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Marginal Efficiency of Fixed Capital, its Economic and Technological Factors, and Dynamics of Russian Economy

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Abstract

Net profit is a main source of investment in fixed assets in Russia. In the paper, we estimate econometric equation of investment from net profit on different regressors. The estimation is fulfilled basing on quarterly macroeconomic data for 1995-2007. It is shown that significant factors are the volume of net profit and the marginal efficiency of fixed capital, and the latter is the strongest one.

We use also the panel data for Russian regions for 2004-2006 and estimate an econometric equation of average efficiency of fixed assets with respect to different factors. The significant factors are three technological variables (scientific expenditures, number of patents and number of personal computers) and a share of export in gross regional product.

Finally, we estimate an econometric equation of personal income in Russian regions on different factors and find out that the strongest factor is the capital intensity of labor and two efficiency variables (labor productivity and capital efficiency).

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Marginal Efficiency of Fixed Capital, its Economic And Technological Factors, and Dynamics of Russian Economy

Sergey Mitsek

Theoretical background

Contemporary theories of investment in fixed capital can be divided into two mainstreams: neoclassical theory[1] and J. Tobin's theory with the Keynesian theory between them. The first one considers a **marginal revenue on fixed capital** as a *positive* factor of investment and a **cost of capital** as a *negative* one. The cost of capital in neoclassical is typically represented by **interest rates** and by **tax rates** on capital elements. Tobin's theory (and, partially, Keynesian theory) pays attention to the **value of firm** as a *positive* factor and considers **replacement value** and **adjustment cost** of physical elements of fixed capital as *negative* ones.[2] Substitution between different factors can weaken these effects.[3]

But the majority of these theories pays mostly not enough attention to **supply of funds** for investment and is virtually based on a presumption of infinite elasticity of their supply that is usually not true.

The sources of funds for investment can be divided into the following groups:

- ✓ **own resources** that for *private companies* include:
  - ❖ net profit;
  - ❖ accumulated depreciation;
- ✓ **attracted resources** that include:
  - ❖ bank credits;
  - ❖ issues of shares, bonds and other securities.

Besides that, there are investments from:

- ✓ government funds;
- ✓ citizens' own savings.

[1] See papers by D. Jorgenson, and others.

[2] See [1], [2], [6] for review of investment theories.

[3] It can be proved mathematically. In accordance with our model described in [8] the increase of marginal revenue on fixed capital increases the use of bank credit for investment but *decreases* investment from net profit.

The sources of investment in Russian economy

The structure of funds for investment in Russia is shown in Table 1.

Table 1 - The structure of different sources of investment in fixed capital in the Russian economy, %[4]

Source / Year	1995	2000	2007
Net profit	27,7%	34,9%	29,9%
Depreciation	30,0%	27,0%	27,3%
Total own resources	57,7%	61,9%	57,3%
Total attracted sources	42,3%	38,1%	42,7%
Among them			
Federal budget	13,4%	7,7%	9,4%
Local budget	13,7%	19,2%	14,4%
Total budget	27,1%	26,9%	23,8%
Bank credits	0,0%	4,3%	16,1%
Securities' market	0,0%	0,6%	2,3%

We see that the share of **own sources** is stable and rather high. Among **attracted sources** the share of **state budget** declined steadily[5] and the share of **bank credits** increased significantly,[6] though it is still much smaller than in developed countries.[7] The role of **securities** is still small (in spite of high activity in IPO in 2006-2008).[8] All

[4] Sources: [4], [5]; authors recalculations. The recalculations are done to take into account small businesses since official statistics cover only large and medium-size businesses. The share of the latter in the total investment is on average 80% and the share of small ones is 20% during the last years. The direct investment of citizens in house construction is also excluded.

[5] The Russian government has more than $400 billion foreign reserves but they are invested in foreign securities.

[6] One of the reasons for this process is the quick growth of foreign credits in the Russian economy in 2005-2008. The World Bank experts give approximately the same figure of the share of bank credits in investment – 15.5 % in 2007. They then increase it to 17.6% in 2008 and decrease it to 12-13 % in 2009. See: [12].

