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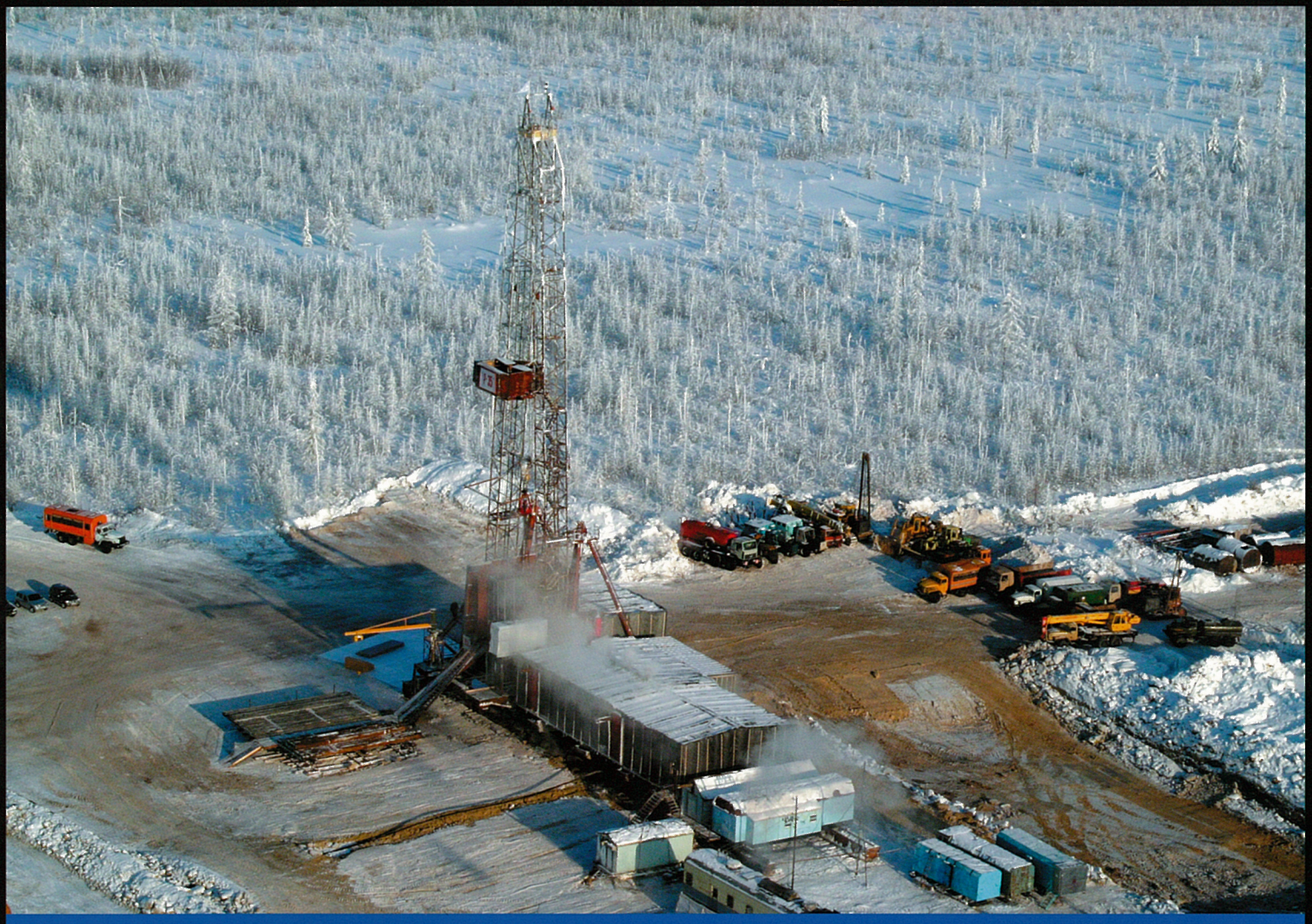

The Eastern Gas Programme – early development phase

Models for gas hydrates decomposition

Газовая промышленность

Natural gas production in Tyumen region: economic-and-mathematic modelling and forecasting

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In terms of statistical criteria, the proposed production functions of gas sector operations regarding the activities in entire Tyumen region and by Gazprom's subsidiaries appears to adequately describe gas production processes which are essentially predictable. There are good applications available for production economics analysis, planning, and forecasting – with all such areas believed to be useful for both related government authorities and domestic oil and gas companies including Gazprom. In particular, such functions can be applied to development of Russia's new energy strategy and gas industry investment programmes.

