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AND DISASTER RISK REDUCTION DIVISION

Infrastructure Corridor Development Series:

Part III: Calculation Results for Determining the Most Promising Scenario for Infrastructure Corridor Development

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Abstract

The Regional Economic Cooperation and Integration (RECI) initiative of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) aims to promote integrated markets for goods, services, information and capital; infrastructure connectivity; financial cooperation; and economic and technical cooperation through a multidimensional and multidisciplinary approach. Promoting seamless connectivity in transport, energy and information and communications technology (ICT) is a central pillar of the RECI initiative.

As part of the RECI initiative, ESCAP is implementing a United Nations Development Account Project on "Addressing the Transboundary Dimensions of the 2030 Agenda for Sustainable Development through RECI in Asia and the Pacific" from 2018 to 2021. This project aims to develop knowledge products such as analysis reports, and build capacity of member States in promoting seamless regional connectivity with a focus on the co-deployment of ICT, transport and energy infrastructures.

Following the recommendations to national capacity building workshops for policymakers of Kazakhstan, Kyrgyzstan, Mongolia, and subregional workshop for countries in East and North-East Asia in October-November 2019, this analysis report is aimed to enhance understanding for planning interstate infrastructure corridors. The scope of this report covers in-depth analysis of the co-deployment of ICT infrastructure along transport and energy infrastructure corridors and support identification of key needs and the selection of the priority projects.

In response to the needs of member States and considering the complex challenges of limited national and regional infrastructures, the key objectives of this research are to: (1) provide in-depth cross-sectoral analysis of three potential interstate infrastructure corridors in the target countries of the RECI project (Kazakhstan and Kyrgyzstan); (2) provide knowledge and capacity building in determining the most promising model for infrastructure corridor development; and (3) promote an enabling environment for infrastructure corridor development, including the co-deployment of ICT, transport and energy infrastructures.

An infrastructure corridor approach is used as an attractive smart solution to link the geographical territories, and improve regional and transboundary connectivity. An infrastructure corridor is a high-tech transportation system integrated with a wide range of ICTs to facilitate the flow of goods, services, knowledge and capital in a cost- and time-effective way towards achieving the 2030 Agenda for Sustainable Development.

This research paper is a part of the Infrastructure Corridor Development Series that supports decision makers and infrastructure owners in their decisions on the development of new infrastructure corridors. The Infrastructure Corridor Development Series is divided into three main parts:

Part 1: An in-depth analysis of three promising infrastructure corridors.

Almaty (Kazakhstan) – Cholpon-Ata (Kyrgyzstan)
Semey (Kazakhstan) – Rubtsovsk (Russian Federation)
Urzhar (Kazakhstan) – Chuguchak (China)

Part 2: A toolkit for determining the most promising scenario for infrastructure corridor development.

Part 3: Calculation results for determining the most promising scenario for infrastructure corridor development.

This is Part Three of the series that explains the principles for identifying the routes along the infrastructure corridors, and the principles for building the databases on standard labour and material costs. The various scenarios for infrastructure corridor construction and upgrade were reviewed and assessed with these principles to estimate the capital expenditures, operating expenditures, potential income and indirect socioeconomic effects.

The recommended scenarios for infrastructure corridor development include the following for policymakers' consideration:

- For the Almaty (Kazakhstan) – Cholpon-Ata (Kyrgyzstan) infrastructure corridor, the co-deployment of the ICT infrastructure with road or railway infrastructure, and a separate deployment of the energy infrastructure using the created tunnel. These are optimal scenarios because the road infrastructure carries 99.8 per cent of passenger traffic and the railway infrastructure carries 94.6 per cent of freight traffic, and they are priority infrastructures in this region. The co-deployment of the ICT infrastructure with road infrastructure, and a separate deployment of the energy infrastructure using the created tunnel, however, is the most optimal given the tourism potential of this infrastructure corridor. Even so, the capital expenditure for the deployment of the road infrastructure is significantly high and the payback period is unacceptably long.

- For the Urzhar (Kazakhstan) – Chuguchak (China) infrastructure corridor, the co-deployment of energy and ICT infrastructures with the railway infrastructure.

- For the Semey (Kazakhstan) – Rubtsovsk (Russian Federation) infrastructure corridor, the co-deployment of the energy and ICT infrastructures with the reconstruction or upgrade of the railway infrastructure, since railway passenger traffic is a priority in this region.

Keywords

Cash flow: The net amount of cash and cash equivalents transferred to and from businesses (source: https://www.investopedia.com).

Co-deployment (infrastructure): The simultaneous deployment of cable ducts and/or fibre-optic cables during the construction of infrastructure such as new roads, highways, railways, power transmission lines and oil/gas pipelines (source: https://www.unescap.org).

Design process: A general set of steps that engineers use when creating telecommunications network designs (source: https://www.wikipedia.org).

Discount factor: A factor used for discounting, that is, bringing the amount of cash flow to the n-th step of a multi-step calculation of the efficiency of an investment project to a moment called the moment of decline. The discount factor shows how much money is received, taking into account the time and risk factors, the reduction of cash flow in the n-th year, based on a given discount rate (source: http://1-fin.ru).

Electricity infrastructure / electrical grid: An integrated network for delivering electricity from supplier to consumers (source: https://www.wikipedia.org).

Energy infrastructure: An organizational structure that allows large-scale transmission of energy from supplier to consumer, as well as directs and controls energy flow. It includes, but is not limited to, the oil and gas transportation infrastructure and the electricity transportation infrastructure (source: https://www.designingbuildings.co.uk).

Fibre-optic communications line: A fibre-optic system consisting of passive and active elements, designed to transmit information in the optical range (source: https://www.wikipedia.org).

ICT infrastructure: The information and communications technology (ICT) infrastructure and systems, including software, hardware, networks and websites (source: https://www.lawinsider.com).

Inflation rate: A steady increase in the general level of prices for goods and services in an economy over a period of time (source: https://www.wikipedia.org).

Infrastructure corridor: A high-tech transportation system integrated with a wide range of ICTs to facilitate the flow of goods, services, knowledge and capital in a cost- and time-effective way towards achieving the 2030 Agenda for Sustainable Development (source: https://www.unescap.org).

Infrastructure sharing: The sharing of real estate and fixed assets, including land, conduits, ducts, manholes and handholes, base station sites, AC networks, trunk lines, radio links, and other resources to avoid infrastructure duplication and reduce costs (source: author).

Net cash flow: The difference between the present value of cash inflow and the present value of cash outflow over a period of time. This metric is used in capital budgeting and investment planning to analyse the profitability of projected investments or projects (source: https://www.investopedia.com).

Road transport infrastructure: The road network and associated physical infrastructure, such as road signs, roadway lighting and petrol stations (source: https://iea-etsap.org).

Transport corridor: A linear area that is defined by one or more modes of transport, such as roads, railways or public transport that share a common route (source: https://www.wikipedia.org).

Abbreviations and Acronyms

AP-IS	Asia-Pacific Information Superhighway
CAPEX	Capital Expenditure
CNY	Chinese Yuan
ESCAP	Economic and Social Commission for Asia and the Pacific
EUR	Euro
GBP	British Pound
ICT	Information and Communications Technology
IDD	Information and Communications Technology and Disaster Risk Reduction Division
IDS	Information and Communications Technology and Development Section
KGS	Kyrgyzstani Som
kWh	Kilowatt-hour
KZT	Kazakhstani Tenge
MB	Megabit
ONAT	Odessa National Academy of Telecommunications
OPEX	Operating Expenditure
RECI	Regional Economic Cooperation and Integration
RUB	Russian Ruble
USD	United States Dollar

1. Data Principles

1.1 Indicators for Simulation Modelling

The data and indicators used for simulation modelling to determine the most promising model for infrastructure corridor development can be divided into three groups:

1. The technologies for construction, upgrade or reconstruction, and maintenance of various types of infrastructure;
2. Primary information on the socioeconomic aspects of the infrastructure corridors; and
3. Secondary information on the socioeconomic aspects of the infrastructure corridors.

The data sources for the first group were technological standards, labour standards for performing technological operations, and the knowledge and experience of experts in the relevant subject areas. The data sources for the second and third groups were official statistical data on the socioeconomic aspects of the regions along the infrastructure corridors, and other information available in the public domain.

Due to limited data available in the public domain, and the challenge of obtaining data for a complete set of indicators for each infrastructure corridor, the principle of extrapolation and averaging of data was used to form the values used in the calculations. In this case, more accurate calculations could be made by detailing all the required values.

A complete list of all indicators used for calculations, their threshold (maximum and minimum) values, the default value used in the simulation model, and justification for these values are given in Table 1.

Table 1: Indicators and values used in calculations for determining the most promising model for infrastructure corridor development

№	Indicator	Unit	Minimum value	Maximum value	Default value	Justification
General characteristics of the infrastructure corridor						
1	Number of households in the region covered by the infrastructure corridor (average for the period)	Number of households	0	1,000,000	50,000	Statistical data. For example, Almaty: population of 1,916,822[2] / average household size of 2.8[3] people = 684,579 households. Cholpon-Ata: population of 13,913[4] / average household size of 3.6[5] people = 3,865 households. In total: 684,579 + 3,865 = 688,444 households, including Almaty and Cholpon-Ata neighbouring districts
2	Average income per household per year	USD per year	0	10,000	6,000	Statistical data. For example, average income of one household in Kazakhstan: KZT1,579,000[6] (USD1,375.29[7])
3	Number of business units in the region covered by the infrastructure corridor (average for the period)	Number of business units	0	1,000,000	400	Statistical data. For example, Almaty: number of active corporate bodies is 16,597.[8] Cholpon-Ata: 509[9] (industry), 1,289[10] (trade, including services). In total: 16,597 + 509 + 1,289 = 18,395 business units
4	Payback period	Years	0	20	5	Kazakhstan: 8 years[11]

[2] Алма-Ата. Население. Available at https://ru.wikipedia.org/wiki/%D0%90%D0%BB%D0%BC%D0%B0-%D0%90%D1%82%D0%B0#%D0%9D%D0%B0%D1%81%D0%B5%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5.
[3] Алматы в цифрах. Available at https://kapital.kz/gosudarstvo/52581/almaty-v-tsifrakh-v-gorode-zhenshchin-na-146-tysyach-bol-she-chem-muzhchin.html.
[4] Национальный статистический комитет Кыргызской Республики. Available at http://www.stat.kg/ru/statistics/naselenie/.
[5] Сколько человек в семьях Кыргызстана. Available at https://ru.sputnik.kg/infographics/20181129/1042204610/kyrgyzstan-infografika-statistika-nacionalnyj-statisticheskij-komitet-semya-naselenie.html.
[6] Сколько зарабатывает в среднем казахская семья. Available at https://kursiv.kz/news/finansy/2019-09/skolko-zarabatyvaet-v-srednem-kazakhstanskaya-semya.
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[8] Статистика предприятий. Available at https://stat.gov.kz/official/industry/13/statistic/7.
[9] Малое и среднее предпринимательство. Available at http://www.stat.kg/ru/statistics/maloe-i-srednee-predprinimatelstvo/.
[10] Число предприятий торговли. Available at http://www.stat.kg/ru/opendata/category/77/.
[11] За какой срок окупаются строящиеся заводы в Казахстане. Available at https://forbes.kz/news/2017/08/23/newsid_153133.

						Kyrgyzstan: 15 years[12]
5	Value-added tax rate	%	0	30	20	Kazakhstan: 12%[13] Kyrgyzstan: 12%[14]
6	Income tax rate	%	0	30	20	Kazakhstan: 20%[15] (for certain types of business –10% and 15%) Kyrgyzstan: 10%[16]
7	Cash discount ratio	%	0	50	10	Kazakhstan: 9%[17] Kyrgyzstan: 5.5%[18]
Characteristics of economic and technological flows						
1	Passenger traffic	Passenger-kilometres per hour	0	1,000,000	50,000	Statistical data. For example, the population of Rubtsovsk is 0.009%[19] of the Russian Federation population, and total passenger traffic is 155.4 million[20] × 0.009% = 0.014 million
2	Freight traffic	Ton-kilometres per hour	0	1,000,000	100,000	Statistical data. For example, the population of Rubtsovsk is 0.009%[21] of the Russian Federation population, and total freight traffic is 18,250.1 million tons[22] × 0.009% = 1.6 million tons
3	Energy flow	Kilowatt-hour	0	1,000,000	100,000	Statistical data. For example, the population of Rubtsovsk is 0.009%[23] of the Russian Federation population, and total electricity consumption is RUB24,704.4 million[24] = USD331.04 million × 0.009% = USD0.029 million

[12] 9 причин, почему инвестиции в Кыргызстане сопровождаются скандалами . Available at https://kaktus.media/doc/332083_regnum:_9_prichin_pochemy_investicii_v_kyrgyzstane_soprovojdautsia_skandalami.html.
[13] Ставка НДС с 1995 по 2020 год. Available at https://uchet.kz/stavki/NDS.
[14] Налог на добавленную стоимость. Available at https://sti.gov.kg/docs/default-source/other/nds.pdf?sfvrsn=2.
[15] Ставки налогов и социальных платежей на 2020 год. Available at https://online.zakon.kz/Document/?doc_id=32469577#pos=20;-58.
[16] Налоговый кодекс Кыргызской Республики. Available at https://online.zakon.kz/document/?doc_id=30355506&doc_id2=30355506#pos=263;-86&pos2=3334;-98.
[17] Официальные ставки Национального Банка Республики Казахстан. Available at https://online.zakon.kz/document/?doc_id=1016416#pos=1472;-53.
[18] Учетная ставка НБКР. Available at https://www.nbkr.kg/index1.jsp?item=123&lang=RUS.
[19] Федеральная служба государственной статистики. Available at https://rosstat.gov.ru/folder/12781.
[20] Транспорт. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/ii/1/1.5.htm; and Основные экономические и социальные показатели. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/i.htm.
[21] Федеральная служба государственной статистики. Available at https://rosstat.gov.ru/folder/12781.
[22] Основные экономические и социальные показатели. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/i.htm.
[23] Федеральная служба государственной статистики. Available at https://rosstat.gov.ru/folder/12781.
[24] Федеральная служба государственной статистики. Available at https://rosstat.gov.ru/folder/11189.

