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Equity-Efficiency Trade-off in Regional Allocation of Production Factors in the Russian Federation

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ABSTRACT

This paper presents a non-econometric estimation of the production function for Federal Districts of Russia over the period from 1996 to 2004. The empirical results show that the regional allocation of employment does not correlate with the marginal productivity of labor, but the distribution of capital stock appears to be closely connected to the marginal productivity of capital. In such an environment, alternative ways of allocating public investment can boost total output but they usually also widen territorial income gaps. The promotion of both growth and equity simultaneously is possible in the case of sufficient income-elastic labor mobility and efficiency-oriented investment policy.

RESEARCH PROJECTS OF RUSSIAN TERRITORIAL DISPARITIES

Regional disparities in allocations of production factors affect the economy in two ways. When labor and capital concentrate in productive regions, it leads to a growth of total output but usually is accompanied by widening territorial gaps. Opposite patterns of distribution can lower possible growth rates but bring more regional equality. Theoretically, it is quite possible to find an optimal balance between effectiveness and equity. But in practice, in most countries the optimum solution cannot easily be achieved.

Russia also faces some fundamental difficulties in devising a balanced regional policy. Starting from the beginning of the 21st Century, the amount of public investment for regional development was constantly growing, but the effectiveness of that expenditure is still highly questionable. In this regard, two major problems attract substantial attention of scholars and government officials. The first is the correlation of regional distribution of labor and capital and the effectiveness of production, and the second are the trade-offs between effectiveness and equity in territorial development. Both mentioned questions are examined in this paper. The first part presents a brief literature review, the second explains the data and methods of estimations, the third part tests the relationships of effectiveness with the actual spatial distribution of factors of production among Federal Districts of Russia, the fourth part presents the simulated results for different scenarios in regional allocation, and the fifth part concludes the paper.

Numerous studies are devoted to territorial differentiation in Russia. The most extensive literature review on this matter before the year 2000 is provided by F.Hanson and M.Bradshaw (Hanson, Bradshaw, 2000, pp. 7-18). Reviews of later papers are performed by several scholars. We can definitely say that the problem of territorial gaps is found to some degree in most studies with a regional dimension. A great number of authors agree to a widening of spatial differentiation in Russia in the 1990's and at the beginning of 21 Century. At the same time, the exact conclusions depend on the analyzed data and the period of research. For example, F.Hanson and M.Bradshaw mentioned the steady growth of differences in average real monetary income per capita during the period 1993-1997 (Hanson, Bradshaw, 2000, p. 31). L. Fedorov used 6 indicators of regional economy and found that the fast differentiation in 1991-1996 somewhat slowed down or even reversed at the end of the 1990's (Fedorov, 2002, p. 455). O.Lugovoi et al. also observed growing disparities in gross regional product per capita but hinted on a reversed process in 1998 and 2004 (Lugovoi et al., 2006, pp. 8-10). The UNCTAD division in Russia came to a conclusion about widening regional gaps in the Human Development Index and its components in 2003-2004, compared to the end of the 1990'.

In spite of rapidly growing literature, the connection between regional differences and effectiveness in spatial distribution of labor and capital is still insufficiently researched. Some relevant studies were conducted for the former USSR (the literature review is presented in Kumo, 2003, pp. 123-124). However, the situation in modern Russia came into focus only once (Gaddy, Ickes, 2003). These works agreed on the ineffective regional distribution of economic resources in Russia but both were based on the logic of natural geography and development policy rather than on an empirical economic approach. One can also mention a clear lack of papers devoted to numerical estimations of the correlation between economic growth and regional differentiation which makes it virtually

impossible to provide theoretically sound directions for government policy makers. This article tries to fill in the gaps, and more specifically, to establish a missing link between the effectiveness and regional distribution of factors of production, to suggest some alternative ways for the spatial allocation of public investment and labor migration, and finally, to evaluate numerically the necessary trade-off between effectiveness and equity in territorial development policy.