[7] In Russia, household deposits are equal to 17% of GDP, while they constitute 45% in the USA. Private pension funds in Russia manage assets that are equal to only 2.5% of GDP, while they form 40% in the USA. Only 5% of Russians invest money in private pension funds. See "Business Week", 2008, October 20. Nevertheless, the construction industry in Russia depends crucially on bank credits.

[8] The majority of people in Russia still have no trust in the securities' market. Foreigners buy 2/3 of securities issued by Russian companies. See "Business Week", 2008, October 20.

this indicates weakness in the Russian financial system and explains a shortage of investment funds here.

Table 1 indicates the crucial role of net profit as a source of investment funds in Russia.[9] Therefore, we analyze here the factors that determine investment from net profit.

Econometric estimate of investment from net profit

To make an econometric estimation we take quarterly data from the period 1995-2007 that constitutes 52 points. The dependent variable is investment from net profit and the independent variables are:

- ✓ total net profit in economy;[10]
- ✓ real interest rates on credits to business and on deposits;[11]
- ✓ index of the Russian Trade System;[12]
- ✓ nominal and real ruble/dollar ratios;[13]
- ✓ marginal revenue on fixed capital;[14]
- ✓ terms of trade as an index of ratio of export ruble prices to import ruble prices.[15]

Using such a set of regressors we try to include a cost of capital, the value of companies and replacement value of capital. Therefore, we use external economy indicators since the Russia economy imports about 90 % of the equipment it invests in.[16]

[9] If we take only private funds the own sources form 72% of gross investment and the net profit constitutes 39% of them in 2007. If we take only *net investment* the net profit forms 62% of total private sources in 2007.

[10] Its value is calculated as follows: gross profit from national accounts minus profit tax paid minus investment from depreciation.

[11] Here we use the time series of nominal rates published in [7]. These nominal rates are then deflated by a GDP deflator. Credit and deposit rates are indicators of the cost of capital.

[12] It is one of two main Russian stock indices. It shows the dynamics of the average value of main Russian companies and the profitability of alternative ways of money investment.

[13] The currency ratio and terms of trade can indicate the profitability of investment in currency index which is important for Russia.

[14] It is calculated by multiplying marginal productivity of a macroeconomic production function by the GDP deflator;

[15] They are taken from national accounts' statistics.

[16] See "Kommersant – DAILY", 2007, N.110, 128. The total import of investment goods is equal to 35% of total gross investment in fixed assets in Russia in 2006, which is higher than the figure of 24% in the year 2000. This is confirmed by the author's calculations based on data from [4]. But in 2009 the Russian import of equipment decreased significantly. See "Kommersant – DAILY", 2009, N.62.

Finally, we get the following equation:[17]

$$\mathbf{LN(I) = 2.52 + 10.018M[LN(\pi)]} \qquad \mathbf{(1)}$$

$$\mathbf{(22.10)\ \ (21.962)}$$

$$\mathbf{R^2 = 0.915}$$

$$\mathbf{DW = 1.417}$$

$$\mathbf{F = 482.35}$$

Here:

I – investment in fixed capital from net profit;

M – marginal revenue on fixed capital;

π - volume of net profit in economy;

LN – the sign of natural logarithm;

R^2 **–** coefficient of determination

DW – Durbin-Watson statistics;

F – Fischer statistics.

Student t-statistics are given in parentheses.

All other variables are insignificant[18]. This fact demonstrates again the weakness of the Russian financial market.

Equation 1 allows us to analyze the input of both variables into dynamics of investment from net profit. The results are shown in Table 2.

Table 2 - The input of net profit and marginal revenue on fixed capital into growth of investment from net profit

	LN(I)	LN(π)	M
1995	4,304	6,023	0,013
2007	7,782	8,886	0,045
Increment	3,479	2,863	0,032
Input[19]		0,841	2,416
Shares		24%	69%
Normalized shares		26%	74%

[17] Real interest rates on credits have negative but insignificant correlation with real (deflated by GDP deflator) values of investment. This variable is insignificant in multiple regressions with other variables. Other indicators of income from investment such as rate on deposits, RTS index and ruble/dollar ratio are insignificant. This result indicates a relative weakness of credit and securities markets in investment processes as one can see in Table 1.

[18] The autocorrelation is fixed by the Breusch-Godfrey procedure and is eliminated by autoregression transformation. The hypothesis of unit root is rejected for all variables.