4	Information flow	Gigabits per second	0	100,000	100	Statistical data. For example, the population of Rubtsovsk is 0.009%[25] of the Russian Federation population, and total consumption of data services is RUB360.0 million[26] = USD4.82 million × 0.009% = USD434
5	Share of household expenditure on services of a particular flow	%	0	50	5	Statistical data. For example, the share of household expenditure on transport in the Russian Federation is 16.1%[27]
6	Average cost of business units, social facilities and local government entities for services of a specific flow	USD per year	0	100,000	1,000	Statistical data. For example, large enterprises in Kazakhstan consume on average 2,000 million kWh per year[28]
7	Average volume of service use of a specific flow by households	USD per year	0	1,000	10	For example, average annual communications cost of residents in Kazakhstan is KZT2,000[29] (USD5)
8	Tariff for corresponding services for the population	USD per unit of consumption	Determined by type of flow			
8.1	Passenger traffic	USD per passenger	0	100	20	Transit by bus from Urzhar to Chuguchak: USD20[30]
8.2	Freight traffic	USD for the carriage of one ton of cargo	0	100	5	From Urzhar to Chuguchak: KZT200 (USD0.48) for the entire route[31]
8.3	Energy flow	USD per kWh	0	100	1	Electricity tariff rate in Kazakhstan:[32] Minimum tariff rate (up to 70 kWh) – KZT10.48/kWh (including value-added tax) (USD0.025)

[25] Федеральная служба государственной статистики. Available at https://rosstat.gov.ru/folder/12781.
[26] Затраты организаций на информационные и телекоммуникационные технологии. Available at https://akstat.gks.ru/storage/mediabank/Vb0h5e09/%D0%97%D0%B0%D1%82%D1%80%D0%B0%D1%82%D1%8B%20%D0%BD%D0%B0%20%20%D0%B8%D0%BD%D1%84.%D1%82%D0%B5%D1%85%D0%BD%D0%BE%D0%BB%D0%BE%D0%B3%D0%B8%D0%B8.htm.
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[28] Отчет анализ рынка электроэнергии и угля Казахстана январь-октябрь 2020 года Available at https://www.samruk-energy.kz/images/%D0%9E%D1%82%D1%87%D0%B5%D1%82_%D0%BF%D0%BE_%D0%90%D0%A0%D0%AD_%D0%B7%D0%B0_10_%D0%BC%D0%B5%D1%81.2020%D0%B3.docx.
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[30] Как добраться в Китай из Казахстана. Available at http://nomoremaps.com/2483/.
[31] Об использовании автомобильной дороги (участка) общего пользования республиканского значения на платной основе. Available at http://adilet.zan.kz/rus/docs/V1800018073.
[32] Астанаэнергосбыт. Available at https://astanaenergosbyt.kz/ru/fiz/tarify1.html.

						Average tariff rate (from 70 to 140 kWh) – KZT16.04/kWh (including value-added tax) (USD0.038) Maximum tariff rate (140 kWh and higher) – KZT20.05/kWh (including value-added tax) (USD0.048)
8.4	Information flow	USD per MB	0	100	1	Kazakhstan: USD0.11 per MB[33]
9	Tariff for corresponding business services	USD per unit of consumption	Determined by type of flow			
9.1	Passenger traffic	USD per passenger	0	100	20	Transit by bus from Urzhar to Chuguchak: USD20[34]
9.2	Freight traffic	USD for the carriage of one ton of cargo	0	100	5	Toll road payment in Kazakhstan: USD1.90 for the entire section for trucks with a carrying capacity of 10-15 tons[35]
9.3	Energy flow	USD per kWh	0	100	1	Electricity rate in Kazakhstan for corporate bodies:[36] KZT16.87/kWh (excluding value-added tax)
9.4	Information flow	USD per MB	0	100	1	Kazakhstan: USD0.11 per MB[37]

[33] Дорогой ли в Казахстане интернет: сравнение цен в других странах. Available at https://forbes.kz/process/expertise/dorogoy_li_v_kazahstane_internet_sravnenie_tsen_v_drugih_stranah/.
[34] Как добраться в Китай из Казахстана. Available at http://nomoremaps.com/2483/.
[35] Тарифы на проезд по платным дорогам вынесли на публичное обсуждение. Available at https://informburo.kz/novosti/tarify-na-proezd-po-platnym-dorogam-vynesli-na-publichnoe-obsuzhdenie.html.
[36] Астанаэнергосбыт. Available at https://astanaenergosbyt.kz/ru/fiz/tarify1.html.
[37] Дорогой ли в Казахстане интернет: сравнение цен в других странах. Available at https://forbes.kz/process/expertise/dorogoy_li_v_kazahstane_internet_sravnenie_tsen_v_drugih_stranah/.

1.2 Principles for Determining the Characteristics of Economic and Technological Flows Along Infrastructure Corridors

In order to identify the data, indicators and method for determining the characteristics of economic and technological flows and the expected profitability of the infrastructure corridor, an algorithm has been developed (Figure 1), which functions as follows:

1. Identify the types of infrastructure (e.g., road, railway, power transmission line, fibre-optic communications line) along the infrastructure corridor (Path A). This information can be obtained from publicly available official sources of relevant government bodies or ministries. If the infrastructure does not exist or if there is no traffic in the direction of the infrastructure corridor along another route, refer to Path B (Figure 2).

2. If the infrastructure exists, determine whether reliable statistics on the use of the infrastructure are available. The availability and reliability of the statistical data must be confirmed by official sources (e.g., state statistical agencies, official websites of relevant ministries and departments, and official websites of service providers). Within the framework of this study, journal articles and assessments, and data from rating agencies are not recognized as reliable, since they may express the subjective opinion of the authors and contain unverified estimates.

3. If all the necessary reliable statistical data can be obtained, determine the intensity of flows in natural and monetary units (in line with the methodology given in Part 2 of this series) using the **method of direct calculation**.

4. If the necessary reliable statistical data cannot be obtained from official sources due to the lack of openness in disclosing data, lack of comparable reporting or lack of information in a regional context, or the methodology given in Part 2 of this series cannot be fully applied, check the feasibility of conducting a direct or indirect economic assessment of the infrastructure.

5. The **method of direct estimation** of the infrastructure implies an assessment of the potential demand for the infrastructure services by existing consumers in monetary terms (i.e., profitability of the flow). This demand can be estimated by extrapolating the cash or in-kind flows existing along the infrastructure in one direction to the projected flows, taking into account its features. This method can also be used to assess a section of the infrastructure.

6. The **method of indirect estimation** assumes a potential demand for the infrastructure services based on indirect indicators from similar projects. In this case, comparable characteristics that are not only technical and economic characteristics are used.

7. At the last stage, the availability of monetary estimates makes it possible to determine the intensity of the flow in natural units by dividing incomes by the average reduced tariffs for services of this flow.

Figure 1: **Algorithm for determining the characteristics of the economic and technological flows along infrastructure corridors**

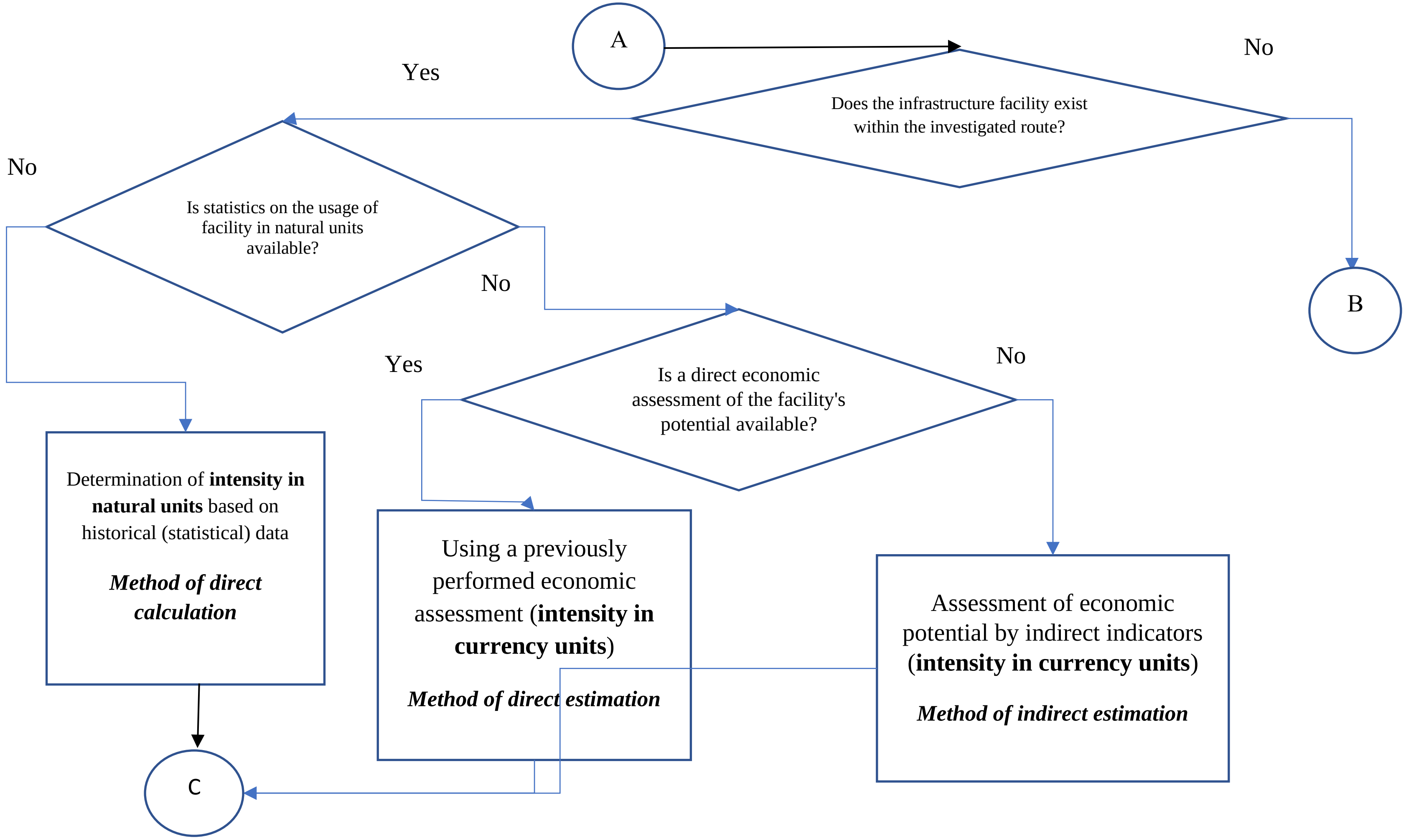
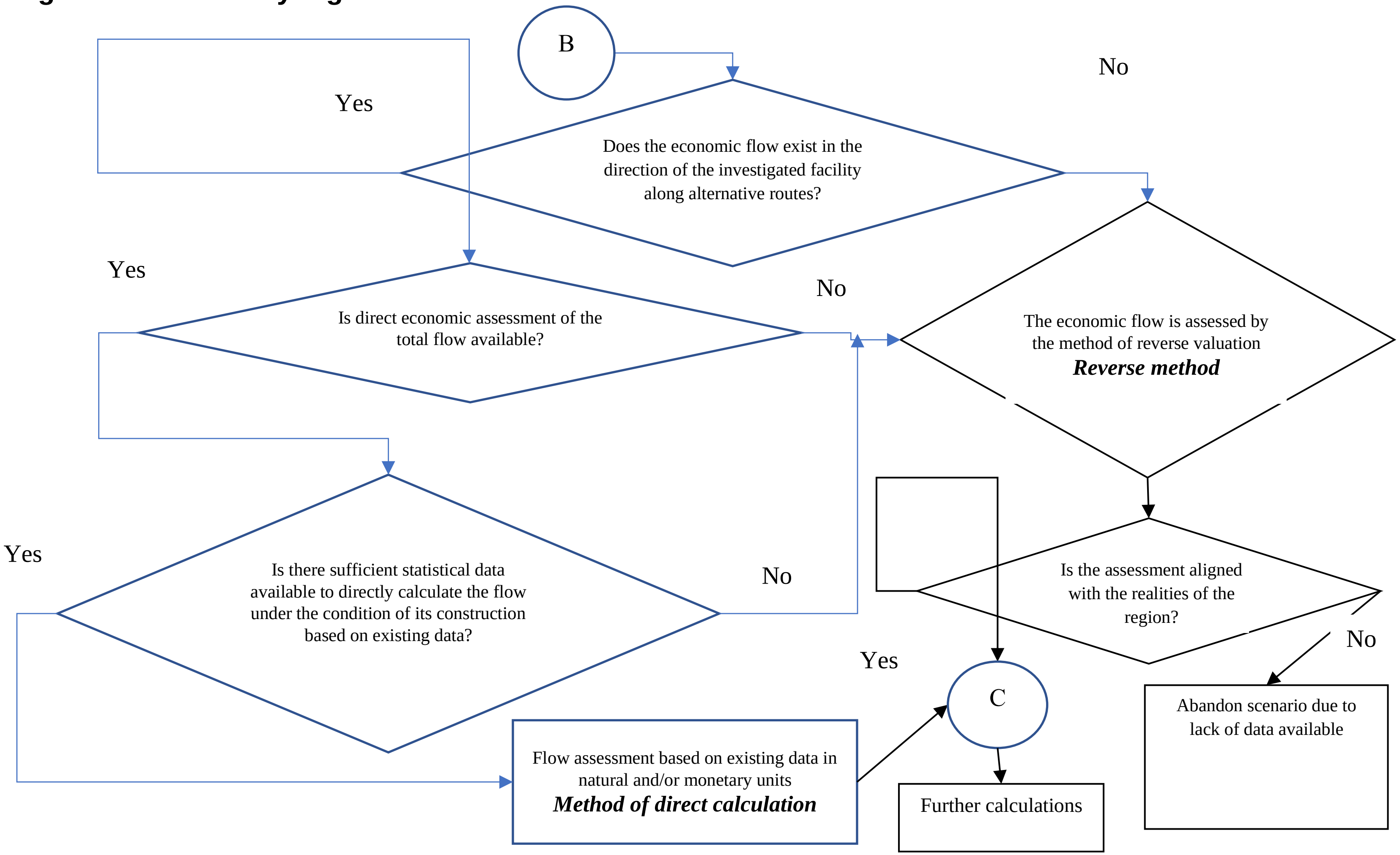


Figure 2: **Subalgorithm identifying data in the absence of infrastructure or traffic**



If the infrastructure does not exist (e.g., there are no power lines along the Urzhar–Chuguchak infrastructure corridor), or if there is no traffic in the direction of the infrastructure corridor along another route, subalgorithm B is used. Subalgorithm B applies other methods to determine the intensity of flows in natural and monetary units, as follows:

1. Find out whether economic flows exist for each infrastructure type in the direction of the infrastructure corridor along alternative routes or alternative types of traffic (e.g., air transport in the absence of land transport, use of renewable energy in the absence of electricity, and satellite communications in the absence of fibre-optic connectivity).