The major theoretical assumption of this paper suggests that the effective utilization of factors of production, including their regional dimensions, depends on the marginal productivity of capital and labor. The latter is calculated out of the standard Cobb-Douglas production function, estimated by non-econometric techniques. The tests on the correlation between marginal productivities and regional shares in national amounts of applied capital stock and labor force present a new angle for the definition of effectiveness in territorial distribution. Finally, alternation of regional stocks by reallocation of investment and redirection of migration flows according to marginal productivity and income provides an answer to the numerical connection of output growth with spatial inequality.

MODEL AND DATA

The Cobb-Douglas type production function with constant returns to scale represents the most widely used instrument for research of relationships between output, labor and capital. Parameters of the function are usually estimated by econometric techniques. At the same time, for Russia at present the standard methods based both on OLS regressions and panel data analysis have serious limitations. The one reason is that the continuous data on regional gross output became available only from 1996, and just 3 years later – in 1999 – the trend of economic dynamics has reversed from slide to growth. The following structural adjustments, as some scholars argued, appeared to be extremely important and could not be ignored in estimations of production function (Oomes, Dynnikova, 2006, pp.4-5). These arguments have been raised about the utilization rates of labor and capital and elasticity coefficients. Consequently, an equation of the production function might be written as follows:

$$Y = A(U_E E_i)^\alpha (U_K K_i)^{1-\alpha}$$

where Y is the gross regional product, A – the parameter related to all regional production environment except labor and capital, and to statistical errors (TFP), E – the annual average number of employees, K – the total value of fixed production funds, i – the Russian region. The regions are defined as Federal Districts (i=1,2...7), because serious obstacles exist in the application of data to smaller “subjects” of the Russian Federation. The respective shares of seven Federal Districts in the national economy are presented in the Table 1.

The UE and UK denotes respectively labor utilization and capital utilization rates, estimated by several statistical and research entities in the Russian Federation. Parameter α is usually interpreted as labor share in gross income. Therefore, its value could be derived directly from national accounts (computed from the gross domestic product by income approach as a “share of average earnings of employees” adjusted for net taxes, production and import subsidies). The exact numbers of UE, UK and α , applied in this paper are borrowed from Oomes and Dynnikova and shown in Table 2.

In the end, all necessary parameters of production function might be obtained by non-econometric techniques. Obviously, the above mentioned logic represents just one possible way for the estimation of parameters. Multivariate calculations are not performed in this paper, but can be pointed out as a promising direction for further research in this area.

Table 1. Federal Districts and Their Respective Shares in the National Economy (% , 2004)

Federal District	Surface Area	Population	Employment	Gross Regional Product (GRP)	Investment
Center	3.8	26.2	27.4	31.5	26.7
North-West	9.8	9.6	10.1	10.1	12.8
South	3.4	15.9	13.2	7.6	9.2
Volga	6.1	21.4	21.8	16.6	16.6
Ural	10.5	8.6	9.1	18.0	18.9
Siberia	30.0	13.8	13.3	11.6	9.2
Far East	36.4	4.6	4.9	4.7	6.6

Sources: Rosstat, Regiony Rossii (2005), pp.28-31

Table 2. Applied Parameters of Production Function

Parameter	1996	1997	1998	1999	2000	2001	2002	2003	2004
UE	73	75	75	83	87	87	87	88	88
UK	47	48	46	51	56	60	62	65	68
α	59	60	57	47	48	51	56	56	55

UE – labor utilization rates, UK – capital utilization rates, α – elasticity of labor by income.

Source: adopted from Oomes, Dynnikova, 2006, pp.8, 10, 19

The figures on GRP, fixed production funds and employment are derived from official publications of Rosstat. The period of the analysis covers the years from 1996-2004. The GRP and fixed production funds are adjusted to the price level of the year 2000 by officially published real growth indexes. As for the fixed funds, where the regional indexes are not available, the all-Russian numbers are applied to Federal Districts. The inevitable simplification seems to be reasonably acceptable, considering the extremely low overall real growth rates of the funds' value, hovering from -0.4% to 0.9%, and the unchanged ranks of Districts in the funds' distribution.

