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DEVELOPMENT OF ACTIVITIES FOR THE OPENING OF THE RAIL BUS ROUTE "R/S ASTANA – R/S NURLY-ZHOL"

Assiltayev Alimzhan
aleemzhan@gmail.com
Eurasian National University, Nur-Sultan, Kazahstan

At the beginning of the century, it was assumed that every enterprise, including a public transport enterprise, should organize passenger servicing, transportation pricing at its own expense, and ensure a balance of operating costs. However, the authorities came to participate in the transport sector for two reasons: ensuring the safety of transportation and protecting the interests of passengers from the arbitrariness of transport enterprises, which played an almost monopolistic role. In the whole sector of urban passenger transport, market economy rules are applied with two reserves of control: technical and rate.

We suggest taking the following vertices using the example of Nur-Sultan and consider in a particular case:

1- R/S “Нур- Султан-1”;
2- Astana Mall;;
3- R/S“Nurly Zhol”.
4- SC“Asia Park”;
5- House of Ministries;
6- SC “MegaSilkWay”.

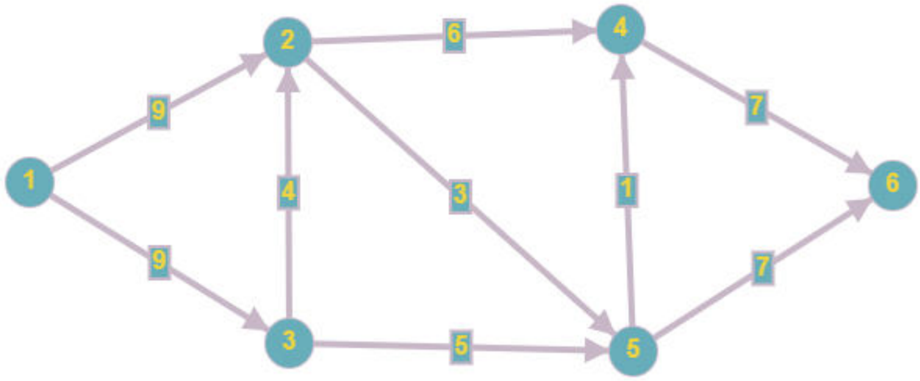

Figure 1 - Example of a graph on a city

In Figure 1, the source is Vertex 1, and drain is Vertex 6. Denote the throughput of each of the arcs: U (1,2) = 9, U (1, 3) = 6, U (2,4) = 6, U (3, 2) = 3, U (2,5) = 3, U (3, 5) = 3, U (5,4) = 1, U (5,6) = 7, U (4,6) = 7. Next, we solve this problem using Delphi software.

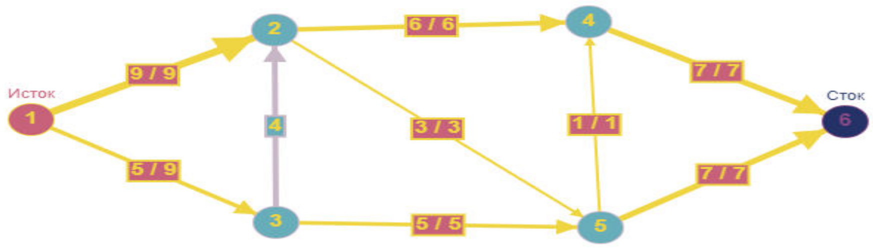

Figure 2 - Capacity for individual arcs

In Figure 2, the author solved the maximum flow problem using Delphi, where it is indicated that the arc U (3,2) was not used, and the arc U (1,2) is used in its entirety, while the possibilities of the arc U (1, 3) is used by half.

The author proposes to create a rail bus between the stations of the Astana R/S and the Nurly-Zhol R/S. Thus, people will give priority to the use of the route between U (1.3) since there are no traffic lights, traffic jams, etc. between stations. Accordingly, the load on the arc U (1,3) falls due to the fact that the demand for the arc U (1,3) has increased. Now we will solve a new problem with the help of Delphi.