[19] As equation is of such a kind as $z = axy$, the inputs of each variable is calculated as follows: the input of x – as $a(\Delta x)\,\bar{y}$, where Δ – the sign of increment, $\bar{y}$ – the average value of y; the input of y – as $a(\Delta y)\,\bar{x}$, where $\bar{x}$ – the average value of x.

We see that the input of the marginal revenue is much larger than the input of net profit. This fact is strengthened when we calculate the elasticity of investment on these factors; the results are shown in Table 3.

Table 3 - Elasticity of investment on the volume of net profit (EIN) and on marginal revenue (EIM) in the 4th quarter

Year / Indicator	EIN	EIM
1995	0,164	0,797
1996	0,139	0,640
1997	0,151	0,732
1998	0,183	1,012
1999	0,291	1,788
2000	0,351	2,232
2001	0,348	2,242
2002	0,347	2,333
2003	0,371	2,524
2004	0,434	3,099
2005	0,475	3,499
2006	0,465	3,466
2007	0,532	4,013

The sensitivity of investment to both variables increases over 12 years, but its elasticity to marginal revenue happens to be much larger.

We can now pose two questions.

1. Why is the role of net profit [as a factor that determines investment] obviously weaker?

2. What reasons determine the value of marginal revenue as a stronger factor of investment?

The answer to the first question is partially given in Table 4.

Table 4 - The dynamics of GDP, profit and investment from net profit in real terms, 1995 = 1.00[20]

Year / Indicator	GDP	Gross profit	Net profit	Investment from net profit
1995	1,000	1,000	1,000	1,000
1996	0,964	0,785	0,727	0,833
1997	0,977	0,765	0,721	0,718
1998	0,926	0,780	0,809	0,739
1999	0,985	1,018	1,169	0,767
2000	1,083	1,082	1,234	1,165
2001	1,139	1,100	1,212	1,362
2002	1,192	1,010	1,088	1,122
2003	1,279	1,108	1,190	1,118
2004	1,371	1,191	1,235	1,335
2005	1,459	1,248	1,273	1,417
2006	1,571	1,303	1,310	1,623
2007	1,699	1,391	1,283	2,375

We see that **gross** and especially **net profit** grow much slower than both GDP and investment from profit. The explanation is shown in Table 5.

[20] National accounts' statistics from [11] and author's calculations.

Table 5 - Ratios of profit and investment[21]

Year / Indicator	Gross profit / GDP	Profit tax / Gross profit	Depreciation / Gross profit[22]	Investment from net profit / Volume of net profit
1995	43%	19,3%	13,1%	17,9%
1996	35%	13,8%	23,6%	20,5%
1997	33%	13,4%	22,9%	17,8%
1998	36%	10,5%	19,3%	16,4%
1999	44%	10,4%	12,0%	11,7%
2000	43%	12,8%	10,1%	16,9%
2001	41%	13,9%	11,5%	20,1%
2002	36%	11,8%	15,4%	18,5%
2003	37%	10,7%	16,6%	16,8%
2004	37%	13,7%	16,2%	19,4%
2005	37%	16,9%	14,2%	19,9%
2006	35%	17,5%	14,5%	22,2%
2007	35%	18,7%	18,9%	33,2%

During the last years we see that:

- the share of **gross profit in GDP** declines steadily;
- the ratio of **profit tax** and **depreciation** to gross profit increases sharply;
- the share of **investment in net profit** also increases, but only in the last two years; before 2006 it is less than 1/5, and that is absolutely unsatisfactory for successful economic growth and innovation.[23] It is lower than in the EU and even lower than in the USA.

The dynamics of *gross* profit is explained in Table 6.

[21] National accounts' statistics from [11] and author's calculations.

[22] It is calculated as a ratio of investment from depreciation to gross profit.

[23] Together with investment from depreciation it is equal to 40 % of *gross* profit in 2007, and less than 30 % in 2000-2006.