In a competitive market economy, both capital and labor are expected to pursue the principle of efficiency. This means that production factors have to concentrate in regions with inherently higher productivity, at least in the short or middle term. The calculations for the period 1996-2004 revealed that the territorial distribution of labor appeared to be practically unrelated to its marginal productivity. The coefficient of the correlation (r) between the Districts' shares in total employment and the discrepancies of marginal productivities of labor against the national average equaled to 0.093 and was statistically insignificant. The analysis of spatial augmentation of capital leads to entirely different conclusions. The coefficient of the correlation between Districts' shares in fixed production funds and discrepancies in marginal productivities of capital amounted to 0.748 and was highly significant at the 0.01 level. Thus, the spatial distribution of capital, compared to that of labor, followed more accurately the chosen criteria of effectiveness. The linkage of investment, or the increase of capital stock, with discrepancies in marginal productivities, proved to be even more intensive ($r=0.845$). More than that, the coefficient of the correlation for public investment (0.898) exceeded the indicator for private investment (0.777). This is a somewhat unusual situation because in most countries public investment does not pursue immediate economic gains. Instead, it is distributed for the purposes of regional development, equalization, infrastructure construction etc. Perhaps in the analyzed period in Russia, given the shortage in investment funds at that time, public investments became substitutional rather than supplemental and started to carry out some functions regularly performed by private capital.

SIMULATIONS OF FACTORS' REALLOCATION BETWEEN FEDERAL DISTRICTS

In the period from 1996 to 2004, the gross regional product (GRP) of Russia adjusted to the year 2000 prices increased from 5.6 trillion to 8.1 trillion Rubles. The weighted average GRP per employee went from 87.5 thousand to 122.7 thousand Rubles. The weighted average coefficient of variation of GRP per employee changed from 0.322 to 0.325. These results were obtained under the actual (base) allocation of labor and capital stock.

In theory the reallocation of employment and fixed production funds according to marginal productivity might boost the growth rates. But how exactly will it affect regional inequalities? Let's try to answer this question by analyzing the alternative variants of factors' endowments.

Federal and regional governments can influence the regional distribution of labor and capital by carrying out an active investment and migration policy. In this paper, the investment policy is regarded as modification of territorial structure of public investment provided by both the federal and consolidated regional budgets. Technically speaking, the federal government cannot redistribute all public regional investment funds. But it still possesses such powerful instruments of investment policy that this assumption, besides being purely theoretical, seems to be acceptable for the purpose of illustrative research. The total public investment (AIB) can be expressed as the sum of central and sub-national consolidated budget investment in Federal Districts ($AIB = \sum IB_i$). Deduction of total investment out of each year's capital stock and then redistribution among Federal Districts will not change the overall sum of investment and fixed capital. But the regional composition of capital stock will be altered, which will result in an increase (or decrease) of gross output and regional inequality.

This paper analyses the following variants of redistribution: 1) "retributive", when the maximum amount of investment is directed to the District with the minimum GRP per employee; 2) "equal", when Districts' shares in investments are equaled to respective shares in employment; 3) "effective", when the District with the highest

marginal productivity of capital is awarded with the biggest sum of investment. At the first stage, the regional allocation of labor force is considered to be stable. Subsequently, following the recommendation of M.Kataoka, an elasticity of labor by gross per capita income is assumed (Kataoka, 2005, pp. 127–128). Then, high and low levels of elasticity are chosen, new regional shares in employment are computed, and modified employment data are incorporated into the mentioned “effective” variant. The new allocation of capital and labor is included into the known production function; the potential output is calculated and compared to the actual figures from the point of view of effectiveness and equity (Table 3).