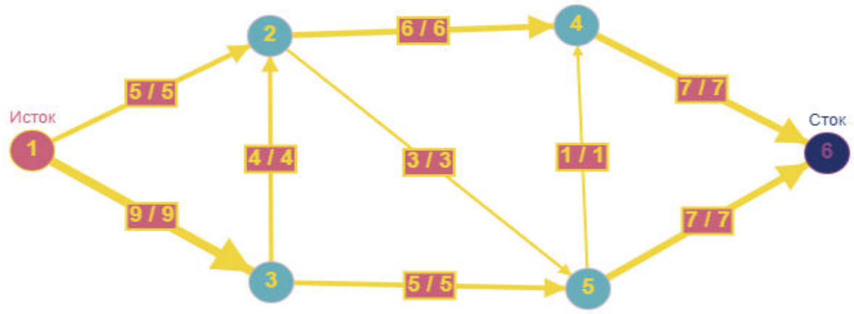

Figure 3 - Changing the graph after adding a route

In Figure 3, we see that the proposed method works for the authors and the arc U (3,2) is used to the full and unloads the transport network along the arc U (1,2). The new rail route along the arc will look like this:

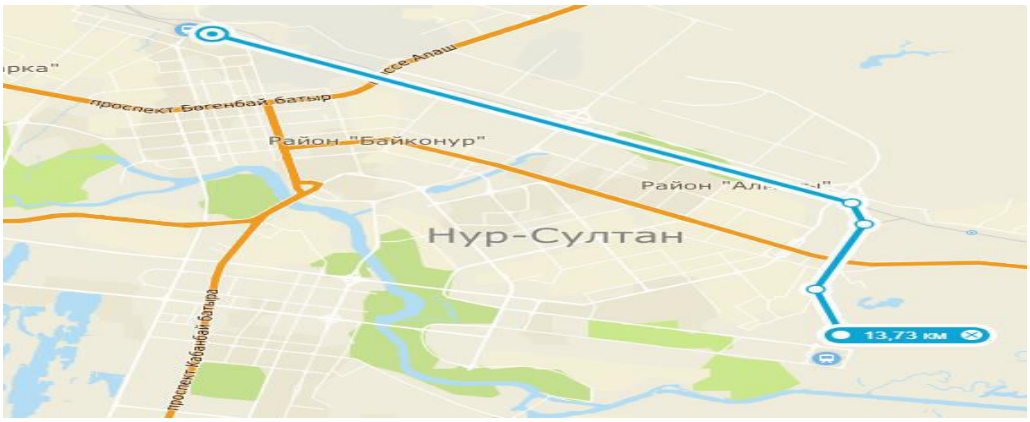

Figure 4 - Map of which is planned to launch a rail bus

Figure 4 Map of the city of Nur-Sultan, the new route will connect the Saryarka district and the Almaty district. The length of the route will be 13.73 km. Further, the author proposes to create another route from the Nurly-Zhol station to the city center, that is, along the arc U (3, 2) which is not used at the moment.

The opening of this bus route is justified by the fact that the route passes through passenger-forming and passenger-dependent points as the arc U (1, 3) became popular after the opening of the rail bus and, accordingly, the passenger traffic increased significantly along the other arcs U (3).

Characteristics of the proposed opening of the bus route:

- route length – 16,6 km;
- the average length of the span is calculated by the formula:

$$l_{пер} = l_м / n , \quad (1)$$

where $l_м$ – route length, km;

n – number of intermediate stops, (n = 17).

$l_{пер}$= 16,6 / 17 = 0,97 km = 970 m

With an unjustified increase in the length of the haul, the time spent by passengers on foot movement increases, and the volume of traffic decreases. Reducing the length of the span leads to a decrease in the speed of the message and the operational speed, because of which dramatically reduces the productivity of the use of buses. The average length of the span is directly proportional to the average operating speed. Operating speed is determined by the formula:

$$V_э = 0, 85 * \sqrt{l_{пер}} \quad (2)$$

$$V_э = 0, 85 * \sqrt{970} = 26,5 \text{ km/h}$$

Turnover time is determined by the formula:

$$t_{об} = l_м / V_э$$

$$t_{об} = 16,6 / 24,9 = 0,62 \text{ h}$$

To work on the route are appointed buses of foreign brands Citelis Irisbus Iveco.

Brief technical characteristics of the bus brand Citelis Irisbus Iveco:

- total nominal capacity – 115 passengers;
- number of seats – 26;
- linear rate of fuel consumption per 100 kilometers – 22 l;
- reference fuel consumption rate per 100 km of run – 28 l;
- number of tires – 6.