In economic sciences, a body of production functions and statistical methods (econometrics) typically serves as one of the most widely used techniques for economic-and-mathematic modelling and forecasting the production of different commodities. Such production functions (PFs) reflect the relationship between maximum product output and factors of production (inputs) as well as the relationship between different factors of production.[1]

Production factors. For economic research into PF, we have chosen – similar to other publications[2, 3] – the following production factors which impact natural gas field output, $Г_t$:

1) Average annual cost of fixed industrial assets (FIA) for a core upstream activity $\bar{Ф}_t$ (in 1990 roubles) comprising the key value for the gas industry.

2) Cumulative natural gas production since start-up of commercial operations (1963) through year of $t-1$ $G_{1963,t-1}$, to be characteristic of reserves depletion.

Labour requirements are critical for gas production, but those are not included as an argument into the PF formula since, due to high gas field automation level, total worker requirements are essentially driven by key upstream assets and their maintenance needs.

Statistics data acquisition and processing. With regard to natural gas production, the 1963 through 2006 Tyumen region data were used, obtained from various sources,[4 - 23] along with Form 1 – Natura excluding East Siberian production with some gas coming from Tyumen since the early 1970s,[24] while reporting as output from producers' official registration areas. Cumulative gas production since 1963 was assessed based on the mentioned data (see Table 1).

The average annual FIA value for core activity areas over 1964 – 1990 was derived from summaries presented in Form 11 (postage stamp) following the Russian Industries Classification (OKONKh 11231) for Tyumen region (see Table 1). From 1991 to 2006, the average annual key asset value was re-assessed in 1990 constant roubles, and between 1991 and 1998 – produced from Form 11 under Russian Classification of Economic Activities (OKVED 11.10.2), while since 1999 – driven by gas sector capital construction reporting (the large-scale enterprises referred in literature[23, 26]) and in the oil sector (broken down by gas exploration and production divisions owned by oil companies), as well as Form 11 (for other entities) based on the methodology below.

Since 1991, the average annual value (in 1990 roubles) was assessed as a simple mean between FIA for a key activity area as of early reporting year, in constant roubles, $ФН_{t(1990)}$, and the same for reporting yearend, $ФК_{t(1990)}$ (see Table 2):

$$\bar{Ф}_t = \frac{ФН_{t(1990)} + ФК_{t(1990)}}{2},$$

Where: t = 1991, ..., 2006

$$ФК_{t(1990)} = ФН_{t(1990)} + ФВ_{t(1990)} - ФЛ_{t(1990)};$$

$$ФН_{t(1990)} = ФК_{t-1(1990)};$$

$$ФН_{1991(1990)} = ФН_{1991};$$

$$ФВ_{t(1990)} = \frac{ФВ_t}{\prod_{i=1991}^{t} ИКС_i};$$

$$ФЛ_{t(1990)} = \frac{ФЛ_t}{\prod_{i=1992}^{t} ИЛ_i};$$

$$ИЛ_t = \frac{ФН_t}{ФК_{t-1}};\ ИЛ_{1991} = 1;$$

$$ИЛ_{1993} = 1.$$

In this case: $ФВ_{t(1990)}$ and $ФЛ_{t(1990)}$ = the value of newly commissioned and decommissioned FIAs for core activity area, in 1990 roubles and over year t; $ФН_t$ and $ФК_t$ = the value of FIA in actual

Table 1

Natural gas production, accumulated production, and average annual asset value, OKONKh 11231 for Tyumen region (less East Siberian producers) and for Gazprom