Table 6 - Distribution of GDP by incomes measured in %[24]

Year / Indicator	Gross wages	Gross profit	Net taxes on production and import
1995	45,4%	42,8%	11,9%
1996	50,9%	34,8%	14,2%
1997	51,4%	33,4%	15,2%
1998	48,0%	36,0%	16,0%
1999	40,1%	44,2%	15,7%
2000	40,2%	42,7%	17,1%
2001	43,0%	41,3%	15,7%
2002	46,7%	36,2%	17,0%
2003	47,1%	37,0%	15,9%
2004	46,0%	37,1%	16,9%
2005	43,8%	36,6%	19,6%
2006	44,5%	35,5%	20,0%
2007	46,2%	35,0%	18,8%

The reason for the decline in the share of **gross profit** is motivated by the increase of **gross wages** and **indirect taxes** in GDP.[25] The first fact can be explained by the quick growth of real wages in Russia during the years of economic recovery.[26]

A relatively large share of indirect taxes reflects the specifics of the Russian tax system. Its foundations are VAT (16% of consolidated budget income in the first half of 2009), payment for natural resource use (7%) and taxes on external trade operations (15.5%).[27] The last two are mostly paid by oil and gas companies.[28] The share of indirect taxes in the Russian GDP is two times larger than in the European Union (where it equals to 12.5% of GDP) and three times larger than in the USA (6.5%).[29]

[24] National accounts' statistics from [11] and author's calculations.

[25] These tendencies have distinctly proceeded in 2008-2009.

[26] It increased by 73 % from 1999 to 2007. But it was growing from a very low level and partially due to restoration of equilibrium in the labor market.

[27] Source: [11]

[28] Total dependence of the state income on oil and gas companies is estimated as 7 % of GDP or 37 % of the total consolidated budget incomes in 2009. See [12].

[29] See [3].

All this means that overgrowth of taxation cuts profits of the Russian business and consequently prevents investment in the Russia economy. It should be stopped if one intends to hike up the investment level.

Let us now turn our attention to the analysis of marginal revenue on capital. To explain the dynamics of **marginal revenue on capital** [as a crucial factor of investment] we design (after numerous experiments) the following equation:

$$\mathbf{M = 0.010 + 0.00344PE} \qquad \mathbf{(2)}$$

$$\mathbf{(12.958)\ \ (28.686)}$$

$$\mathbf{R^2 = 0.942}$$

$$\mathbf{DW = 1.724}$$

$$\mathbf{F = 822.9,}$$

Here PE – **ruble index of prices on Russian export goods**. Equation (2) means that marginal revenue of capital in the Russian economy depends strongly on the world economy's factors. [30] This result is supported by the data from Table 7.[31]

Table 7- Dynamics of marginal revenue on fixed capital, export prices and corresponding elasticity coefficients (geometric averages of the 4th quarter)

Year	Marginal revenue on fixed capital (M)	Ruble index of export prices (PE; 1994=1)	[dM/d(PE)]/(PE/M)
1996	0,012	1,246	0,346
1997	0,014	1,395	0,343
1998	0,015	1,794	0,411
1999	0,025	4,333	0,587
2000	0,033	6,218	0,639
2001	0,034	6,120	0,624
2002	0,033	6,364	0,657
2003	0,034	6,953	0,696
2004	0,039	7,630	0,666
2005	0,043	9,324	0,743
2006	0,046	10,445	0,789
2007	0,047	10,809	0,790

[30] It is worth noting that the share of export is more than 30% of the Russian GDP.

[31] Let us note that main jumps of the elasticity of marginal revenue *M* on the ruble index *PE* took place in 1998-2000, when the share of export in GDP increased sharply, and in 2005-2006, when there was a large increase in prices on Russian goods exports, starting with oil and metals.

Estimates of marginal efficiency on fixed capital by panel regional data

The results of the previous section show:

- an important role of marginal efficiency in the formation of investment in fixed capital;
- strong dependence of marginal efficiency on export prices.

This result is obtained from the analysis of macroeconomic data. But regional panel data can provide a much richer sample for estimating a regression of marginal revenue on different factors. To simplify the estimation, the *marginal* revenue is replaced by *average* revenue on fixed capital since it can be proved that in most cases they are proportional. [32]

Proof Sketch. The Cobb-Douglas production function marginal productivity of fixed capital is really determined by relation

$$\mathbf{dY/dK = \alpha Y/K.} \qquad \mathbf{(3)}$$

Here Y/K is the average efficiency of fixed capital, and α is a fixed parameter that is equal to the elasticity of output on fixed capital.