The required number of buses operating on the route is determined by the formula:

$$A_э = F_{max} * t_{об} / q_н * \gamma_н , \quad (3)$$

where F_{max} – maximum passenger traffic, pass / h;

$t_{об}$ – turnover time, h;

$q_н$ – bus rated capacity;

$\gamma_н$ – nominal filling level.

$$\gamma_н = \gamma_{max} + \gamma_{min} / 2 ,$$

where γ_{max} – maximum filling level;

γ_{min} – minimum filling level.

The minimum filling ratio is chosen for reasons of economic feasibility, that is, does it make sense to invest in the production of buses, if the effect may be lower than the costs incurredIts value depends on the hours saved by passengers and the cost of transport [9].

Approximately it can be taken 0,2 – 0,25.

The maximum filling level is the limit value of the average along the length of the route coefficient of capacity utilization (providing a single filling ratio on the busiest route of the route in the busiest peak hour period) where $\gamma_{max} = 1$.

$$\gamma_н = 0,2 + 1 / 2 = 0,6$$

$$А_э = 355 * 0,62 / 115 * 0,6 = 3,2 \text{ un.}$$

Accept $А_э$= 4 units.

The traffic interval on the route is determined by the formula:

$$I = t_{об} / А_э \quad (4)$$

$$I = 0,62 / 4 = 0,15 \text{ h} = 9 \text{ min}$$

Frequency of movement on the route is determined by the formula:

$$v = 60 / I \quad (5)$$

$$v = 60 / 9 = 6,6 \text{ fr/h}$$

The number of rounds is determined by the formula:

$$Z_{кр} = Т_м / t_{об}, \quad (6)$$

where $Т_м$ – the time on the route for the enterprise that will serve the route being opened is equal to $Т_м$ = 10,5 h.

$$Z_{кр} = 10,5 / 0,62 = 16 \text{ rounds or } 8 \text{ rounds}$$

The number of round trips performed by 5 buses per day is:

$$Z_{кр} = 8 * 4 = 32$$

The total mileage for the year is determined by the formula:

$$L_{общ} = (l_м * Z_{кр} + l_о) * Д_р, \quad (7)$$

where $l_о$ – zero mileage, km ($l_о$ = 10 km);

$Д_р$ – working days ($Д_р$ = 365 day).

$$L_{общ} = (16,6 * 32 + 10) * 365 = 197\ 538 \text{ km}$$

When opening the route, a passport of the route is compiled (Table 1).

Passport of the route	
Name:	«r/s Nurly-Zhol – SC Astana Mall»
Type:	Urban (linear)
Date of the passport:	20.04.19
Route length:	16,6 km
Round trip time:	0,62
Operating speed:	26,5
Seasonality of work:	constant
Route rate:	90 KZT (adult), 40 KZT (for children).

Table 2 Passport of the route

The act of measuring the distance on the route is presented in application.

The scheme of the route being opened is shown in Figure 5

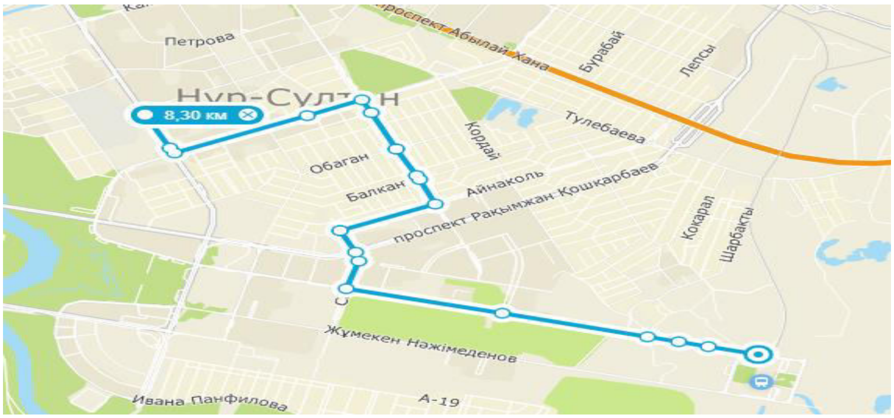

Figure 5 - Adding a new route

Figure 5 Route scheme «r/s Astana – SC Astana Mall»

To determine the total operating costs, you first need to calculate the total fuel and lubricant consumption per year for the route being opened.