Year, t	Production, $Г_t$,, million m³	Accum. production, $G_{1963,\,t-1}$,, million m³	Ave. annual assets value, $\bar{Ф}_t$ '000 const. roubles	Year, t	Production, $Г_t$,, million m³		Accum. production, $G_{1963,\,t-1}$,, million m³	
	Tyumen region (Gazprom)				Tyumen region	Including Gazprom*	Tyumen region	Including Gazprom*
1983	251,183	960,034	2,128,293	1997	496,204	495,795	7,403,838	7,403,838
1984	300,443	1,211,217	2,720,530	1998	516,159	514,626	7,900,042	7,899,633
1985	350,629	1,511,659	3,253,521	1999	514,938	509,913	8,416,200	8,414,259
1986	390,285	1,862,288	4,002,909	2000	503,487	496,891	8,931,138	8,924,172
1987	430,815	2,252,573	5,255,322	2001	498,336	487,781	9,434,625	9,421,063
1988	474,807	2,683,387	6,475,879	2002	511,210	492,786	9,932,960	9,908,845
1989	507,538	3,158,194	7,602,308	2003	531,647	506,360	10,444,171	10,401,630
1990	536,583	3,665,732	8,315,808	2004	542,924	512,767	10,975,817	10,907,991
1991	544,733	4,202,315	See Table 2	2005	549,692	514,634	11,518,742	11,420,757
1992	549,463	4,747,048		2006	563,904	514,655	12,068,434	11,935,391
1993	533,438	5,296,510						
1994	528,721	5,829,948						
1995	518,731	6,358,669						
1996	526,438	6,877,40						

* From 1998 on, following the production estimate methodology in 2007.[25]

prices in early year and yearend t; $ФВ_t$ and $ФЛ_t$ = the value of newly commissioned and decommissioned FIAs, for key activity area and in actual prices, over year t; $ИКС_t$ = index of actual prices for capital construction over year t (for 1992 – 1999, annual average index for the Russian gas industry,[27, 28] for 2000 – 2004, December of reporting year against December of previous year, for the Yamal-Nenets Okrug's gas sector,[29] for 2005 – 2006, December of reporting year against December a year earlier, according to OKVED 11, "Crude oil and natural gas production, and services in these areas," for Yamal-Nenets Okrug[30–31]);* $ИЛ_t$ = index of actual re-assessment of key assets over year t which was 1 in 1991 and 1993 as there had been no re-evaluation of the fixed assets in the beginning of respective years; for 1998, the index was assessed based on summary for four enterprises (early 1998 through 1997 yearend), and the cost of assets already written off in 1998 in comparable roubles was calculated from six reporting enterprises of which two emerged in 1998.

The assets entered into production or decommissioned for other reasons were not considered while assessing the average annual value since 1991 as it was unclear, due to nonavailability of exact information regarding the value and its movement, which indices should apply and how the value was to be converted into constant roubles.

Due to nonavailability of average annual indices for actual prices regarding the capital construction area over 1991, *ИКС*1991, the cost for newly commissioned assets for core activity areas, in this year and in comparable prices [*ФВ*1991(1990)], was calculated as a sum of ratios between total installed new machinery and equipment costs (Rb207,915,000) and annual average actual prices index for oil and chemical engineering products, 2.1,[32] and cost of all other newly installed assets (Rb609,940,000), and index of estimated pricing for construction and installation work regarding gas field development, 1.56, multiplied by a territorial coefficient for Tyumen Oblast, 0.91.[33]

$$ФВ_{1991(1990)} = \frac{207915}{2,1} +$$

$$+ \frac{609940}{1,56 \cdot 0,91} = \text{Rb}528,663,000$$

$$ИКС_{1991} = \frac{817855}{528663} = 1.547 \text{ times.}$$

Since 1999, the abandoning cost for key assets was never accounted for while estimating annual average costs, due to nonavailability of complete data – as a significant proportion of the assets (in core activity areas for major Tyumen gas producers) was transferred to Gazprom's subsidiaries for which trading remains the central operating area.[34]

For the same reason, since 1999, rather than cost of installed facilities, *in core activity areas*, actual costs for major gas producers began increasingly absorbing reported expenses for key installed

* Over 1991 – 1999, the indices for actual prices in capital construction area, broken down by region and industry sector, were never assessed by Rosstat (the Russian statistics office). Since 2000, such indices remain unpublished by Rosstat and its local subsidiaries, while OKONKh 11231, "Natural gas production," and OKVED 11.10.2, "Natural gas and gas condensate production," ceased to be ever calculated.