For the CES production function $Y = A[kK^{-\rho} + (1 - k)L^{-\rho}]^{-\nu/\rho}$ (where Y is output, K is fixed capital and L is labor, others are fixed parameters) marginal productivity of fixed capital is given by equation

$$\mathbf{dY/dK = k\nu Y^{(\rho/\nu + 1)}/K^{\rho + 1}} \qquad \mathbf{(4)}$$

For constant economies of scale in the CES function we have $\nu = 1$ and

$$\mathbf{dY/dK = k(Y/K)^{\rho + 1}} \qquad \mathbf{(5)}$$

This means that marginal productivity of capital is proportional to its average productivity when $\rho > -1$. The probability of this fact is very high when $\rho = -1$ the elasticity of substitution between capital and labor equals to infinity and production function is linear. In the case where $\rho > -1$, the elasticity of substitution between capital and labor is less than infinity and production function is non-linear.

We use panel data for 68 regions of Russia for the years 2004-06, that is, 204 points as we did in our previous work.[33] The average efficiency of fixed capital is taken as the dependent variable and a set of regressors – economic, social, technical and other variables are taken from the research mentioned above. [34]

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[32] Besides that, in our previous work [9] we show that average efficiency of fixed capital is the strongest factor that determines its renovation.

[33] See [9]. The data are taken from [10].

[34] See [9].

The results of econometric estimation for panel data

The results of the econometric estimation are given below in Table 8.

Table 8 - Results of the econometric estimation (equation 6)

Dependent variable: QK		
Independent variables	Parameters estimates	t-statistics
CTK	5.907132	5.294060
D06	0.032675	4.094191
DC	-0.036816	-3.503986
DM	0.251501	5.496336
DU	-0.073991	-5.718489
DV	-0.045794	-4.238790
EXPDQ	0.194605	8.848490
PAK	65.50669	5.499872
PCLI	0.005683	2.885630
VC	-0.007713	-5.470459
VE	-0.009726	-6.869834
VR	-0.011079	-6.115226
VT	-0.003510	-4.044207
VTRAN	-0.004590	-6.202710
C	0.534178	19.00217
R^2	0.819905	
F	61.46050	
DW	2.175153	

Here:

QK – average efficiency of fixed capital that is gross regional product (GRP) divided by volume of fixed capital for each region;

CTK – internal expenditures on R&D divided by volume of fixed capital ("per capita R&D");

D06 – dummy variable for 2006 year;

DC – dummy variable for the Central Federal District;

DM – dummy variable for Moscow City;

DU – dummy variable for the Urals Federal District;

DV – dummy variable for the Volga Federal District;

EXPDQ – share of export for "far" foreign countries in GRP;

PAK – patents divided by volume of fixed capital ("per capita patents");

PCLI – personal computers per 100 employees;

VC – share of construction in GRP, %;

VE – share of production and distribution of electricity, gas and water in GRP, %;

VR – share of retailing in GRP, %;

VT – share of trade and restaurants in GRP, %;

VTRAN – share of transport and communications in GRP, %;

C – the intercept;

$\mathbf{R^2}$ – determination coefficient;

F – Fischer's statistics;

DW – Durbin-Watson coefficient.

The estimated equation allows us to calculate input of main variables such as internal expenditures CTK, share of export EXPDQ, amount of patents PAK, and the amount of computers PCLI in variation of average efficiency QK. The results are given in Table 9.

Table 9 - Input of different factors in variation of average efficiency of fixed capital

Variable	Normalized input, %
CTK	24,2%
EXPDQ	28,8%
PAK	22,5%
PCLI	24,5%

Here we observe the crucial importance of three technological variables (CTK, PAK and PCLI) and export orientation of the region (EXPDQ) for the estimation of the value of average efficiency of fixed capital.

In accordance with this table, we calculate the **index of technological development (TI)** and **the dynamic index (DI)** for the considered regions. The first one is a weighted sum of three technological variables for regions with the minimal value equal to 1. The second one is a weighted sum of technological index and the **export index (EI)**. The latter is the share of export in GRP when the minimal value also equals to 1.

Remark. It is done according to the following algorithm.