1) “Retributive” allocation:

Public investments are reallocated according to GRP per employee (Y/E). The only rule is that the district with the lower GRP receives more than its wealthier counterpart. Computation formulas for public investment in each district (IB_i^{Re}) are borrowed from N.Yamano and T.Ohkawara (Yamano, Ohkawara, 2000, p. 220) and have the following shape:

$$IB_1^{Re} > IB_2^{Re} > \dots > IB_n^{Re}; (Y/E)_1 < (Y/E)_2 < \dots < (Y/E)_n$$

$$IB_i^{Re} = \frac{(1 - \lambda_i)}{\sum_{j=1}^7 (1 - \lambda_j)} AIB \quad ; \quad \lambda_i = \left[\frac{(Y/E)_i - (Y/E)_{Max}}{(Y/E)_{Max}} \right]$$

According to these criteria, the largest share of public investment is directed to the low income South and Volga areas. High income Ural and Center Districts receive a lesser amount. Gross output decreases against the base, but regional distribution per employee becomes more equal.

2) “Equal” allocation:

The District's share in total public investment (IB_i^{Eq}) is assumed to be equal to the share in total employment:

$$IB_i^{Eq} = \frac{E_i}{\sum_{j=1}^7 E_j} AIB$$

In this case, public investment is reallocated in favor of relatively “Underinvested Districts”, which have a lower share in total investment than the share in employment. Consequently, the results demonstrate the investment growth in the South, Volga, Siberia and North-West areas, accompanied by a fall in the Ural, Center and Far-East areas. Output decreases, but equality indicators improve compared to the base case.

Table 3. Simulation Results of Regional Reallocation of Public Investment

Characteristics of Allocation Scenarios		Base	Retri-butive	Equal	Effective (elasticity)		
					Zero	Low	High
Effectiveness	GRP*						
	total (bln Rubles)						
	1996	5,602					
	2000	6,219	6,196	6,208	6,259	6,263	6,303
	2004	8,148	8,081	8,119	8,240	8,268	8,370
	Per employee (1000 Rubles) **						
	1996	87,4					
	2000	96,6	96,3	96,5	97,3	97,4	97,9
	2004	122,6	121,6	122,2	124,0	124,3	126,0
Equity	GRP per employee						
	max/min						
	1996	2.840					
	2000	2.807	2.713	2.736	2.781	2.701	2.481
	2004	2.861	2.684	2.722	2.936	2.775	2.418
	Weighted CV***						
	1996	0.322					
	2000	0.324	0.313	0.313	0.321	0.312	0.282
	2004	0.325	0.305	0.306	0.342	0.332	0.287

* adjusted to price level of year 2000; ** weighted average; *** weighted coefficient of variation

Source: author's calculations

3) "Effective" allocation:

Public investments are reallocated according to the marginal productivity of capital MPK:

$$IB_1^{Ef} > IB_2^{Ef} > \dots > IB_n^{Ef}; MP_{K1} > MP_{K2} > \dots > MP_{Kn}$$

Federal districts are ranked according to marginal productivity. At the starting point of the allocation process, one unit of public investment is directed to the first District with the highest productivity. Capital stock in this region rises and marginal productivity inevitably goes down. When the decreasing marginal productivity of the first District reaches the level of the second, both of them receive some public investments until their productivity falls to the level of the third District and so on. Under this rule, some territories with low productivity may receive no investments, but highly productive areas will be awarded much more public funds.

In the period from 1996-2004, the federal Districts of Russia were significantly differentiated by the marginal productivity of capital. The highest level (Center) was 1.6-2.0 times greater than the lowest figures (South and Far-East). Amounts of public investment remained comparatively modest at the level of 2.8-4.2% of GRP. In such circumstances, the allocation according to marginal productivity resulted in a situation where all public investments were awarded to only one Center District (1996-2000) and later to the Center and Ural Districts (2001-2004). By the year 2004, GRP increased substantially, but the entire growth was concentrated in the highly efficient Center and Ural Districts. Consequently, both the GRP growth rates and the inequality of its distribution came up to the highest points compared to the "base", "retributive" and "equal" scenarios.