2. If economic flows exist, assess the possibility of carrying out a direct economic assessment of the total flow. For this, the availability, accessibility and reliability of statistical data is determined by assessing whether it is possible to extract the shared value of this flow from the general array of statistical data on the flow (in natural and/or monetary terms) based on similar flows or general statistical data (e.g., gross regional product and purchasing power parity in the region).

3. If statistical data can be obtained, assess the economic potential of the infrastructure using the **method of direct calculation**.

4. If a direct economic assessment of the total flow is not possible due to the absence or lack of reliable data, assess the economic flow using the reverse method. In this case, critical values of project implementation indicators (e.g., minimum profit, maximum payback period and capital costs) are set by applying the reverse method and using current tariffs for similar services in the region or existing discount rates, where the minimum allowable flow volume at which the project will be efficient is calculated.

5. If the calculated values obtained by reverse method are not aligned with the realities of the region (e.g., the calculated flow volume significantly exceeds the regional average consumption indicators for this type of service, and there are no factors for increasing this consumption by both internal and external consumers), abandon this scenario due to the lack of data available.

6. Use the data obtained by any of the methods for further calculations (Path C).

Table 2 helps to select the assessment method based on the availability of data.

Table 2: **Selection of assessment method based on the availability of data**

Corridor	Infrastructure	Is there an infrastructure facility along the corridor (direct route)?	Is statistical (historical) data available for the direct route?	Is there a similar infrastructure between countries along an alternative route?	Is statistical (historical) data available for the alternative route?	Selected calculation method
Almaty (Kazakhstan) – Cholpon-Ata (Kyrgyzstan)	Highway	No	-	Yes	+	Direct calculation
	Railway	No	-	No	-	Reverse
	Power line	No	-	Yes	+/-	Direct estimation
	Fibre-optic line	No	-	Yes	+/-	Direct estimation
Semey (Kazakhstan) – Rubtsovsk (Russian Federation)	Highway	Yes	+	Yes	+/-	Direct estimation
	Railway	Yes	+	Yes	+/-	Direct estimation
	Power line	Yes	-	Yes	+/-	Direct estimation
	Fibre-optic line	No	-	Yes	+/-	Direct estimation
Urzhar (Kazakhstan) – Chuguchak (China)	Highway	Yes	+/-	Yes	+/-	Indirect estimation
	Railway	No	-	Yes/No [38]	-	Reverse
	Power line	No	-	No	-	Reverse
	Fibre-optic line	No	-	Yes	+/-	Indirect estimation

[38] The existing railway transit and transport corridor Viet Nam–China–Kazakhstan–Europe cannot be recognized as a direct alternative since it passes through the Dzungarian Gate, against the flow of the infrastructure corridor, and is not intended for the transportation of goods over short distances as there are no large shipping and receiving terminals. There are, however, public transport stops. Available at https://liter.kz/ru/news/show/56782-zapushen_transkontinentalnyi_zheleznodorozhnyi_marshrut_vetnam-kitai-kazahstan-evropa.

Four examples of applying the above algorithm to calculate potential flows are illustrated below.

1.2.1 Example 1: A Straight Highway Along the Almaty–Cholpon-Ata Infrastructure Corridor

In this case, the flow is absent, which means data does not exist. However, there is an alternative route with a full set of official statistical data available on existing flows and experts' assessment of the changes in flow volume if the projected highway is implemented along a direct route. Based on the data and information, it is possible to apply the method of direct calculation.

The existing tourist flows on the Almaty–Cholpon-Ata section today use a 450km route through Bishkek. According to official data, there are about 0.9 million tourists annually, which brings an estimated average of USD272.80 from each tourist, in which about USD70 relates to transportation costs. Thus, annual transport revenue along the Almaty–Cholpon-Ata section is estimated at USD63 million (0.9 million tourists × USD70).

According to experts, the presence of a direct route with a length of 117km will lead to an increase in passenger and freight traffic by reducing travel time, and may increase the flow of tourists by 60 per cent. With the reduction in mileage, transportation costs will be reduced to USD45-USD50 (due to a reduction in the variable components of the tariff, specifically the cost of fuel and lubricants, while maintaining the volume of the constant components of the tariff, specifically insurance, depreciation and management costs).

However, with a potential increase in demand by 60 per cent (according to experts), an increase by up to 1.44 million tourists is likely (0.9 million tourists × 60 per cent). Thus, the total annual revenue from passenger traffic will be between USD64.8 million (1.44 million × USD45) and USD72 million (1.44 million × USD50).

In summary, the expected annual flow of a straight highway along the Almaty–Cholpon-Ata infrastructure corridor is 1.44 million passengers and, in monetary terms, between USD64.8 million and USD72 million per year.

Similarly, freight traffic flows can be calculated for a projected route that has a tunnel passing directly through the mountains, reducing the distance of the route from 450km to 70.5km:

- From Kazakhstan – 181.08 million tons of cargo per year[39] at a price of USD1.90 for the entire route for trucks with a capacity of 10-15 tons amounts to USD34.4 million per year; and
- From Kyrgyzstan – 4.2 million tons of cargo per year[40] at a price of KGS14 per km for the maximum allowed weight (USD0.17) for 70.5km amounts to USD5.03 million per year.

Thus, total freight traffic is USD34.4 million + USD5.03 million = USD39.43 million, and the total flow on the Almaty–Cholpon-Ata infrastructure corridor is USD72 million (for passenger traffic) + USD39.43 million (for freight traffic) = USD111.43 million per year.

With information about the proportion of road and rail traffic, it is possible to determine the expected values of these flows along railway routes (if they are constructed), based on the assumption that the distribution of road and rail traffic will remain the same. In this region, the distribution of passengers by road and rail is 99.8 per cent and 0.2 per cent, respectively. Thus, almost all potential passengers will likely use road transport on this infrastructure corridor. On the contrary, the distribution of freight traffic by mode of transport for international transport indicates

[39] Конкурентоспособность логистики и транспорта в Республике Казахстан. Available at https://unece.org/DAM/trans/publications/Report_-_Kazakhstan_as_a_transport_logistics_centre_Europe-Asia_RU.pdf.

[40] Национальный статистический комитет Кыргызской Республики. Available at http://www.stat.kg/ru/statistics/transport-i-svyaz/.

that 94.6 per cent of Kazakhstan's freight traffic[41] and 98.6 per cent of Kyrgyzstan's freight traffic[42] are by rail. Thus, 5.4 per cent and 1.4 per cent of freight traffic, respectively, are by road. This is due to the higher carrying capacity and relatively lower tariffs for rail transportation.

As a result, it can be assumed that most of the expected traffic flows will switch to the railway route (if constructed). Further, the resulting flows are subject to correction, taking into account the unevenness of the load and the effects of internal and external circuits. The data and calculations are summarized in Table 3.

1.2.2 Example 2: A Fibre-Optic Communications Line Along the Almaty–Cholpon-Ata Infrastructure Corridor

In this case, the flow is absent, which means data does not exist. However, there is an alternative route with a partial set of official statistical data available on existing flows from residents of the region and from tourists staying in Issyk-Kul, a major tourist destination in Kyrgyzstan. Based on the data and information, it is possible to apply the method of direct estimation and extrapolate the existing flows, considering the potential increase in the flow due to the increase in tourists if the Almaty–Cholpon-Ata infrastructure corridor is developed.

The existing profit from the provision of services to the following residents is (at the exchange rate of early 2021):

- From Kazakhstan – KZT1,349,561.9 million[43] = USD792.3 million;[44] and
- From Kyrgyzstan – KGS16,450.1 million[45] = USD193.9 million.[46]

The existing profit from the provision of services to residents in the region (based on the share of the region's population to the total population) is as follows:

- From Almaty (11.04 per cent of the population[47]) – 11.04 per cent × USD792.3 million = USD87.46 million; and
- From Cholpon-Ata (0.3 per cent of the population[48]) – 0.3 per cent × USD193.9 million = USD0.5817 million.

The existing structure for the formation of tariffs for flow services shows that the share of profit from traffic transportation is as follows:

- For Almaty (15 per cent[49]) – 15.0 per cent × USD87.46 million = USD13.12 million; and
- For Cholpon-Ata (2.5 per cent[50]) – 2.5 per cent × USD0.5817 million = USD0.0145 million.

Thus, the total flow from residents in the region (excluding tourists) is USD13.12 million + USD0.0145 million = USD13.13 million.

Considering that tourist flow in the direction of Almaty → Cholpon-Ata is expected to increase by 60 per cent, it is necessary to increase the existing flows, taking into account the increase in users, however, not

[41] Перевозка грузов по видам транспорта. Available at http://www.stat.kg/ru/statistics/transport-i-svyaz/.
[42] Перевозка грузов всеми видами транспорта. Available at https://stat.gov.kz/official/industry/18/statistic/7.
[43] Статистика транспорта. Available at https://stat.gov.kz/official/industry/11/statistic/7.
[44] Курс тенге к доллару США по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KZT-USD/.
[45] ВВП по видам экономической деятельности в текущих ценах. Available at http://www.stat.kg/ru/opendata/category/164/.
[46] Курс сома к доллару США по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KGS-USD/.
[47] Демограическая статистика. Available at https://stat.gov.kz/official/industry/61/statistic/7.
[48] Население. Available at http://www.stat.kg/ru/opendata/category/4/.
[49] Отчет о финансовых результатах. Available at https://telecom.kz/storage/uploads/58/f4/044e580bf4dc8ecf970c9f40eafed7014ad08fe7/GCGg9iz0XYslR7r6iHdXGnpx4zzhuD2BReBtZ7vB.pdf.
[50] Годовой отчет ОАО «Кыргызтелеком» за 2019 год. Available at http://kt.kg/about_us/documents_and_tender/annual_report/AR_2019.pdf.

by direct extrapolation since tourists are not constant users of the flow service.

To calculate the increase in the flow due to the increase in tourists, data on the average adult's expenditure on communications services in the region is used, which makes up about 3.2 per cent of total expenditure. Thus, 3.2 per cent of tourists' total average expenditure of USD272.80 is USD8.73 for communications services.

If the potential flow of tourists is 1.44 million, then the potential increase in traffic through the projected fibre-optic communications line is USD1.88 million (1.44 million × USD8.73 × 15 per cent), and the total flow, including tourists, will be USD13.13 million + USD1.88 million = USD15.01 million.

The resulting flows are subject to correction, taking into account the unevenness of the load and the effects of internal and external circuits. The data and calculations are summarized in Table 4.

1.2.3 Example 3: A Road Along the Urzhar–Chuguchak Infrastructure Corridor

The flow exists, but due to the lack of openness of one the parties in disclosing data, access to statistical data on this flow is problematic. However, there is an alternative route with a partial set of data (mostly estimates and journalistic) about existing flows circulating along it. Based on this set of data, the method of indirect estimation is applied using indirect indicators from similar projects.

As presented in Part 1 of this series, the capacity of the alternative road through the Bakhty checkpoint is 200,000 tons of cargo and 100,000 passengers per year. The functioning of the "green corridor" at the Bakhty checkpoint accelerates the flow of agricultural products by up to 6,400 tons per month. Moreover, the 72-hour visa-free regime attracts up to 10,000 tourists from Kazakhstan to China[51] and increases tourists flow from China to Lake Alakol in Kazakhstan by 2.5 times.[52]

However, the low quality of the road surface, lack of roadside infrastructure and the low rates of development of related services reduce the potential for infrastructure corridor development. According to some reports, investors perceive transport logistics as a factor limiting economic growth, and are actively investing in infrastructure along the coast resulting in significant growth in the number of tourist facilities by 116.3 per cent in 2019, the number of tourists served by 30.2 per cent, and the volume of paid services by 35.6 per cent.

Thus, it is possible to determine the potential volume of traffic using these indirect indicators that consider the expected increase in tourists.

According to reports,[53] about 1.5 per cent of tourists to Kazakhstan are from China travelling on vacation (95,000 per year), and 82 per cent are tourists from neighbouring countries, including Uzbekistan (43.4 per cent), the Russian Federation (22.1 per cent) and Kyrgyzstan (16.5 per cent). An agreement between China and Kazakhstan to attract Chinese tourists to Alakol[54] is likely to promote tourism growth in this region by 250 per cent, resulting in an increase in the number of accommodations.

These developments can potentially increase the flow of tourists from China passing through this infrastructure corridor to 237,500 people per year (95,000 × 250 per cent). However, a significant increase in freight traffic is not expected since there are restrictions on duty-free carriage of goods and the limited throughput at checkpoints.

[51] Казахстан продлил безвизовый режим для транзитных туристов из Китая и Индии. Available at https://tengritravel.kz/my-country/kazakhstan-prodlil-bezvizovyiy-rejim-tranzitnyih-turistov-388047/.

[52] Пёстрые впечатления: как развивается туристический бизнес на Алаколе. Available at https://forbes.kz/finances/markets/pestryie_vpechatleniya_1575972427/.

[53] Из каких стран чаще всего едут в Казахстан. Available at https://profi.travel/news/34931/details.

[54] YK-news.kz. Available at https://m.yk-news.kz.

Based on the available data, it is possible to estimate potential passenger and freight traffic along this infrastructure corridor. The total passenger traffic can be estimated as the sum of potential tourist and other flows described above:

- From Kazakhstan – 100,000 people;
- From China – 237,500 people; and
- Average transport cost is USD20.[55]

Thus, the passenger traffic in monetary terms is USD6.75 million (337,500 people × USD20).

Freight flows are likely to remain the same due to the limited capacity of the existing checkpoints (200,000 tons). However, it is possible to increase the flow of agricultural products through the green corridor by up to 75,000 tons per year. Thus, the total cargo turnover may be about 275,000 tons (200,000 tons + 75,000 tons).

The average cost of transportation on toll roads in the region is USD1.90 for the entire projected length for trucks with a carrying capacity of 10-15 tons.[56] This amounts to USD52,250 per year (275,000 × USD1.90 / 10).

Based on the Nurly Zhol State Infrastructure Development Programme for 2020-2025,[57] the expected increase in road traffic in the coming years should be 27-33 per cent. From this estimate, a 30 per cent growth of the flow can be assumed.

Considering the distribution of flows between highways and railways indicated in Example 1, it can be assumed that almost all passenger traffic will remain as road transport, and freight traffic (up to 95 per cent) will switch to rail transport (in the case of the construction of a direct railway from Urzhar to Chuguchak).

The resulting flows are subject to correction, taking into account the unevenness of the load and the effects of internal and external circuits. The data and calculations are summarized in Table 5.