1. The meaning for each indicator of technology in the table (CTK, PAK and PCLI) for each region is divided by its minimum value in the sample (the value for the region that is minimal in the sample), which provides the normalized value of each one.

2. The weighted sum of three indices is calculated using normalized values from the obtained table. They are: 0.340 for CTK, 0.316 for PAK, and 0.344 for PCLI.

3. These values are again normalized by dividing them by the recalculated minimum value in the sample. That is, the minimum value of index is 1.00 for the Tumen Oblast in the sample.

Finally, we calculate a weighted index that is a weighted sum of the technological index and the share of export in GRP. Since the share of technological factors is 0.712 and the share of export is 0.288 in Table 9, they are taken as weights, and the values are again normalized in such a way that the smallest index value is equal to 1.00. The new index is called "**dynamic index**" since it has crucial influence on the marginal productivity of capital.[35]

The regions with the best values of both indices for the year 2006 (above 15.00) are given in Tables 10 and Table 11.

Table 10 - Regions with the best values of the technological index (TI; minimum = 1.00)[36]

Regions	Index
S. Petersburg City	30.59
Moscow City	25.13
Nizhniy Novgorod oblast	23.57
Moscow oblast	19.75
Ulyanovsk oblast	18.91
Kaluga oblast	17.39
Novosibirsk oblast	15.86
Tomsk oblast	15.46

[35] The differential of a macroeconomic two factors production function is: $dY = dA + mk(dK) + ml(dL)$, where *mk* and *ml* are marginal productivities of capital and labor, respectively. If dynamics of technological progress *(dA)* and labor *(dL)* is small or negative as in the Russian economy now, then the role of *mk* in economic dynamics becomes crucial.

[36] Nizhniy Novgorod, Ulyanovsk and Kaluga oblasts are full of high technology machinery tool business. Novosibirsk and Tomsk are well-known due to their scientific potential.

Table 11 - Regions with the best values of the dynamic index (DI; minimum = 1.00)

Regions	Index
Moscow City	41.56
S. Petersburg City	26.03
Omsk oblast	24.85
Leningrad oblast	23.18
Krasnoyarsk kray	19.89
Lipetsk oblast	15.90
Kemerovo oblast	15.82
Bashkortostan Rep.	15.70
Samara oblast	15.03
Tatarstan Rep.	15.02
Khabarovsk kray	15.01

The main difference between Tables 10 and 11 is that in Table 10 there are regions with a high share of export.[37]

In Tables 12 and 13 we compare regions with the best values of dynamic index (DI) and average productivity of capital (QK), respectively.

[37] Among them Krasnoyarsk and Lipetsk export mostly metals, while Samara, Baskortostan and Tatarstan export mostly oil. Leningrad Oblast also exports oil from its ports, Kemerovo exports coal, Khabarovsk – lumber, Omsk – chemistry products.

Table 12 - Regions with the best values of dynamic index (DI)

Regions	DI	QK
Moscow City	41.56	0,838
S. Petersburg City	26.03	0,571
Omsk oblast	24.85	0,615
Leningrad oblast	23.18	0,434
Krasnoyarsk kray	19.89	0,632
Lipetsk oblast	15.90	0,516
Kemerovo oblast	15.82	0,452
Bashkortostan Rep.	15.70	0,519
Samara oblast	15.03	0,425
Tatarstan Rep.	15.02	0,490
Khabarovsk kray	15.01	0,401
Group average	20,73	0,536
Russian average	8,45	0,398

Table 13 - Regions with the best values of average productivity of capital (QK)

Regions	QK	DI
Moscow City	0,838	41,56
Krasnoyarsk kray	0,632	19,89
Omsk oblast	0,615	24,85
S. Petersburg City	0,571	26,03
Belgorod oblast	0,545	7,29
Orenburg oblast	0,542	6,66
Bashkortostan Rep.	0,519	15,70
Lipetsk oblast	0,516	15,90
Tomsk oblast	0,516	8,14
Kaliningrad oblast	0,510	13,78
Group average	0,580	17,98
Russian average	0,398	8,45

From Tables 12 and 13 one can see that:

1. In each group both average productivity of capital and dynamic index are much higher on average than the all-Russian average.
2. They have 6 “common members” among 10 in the second group.
3. Each member of the group with the highest index DI has a better index than the Russian average.
4. In the second group only Belgorod, Tomsk and Orenburg have a value of dynamic index *lower* than the Russian average, but Tomsk has the advanced technological index. High values of index QK in Belgorod and Orenburg can be explained by the fact that they are much better supplied with labor than the Russian average (low capital intensity leads to high average productivity of capital).[38] Orenburg is also rich with oil and gas extraction and processing.