Fuel consumption is determined by the following formula:

$$Q_т = H_л * L_{общ} / 100, \tag{8}$$

where H_L – linear rate of fuel consumption per 100 km, l ($H_л$ = 28 l).

$$Q_т = 28 * 197\ 538 / 100 = 55\ 310 \text{ l.}$$

Fuel consumption in winter conditions is determined by the formula:

$$Q_{зу} = H_{зм} * Q_т / 100, \tag{9}$$

where $H_{зм}$– the increase in the rate of fuel consumption in winter conditions, it is determined by the formula:

$$H_{зм} = N_{зм} * X_{ув} / N_{мес}, \tag{10}$$

where $N_{зм}$ – number of winter months (5);
$X_{ув}$ – percentage increase rate (10%);
$N_{мес}$ – number of months in a year (12).

$$H_{зм} = 5 * 10 / 12 = 4{,}17$$
$$Q_{зу} = 4{,}17 * 55\ 310 / 100 = 2306 \text{ l.}$$

Fuel consumption for intra-garage needs is determined by the formula:

$$Q_{вг} = 0{,}5 * (Q_т + Q_{зу}) / 100 \tag{11}$$

$$Q_{вг} = 0{,}5 * (55\ 310 + 2\ 306) / 100 = 288 \text{ l}$$

Total fuel consumption is determined by the formula:

$$Q^{общ}_т = Q_т + Q_{зу} + Q_{вг} \tag{12}$$
$$Q^{общ}_т = 55\ 310 + 2\ 306 + 288 = 57\ 904 \text{ l}$$

Fuel costs are determined by the formula:

$$C_т = Q_т * Ц_т \,, \tag{13}$$

where $Ц_т$ – price of 1 l. of fuel at the time of the development of the event, KZT ($Ц_т$ = 150 KZT).

$$C_т = 57\ 904 * 150 = 8\ 685{,}6 \text{ th.tg}$$

Next, you need to calculate the cost of lubricating materials.

These costs are calculated for each type of material - various oils, greases, cleaning and other materials based on the established consumption rates and prices, which are presented in table 3.

Table 2

Oil consumption rates (l) and lubricants (kg) per 100 liters of total fuel consumption and prices of 1 l (kg) oils and lubricants

Types and grades of oils and lubricants	Consumption rate	Price of 1 l (kg) of materials, tg
Motor oils	3,2 l	850
Gear oils	0,4 l	800
Special oils	0,1 l	750
Grease	0,2 kg	700
Kerosene	0.5 %	200

The need for lubricants and maintenance materials is determined by the formula:

$$Q_{смi} = H_{смi} * Q^{общ}_{т} / 100 \,, \tag{14}$$

where $H_{смi}$ – consumption rate of the i-th material l (kg).

For motor oils:

$$Q_{м.м} = 3{,}2 * 57\ 904 / 100 = 1853 \text{ l}$$

For gear oils:

$$Q_{тр.м} = 0{,}4 * 57\ 904 / 100 = 232 \text{ l}$$

For special oils:

$$Q_{сп} = 0{,}1 * 57\ 904 / 100 = 58 \text{ l}$$

For grease:

$$Q_{конс} = 0{,}2 * 57\ 904 / 100 = 116 \text{ kg}$$

For kerosene:

$$Q_{кер} = 0{,}5 * 57\ 904 /100 = 290 \text{ l}$$

The cost of lubricants and maintenance materials are determined by the formula:

$$C_{смi} = Q_{смi} * Ц_{1л(кг)} \,, \tag{15}$$

where $Ц_{1л(кг)}$ – price of 1 l (kg) of the i-th material, tg.