1.2.4 Example 4: A Railway Along the Almaty–Cholpon-Ata Infrastructure Corridor

In this case, both the existing flow and comparable alternatives are absent, thus, the reverse method can be used to determine the flow parameters and the feasibility of implementing the infrastructure corridor. The method determines the desired level of project efficiency at which construction is feasible, and then by reverse calculation of the project costs, the flow volumes are determined that can provide the expected profitability. If the flow volumes cannot be obtained due to the absence of existing and potential demand, the project is potentially inefficient and is not recommended for implementation.

As a criterion of efficiency, the growth rate index (IS) is used as described in Part 2 of this series. It is recommended that the results from this calculation is compared with similar flows in the participating countries (ISc).

The formula for calculating ISc is similar to the standard formula for calculating IS with adjustments, as follows:

$$\text{ISc} = \frac{NPV^c}{T^p \times ES^{es}}$$

$$\text{NPVc} = \text{CFesdisc} - \text{Kes}$$

- CFdisc – Discounted cash flow from the area of economic activity to which the flow belongs (in this case, rail transport) for the entire period (years for which the project is designed);
- Кes – State capital investments in this area of economic activity;

[55] Как добраться в Китай из Казахстана. Available at http://nomoremaps.com/2483/.
[56] Тарифы на проезд по платным дорогам вынесли на публичное обсуждение. Available at https://informburo.kz/novosti/tarify-na-proezd-po-platnym-dorogam-vynesli-na-publichnoe-obsuzhdenie.html.
[57] Государственная программа инфраструктурного развития "Нұрлы жол" на 2020 – 2025 годы. Available at http://adilet.zan.kz/rus/docs/P1900001055#z461.

- Tp – Average payback period for similar projects in the country; and
- ESes – Average annual cost of production of goods or services in the field of economic activity to which the flow belongs.

The project is recognized as cost-efficient if the estimated IS of the project is higher than the ISc obtained at the macroeconomic level. This is because the project should be more profitable than state capital investments. Based on macroeconomic data, Table 6 calculates the ISc for transport flows in Kazakhstan.

Determination of the minimum allowable flow volume (CFmin), which provides the required rate of specific cost increment, is carried out using the following formula (see Table 7):

$$CFmin = (Кp + ISp \times Tp \times ESp)\ (1 + Kd)$$

$$= (13{,}065.94 + 0.0869 \times 8 \times 8.363)\ (1 + 0.09) = 14{,}248.21$$

- CFmin – Minimum allowable flow volume;
- Кp – Capital cost for this project;
- ISp – Rate of specific increase in value, ISp ≥ ISc;
- Tp – Expected payback period of the project;
- ESp – Average annual cost; and
- Kd – Discount coefficient.

The resulting flows are subject to correction, taking into account the unevenness of the load and the effects of internal and external circuits. Considering all the correction factors, the total volume of the flow should be USD18,678 million annually. The data and calculations are summarized in Table 7.

Table 3: **Calculation for Example 1 – A straight highway along the Almaty–Cholpon-Ata infrastructure corridor**

Flow type	**Existing flow on alternative route**	**Average existing unit income**	**Estimation of increase in flow**	**Average expected unit income**	**Expected flow along projected route**	**Expected income on passenger traffic**	**NUFmax = Кмкmax × Кдкmax × Кчкmax**			**Correction factor (factor of influence of outer loop), Corf**	**Factor of influence of outer loop, Cf**	**Total flow taking into account all coefficients, USD million T × NUFmax × Corf × Cf**
							Flow concentration factor by months, Кмкmax	**Flow concentration factor by days, Кдкmax**	**Flow concentration factor by hours, Кчкmax**			
Total passenger traffic	0.9 million people	USD70	60%	USD45-50	0.9 million × 60% = 1.44 million people	1.44 million people × USD50 = USD72 million						
Cargo turnover Kazakhstan	181.08 million tons	USD1.90 for the whole section for 10 tons	-	USD1.90 for the whole section for 10 tons	181.08 million tons	USD34.4 million						
Cargo turnover Kyrgyzstan	4.204 million tons	USD0.17 per km for 10 tons	-	USD0.17 per km for 10 tons	4.204 million tons	USD5.03 million						
Total						USD111.43 million	1.035	1.05	1.001	1.05	1.04	**132.36**

Table 4: **Calculation for Example 2 – A fibre-optic communications line along the Almaty–Cholpon-Ata infrastructure corridor**

Flow type	Existing flow on alternative route	Average total profitability of flow in the region (taking into account the population)	Profitability level of flow	Estimation of increase in flow	Expected increase in profitability	Expected income	NUFmax = Кмкmax × Кдкmax × Кчкmax			Correction factor (factor of influence of outer loop), Corf	Factor of influence of outer loop, Cf	Total flow taking into account all coefficients, USD million T × NUFmax × Corf × Cf
							Flow concentration factor by months, Кмкmax	Flow concentration factor by days, Кдкmax	Flow concentration factor by hours, Кчкmax			
Traffic Kazakhstan	USD792.3 million	USD87.46 million	15%	1.44 million people	1.44 million people × USD8.73 × 15% = USD1.88 million	USD13.12 million + USD1.88 million = USD15.0 million						
Traffic Kyrgyzstan	USD193.9 million	USD0.581 million	2.5%			USD0.581 million × 2.5% = USD0.0145 million						
Total						USD15.01 million	1.025	1.002	1.07	1.03	1.02	**17.34**

Table 5: **Calculation for Example 3 – A road along the Urzhar–Chuguchak infrastructure corridor**

Flow type	Existing flow on alternative route	Average existing unit income	Expected flows, taking into account the increase along the projected route	Expected income on passenger traffic	NUFmax = Кмкmax × Кдкmax × Кчкmax			Correction factor (factor of influence of outer loop), Corf	Factor of influence of outer loop, Cf	Total flow taking into account all coefficients, USD million T × NUFmax × Corf × Cf
					Flow concentration factor by months, Кмкmax	Flow concentration factor by days, Кдкmax	Flow concentration factor by hours, Кчкmax			
Passenger traffic Kazakhstan	100,000 people	USD20	100,000 people	100,000 people × USD20 = USD2 million						
Passenger traffic China	95,000 people	USD20	95,000 people × 250% = 237,500 people	237,500 people × USD20 = USD4.75 million						
Total passenger traffic				USD6.75 million						
Total cargo turnover (126 km)	200,000 tons	USD1.90 for the entire route for 10 tons	200,000 tons + 75,000 tons	275,000 tons × 1.90 / 10 = USD0.05225 million						
Total existing flows				USD6.802 million						
Potential flow growth (30%[58])				USD2.04 million	1.01	1.00	1.01	1.04	1.10	**2.38**

[58] Об утверждении Государственной программы инфраструктурного развития "Нұрлы жол" на 2020 – 2025 годы. Available at http://adilet.zan.kz/rus/docs/P1900001055#z461.

Table 6: **Macroeconomic data of transport flows in Kazakhstan**

Indicators	Kazakhstan, traffic flows
Cash flow, national currency, thousand, *CF*	5,589,850.6[59]
Recommended discount rate, d, %	9[60]
Discounted cash flow, national currency, thousand, CF^{es}_{disc}	5,128,303.3
State capital investment in the sector, national currency, thousand, K^{es}	1,223,766[61]
Average payback period for similar projects, years, T^p	8[62]
Average annual cost of production of goods or services, national currency, thousand, ES^{es}	5,615,552.0[63]
Net present value, NPV^c	3,904,537.3
Growth rate index, IS^c	0.0869

Table 7: Calculation for Example 4 – A railway along the Almaty–Cholpon-Ata infrastructure corridor

Flow type	K^p – Capital expenditure for this project, USD million	IS^p – Rate of unit value growth	T^p – Expected payback period of the project, year	ES^p – Average annual costs, USD million	K^d – Discount coefficient	CF_{min} – Minimum allowable flow volume, USD million	NUFmax = Кмкmax × Кдкmax × Кчкmax			Correction factor (factor of influence of outer loop), Corf	Factor of influence of outer loop, Cf	Total flow taking into account all coefficients, USD million $T \times NUF_{max} \times Corf \times Cf$
							Flow concentration factor by months, Кмкmax	Flow concentration factor by days, Кдкmax	Flow concentration factor by hours, Кчкmax			
Total flow	13065.940	0.0869	8	8.363	9	14,248.24	1.025	1.01	1.001	1.15	1.10	18,678

The minimum allowable flow volume (CF_{min}) is: $CF_{min} = (K^p + IS^p \times T^p \times ES^p)\ (1 + K^d)$ = (13065.94 + 0.0869 × 8 × 8.363) (1 + 0.09) = 14,248.21.

[59] Статистика транспорта. Available at https://stat.gov.kz/official/industry/18/statistic/7.
[60] Официальные ставки Национального Банка Республики Казахстан (1992-2020). Available at https://online.zakon.kz/document/?doc_id=1016416#pos=1452;-55.
[61] Статистика инвестиций. Available at https://stat.gov.kz/official/industry/161/statistic/8.
[62] Рекомендации по расчету экономических эффектов от строительства, реконструкции, ремонта и содержания автомобильных дорог на макро и микро экономическом уровне. Available at http://adilet.zan.kz/rus/docs/E17000179AD.
[63] Статистические сборники. Available at https://stat.gov.kz/edition/publication/collection.

Table 8: Results of flow calculations

Type of infrastructure	Is there an infrastructure facility within the corridor (direct route)?	Selected calculation method	Existing flow volume (natural or monetary unit)	Unit income, USD	Expected increase in flow	Cash flow	Total expected flow, USD million	Comments
Almaty–Cholpon-Ata								
Highway	No	Method of direct calculation	0.9 million passengers[64]	USD50	1.44 million passengers (+60%[65])	1.44 million × USD50 = USD72 million	111.43	Distribution of passengers by mode of transport: railway – 0.2%, road – 99.8%[66]
			Kazakhstan: 181.08 million tons[67]	USD1.90 (average for the entire section for trucks with a carrying capacity of 10-15 tons)[68]		181.08 × 1.9 / 10 = USD34.4 million		Distribution of freight traffic by mode of transport for international transport: railway – 94.6%, road – 5.4%[69]
			Kyrgyzstan 4.20 million tons[70]	KGS14 per km[71] (USD0.17) for trucks with a carrying capacity of 10-15 tons		4.2 / 10 × 0.17 × 70.5 = USD5.03 million		Distribution of freight traffic by mode of transport for international transport: railway – 98.6%, road – 1.4%[72]
Railway	No	Reverse method					18,678	

64 Средние расходы одного туриста в разных странах мира. Available at https://pikabu.ru/story/srednie_raskhodyi_odnogo_turista_v_raznyikh_stranakh_mira_3705864.
65 Дорога Алматы — Иссык-Куль: Похороненный проект на миллионы. Available at https://kloop.kg/blog/2014/10/15/doroga-almaty-issyk-kul-pohoronennyj-proekt-na-milliony/.
66 Статистика транспорта. Available at Перевозки пассажиров всеми видами транспорта. Available at https://stat.gov.kz/official/industry/18/statistic/7.
67 Конкурентоспособность логистики и транспорта в Республике Казахстан. Available at https://unece.org/DAM/trans/publications/Report_-_Kazakhstan_as_a_transport_logistics_centre_Europe-Asia_RU.pdf.
68 Тарифы на проезд по платным дорогам вынесли на публичное обсуждение. Available at https://informburo.kz/novosti/tarify-na-proezd-po-platnym-dorogam-vynesli-na-publichnoe-obsuzhdenie.html.
69 Перевозка грузов всеми видами транспорта. Available at https://stat.gov.kz/official/industry/18/statistic/7.
70 Статистика транспорта. Available at http://www.stat.kg/ru/statistics/transport-i-svyaz/.
71 Минтранс Кыргызстана назвал предварительные цены за проезд по платным дорогам. Available at https://24.kg/ekonomika/99933_mintrans_kyirgyizstana_nazval_predvaritelnyie_tsenyi_zaproezd_poplatnyim_dorogam/.
72 Перевозка грузов по видам транспорта. Available at http://www.stat.kg/ru/statistics/transport-i-svyaz/.

Power line	No	Method of direct estimation	KZT980,795.2 million[73] = USD2,332.52 million[74] × 11.04% population[75] = USD257.5 million	15.8%[76]		15.8% × USD257.5 million = USD40.68 million	40.74	
			KGS13,705.8 million[77] = USD161.6 million[78] × 0.3% population[79] = USD0.4848 million	5%	155%[80]	(USD0.4848 million + 155%) × 5% = USD0.061 million		
Fibre-optic communications line	No	Method of direct estimation	KZT331,800 million[81] = USD792.3 million[82] × 11.04% population[83] = USD87.46 million	15% [84]	1.44 million × USD272.80 × 3.2%[85] × 15%[86] = USD1.88 million	USD87.46 million × 15% = USD13.12 million USD13.12 million + USD1.88 million = USD15.0 million	15.02	
			KGS16,450.1 million[87] = USD193.9 million[88] × 0.3% population[89] = USD0.5817 million	2.5%[90]		USD0.5817 million × 2.5% = USD0.0145 million		
Urzhar–Chuguchak								

[73] Статистика национальных счетов. Available at https://stat.gov.kz/official/industry/11/statistic/7.
[74] Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KZT-USD/.
[75] Демографическая статистика. Available at https://stat.gov.kz/official/industry/61/statistic/7.
[76] Энергетика преобразований. Available at https://www.sevkazenergo.kz/assets/files/go_2016_ru.pdf.
[77] Национальные счета. Available at http://www.stat.kg/ru/statistics/nacionalnye-scheta/.
[78] Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KGS-USD/.
[79] Население. Available at http://www.stat.kg/ru/opendata/category/4/.
[80] Концепция устойчивого развития эколого-экономической системы "Иссык-Куль" на период до 2020 года. Available at http://cbd.minjust.gov.kg/act/view/ru-ru/80070?cl=ru-ru.
[81] Доходы от услуг связи в Казахстане в январе-декабре 2020 года. Available at https://profit.kz/news/59155/Dohodi-ot-uslug-svyazi-v-Kazahstane-v-yanvare-dekabre-2020-goda/.
[82] Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KZT-USD/.
[83] Демографическая статистика. Available at https://stat.gov.kz/official/industry/61/statistic/7.
[84] Отчет о финансовых результатах. Available at https://telecom.kz/storage/uploads/58/f4/044e580bf4dc8ecf970c9f40eafed7014ad08fe7/GCGg9iz0XYslR7r6iHdXGnpx4zzhuD2BReBtZ7vB.pdf.
[85] Расходы семьи: Россия vs Мир. Available at https://zen.yandex.ru/media/id/5e48aab040e9c554bad4fa94/rashody-semi-rossiia-vs-mir-5e58994e70934f328e7f0d36.
[86] Отчет о финансовых результатах. Available at https://telecom.kz/storage/uploads/58/f4/044e580bf4dc8ecf970c9f40eafed7014ad08fe7/GCGg9iz0XYslR7r6iHdXGnpx4zzhuD2BReBtZ7vB.pdf.
[87] ВВП по видам экономической деятельности в текущих ценах. Available at http://www.stat.kg/ru/opendata/category/164/.
[88] Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KGS-USD/.
[89] Население. Available at http://www.stat.kg/ru/opendata/category/4/
[90] Годовой отчет ОАО «Кыргызтелеком» за 2019 год . Available at http://kt.kg/about_us/documents_and_tender/annual_report/AR_2019.pdf