"Effective" allocation with domestic labor migration:

Public investments are reallocated according to the marginal productivity of capital MPK, as mentioned previously in the "effective" variant. In addition, the assumed mobility of the labor force following the per employee income, i.e. the labor elasticity by income, is included as a new perspective for the analysis of factor augmentation. Practical calculations are based on the methods devised by M.Kataoka (Kataoka, 2005, c.130):

$$\frac{E_{it+1}}{E_{t+1}} = \left(1 + \delta_{1,2} \frac{\omega_{it} - \omega_t}{\omega_t} \right) \frac{E_{it}}{E_t}, \quad \delta_1 = 0,01; \delta_2 = 0,05$$

$$\omega_{it} = \frac{Y_{it}}{E_{it}}, \quad \omega_t = \frac{\sum_{i=1}^7 Y_{it}}{\sum_{i=1}^7 E_{it}}$$

where (δ) stands for a coefficient of elasticity of labor by the per employee's GRP. The level of ($\delta_1=0.01$) is considered as a sign of low elasticity. In this case, if in the base year (t) the GRP per employee in the District (i) is twice as high as the national average (ω_t), then in the next year ($t+1$) the District's share in total employment (E_{it+1}/E_{t+1}) will grow by 1%. In the case of high elasticity ($\delta_2=0.05$), the District's share will increase respectively by 5%.

It is worth emphasizing that in the presented model, the elasticity of labor leads merely to spatial reallocation of employment. The industrial structure, employment composition and other characteristics of absorption capacities of the recipient Districts are unavoidably ignored. Perhaps the omitted distinctive points of the recipient regions should be regarded as a promising direction of future research.

In the years from 1996 to 2004, the Center and Ural Districts sustainably enjoyed higher-than-average GRP per employee. Therefore, under the applied assumption, both districts should attract labor migrants from relatively backward areas, such as the South, Volga and Siberia Districts. The reallocation of employment in the close-to-average Districts of the North-West and Far-East should remain fairly stable.

The calculations under the supposition of low elasticity and mobility ($\delta_1=0.01$) demonstrate that the share of the Ural District on national employment increased from 9.1% to 9.6%, the share of Center District – from 26.6% to 27.2%. On the other hand, the shares of the South and Volga Districts dropped from 12.7% to 12.3%, and from 22.1% to 21.7%.

The assumption of higher elasticity ($\delta_1=0.05$) leads to even more obvious results. For instance, the share of the Ural District went up from 9.1% to 11.5%, and that of the Center – from 26.6% to 28.4%. The total employment expansion in these two advanced areas came to 4.2% or 2789 thousand workers by the year 2004. The additional employment was again supplied by mostly the South and Volga Districts, whose respective shares decreased from 12.7% to 10.9% and from 22.1% to 20.7%. Some negligible out-migration appeared in the North-West and Siberia Districts, and only the Far-East remained entirely unchanged. Output of GRP reached the highest point in the model. And this impressive result was accompanied by a considerable improvement of equity in spatial distribution.

The calculated migration figures did not match the actual labor flows. In reality, during the period 1996-2004, the share of the Center District increased from 26.6% to 27.4%, the share of the Ural District stood at 9.1%, and the share of the South District, against theoretical expectations, actually grew from 12.7% to 13.2%. Such dynamics could not be explained solely by income-elastic flows of labor. Perhaps the difference between the predicted and actual results indirectly proves the previously mentioned ineffectiveness in spatial augmentation of labor and reveals the influence of some non-economic determinants on the migration process.

The simulation results, classified by effectiveness and equity, are presented in the Table 5. Obviously, considering all of the applied assumptions and unavoidable statistical inaccuracies, not the presented figures per se but rather the underlying tendencies seem to constitute the most interesting part among the results. The fastest GRP growth against the base is achieved under the public investments allocation in accordance with marginal productivity of capital. "Effective" allocation ensures 1.1% of additional growth under conditions of non-elastic labor, 1.4% under low labor migration and 2.7% under high mobility of employees. In all remaining variants, GRP plunges for instance by 0.8% under "retributive" and by 0.3% under "equal" allocations.