Table 2

Fixed industrial assets for core gas producer activities in Tyumen region in 1991 – 2006 (actual and constant 1990 roubles)

Year, *t*	Actual prices, '000 roubles (constant roubles prior to 1994)				Count of gas producers by rules**	Actual capital construction price indices, times the previous period,*** $ИКС_t$	Indices of actual reassessment of assets, times the previous period, $ИЛ_t$	In constant 1990 roubles (thous.)					
	Count, early reporting year, $ФН_t$	Newly commissioned,* $ФВ_t$	Abandoned (write-offs), $ФЛ_t$	Count, by reporting yearend, $ФК_t$				Count, early reporting year, $ФН_{t(1990)}$	Newly commissioned, $ФВ_{t(1990)}$	Abandoned write-offs), $ФЛ_{t(1990)}$	Count, by reporting yearend, $ФК_{t(1990)}$	Entire region, $\bar{Ф}_t$	Incl. Gazprom,**** $\bar{Ф}_t$
1991	8,898,647	817,855	14,988	9,617,017	5	1.547	1.0000	8,898,647	528,663	14,988	9,412,322	9,155,485	9,155,485
1992	221,,976,,016	13,190,590	71,743	235,401,549	5	15.7	23.0816	9,412,322	543,085	3108	9,952,299	9,682,311	9,682,311
1993	246,018,523	78,555,661	412,065	310,769,116	4	11.5	1.0000	9,952,299	281,244	17,853	10,215,690	10,083,994	10,083,994
1994	7,561,302	980,498	18,291	8,548,785	4	4.4	24.3309	10,215,690	797,810	32,570	10,980,930	10,598,310	10,598,310
1995	32,048,452	2,087,771	42,699	34,186,096	4	3.1	3.7489	10,980,930	547,992	20281	11,508,641	11,244,786	11,244,786
1996	91,366,712	8,631,685	184,223	100,798,757	4	1.750	2.6726	11,508,641	1,294,639	32,740	12,770,540	12,139,590	12,139,590
1997	70,962,373	7,605,151	244,794	78,555,246	4	1.143	0.7040	12,770,540	997,963	61,796	13,706,707	13,238,623	13,238,623
1998	77,370,998	4,710,636	249,362	81,441,049	4 6	1.049	0.9849	13,706,707	589,265	63,913	14,232,059	13,969,383	13,954,843
1999	NA*****	8,101,028	NA	NA	6	1.410	NA	14,232,059	718,708	0	14,950,767	14,591,413	14,558,696
2000	NA	22,020,050	NA	NA	6	1.365	NA	14,950,767	1,431,192	0	16,381,959	15,666,363	15,628,308
2001	NA	45,434,752	NA	NA	9	1.119	NA	16,381,959	2,638,989	0	19,020,948	17,701,453	17,646,261
2002	NA	44,900,645	NA	NA	8	1.055	NA	19,020,948	2,472,006	0	21,492,954	20,256,951	20,095,333
2003	NA	71,975,827	NA	NA	11	1.217	NA	21,492,954	3,256,065	0	24,749,019	23,120,986	22,766,464
2004	NA	92,584,187 91,680,370	NA	NA	15	1.174	NA	24,749,019	3,567,591	0	28,316,610	26,532,815	25,772,162
2005	NA	66,915,022 69,976,723	NA	NA	16	1.1139	NA	28,316,610	2,314,812	0	30,631,422	29,474,016	28,034,862
2006	NA	78,768,529	NA	NA	17	1.1638	NA	30,631,422	2,341,351	0	32,972,773	31,802,098	29,823,655

* In 2004 and 2005, upper figures – adjusted value, lower figures – initial value; adjusted figures were used for constant rouble estimates.
** In 1998, "available" based on 4 enterprises (for write-off ratio estimates); commissioning and write-offs – based on 6 enterprises.
*** In 1991 – 1999, year-on-year; since 2000 – against December a year earlier.
**** Since 1998, key assets of Gazprom's subsidiaries are factored in accordance with 2007 production accounting methodology.[25]
***** Full data non-available.

facilities covering *target producing assets* (owned or leased). For all other facilities covered by OKVED 11.10.2, "Production of natural gas and gas condensate," we have additionally introduced only the cost of new assets for core activity areas (from 2003, mineral resources production assets, "C") while estimating annual average costs since 1999, obtained from Form 11, as there appears to be no sense taking into consideration the cost of abandoned assets, without major enterprises. Since 2004, facilities cumulative data has been augmented by the cost of key production assets commissioned, broken down by two gas producers incorporated into oil companies' exploration divisions [as follows from FGUP TsDU TEK (Central Energy Dispatch Office) data].

Aiming to ensure comparability of data over 2004 with those for 2003 and 2005, the cost of newly introduced production assets, in "C" category, for two producers, was adjusted to the upside: it became equal the cost of all newly installed key assets, both for 2003 and 2005. In 2005, the cost of all new OKVED assets ("C") of one of producers was reduced by value, equivalent to asset decommissioning for another one which was associated with the first one, but decommissioned in that year (see Table 2).