Highway	Yes	Method of indirect estimation	Kazakhstan: 100,000 passengers	USD20[91]		100,000 × USD20 = USD2 million	USD6.83 million × 30%[92] = 2.38	
			China: 95,000 passengers[93]	USD20	237,500 people (95,000 × 250%[94])	237,500 × USD20 = USD4.75 million		
			200,000 tons	USD1.90 (average for the entire section for trucks with a carrying capacity of 10-15 tons)[95]	≈ 0.075 million tons per year [96] 0.225 million tons over 3 years	0.42 million tons × USD1.90 / 10 = USD0.08 million		
Railway	No	Reverse method					7.97	
Power line	No	Reverse method					10.287[97]	
Fibre-optic communications line	No	Method of indirect estimation	Kazakhstan: KZT 331,800 million[98] = USD792.3 million[99] × 0.4% population[100] = USD3.17 million	15%	≈ +1.5% annually[101] 4.5% over 3 years	(USD3.17 million + 4.5%) × 15% = USD0.49 million	1.29	
			China: CNY 61,908 million =	≈ 10%	≈ +4% annually[104] ≈ 4.5% over 3 years	(USD7.66 million + 4.5%) × 10% = USD0.8 million		Relative income data

[91] Как добраться в Китай из Казахстана. Available at http://nomoremaps.com/2483/
[92] Об утверждении Государственной программы инфраструктурного развития "Нұрлы жол" на 2020 – 2025 годы. Available at http://adilet.zan.kz/rus/docs/P1900001055#z461
[93] Из каких стран чаще всего едут в Казахстан . Available at https://profi.travel/news/34931/details
[94] Пёстрые впечатления: как развивается туристический бизнес на Алаколе. Available at https://forbes.kz/finances/markets/pestryie_vpechatleniya_1575972427/
[95] Тарифы на проезд по платным дорогам вынесли на публичное обсуждение. Available at https://informburo.kz/novosti/tarify-na-proezd-po-platnym-dorogam-vynesli-na-publichnoe-obsuzhdenie.html
[96] За месяц через КПП «Бахты» в Казахстан завезено 6,4 тыс. тонн китайских овощей и фруктов. Available at https://kazakh-zerno.net/91263-za-mesyats-cherez-kpp-bakhty-v-kazakhstan-zavezeno-6-4-tys-tonn-kitajskikh-ovoshchej-i-fruktov/
[97] CF Energy $=(K^p + IS^p \times T^p \times ES^p)(1+K^d)$=(7,757 +0,097× 7× 1,527)(1+0,09)=9,585×1,01×1,01×1,05×1,01×1,002=10,287
[98] Доходы от услуг связи в Казахстане в январе-декабре 2020 года. Available at https://profit.kz/news/59155/Dohodi-ot-uslug-svyazi-v-Kazahstane-v-yanvare-dekabre-2020-goda/
[99] Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KZT-USD/
[100] Урджарский район. Available at https://ru.wikipedia.org/wiki/%D0%A3%D1%80%D0%B4%D0%B6%D0%B0%D1%80%D1%81%D0%BA%D0%B8%D0%B9_%D1%80%D0%B0%D0%B9%D0%BE%D0%BD.
[101] Статистика информационно-коммуникационных технологий. Available at https://stat.gov.kz/official/industry/29/statistic/7.
[104] Китай ушел в рост. Available at https://rg.ru/2020/10/19/knr-stala-edinstvennoj-krupnoj-ekonomikoj-kotoraia-rastet-nesmotria-na-pandemiiu.html.

			USD9,576.16 million[102] × 0.08% population[103] = USD7.66 million					
Semey–Rubtsovsk								
Highway	Yes	Method of direct calculation	1.7% of Kazakhstan population Passengers: KZT90,843.1 million = USD216.04 million[105] × 1.7% = USD3.67 million Cargo: 4,100 million tons × 1.7% = 69.7 million tons	USD1.90 (average for the entire section for trucks with a carrying capacity of 10-15 tons)[106]	+22%[107] (tourism)	Passengers: USD3.67 million × 22% = USD4.47 million Cargo: 69.7 million tons × USD1.90 / 10 = USD13.25 million	USD21.96 million × 30%[108] = 6.5	
			0.009% of Russian Federation population[109] Cargo: 18,250.1 million tons [110]× 0.00009% = 1.6 million tons	For the entire route: Cargo ≈ RUB170[112] ton = USD2.30 Passengers ≈ RUB480[113] = USD6.45	Cargo 13%[114]	Cargo: (1.6 million tons + 13%) × USD2.30 = USD4.15 million Passengers: 0.014 million passengers		Distribution of freight traffic by mode of transport for international transport: railway – 18%, road – 82%[115] Distribution of passengers by mode of transport: railway – 50%, road – 50%[116]

[102] Курс обмена валют по состоянию на февраль 2021 года. Available at https://www.google.com/search?q=%D0%BA%D1%83%D1%80%D1%81+%D1%82%D0%B5%D0%BD%D0%B3%D0%B5+%D0%BA+%D0%B4%D0%BE%D0%BB%D0%BB%D0%B0%D1%80%D1%83&oq=%D0%BA%D1%83%D1%80%D1%81+%D1%82%D0%B5%D0%BD&aqs=chrome.0.69i59j0j0i433j69i57j0l3j69i61.2284j1j7&sourceid=chrome&ie=UTF-8.

[103] Чугучак (округ). Available at https://ru.wikipedia.org/wiki/%D0%A7%D1%83%D0%B3%D1%83%D1%87%D0%B0%D0%BA_(%D0%BE%D0%BA%D1%80%D1%83%D0%B3).

[105] Статистика транспорта. Available at https://stat.gov.kz/official/industry/18/statistic/7.

[106] Тарифы на проезд по платным дорогам вынесли на публичное обсуждение. Available at https://informburo.kz/novosti/tarify-na-proezd-po-platnym-dorogam-vynesli-na-publichnoe-obsuzhdenie.html.

[107] Стратегия социально-экономического развития Алтайского края до 2035 года. Available at https://economy.gov.ru/material/file/ff2df63883cef734f344126c2294c79e/ak_2019.pdf.

[108] Об утверждении Государственной программы инфраструктурного развития "Нұрлы жол" на 2020 – 2025 годы. Available at http://adilet.zan.kz/rus/docs/P1900001055#z461.

[109] Демография. Available at https://rosstat.gov.ru/folder/12781.

[110] Основные экономические и социальные показатели. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/i.htm.

[112] Тарифы на проезд. Available at https://avtodor-tr.ru/ru/platnye-uchastki/fares/m3/.

[113] Автобус Рубцовск — Семей: билеты, цены, расписание. Available at https://bus.biletyplus.ru/avtobus/rubcovsk/semei.

[114] Стратегия социально-экономического развития Алтайского края до 2035 года. Available at https://economy.gov.ru/material/file/ff2df63883cef734f344126c2294c79e/ak_2019.pdf.

[115] Грузооборот российского транспорта. Available at https://seanews.ru/2020/02/03/ru-gruzooborot-rossijskogo-transporta-17/.

[116] Пассажирооборот. Available at https://ru.wikipedia.org/wiki/%D0%9F%D0%B0%D1%81%D1%81%D0%B0%D0%B6%D0%B8%D1%80%D0%BE%D0%BE%D0%B1%D0%BE%D1%80%D0%BE%D1%82.

			Passengers: 155.4 million[111] × 0.00009% = 0.014 million			× USD6.45 = USD0.09 million		
Railway	Yes	Method of direct calculation	1.7% of Kazakhstan population Passengers: KZT89,193.1 million = USD1,212.12 million × 1.7% = USD20.61 million Cargo: KZT842,824.3 million = USD2,004.4 million × 1.7% = USD34.07 million			USD54.68 million	57.07	
			0.009% of Russian Federation population Cargo: 1,339 million tons[117] × 0.009% = 0.12 million tons Passengers: 1,201 million[118] × 0.009% = 0.10 million	For the entire route: Cargo ≈ RUB236 ton[119] = USD3.17 Passengers ≈ RUB1,500[120] = USD20.15		Cargo: 0.12 million tons × USD3.17 = USD0.38 million Passengers: 0.10 million × USD20.15 = USD2.015 million		
Power line	Yes	Method of direct estimation	KZT980,795.2 [121] million = USD2,332.52 million × 1.7% = USD39.65 million	15.4%[122]		USD39.65 million × 15.4% = USD5.49 million	5.491	

[111] Транспорт. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/ii/1/1.5.htm; and Основные экономические и социальные показатели. Available at https://gks.ru/region/docl1101/IssWWW.exe/Stg/d1912/i.htm.
[117] Транспорт. Available at https://rosstat.gov.ru/folder/23455.
[118] Транспорт. Available at https://rosstat.gov.ru/folder/23455.
[119] Приложение 2. Прейскурант N 10-01 "Тарифы на перевозку грузов и услуги инфраструктуры, выполняемые российскими железными дорогами. Часть II (расчетные таблицы плат за перевозку грузов)" (часть 1). Available at http://base.garant.ru/12131790/f7ee959fd36b5699076b35abf4f52c5c/#block_2025.
[120] Автобус Рубцовск — Семей: билеты, цены, расписание. Available at https://bus.biletyplus.ru/avtobus/rubcovsk/semei.
[121] Статистика национальных счетов. Available at https://stat.gov.kz/official/industry/11/statistic/7.
[122] Россети Сибирь. Available at https://rosseti-sib.ru/index.php?option=com_content&view=category&layout=blog&id=1195&Itemid=2000&lang=ru40.

			RUB24,704.4 million = USD331.04 million × 0.009% = USD0.029 million	4.4%[123]		USD0.029 million × 4.4% = USD0.0012 million		
Fibre-optic communications line	No	Method of direct estimation	KZT331,800 million[124] = USD792.3 million[125] × 11.04% population[126] = USD87.46 million × 1.7% = USD1.48 million	15%		USD1.48 million × 15% = USD0.222 million	0.228	
			RUB360.0 million[127] = USD4.82 million × 0.009% = USD0.029 million	18%[128]	+30%[22]	USD0.029 million × 30% × 18% = USD0.006 million		

123 Бухгалтерский баланс. Available at https://altke.ru/uploads/files/2020/03/buhgalterskaya-otchetnost-za-2019-god_1585283473.pdf.
124 Доходы от услуг связи в Казахстане в январе-декабре 2020 года. Available at https://profit.kz/news/59155/Dohodi-ot-uslug-svyazi-v-Kazahstane-v-yanvare-dekabre-2020-goda/.
125 Курс обмена валют по состоянию на февраль 2021 года. Available at https://finance.rambler.ru/calculators/converter/1-KZT-USD/.
126 Демографическая статистика. Available at https://stat.gov.kz/official/industry/61/statistic/7.
127 Затраты организаций на информационные и телекоммуникационные технологии. Available at https://akstat.gks.ru/storage/mediabank/Vb0h5e09/%D0%97%D0%B0%D1%82%D1%80%D0%B0%D1%82%D1%8B%20%D0%BD%D0%B0%20%20%D0%B8%D0%BD%D1%84.%D1%82%D0%B5%D1%85%D0%BD%D0%BE%D0%BB%D0%BE%D0%B3%D0%B8%D0%B8.htm.
128 Тенденции деятельности крупнейших российских телекоммуникационных компаний. Available at https://credinform.ru/ru-RU/Publications/Article/9941e91d17c3.

1.3 General Principles and Data Sources for Forming Routes of Existing and Potential Infrastructures

For the design of infrastructure facilities, results of engineering surveys, which include geological and geodetic surveys, and aerial photography are normally used. However, their disadvantages are their high cost and narrow range (i.e., surveying of one potential section of the route excludes the assessment of a parallel section of the route). Surveys of all possible sections therefore increase the cost and duration.

As a result, Google Earth was used as a source of data for this study in the formation of routes for existing and potential infrastructures. Using satellite and aerial photographs, Google Earth enables viewing of the vertical relief of the routes and tracking of detailed features by section and for the entire route.

Based on past experience of infrastructure project design work, criteria for route segmentation along the horizontal and vertical planes were developed. The main criteria for route segmentation along the horizontal plane are:

- Change in external environment. For example, Section A of the route passes a field, and Section B of the route passes a forest. This segmentation is necessary as the construction requirements for routes along a field and a forest are different;
- Change in the width of the route;
- Change in the number of traffic lanes. For example, Section A is a four-lane route, and Section B begins after a road fork when it becomes a two-lane route, which reduces the construction work required; and
- Change in the supporting infrastructure of the route (e.g., ground surface, viaduct, aqueduct, tunnel).

The main criterion for route segmentation along the vertical plane is significant changes in the relief. For example, Section A is along an almost horizontal plateau, and Section B begins at a descent to the river and the slope of the route changes.

When the path along the route changes, at least one of the above criteria will select the next section and, accordingly, changes will be made in the scope of construction work for each specific section of the route. However, each section of the route may have the following features, which can increase the complexity of construction works:

- The number of intersections. Each intersection requires the installation of traffic lights, the application of appropriate marking signs, etc.;
- The number of turns. Each turn requires the formation roadway slope and the installation of appropriate road signs;
- The number of railway crossings;
- The number of junctions; and
- The mean absolute value of the slope of the road section.

Depending on these features, the complexity coefficient was calculated for each section by multiplying the number of complex elements by the estimated weight of each element. The weight of each element was assumed to correspond with the cost of the route section and was determined by any expert method, for example, by pairwise comparison or point assessment.

Route drawings for existing and planned infrastructure facilities using Google Earth are shown in Figures 3-5. After constructing the routes on Google Earth and calculating the corresponding complexity coefficients for each of the scalable and non-trivial segments, configuration files of the corresponding infrastructure facilities were generated, which were used for further calculations using the simulation model.

A summary of the segmentation for the infrastructure corridors is given in Table 9. The configuration files are available at: https://owncloud.onat.edu.ua/index.php/s/065T63GtOoBA0dm.