The most equal distribution of GRP per employee is registered under the "effective" scenario coupled with the highly mobile labor force. In this case, the weighted average coefficient of variation slides to 0.287 against the base level of 0.325. Some decreases in territorial income gaps, offset by lower growth rates, are also pointed out under the "retributive" and "equal" allocations.

Without substantial migration or under conditions of insufficient labor mobility, the growth of GRP usually comes together with an increase in regional inequality. Probably the extremely short phase of unstable development in the period 1999-2000 presented the only exception to this rule. These 2 years produced a unique mixture of high growth with fast structural adjustments which made possible a simultaneous boosting of output and a narrowing in territorial income gaps, effectively distributing though limited public investments.

Let us point out that the economic growth accompanied by a decrease in regional disparities appears to be possible in the period of fast structural changes, as was demonstrated by postwar Japan in the beginning of the 1950s (Merriman, 1991, p.457). Nevertheless, in modern Russia more territorial equity means either less output or more intensive inter-regional migration. Growth of GRP synchronized with a decrease in regional disparities is realistic only under the following conditions: distribution of public investment resources according to principles of marginal productivity and ensuring a high mobility of labor force.

CONCLUSIONS

The conducted empirical research has revealed several interesting aspects in the augmentation of production factors among Russian regions. The spatial distribution of employment showed an extremely weak correlation with marginal productivity of labor and from this point of view might be described as ineffective. The allocation of fixed production funds, especially recently acquired through investment, was much more closely related to the marginal productivity of capital. Therefore, equal efforts for the spatial reallocation of labor force could potentially generate a more pronounced effect than improvements in the investment process. In this sense, an active market-oriented migration policy should be considered as a priority in the optimization of territorial economic structure.

The numerical simulations have demonstrated the existence of a two-way cause-and-effect relationship between the growth of GRP and indicators of regional inequality. In most cases, without substantial labor migration, an increase in the effectiveness of investment brings together a widening of territorial income gaps. Conversely, more equality in regional distribution implies lower productivity and a reduction in output. Consequently, the Russian government faces a well-known trade-off between efficiency and equity in regional development.

In theory, it was possible to simultaneously increase output and reduce spatial inequality, given the effective allocation of public investment and sufficiently high income-elastic mobility of labor. Nevertheless, the fulfilling of these two preconditions would lead to a concentration of the entire available public investment funds in the Center and Ural Districts, along with the necessity to absorb there about 2.8 million workers from low-income areas of the country. Obviously, it is an extremely challenging task. Little wonder that in practice, the government's policy in the analyzed period of 1996-2004 perhaps might be described as a thorny search for compromise, when regional differences considerably increased but production still did not reach a maximum feasible level.

However, an increase of market effectiveness in the spatial distribution of labor, stimulation of economic growth along with improvement of its quality in the sense of reduced territorial gaps in present day Russia, seems already impossible without large scale domestic migration. Therefore, the encouragement of territorial mobility of labor, which is often excluded from the main concerns of Russian policy makers, should be regarded as an indispensable component of effective and proportional regional development.

The presented analysis could be substantially improved in numerous ways. As topics for future research, one can suggest replacing large Districts by smaller regions from the Russian Federation, utilizing more accurate methods in the estimation of production function parameters, splitting public and private capital and exploring separately its marginal productivities, adjusting for regional differences in industrial composition, examining links of migration with unemployment and so on. At the same time, the necessary improvements most probably will not alter the principal findings, such as the ineffectiveness in regional distribution of employment, the existence of computable trade-offs between effectiveness and equity in the allocation of public investments, and the high priority of labor migration for the sustainable development of Russian regions. Therefore, I believe this study alone can contribute to a further discussion, especially when one considers the performed numerical estimation of trade-offs between effectiveness and equity under the different assumptions on inter-regional allocation of public investment and mobility of labor.

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