For motor oils:

$C_{м.м}$= 1853 * 850 = 1575 th.tg

For transmission oils:

$$C_{тр.м} = 232 * 800 = 185{,}6 \text{ th.tg}$$

For special oils:

$$C_{сп} = 58 * 750 = 43{,}5 \text{ th.tg}$$

For greases:

$$C_{конс} = 116 * 700 = 81{,}2 \text{ th.tg}$$

For kerosene:

$$C_{кер} = 290 * 200 = 58 \text{ th.tg}$$

The total cost of lubricants and maintenance materials are determined by the formula:

$$C^{общ}_{см} = C_{м.м} + C_{тр.м} + C_{сп} + C_{конс} + C_{кер} \quad (16)$$
$$C^{общ}_{см} = 1575 + 185,6 + 43,5 + 81,2 + 58 = 1\,943,3 \text{ th.tg}$$

The cost of TC and W is determined by the formula:

$$C_{то.р} = H_{то.р} * L_{общ} / 1000 \quad (17)$$

where $H_{то.р.}$ - salary standard for maintenance workers per 1000 km, tg ($H_{то.р} = 1200$ tg).

$$C_{то.р} = 1200 * 197\,538 / 1000 = 237,6 \text{ th.tg}$$

The cost of spare parts and materials are determined by the formula:

$$C_{з.ч.м} = H_{з.ч.м} * L_{общ} / 1000, \quad (18)$$

where $H_{з.ч.м}$ – consumption rate of spare parts per 1000 km, un. ($H_{з.ч.м} = 1100$ un.).

$$C_{з.ч.м} = 1100 * 197\,538 / 1000 = 217,8 \text{ th.tg}$$

The total cost of TC and W, as well as the cost of spare parts and materials are determined by the formula:

$$C_{то.р\text{-}зч.м} = C_{то.р} + C_{з.ч.м} \quad (19)$$
$$C_{то.р\text{-}зч.м} = 237,6 + 217,8 = 455,4 \text{ th.tg}$$

The cost of restoring and repairing tires is determined by the formula:

$$C_{ш} = H_{ш} * N_{пш} * Ц_{ш} * L_{общ} / 100 * 1000, \quad (20)$$

where $H_{ш}$ – the standard cost of restoring and repairing one set of tires (tire, tube, rim tape) is 0.99% of the cost per 1000 km of run;

$N_{пш}$ – number of tire sets on the bus, pcs ($N_{пш} = 6$ pcs);

$Ц_{ш}$ – price of one set of tires, tg ($Ц_{ш} = 40000$ tg).

$$C_{ш} = 0,99 * 6 * 40000 * 197\,538 / 100 * 1000 = 469,3 \text{ th.tg}$$

The costs of depreciation are determined by the formula:

$$A_{м} = C_{бал} * H_{ам} * L_{общ} / 100 * 1000, \quad (21)$$

where $C_{бал}$ – book value of one car, tg ($C_{бал} = 70000000$ tg);

$H_{ам}$ – the depreciation rate for the full restoration of the bus is 0.18% of the book value per 1000 km.

$$A_{м} = 70000000 * 0,18 * 197\,538 / 100 * 1000 = 24\,889 \text{ th.tg}$$

Drivers salary is determined by the formula:

$$ЗП_{в} = (t_{час(в)} + t_{час(к)}) * АЧ_{р} * Д_{р}, \quad (22)$$

where $АЧ_{р}$- car-hours of operation or average time in dress, c-h;

$t_{час}$- hourly rate (she makes up for drivers - 220 tenge).

$$АЧ_р = А_э * Z_{кр} * 1,67 \quad (23)$$

where $А_э$ – number of buses on the route, un ($А_э$ = 4 un);
$Z_{кр}$ – turnaround time, ($Z_{кр}$ = 6 round trip).

$$АЧ_р = 4 * 8 * 1,67 = 53,4$$
$$ЗП_в = 220 * 53,4 * 365 = 4\ 288 \text{ th.tg}$$

Salary accruals are determined by the formula:

$$ФЗП_{снач} = ЗП_в * 1,2 * 1,11 \quad (24)$$

where 1,2 – coefficient taking into account premiums and allowances;
1,11 – coefficient of social tax.

$$ФЗП_{снач} = 4\ 288 \cdot 1,2 \cdot 1,11 = 5\ 711,6 \text{ th.tg.}$$

General operating costs are determined by the formula:

$$С_{общ} = С_т + С^{общ}_{см} + С_{то.тр-зч.м} + С_ш + С_{Ам} + ФЗП_{снач} \quad (25)$$

$$С_{общ} = 8\ 685,6 + 1943,3 + 455,4 + 469,3 + 24\ 889 + 5\ 711,6 = 42\ 154,2 \text{ th.tg}$$

The cost can not be judged on economic efficiency, so you need to calculate the estimated income from the route being opened. It is determined by the formula:

$$D = Q_{пас} * \tau , \quad (26)$$

where $Q_{пас}$ – passenger traffic, pass;
τ - fare, tg.