Figure 3: **Routes along the Almaty–Cholpon-Ata infrastructure corridor**

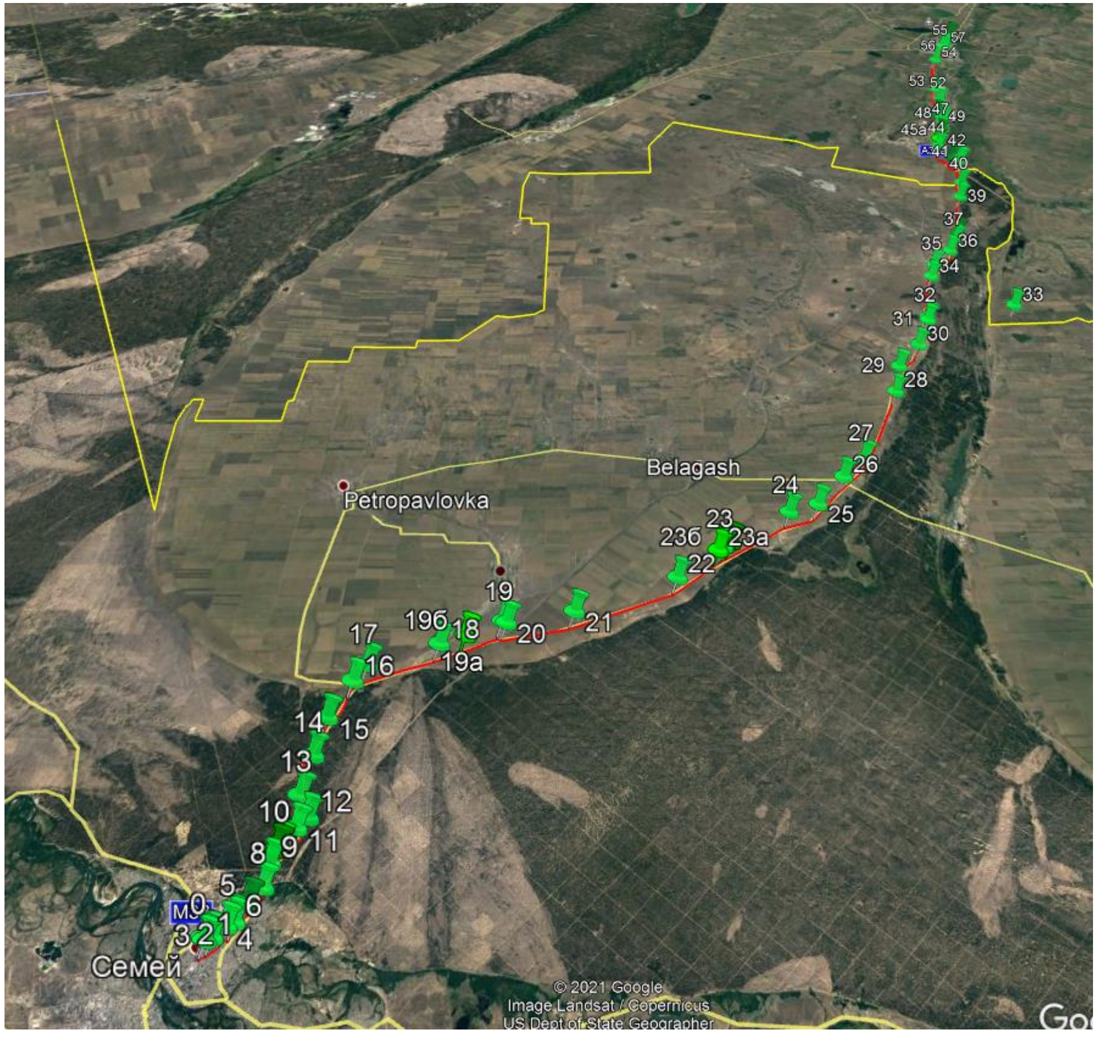


Figure 4: **Routes along the Semey–Rubtsovsk infrastructure corridor**

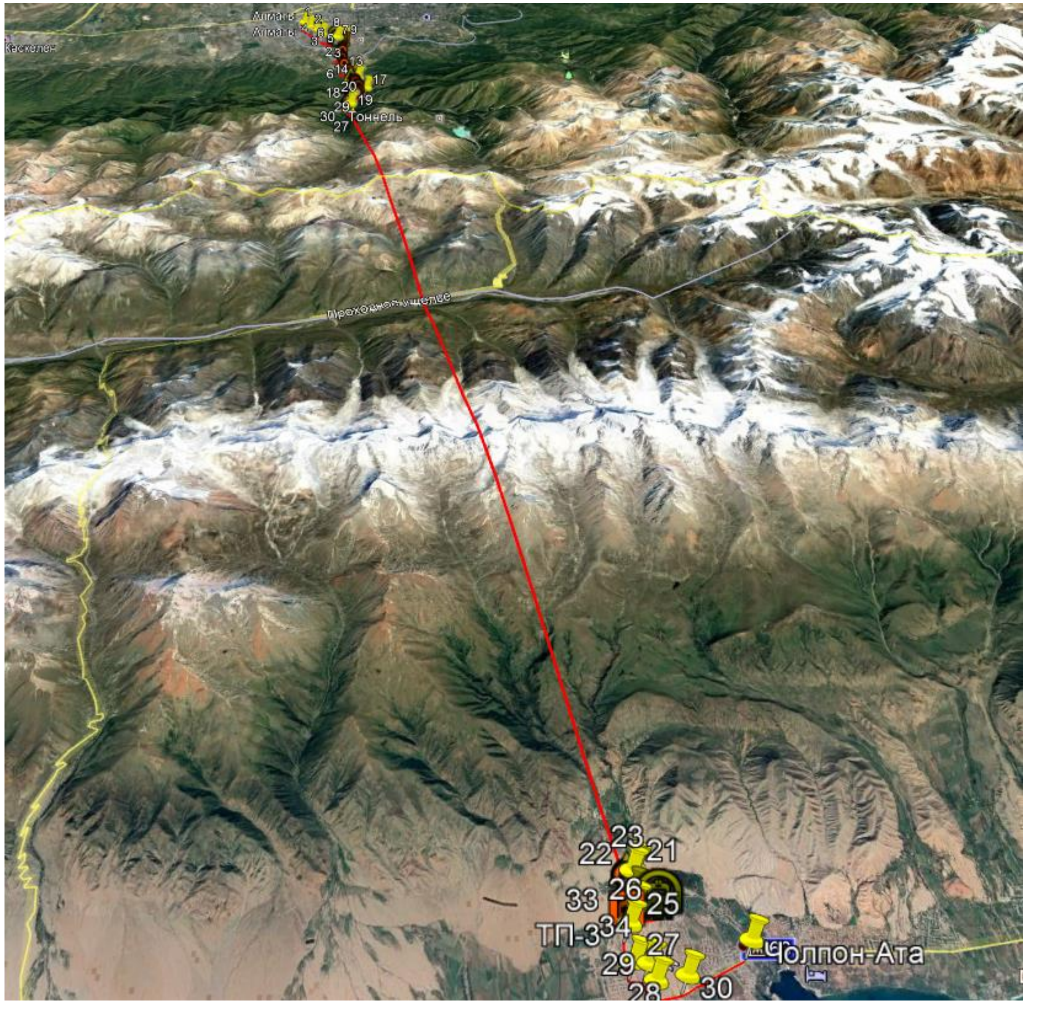

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Figure 5: **Routes along the Urzhar–Chuguchak infrastructure corridor**

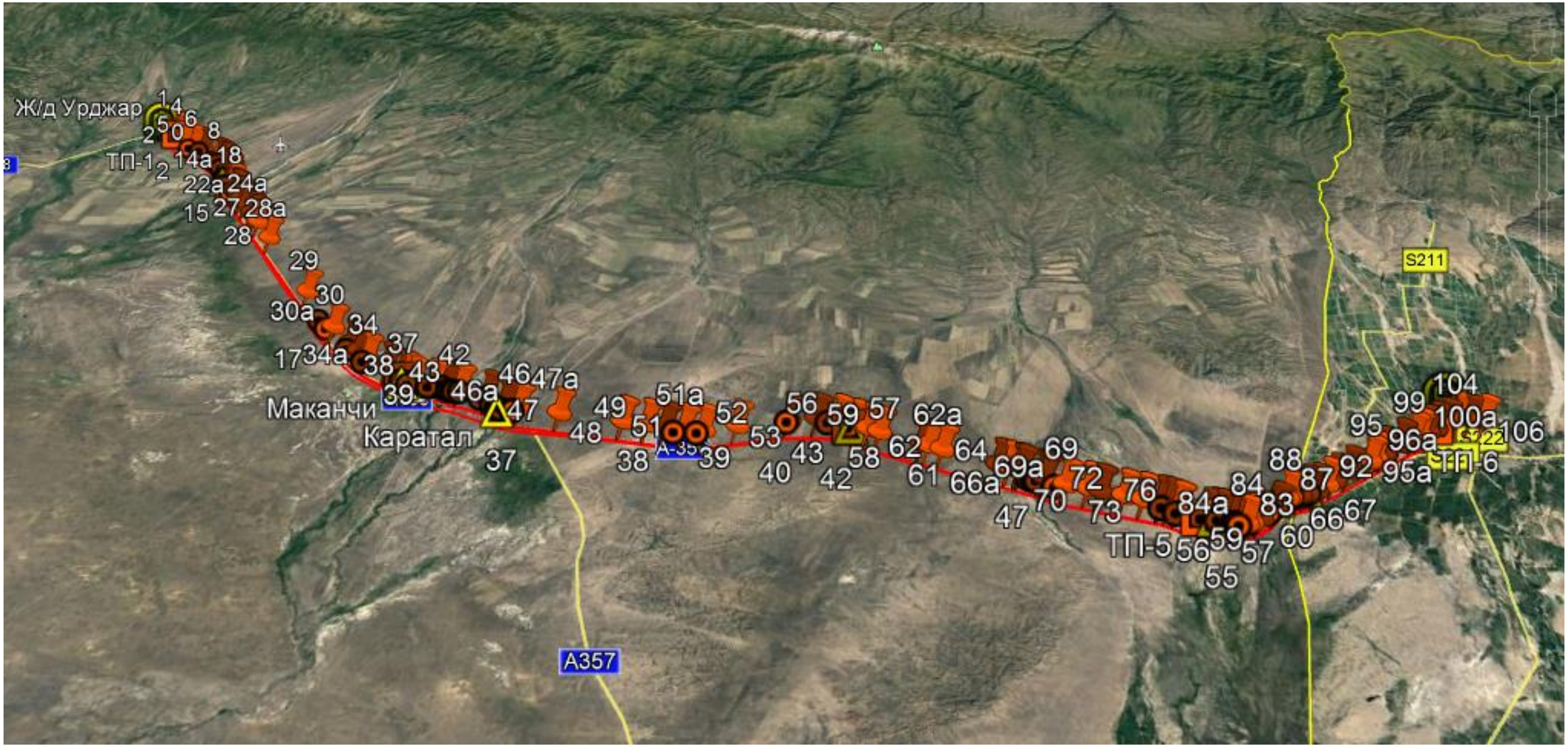


Table 9: **Summary of information on existing and planned routes**

Corridor	Infrastructure facility	Type (existing / planned)	Duration, km	Number of scalable segments and average complexity	Number and main types of non-trivial segments	Note
Almaty (Kazakhstan) – Cholpon-Ata (Kyrgyzstan)	Highway	Planned	71.2	26 (1.4)	Bridge – 5 units Tunnel – 1 unit (48km)	This route was chosen to minimize the height of the passage. With the co-deployment of infrastructures, the building of one common tunnel is planned
	Railway	Planned	62.1	4 (1.22)	Tunnel – 1 unit (48km)	
	Power line	Planned	61.4	34 (1.42)	Substation – 3 units Tunnel – 1 unit (48km)	
	Fibre-optic line	Planned	71.2	31 (1.17)	Substation – 2 units Tunnel – 1 unit (48km)	
Semey (Kazakhstan) – Rubtsovsk (Russian Federation)	Highway	Existing	155.9	69 (1.11)	Bridge – 6 units	The routes of fibre-optic communications lines and power transmission lines were chosen to promote their shared use with other infrastructure facilities
	Railway	Existing	146.7	8 (1.05)	–	
	Power line	Planned	145.7	111 (1.23)	Substation – 7 units	
	Fibre-optic line	Planned	155.9	75 (1.07)	Substation – 3 units	
Urzhar (Kazakhstan) – Chuguchak (China)	Highway	Existing	126	107 (1.23)	Bridge – 61 units	
	Railway	Planned	122.9	8 (1.42)	–	
	Power line	Planned	118.6	68 (1.14)	Substation – 6 units	
	Fibre-optic line	Planned	126	167 (1.04)	Substation – 3 units	

1.4 General Principles and Data Sources for Labour and Material Costs for the Construction, Reconstruction and Maintenance of Infrastructures

In determining the labour intensity of each type of work, technological standards for labour intensity of main works (e.g., construction, installation, commissioning and maintenance) were used. The averaged technological standards were taken from the Russian Federation[129] and Kazakhstan.

They were used in the preparation of estimate documentation using the resource method, categorized by type of infrastructure (e.g., road, railway, power transmission line and fibre-optic communications line), and contained a list of technological actions with the corresponding indicators of standard labour intensity and qualifications of staff for the construction of the various infrastructure types.

Labour intensity is determined by summing up the values of labour intensity for performing the technological operations included in the scope of development of each type of work. The cost of materials takes into account the cost of their purchase and delivery to on-site warehouses (places intended for storage, from where the material enters the working area).

The estimated cost of materials includes the following:

- Factory gate price;
- Supply and sales agency extra charges;
- Cost of containers, packaging and properties;
- Custom duties (if required);
- Shipping charges; and
- Procurement and storage charges.

To perform the calculations, six databases were created (Table 10) based on the principles of forming consolidated construction price standards. Configuration files containing the above databases are available at: https://owncloud.onat.edu.ua/index.php/s/HUSKxKmzYMl0mEy.

Table 10: **Types of databases organized for calculations**

№	Type of action	Type of database	Type of infrastructure included in the database	Number of records in the database
1	Construction	Labour costs	Road, railway, power transmission line, fibre-optic communications line + all possible options for co-deployment	180
2	Construction	Materials		1,177
3	Reconstruction	Labour costs	Road, railway	24
4	Reconstruction	Materials		172
5	Maintenance	Labour costs	Road, railway, power transmission line, fibre-optic communications line + all possible options for co-deployment	215
6	Maintenance	Materials		124

When calculating the standard labour costs, the following assumptions were used:

[129] For example, ФЕР 81-02-XX-2001 (federal unit rates for construction work) and ФСЭМ 81-01-2001 (prices for the operation of construction machines and vehicles).