Choice of functions for econometric research. Here we address several types of production functions, PFs, to make a choice of those which are believed to better fit, in terms of statistical evaluation and economic sense, the description of gas production operations in Tyumen region. The following five PFs were chosen for our econometric analysis:

Table 3

Production functions most adequately describing Tyumen gas production in terms of classical econometrics criteria, and PFs featuring the most accurate predictability, in terms of ex-post forecast principle

Function	Time interval, t_0, ..., 2006	Coefficients, and *t*-statistics* α_0	α_1	α_2	R^2	*DW*
		Tyumen region (excl. East Siberian operations)				
Transcendental	1985–2006	4,749 373 943 (17]	0,549 705 694 6 (29]	−8,287 257 323·10^{-8} (−22]	0,99	2,13
$\Gamma_t = e^{\alpha_0+\alpha_2 G_{1963,\,t-2}} \bar{\Phi}_{t-1}^{\alpha_1}$	1987–2006	5,578 176 356 (14]	0,495 423 055 5 (19]	−7,432 950 292·10^{-8} (−16]	0,96	2,64
		Tyumen region (Gazprom's subsidiaries)				
Power-exponential	1984–2006	3,999 666 269 (14]	0,598 830 467 4 (32]	−5,623 297 311·10^{-8} (−25]	0,99	1,37
$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1+\alpha_2 G_{1963,\,t-2}}$	1986–2006	5,043 940 423 (15]	0,530 425 354 6 (23]	−4,980 719 154·10^{-8} (−21]	0,97	1,94
	1989–2006	6,434 100 762 (7]	0,440 235 760 5 (7]	−4,225 182 463·10^{-8} (−8]	0,85	2,25

* In brackets – *t*-statistics for α_i coefficients.

1) Linear

$$\Gamma_t = \alpha_0 + \alpha_1 \bar{\Phi}_{t-1} + \alpha_2 G_{1963,\,t-2};$$

2) Power

$$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1} G_{1963,\,t-2}^{\alpha_2};$$

3) Power-exponential

$$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1+\alpha_2 G_{1963,\,t-2}};$$

4) Transcendental ("kinetic")[35]

$$\Gamma_t = e^{\alpha_0+\alpha_2 G_{1963,\,t-2}} \bar{\Phi}_{t-1}^{\alpha_1};$$

5) Power-exponential, logarithmic[2]

$$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1+\alpha_2 \ln G_{1963,\,t-2}},$$

Where: Γ_t = natural gas output over year *t* (see table 1); $\bar{\Phi}_{t-1}$ = average annual FIA value for key activity area in 1990 roubles, in year $t-1$ (see Tables 1 and 2); $G_{1963,t-2}$ = accumulated gas production from start-up year (1963) through year $t-2$ (see Table 1).

Study results. The studies of these functions were using underlying data from 1964 to 2006, and a least square method, to employ Mesosaur package (version 1.2) and Eviews (v. 3.1) software. As a result, of all PFs under study, the gas production process can be best approximated – in terms of classic econometrics criteria (i.e. proximity of R^2 to 1, *DW* to 2, and the steady state of residuals – by power-exponential and transcendental functions built around data from a time interval starting from any year between 1984 and 1989 and ending 2006. Of those, the following PFs appear to be most applicable to Tyumen gas production when classical econometrics criteria apply (see Table 3):

1) Across the region as a whole – the transcendental function built from 1985 – 2006 time interval data.

2) Across Gazprom's subsidiaries in Tyumen region – a power-exponential PF built from 1986 – 2006 time interval data.

Two notes here apply. First, these two functions have very high squared multiple correlation coefficient, R^2, which reflects tightness of statistical connection between a regressand (natural gas production level) and explanatory variables (annual average key asset value and accumulated production). Second, proximity to 2 of Durbin-Watson (*DW*) statistics indicate nonavailability of the 1st-order autocorrelation for residuals of assessed regressions under 5% significance level, thereby evidencing the correctness of this functions choice.

In addition, *t*-statistics exceeding, by Modulus 2, the assessments of PF factors indicate that all such factors involved tend to be statistically valuable. Related factor signs (positive or negative) were found to well agree with their economic sense. Indeed, the negative factor, under cumulative production, $б_2$, appears to confirm that the production tends to fall with greater depletion under the unchanged assets involved. Conversely, the positive factor for core assets, $б_1$, indicates that under the given gas depletion rate in Tyumen, the output tends to progressively grow with expansion of upstream assets.