$$Q_{пас} = q_н * А_э * Z_{кр} * \eta_{см} * \gamma_{вм} * Д_{др} * К_{рег} , \quad (27)$$

where $q_н$– bus capacity, pass. ($q_н$ = 115 pass.);
$А_э$ – number of buses on the route, un ($А_э$ = 4 un);
$Z_{кр}$ – number of rounds per day, ($Z_{кр}$ = 8);
$\eta_{см}$– passenger shift factor, ($\eta_{см}$= 1,9);
$\gamma_{вм}$– coefficient of occupancy, ($\gamma_{вм}$= 0,68);
$Д_{кал}$– calendar days, ($Д_{кал}$ = 365 days);
$К_{рег}$ – coefficient of regularity, ($К_{рег}$ = 0,963).

$Q_{пас}$= 115 * 4 * 8 * 1,9 * 0,68 * 365 * 0,963 = 1 671,2 th.pass

Next, it is necessary to determine the income from the route being opened, with 90% of passengers traveling at 90 tenge, and 10% at 40 tenge

$$D = 1\ 671,2 * 0,9 * 90 = 135\ 357,2 \text{ th.tg}$$
$$D = 1\ 671,2 * 0,1 * 40 = 6\ 684,8 \text{ th.tg}$$

The total income on the route is:

$$D_{общ} = 135\ 357,2 + 6\ 684,8 = 142\ 042 \text{ th.tg.}$$

Income without VAT is determined by the formula:

$$D^* = D_{общ} – D_{общ} * НДС / 100 , \quad (28)$$

where VAT – value added tax, % (VAT = 12 %).

$$D^{*} = 142\ 042 – 142\ 042 * 12 / 100 = 124\ 996{,}9 \text{ th.tg}$$

The taxable tax is determined by the formula:

$$D^{**} = D^{*} – C_{общ} \tag{29}$$

D^{**} = 124 996,9 – 42 154,2 = 82 842,7th.tg

Net income of the bus fleet is determined by the formula:

$$ЧД = D^{**} - D^{**} * 20 / 100 , \tag{30}$$

where 20 – corporate tax, %.

ЧД = 82 842,7- 82 842,7* 20 / 100 = 66 274,1 th.tg

The calculation results are summarized in table 3.

Table 3

Indicators of the effectiveness of the opening route

The name of indicators	Unit measuring	Value of indicators
1	2	3
Route length	km	16,6
Turnaround time	h	0,62
Number of stops in one direction	un	17
Number of buses on the route	un	4
Traffic interval	min	9
Passenger traffic per year	th.pass	1 671,2
Total mileage for the year	th.km	197 538
Drivers salary	th.tg	5 711,6
General operating costs	th.tg	42 154,2
Income from transportation without VAT	th.tg	124 996,9
Net income	th.tg	66 274,1

According to the results of the calculations made in this subsection, we can conclude that the opening of the “R/S Nurly-Zhol – SC Astana Mall” route is appropriate, since the volume of traffic for the year on this route is 1,671.2 thousand passengers. From the route being opened, the bus fleet number 1 has a net profit of 66,274.1 thousand tenge.

References

1. Володин Е.П., Громов Н.Н. Организация и планирование перевозок пассажиров автомобильным транспортом. — М.: Транспорт, 1982. - 198 с.

2. Вучик В.. Транспорт в городах, удобных для жизни. Пер. с англ. под ред. М.Блинкина. – М: Территория будущего, 2011. – (Серия «Университетская библиотека Александра Погорельского»). – 576 с.

3. Трофименко Ю. В., Якимов М. Р. Транспортное планирование: формирование эффективных транспортных систем крупных городов: монография. – М.: Логос, 2013. – 464 с.

4. Гудков В.А., Миротин Л.Б. Технология, организация и управление пассажирскими автомобильными перевозками: Учебник для вузов / Под ред. Миротина Л.Б. - М.: Транспорт, 1997. - 256 с.

5. Кабалина Т.В. Традиции и модернизм в экономикоматематическом моделировании городского общественного транспорта 11 Проблемы и перспективы социально-экономического реформирования современного государства и общества : материалы международной научно-практической конференции. - М: Инстйтут стратегических исследований, 2010. -0,35