- Average wage for construction in Kazakhstan – KZT273,492[130] (20.5 days × 8 hours[131] = 164 hours), 273,492 / 164 = KZT1,667.63 per hour = USD3.97 per hour;
- Average wage for construction in Kyrgyzstan – KGS17,842[132] (164 hours[133]), 17,842 / 164 = KGS108.79 per hour = USD1.29 per hour;
- Average wage for construction in the Russian Federation – RUB38,518[134] (164 hours[135]), 38,518 / 164 = RUB234.86 per hour = USD3.19 per hour; and
- Average wage for construction in China ≈ USD8,000 per year,[136] USD666.6 per month. Working time – 44 hours per week[137] = 190 hours per month, USD666.6 / 190 = USD3.51 per hour.

Considering the above, the value of USD4 per hour was used in the calculations as the base standard for labour cost.

[130] Статистика труда и занятости. Available at https://stat.gov.kz/official/industry/25/statistic/7.
[131] Баланс рабочего времени. Available at http://outsourc.kz/news/61-balans-rabochego-vremeni-i-proizvodstvennyy-kalendar-na-2020-god.html#:~:text=%D0%A1%D1%80%D0%B5%D0%B4%D0%BD%D0%B5%D0%BC%D0%B5%D1%81%D1%8F%D1%87%D0%BD%D0%BE%D0%B5%20%D1%87%D0%B8%D1%81%D0%BB%D0%BE%20%D1%80%D0%B0%D0%B1%D0%BE%D1%87%D0%B8%D1%85%20%D0%B4%D0%BD%D0%B5%D0%B9%20%D0%BD%D0%B0,%2C%20%D1%83%D1%81%D1%82%D0%B0%D0%BD%D0%BE%D0%B2%D0%BB%D0%B5%D0%BD%D0%BD%D1%8B%D1%85%20%D0%B7%D0%B0%D0%BA%D0%BE%D0%BD%D0%BE%D0%B4%D0%B0%D1%82%D0%B5%D0%BB%D1%8C%D1%81%D1%82%D0%B2%D0%BE%D0%BC%20%D0%A0%D0%B5%D1%81%D0%BF%D1%83%D0%B1%D0%BB%D0%B8%D0%BA%D0%B8%20%D0%9A%D0%B0%D0%B7%D0%B0%D1%85%D1%81%D1%82%D0%B0%D0%BD).
[132] Заработная плата. Available at http://www.stat.kg/ru/statistics/trud-i-zarabotnaya-plata/.
[133] Кыргызстан - производственный календарь на 2021 год. Available at https://www.calend.ru/work/kirgizstan/.
[134] Заработная плата. Available at https://rosstat.gov.ru/labour_costs.
[135] Производственный календарь. Available at http://www.garant.ru/calendar/buhpravo/.
[136] Средние зарплаты в Китае. Available at https://visasam.ru/emigration/rabota/srednyaya-zarplata-v-kitae.html.
[137] Закон Китайской Народной Республики о труде. Available at https://chinaperevod.com/law/glava-4-rezhim-truda-i-otdyha.

2. Calculation Results for Determining the Most Promising Scenario for Development of the Almaty–Cholpon-Ata Infrastructure Corridor

2.1 Determination of the Economic Efficiency of Scenario Implementation

From the standpoint of economic efficiency and expected profitability, the deployment of the transport infrastructure, both road and railway, is most promising along the Almaty–Cholpon-Ata infrastructure corridor (Table 11).

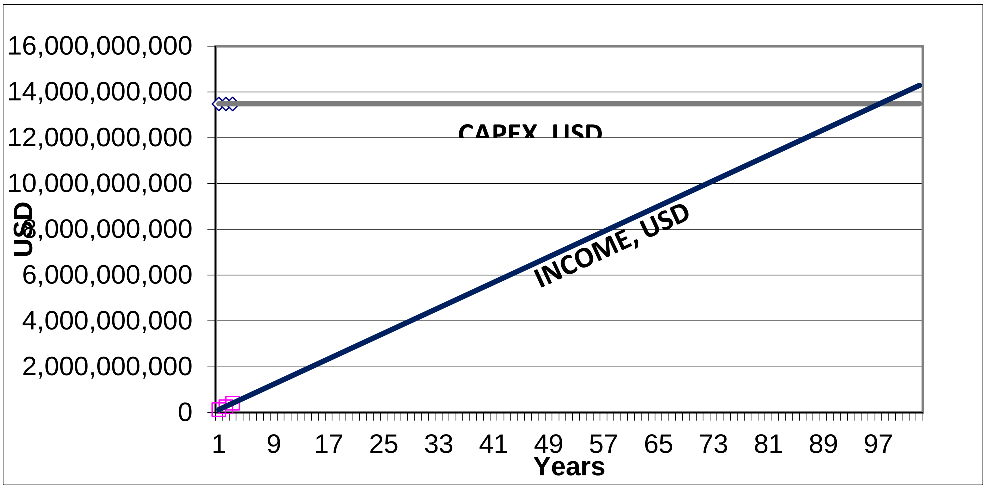
However, the capital expenditure (CAPEX) for the deployment of the transport infrastructure exceeds USD13 billion, which, with a total expected profit of about USD140 million per year, results in an unacceptable payback period of more than 90 years, and this does not take into account the operating expenditure (OPEX) and inflation rate (Figure 6).

Table 11: **Financial indicators by type of infrastructure along the Almaty–Cholpon-Ata infrastructure corridor**

Type of infrastructure	CAPEX,* USD	OPEX, USD per year	Income, USD per year
Road (construction)	13,487,959,903	5,877,349	132,360,000
Railway (construction)	13,065,940,397	8,363,381	132,360,000
Power line (construction)	13,205,893,958	192,353**	42,930,000
Fibre-optic communications line (construction)	13,205,319,126	6,430**	1,740,000

Notes: * Taking into account the construction of a tunnel for each type of infrastructure separately; and
** Excluding the cost of tunnel maintenance.

Figure 6: **Linear trend for payback of the road infrastructure along the Almaty–Cholpon-Ata infrastructure corridor**



An analysis of various development scenarios that consider both separate and co-deployment of infrastructures shows the following (Table 12):

Co-deployment of the information and communications technology (ICT) infrastructure with road and/or railway infrastructure, and separate deployment of the energy infrastructure – Annual profit is USD192.6 million;
Separate deployment of the road, energy and ICT infrastructures – Annual profit is USD192.6 million, but CAPEX is more than USD39 billion;
Separate deployment of road or railway and the energy infrastructure – Annual profit is USD175 million;
Co-deployment or separate deployment of road or railway with the ICT infrastructure – Annual profit is USD150 million;
Separate deployment of road or railway – Annual profit is USD132 million; and
Minimum profit is expected in the deployment of the energy infrastructure.

Table 12: **Financial indicators of development scenarios for the Almaty–Cholpon-Ata infrastructure corridor**

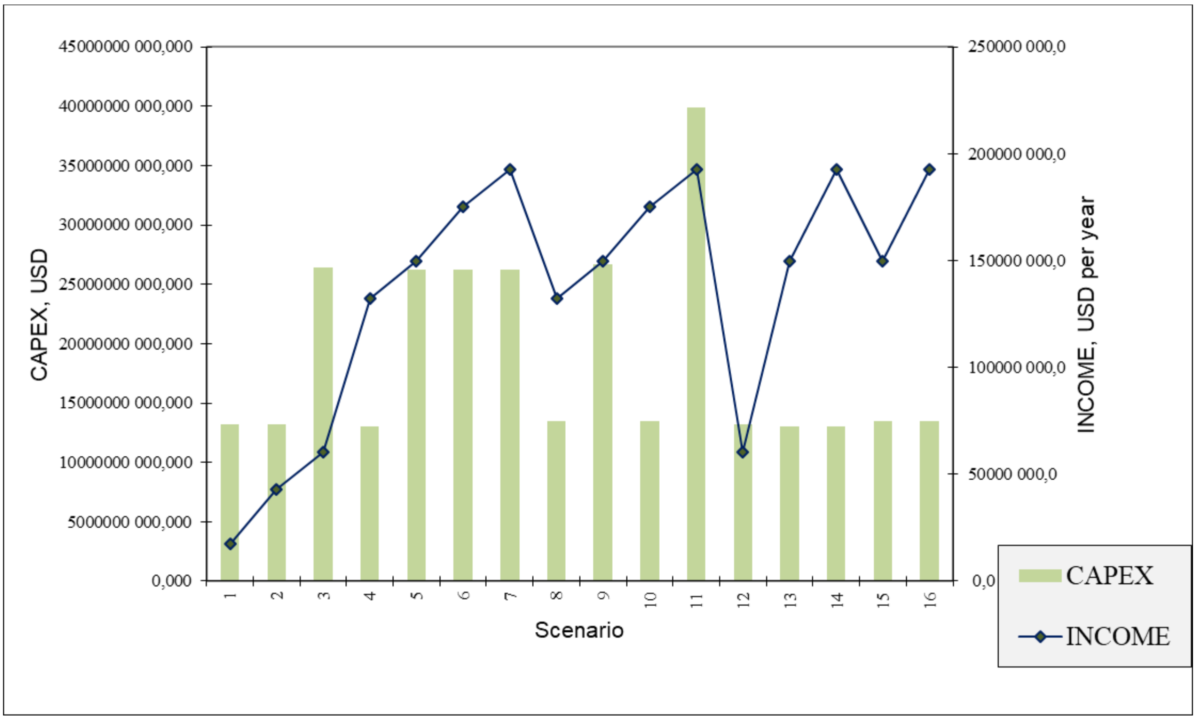
Road	Railway	Power line	Fibre-optic communications line	CAPEX, USD	OPEX, USD per year	Income, USD per year	Income / (CAPEX + OPEX)
S0	S0	S0	Sn	13,205,319,126	6,430.00	17,340,000	0.0656
S0	S0	Sn	S0	13,205,893,958	192,353.00	42,930,000	0.1624
S0	S0	Sn	Sn	26,411,213,084	198,783.00	60,270,000	0.1140
S0	Sn	S0	S0	13,065,940,397	8,363,381.00	132,360,000	0.4907
S0	Sn	S0	Sn	26,271,259,523	8,369,811.00	149,700,000	0.2804
S0	Sn	Sn	S0	26,271,834,355	8,555,734.00	175,290,000	0.3282
S0	Sn	Sn	Sn	26,272,433,451	8,562,164.00	192,630,000	0.3607
Sn	S0	S0	S0	13,487,959,903	5,877,349.00	132,360,000	0.4801
Sn	S0	S0	Sn	26,693,279,029	5,883,779.00	149,700,000	0.2773
Sn	S0	Sn	S0	13,489,133,830	6,069,702.00	175,290,000	0.6354

Sn	S0	Sn	Sn	39,899,172,987	6,076,132.00	192,630,000	0.2395
S0	S0	Scd+it	S0	13,205,910,761	194,954.00	60,270,000	0.2280
S0	Scd+it	S0	S0	13,066,304,441	8,377,708.00	149,700,000	0.5550
S0	**Scd+it**	**Sn**	**S0**	**13,067,478,368**	**8,570,061.00**	**192,630,000**	**0.7136**
Scd+ it	S0	S0	S0	13,488,300,397	5,883,612.00	149,700,000	0.5430
Scd+ it	**S0**	**Sn**	**S0**	**13,489,474,324**	**6,075,965.00**	**192,630,000**	**0.6982**

Notes: Sn – Construction of new infrastructure; S0 – No action taken; Scd+it – Co-deployment of infrastructure with ICT infrastructure (for more information see Part 2 of this series).

In summary, the optimal development scenario for the Almaty–Cholpon-Ata infrastructure corridor is the co-deployment of the ICT infrastructure with road or railway infrastructure, and a separate deployment of the energy infrastructure using the created tunnel. This scenario requires relatively low CAPEX, and is expected to generate the maximum profit (Figure 7).

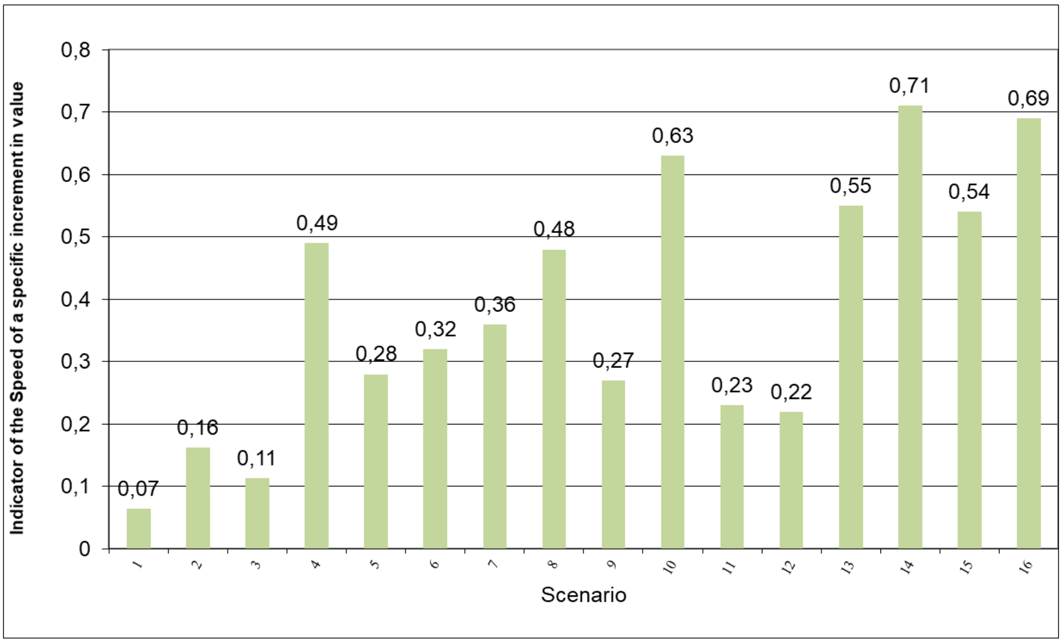
Figure 7: **Scenarios' CAPEX and expected income for the Almaty–Cholpon-Ata infrastructure corridor**



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy infrastructure; 3 – Separate construction of energy and ICT infrastructure; 4 – Separate construction of railway; 5 – Separate construction of railway and ICT infrastructure; 6 – Separate construction of railway and energy infrastructure; 7 – Separate construction of railway, energy and ICT infrastructure; 8 – Separate construction of road; 9 – Separate construction of road and ICT infrastructure; 10 – Separate construction of road and energy infrastructure; 11 – Separate construction of road, energy and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure; 13 – Co-deployment of railway and ICT infrastructure; 14 – Co-deployment of ICT infrastructure with railway and separate construction of energy infrastructure; 15 – Co-deployment of road and ICT infrastructure; and 16 – Co-deployment of ICT infrastructure with road and separate construction of energy infrastructure.