Meanwhile, these two functions typically fail to provide the requied gas production projections, in terms of ex post forecast principle which is "most commonly used and is yielding the highest efficiency while verification of the econometric model,"[36] as soon as ex post estimation of absolute value of average relative forecast error, $\Delta(\tau)_{отн}$, for these functions over one year ahead or longer tends to be away from a minimum value (see Table 4).

Choice of functions for gas production projections. Ex post estimation of absolute value of average relative error in this projection, $\Delta(\tau)_{отн}$, against the control sample, for τ years ahead, is calculated as a sum of modules of ratios of predicted gas production $\hat{\Gamma}_{t_{об}+i-1+\tau}$ over year $t_{об} + i - 1 + \tau$, to actual gas production levels in this year $\Gamma_{t_{об}+i-1+\tau}$, less 1, divided by number of projection runs, *n*:

$$\Delta(\tau)_{отн} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{\hat{\Gamma}_{t_{об}+i-1+\tau}}{\Gamma_{t_{об}+i-1+\tau}} - 1 \right| 100\ \%;$$

Table 4

Key results of ex-post estimates, τ years ahead

Industry-related function	Time interval, жуток t_0, ..., 2006	Ex-post estimation of average relative error absolute value, τ years ahead, $\Delta(\tau)_{отн}$, %				
		τ = 1	τ = 2	τ = 3	τ = 4	τ = 5
	Tyumen region (excl. East Siberian operations)					
Transcendental	1984–2006	1,08	1,20	1,30	1,54	1,74
$\Gamma_t = e^{\alpha_0+\alpha_2 G_{1963,\,t-2}} \bar{\Phi}_{t-1}^{\alpha_1}$	1985–2006	0,80	0,88	1,00	1,30	1,54
	1986–2006	0,68	0,81	0,88	1,06	1,49
	1987–2006	0,59	0,76	0,75	1,03	0,38
	1988–2006	0,89	1,41	1,91	1,19	–
	1989–2006	1,29	2,33	2,24	–	–
Power-exponential	1984–2006	1,19	1,28	1,39	1,69	2,02
$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1+\alpha_2 G_{1963,\,t-2}}$	1985–2006	0,89	0,98	1,21	1,52	1,50
	1986–2006	0,90	1,16	1,53	1,62	1,64
	1987–2006	1,11	1,47	1,63	1,83	2,87
	1988–2006	1,13	0,95	0,85	2,09	–
	1989–2006	0,83	0,82	0,01	–	–
	Tyumen region (Gazprom's subsidiaries)					
Power-exponential	1984–2006	1,57	1,89	2,13	2,54	2,90
$\Gamma_t = e^{\alpha_0} \bar{\Phi}_{t-1}^{\alpha_1+\alpha_2 G_{1963,\,t-2}}$	1985–2006	1,47	2,01	2,48	2,97	3,66
	1986–2006	1,65	2,11	2,45	3,07	3,81
	1987–2006	1,59	1,92	2,46	3,07	3,26
	1988–2006	1,71	2,45	3,18	3,28	–
	1989–2006	1,44	2,33	2,68	–	–

$$t_{об} = t_0 + 5m - 1;$$

$$n = 2006 - t_{об} - \tau + 1,$$

Where: $t_{об}$ = minimum end-year of a training sample; t_0 = initial year of a common sample (see column 2 in Table 4); m = number of PF coefficients (in this case, m = 3).[36, 37]

Of all functions under study, the following transcendent function features the smallest ex post forecast assessed absolute average relative projection error over a single year or longer ahead for Tyumen region:

$$\Gamma_t = e^{5,578\,176\,356 - 7,432\,950\,292 \cdot 10^{-8} G_{1963,\,t-2}} \times \bar{\Phi}_{t-1}^{0,495\,423\,055\,5}, \quad (1)$$

which is built around data over 1987 – 2006 (see Tables 3 and 4).

