oil refining and 0.04% in passenger transport and nonproduction communications.

To evaluate the general quality of the forecast, we used the inequality coefficient \[ u^2 = \frac{1}{n} \sum_{i=1}^{n} (A_i - P_i)^2 \] , where \( A_i \) is the observed, and \( P_i \) is the forecast value, the value of \( u \), the inequality coefficient, would be limited to segment \([0; 1]\). By substantially facilitating the process of comparison, this reduction to a unified base makes it possible to adequately evaluate different-length forecasts. The value of \( u = 0 \), that is, when \( A_i = P_i \) (the forecast value coincides with the observed one), means an ideal forecast; and the other way around, the closer the value of \( u \) to 1, the poorer the evaluations of the examined parameters.

Within the framework of this study, the highest values of the inequality coefficient were obtained for management, finances, crediting, and insurance (0.315); the coal industry (0.268); and the chemical and petrochemical industry (0.158). The lowest values were obtained for electricity production (0.036), nonferrous metallurgy (0.028), and engineering and metalworking (0.016). The minimal value was obtained for passenger transport and nonproduction communications (0.006).

This means that the sectoral employment equations obtained at this stage of the study adequately describe
the real-life processes under way in the Russian economy and provide a statistically significant short- and medium-term forecast of the revealed trends. The constructed trend forecast of the macroeconomic indicators used (two versions, optimistic, 1980–1993, and pessimistic, 1980–1997), is largely approximate and tentative.

The prognostic estimates made from employment forecasting models as part of the interindustry model being developed at the RAS Institute of Economic Forecasting, make it possible to identify trends in employment and its sectoral structure coordinated with macroeconomic estimates, and to assess the implications of economic decisions for employment.

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