The calculated Spearmen rank correlation for the year 2006 (based on data of 66 regions)[39] has the following values:

- between indices QK and TI it is 0.364;
- between indices QK and EI it is 0.699;
- between indices QK and DI it is 0.793.

These calculations support the conclusion about the crucial role of export in determination of capital efficiency. But they also show the unmistakable significance of technological factors.

The adjusted R-squared of index QK on index DI is 0.681, which is rather high for the sample of the year 2006 that is for 66 points.[40] The scatter with linear regression demonstrates a rather high correlation between index QK and index DI in Figure 1.

[38] Omsk, Bashkortostan, Kaliningrad, and Lipetsk have the same feature. Besides, Belgorod occupies 1/5 of the Russian trade with Ukraine.

[39] Hanty-Mansiisk and Yamalo-Nenets are parts of the Tyumen Oblast.

[40] We eliminate Khanty-Mansiisk and Yamalo-Nenetskii regions from the sample here as they are parts of the Tyumen oblast.

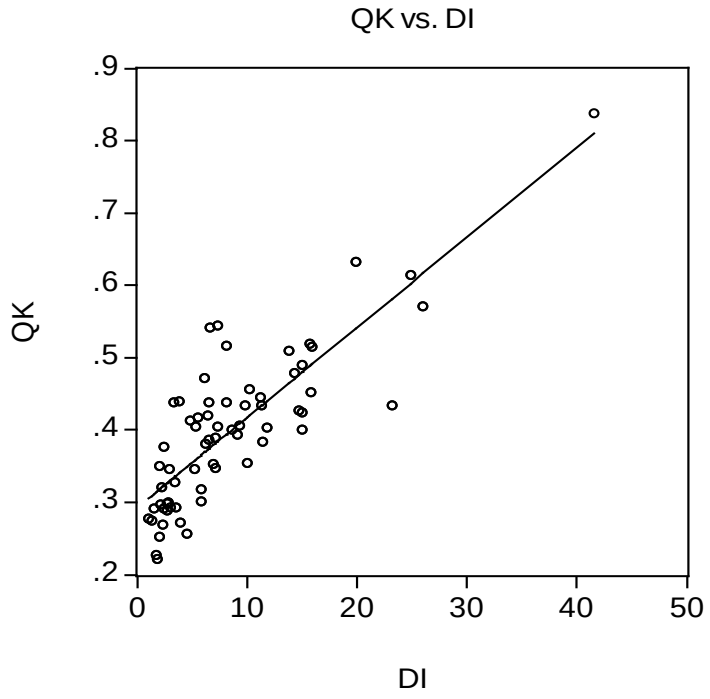

Figure 1- Index QK versus index DI

Incidentally, if we take the regions with the best values of the technological index we see that two of them (Ulyanovsk and Kaluga) have *lower* values of index QK than the Russian average. In contrast, among 10 regions with the highest value of index QK, 6 regions have a value of index TI lower than the Russian average. This fact underlines the role of export in formation of the level of capital efficiency.

Investment and incomes in Russian regions

Finally, we calculate the influence of investment in fixed capital on household incomes in Russian regions. We use the same sample for 68 regions for the years 2003-2006 and estimate a regression of this indicator on different variables, thereby getting the following results:

Table 14 - List of variables

Title	Symbol	Dimension
Dependent variable		
Income per capita	IN	Ruble
Independent variables		
Capital intensity	KL	Thousands of rubles per employee
Labor productivity	QL	Thousands of rubles per employee
Average productivity of capital	QK	Ruble / ruble
Share of employed in total population	LN	%
Share of export in GRP	EXPDQ	%
Share of employees with higher education	HE	%
Share of agriculture in GRP	VA	%
Share of mining in GRP	VMI	%
Share of manufacturing in GRP	VMO	%
Share of real estate operations in GRP	VR	%
Share of transport in GRP	VTRAN	%
Share of construction in GRP	VC	%
Share of electricity, gas and water production and distribution in GRP	VE	%
Share of trade in GRP	VT	%