Among Gazprom's subsidiaries in Tyumen, the smallest such error, for one year ahead, is attributable to the power-exponential function:

$$\Gamma_t = e^{6,434\,100\,762} \times \bar{\Phi}_{t-1}^{0,440\,235\,760\,5 - 4,225\,182\,463 \cdot 10^{-9} G_{1963,\,t-2}}, \quad (2)$$

built for 1989 – 2006 (see tables 3 and 4), and that for two years or longer – to the following power-exponential function:

$$\Gamma_t = e^{3,999\,666\,269} \times \bar{\Phi}_{t-1}^{0,598\,830\,467\,4 - 5,623\,297\,311 \cdot 10^{-9} G_{1963,\,t-2}}, \quad (3)$$

built for 1984 – 2006 (see Tables 3 and 4).

Therefore, when predicting gas output for 2007, Eqs. 1 and 2 are believed to be most preferable as they provide good description of the gas production process in terms of classical econometrics criteria (i.e. proximity of R^2 to 1 and DW to 2, see Table 3) and economic sense.

The 2007 gas production outlook. The PFs chosen based on the ex post forecast, Eqs. 1 and 2, have yielded the following gas production outlooks for Tyumen region in 2007 (with 7 Bcm average RMS error):

1) For Tyumen region overall (excluding East Siberian producers) – 562.2 Bcm (against 563.9 Bcm in 2006).

2) Gazprom's affiliates in this region (accounted for by methodology[25]) in 2007 – 510.4 Bcm (against 514.7 Bcm in 2006).

Therefore, the both PFs demonstrate slightly smaller (within 1%) gas production levels for both Tyumen region and its Gazprom's producers (see Figures 1 and 2) which, in turn, appears to be well in line with Gazprom's expectations for lower gas output in 2007, by 5 – 8 Bcm, compared with 2006.

According to initial estimates, Tyumen gas production in 2007 showed some declines, falling to 555 BCM (excluding East Siberian producers), against 563.9 Bcm in 2006, with figures for Gazprom being 506.5 Bcm versus 514.7 Bcm, respectively. The divergence between estimates from Eqs. 1 and 2 and actual volumes in 2007 was 1.29% for the entire region, and 0.77% for Gazprom.

Fixed assets commissioning plan for 2008 – 2010, to sustain production levels under provisions of the Russian Energy Strategy to 2020. Gas production

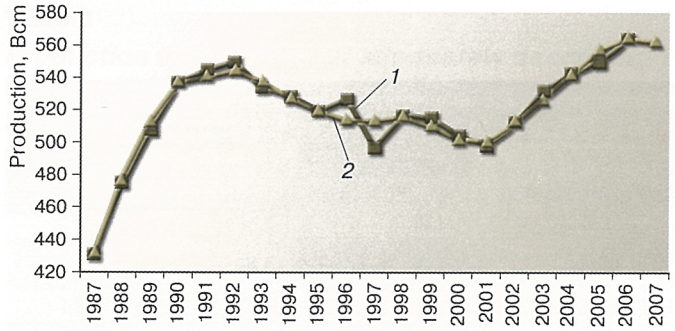

Figure 1. Actual (*1*) and estimated (*2*) natural gas production in Tyumen region (East Siberian producers excluded) in 1987 – 2006, and forecast for 2007 (562.2 Bcm)

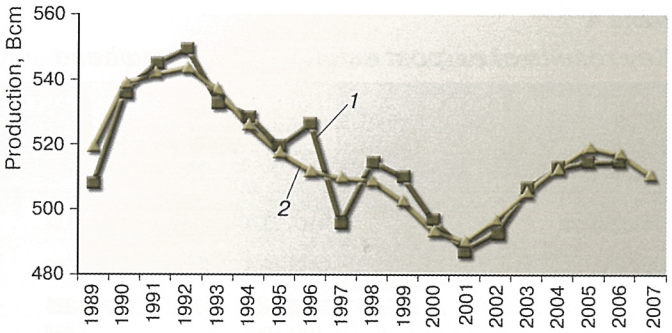

Figure 2. Actual (*1*) and estimated (*2*) natural gas production in Tyumen region (by Gazprom) in 1989 – 2006, and forecast for 2007 (510.4 Bcm)

outlooks for Tyumen region (excluding East Siberian producers) over 2008 – 2010, based on Eq. 1 transcendent function, yields the following results:

Medium-case option. Given the target of progressively growing gas production in Tyumen region (excluding East Siberian producers) from 562.2 Bcm in 2007 to 564 Bcm in 2010, gas producers would have to invest, in 2006 roubles, into upstream assets (in billion roubles):

in 2007 – 115.4
in 2008 – 95.5
in 2009 – 134.6

Therefore, to sustain the moderate Tyumen gas production scenario by 2010, a total of Rb345.5 billion investments would be required over 2007 – 2009, in 2006 roubles.