We use the following equation for econometric analysis:

$$IN = -3061,2 + 816,4D05 + 1990,7D06 + 8232,4DM + 680,4EXPDQ$$
$$(-2,211) \quad (4,738) \quad (10,571) \quad (9,413) \quad (3,027)$$
$$+59,4HE + 1,972KL + 12458,3LN + 4895,3QK + 2,965QL - 148,0VA$$
$$(2,739) \quad (7,043) \quad (4,407) \quad (3,860) \quad (3,215) \quad (-7,173)$$
$$- 25,0VMI - 60,2VMO + 101,3VR$$
$$(-2,697) \quad (-6,571) \quad (2,889)$$

R^2 = 0,947

DW = 2,041

F = 265,7

Here:

D05 – dummy variable for 2005;

D06 – dummy variable for 2006;

DM – dummy variable for Moscow City;

R^2 – determination coefficient;

DW – Durbin-Watson coefficient;

F – Fischer statistics;

Student statistics are indicated in parentheses.

The introduced econometric equation allows us to calculate the input of the main variables in the variation of dependent variable. See Table 15.

Table 15 - "Normalized" inputs of main factors in the variation of income per capita

Variable	Normalized input
EXPDQ	5,0%
HE	7,2%
KL	46,1%
LN	12,4%
QK	11,0%
QL	18,3%

This result implies the following:

1. Capital intensity of labor provides almost a half of income variation among regions.
2. Factor productivity is also very important; together two indicators explain about 1/3 of income variations.
3. The share of employees in total population explains about 12% of income variation.
4. Two other significant variables – the share of employees with a higher education and the share of export in GDP are not as strong as the previous ones. But the last one has a strong indirect influence via the marginal productivity of capital.

Rank and statistical analysis

We now calculate the index of wealth and capital intensity for each region with the minimum value equal to one for the lowest value. Besides that, we calculate two indices of the total factor productivity (TFP). The formula for calculation is:

$$I = (I_C)^{wc}(I_L)^{wl}.$$

Here I_C is the index of average capital productivity, I_L is the index of average labor productivity, both equal to one for the region with the minimum value. Indices *wc* and *wl* are the weights, but for the first index we use coefficients of factor elasticity from the macroeconomic production function and for the second one we use shares of gross wages and gross profit in GDP. We call the first index macro index and the second one equilibrium index. The values for the richest Russian regions are given in Table 16.

Table 16 - Characteristics for the richest Russian regions for 2006 (min of each index = 1 with the exception of LN-values)

Region / Indicator	Income index	TFP - macro	TRP - equilibrium	Capital intensity index	LN
Moscow City	6,675	6,972	4,708	2,976	59,8%
Yamalo-Nenets	6,065	14,1015,8	5,851	21,227	65,9%
Hanty-Mansiisk	5,012	11,061,6	3,682	11,514	59,1%
S.-Petersburg City	3,157	2,928	2,391	1,757	53,5%
Magadan	3,079	2,669	1,749	3,235	55,6%
Sakha Rep.	3,053	3,641	2,389	3,225	50,0%
Komi Rep.	3,003	3,642	2,097	4,634	48,7%
Russian average	2,039	2,453	1,791	2,421	48,2%

We see that the richest regions usually have high TFP, capital intensity and employment level. St. Petersburg city has a relatively low capital intensity level but high technological and dynamic indices, high education level and a high share of export in GDP.

Conclusions

The implemented analysis shows that:

1. Net profit is the most important origin of investment from private sources in the Russian economy. But its dynamics are worsened by the increase of taxation and the rapid growth of real wages, and this harms the investment process in Russia.
2. Investment from net profit is explained mostly by the volume of net profit and marginal revenue from fixed capital.
3. The marginal revenue depends strongly on export prices of Russian goods and on technological factors.
4. The indices of average and marginal productivity of capital attain high values and investment moves forward when technological and an export factors act in interrelation.
5. Investment in fixed capital has a strong influence on the income of Russian citizens.

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