Optimistic option. Aiming to achieve gas production incremental increases in Tyumen region (excluding East Siberian producers) from 562.2 Bcm in 2007 to 565 Bcm in 2008, 568 Bcm in 2009, and 572 Bcm in 2010, Tyumen producers would have to ensure the following upstream asset investments (in 2006 billion roubles):

in 2007 – 134.6
in 2008 – 100.9
in 2009 – 167.2

Therefore, to sustain the optimistic Tyumen gas production scenario by 2010, a total of Rb402.7 billion investments would be required over 2007 – 2009, in 2006 roubles, which is Rb57.2 billion higher than in the medium-case option.

In future, it is expected to slightly increase the projection capacity of the addressed functions for the long-run, which would be largely dependent upon willingness of major producers in this region to provide a more complete history information regarding the abandoning of upstream assets including those leased from the parent company, between 1999 and 2007.

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Literature cited:

1. Brown, M. *On the theory and measurement of technological change* (translated from English by V.V. Zotov, ed. by V.G. Grebennikov and G.G. Pirogov). Moscow, Statistika Publ., 1971, p. 21.
2. Klimenko, A.V. "Predicting producing sectors with environmental provisions." In: *Methods for building and use of macroeconomic and production functions.* Moscow, CEMI Acad. Sc. USSR, 1980, p. 172.
3. Afanasyev, A.A. "Industry-related function for West Siberia's oil production function." Proc. 8th Russian Symp. Section 2. *Strategic planning and business development.* Moscow, 10 – 12 April 2007. Moscow CEMI Rus. Acad. Sc., 2007, pp. 21–23.
4 – 8. *The USSR Gas Industry in 1963, 1964, 1965, 1966, and 1967*. Moscow, Nedra Publ., 1964 – 1969, p. 84; p. 66; p. 60; p. 52; p. 84.
9 – 18. *The USSR Gas Industry in 1969, 1974, 1976, 1977, 1979, 1982, 1984, 1985, 1987, and 1990.* Moscow, VNIIEGazprom, 1970 – 1991, p. 133; pp. 26–27; p. 28; p. 29; pp. 32–33; pp. 26–27; pp. 30–31; p. 31; pp. 24–25; p. 33.
19 – 20. *The Gas Industry: Economics and Statistics Review, 1995 and 1996.* Moscow, IRTs Gazprom, 1996 (p. 59) and 1997 (p. 63).
21 – 22. *Statistics Yearbooks, 1990 – 2004 and 1990 – 2006*. Part I. Territorial state statistics agency of the Russian Federation, Tyumen Oblast. Tyumen, 2005, p. 58, and 2007, p. 40.
23. *The Gas Industry in 2000: Economics and Statistics Review*. Moscow, IRTs Gazprom, 2001, p. 82, p. 164.
24. *Quarterly Report, 3Q2007*. Norilsk, Norilskgazprom, 2007, pp 27 – 30.
25. *Quarterly Report, 2Q2007.* Moscow, Gazprom, 2007, p. 69.
26. *The Gas industry in 1999: Economics and Statistics Review*. Moscow, IRTs Gazprom, 2000, p. 168.
27 – 28. *Prices in Russia*. Moscow, Goskomstat Russia, 1996 (p. 188) and 2000 (p. 143).
29 – 31. *Construction operations in Tyumen Oblast (2000–2004), (2001–2005), (2002–2006)*. Territorial state statistics agency of the Russian Federation, Tyumen Oblast. Tyumen, 2005, p. 144, 2006, p. 97, and 2007, p. 78.
32. *Prices in the Russian Federation*. Moscow, Goskomstat Russia, 1995, p. 123.
33. *Cost profile indices for construction, installation, and other operations, and construction costs.* Letter of USSR Gosstroy, 14-D, 6 September 1990.
34. *Russian Statistics Yearbook, 2004.* Statistics Review, Moscow, Rosstat, 2004, p. 371.
35. Nasinnik, Z.A. *Predicting petroleum and associated gas upstream costs.* Moscow, Nedra, 1975, p. 84.
36. Aivazyan, S.A. *Applied Statistics. Econometrics Fundamentals, V. 2*, Moscow, YUNITI-DANA, 2001, p. 36.
37. Green W.H. *Econometric Analysis*. New York, Macmillan, 1993. p. 197.