An analysis of the expected efficiency based on the ratio of expected profitability to costs produces the same optimal development scenario for the Almaty–Cholpon-Ata infrastructure corridor (Figure 8).

Figure 8: **Scenarios' ratio of expected profitability to costs for the Almaty–Cholpon-Ata infrastructure corridor**



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy infrastructure; 3 – Separate construction of energy and ICT infrastructure; 4 – Separate construction of railway; 5 – Separate construction of railway and ICT infrastructure; 6 – Separate construction of railway and energy infrastructure; 7 – Separate construction of railway, energy and ICT infrastructure; 8 – Separate construction of road; 9 – Separate construction of road and ICT infrastructure; 10 – Separate construction of road and energy infrastructure; 11 – Separate construction of road, energy and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure; 13 – Co-deployment of railway and ICT infrastructure; 14 – Co-deployment of ICT infrastructure with railway and separate construction of energy infrastructure; 15 – Co-deployment of road and ICT infrastructure; and 16 – Co-deployment of ICT infrastructure with road and separate construction of energy infrastructure.

Results from both the simulation modelling and the in-depth analysis of the socioeconomic and geopolitical state of the region along the Almaty–Cholpon-Ata infrastructure corridor presented in Part 1 of this series, give the same optimal development scenario. This conclusion is based on the fact that both road (carrying 99.8 per cent of passenger traffic) and railway (carrying 94.6 per cent of freight traffic) are priorities in this region. But since the main purpose of this infrastructure corridor is to promote tourism, it is the co-deployment of the ICT infrastructure with the road infrastructure and the separate deployment of the energy infrastructure using the created tunnel that is considered the most optimal scenario.

However, the significantly high CAPEX should be taken into account. This investment is comparable to the construction cost of the Eurotunnel under the English Channel, connecting the United Kingdom and continental Europe. The CAPEX for this project was about GBP10 billion (USD14 billion), according to various estimates. The construction was financed by private capital with support from member States. Opened in 1994, it only started to make a profit in 2007 when passenger traffic reached 19 million. With the cost of the trip set at about EUR150, the payback period of the project is several hundred years. Despite the low economic benefits of the Eurotunnel, there are high levels of social, geopolitical, sociocultural and other types of benefits.

In the given conditions, the following decisions can be made for the development of the Almaty–Cholpon-Ata infrastructure corridor:

- Reject the development scenario;
- Find investors and potential partners who are interested in this project not only as a tourist corridor, since tourist and other present flows are not able to generate the cash flows necessary to ensure an acceptable payback period;
- Deploy the project initially as a social intervention. In this case, the bulk of the investment will have to be undertaken by the participating countries or foreign funds, which is unlikely in the context of the global crisis due to the absence of an urgent need to deploy this infrastructure corridor since there are several alternative routes; or
- Continue to find a less expensive solution from a technical perspective while simultaneously searching for interested partners.

The priority of the Almaty–Cholpon-Ata infrastructure corridor is likely to not only be economical, but also social (e.g., to promote tourism and intercountry interactions) and environmental (e.g., reduction of harmful emissions due to a significant shortening of the route).

2.2 Identification of the Optimal Form of Partnership for Scenario Implementation

If a decision is made to develop this infrastructure corridor, despite its high cost, a public-private partnership model is recommended, where representatives of large multinational corporations in both the participating countries and other interested countries will act as private partners. This type of partnership can provide the necessary financial and regulatory support for the Almaty–Cholpon-Ata infrastructure corridor.

Another potential partnership model is the unification of all interested business units into an alliance or trust to finance and develop the infrastructure corridor. This form of partnership will be able to provide an acceptable payback period by intensifying the use of the infrastructure through the diversification of traffic and attraction of new users and partners.

The matrix of possible forms of partnership for the development of the Almaty–Cholpon-Ata infrastructure corridor is shown in Table 13.

Table 13: **Matrix of potential forms of partnership for development of the Almaty–Cholpon-Ata infrastructure corridor**

Kazakhstan / Kyrgyzstan	Macro level	Meso level	Micro level	Individuals (hired workers and small business owners)
Macro level	Public-private partnership with the participation of interested investors from other countries (e.g., extractive industry, ecotourism)	Public-private partnership	–	–
Meso level	Public-private partnership	Regional cluster of tourism and other sectors	Network structure, and hotel, restaurant and logistics franchising	Labour contract and contract for small wholesale deliveries
Micro level	–	Network structure, and hotel, restaurant and logistics franchising	Alliance and/or direct contractual relationship between partners	Labour contract and contract for small wholesale deliveries
Individuals (hired workers and small business owners)	–	–	Labour contract and contract for small wholesale deliveries	Direct contractual relationship

3. Calculation Results for Determining the Most Promising Scenario for Development of the Urzhar–Chuguchak Infrastructure Corridor

3.1 Determination of the Economic Efficiency of Scenario Implementation

For the Urzhar–Chuguchak infrastructure corridor, the simulation of flows indicates that the optimal scenario is the co-deployment of the ICT infrastructure with the railway infrastructure (Table 14 and Figure 9). This scenario provides the maximum return with a payback period of about 4.5 years.

ts optimality is confirmed by the in-depth analysis presented in Part 1 of this series, which shows the absence of a railway line on this route, and potential demand for transport services, both from businesses and from the local population carrying out small-scale wholesale cross-border trade, tourism and personal communications under the three-day visa-free visit programme.

Table 14: **Financial indicators by type of infrastructure along the Urzhar–Chuguchak infrastructure corridor**

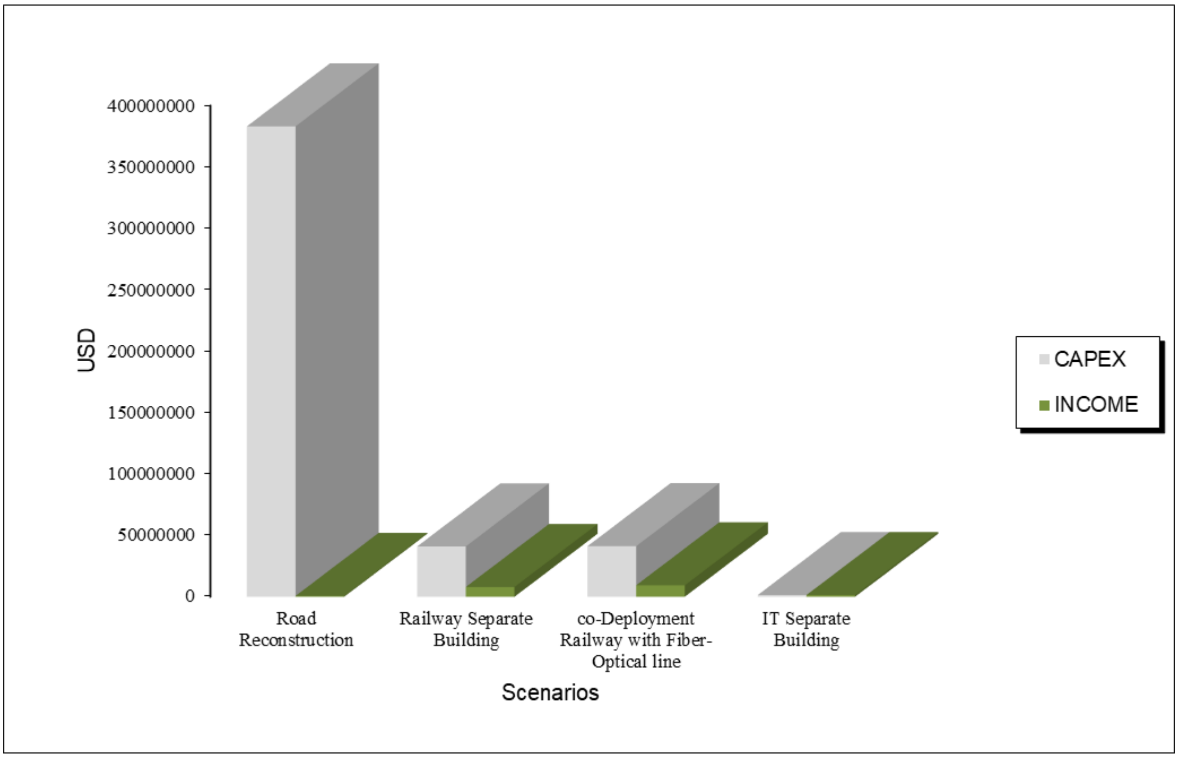
Type of infrastructure	CAPEX, USD	OPEX, USD per year	Income, USD per year
Road (reconstruction)	382,990,570.82	32,231,002.00	683,000.00
Railway (construction)	41,025,878.48	20,102,772.00	7,970,000.00
Power line (construction)	7,757,446.00	1,527,017.00	–
Fibre-optic communications line (construction)	1,444,257.65	25,983.00	1,380,000.00

Its optimality is also confirmed by previous studies, which show the differential levels of broadband access in the border areas of Kazakhstan (76.4 per cent) and China (98 per cent). The presence of fibre-optic communications lines will improve and even out broadband access in both countries.

The simulation of flows indicates that a separate deployment of the ICT infrastructure is also efficient. In this scenario, the cost is insignificant and it has a high potential for profitability associated with a high level of demand from China due to active use of Internet services and instant messengers, and from Kazakhstan due to the presence of unmet demand for Internet services. In this scenario, the payback period is a little over a year.

Road reconstruction activities are the least attractive from the point of view of economic efficiency since they have disparate indicators of costs and expected revenues (Figure 9).

Figure 9: **Profitability of actions by scenario**



Considering the scenarios' expected profitability and costs (Table 15 and Figure 10), the following conclusions can be drawn:

- The most economically efficient scenario is the separate construction of the railway, energy and ICT infrastructures, and their co-deployment in various combinations; and
- All scenarios related to the construction of a railway are efficient; and
- All scenarios related to the reconstruction of an existing road are inefficient and are therefore not recommended.

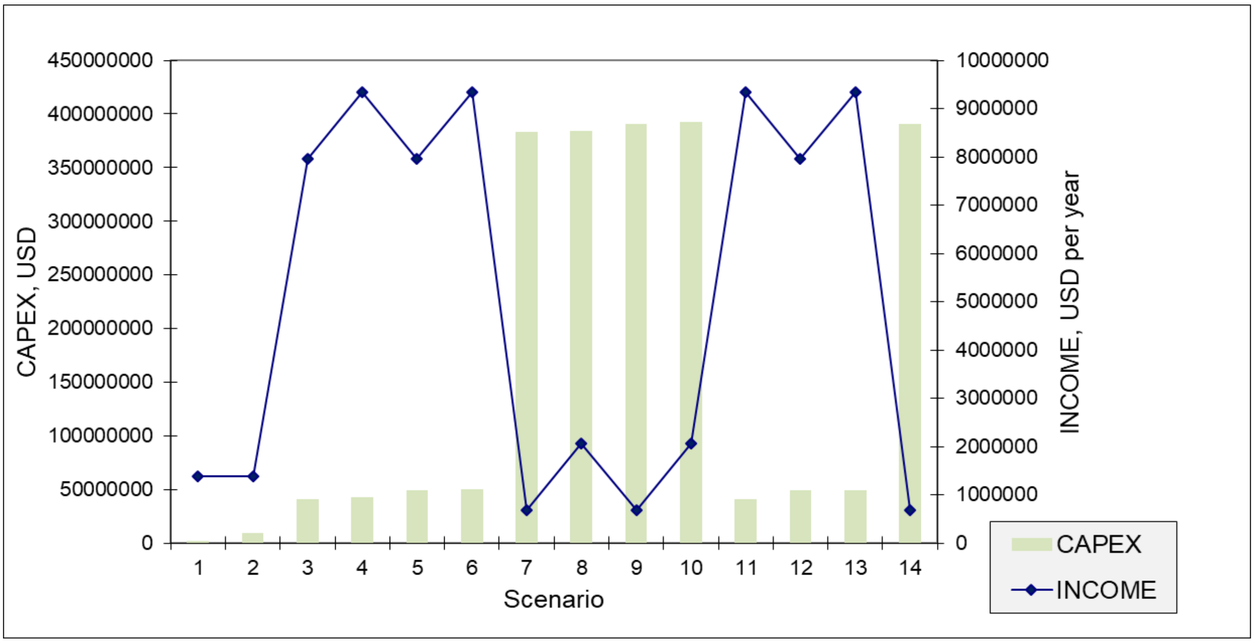
Table 15: **Financial indicators of development scenarios for the Urzhar–Chuguchak infrastructure corridor**

Road	Railway	Power line	Fibre-optic communications line	CAPEX, USD	OPEX, USD per year	Income, USD per year	Income / (CAPEX + OPEX)
S0	S0	S0	Sn	1,444,257.65	25,983.00	1,380,000.00	4.3832
S0	S0	Sn	S0	7,757,446.00	1,527,017.00	0.00	0
S0	S0	Sn	Sn	9,201,703.65	1,553,000.00	1,380,000.00	0.4066
S0	Sn	S0	S0	41,025,878.48	20,102,772.00	7,970,000.00	0.2815
S0	Sn	S0	Sn	42,470,136.13	20,128,755.00	9,350,000.00	0.3266

S0	Sn	Sn	S0	48,783,324.48	21,629,789.00	7,970,000.00	0.2539
S0	Sn	Sn	Sn	50,227,582.13	21,655,772.00	9,350,000.00	0.2949
Sr	S0	S0	S0	382,990,570.82	32,231,002.00	683,000.00	0.0062
Sr	S0	S0	Sn	384,434,828.47	32,256,985.00	2,063,000.00	0.0189
Sr	S0	Sn	S0	390,748,016.82	33,758,019.00	683,000.00	0.0061
Sr	S0	Sn	Sn	392,192,274.47	33,784,002.00	2,063,000.00	0.0183
S0	S0	Scd+it	S0	7,866,951.38	1,546,503.00	0.00	0
S0	**Scd+it**	**S0**	**S0**	**41,184,007.00**	**20,137,265.00**	**9,350,000.00**	**0.3295**
S0	Sn	Scd+it	S0	48,892,829.86	21,649,275.00	7,970,000.00	0.2535
S0	Scd+it	Sn	S0	48,941,453.00	21,664,282.00	9,350,000.00	0.2972
Sr	S0	Scd+it	S0	390,857,522.20	33,777,505.00	683,000.00	0.0061

Notes: Sn – Construction of new infrastructure; S0 – No action taken; Sr – Reconstruction of infrastructure; Scd+it – Co-deployment of infrastructure with ICT infrastructure (for more information see Part 2 of this series).

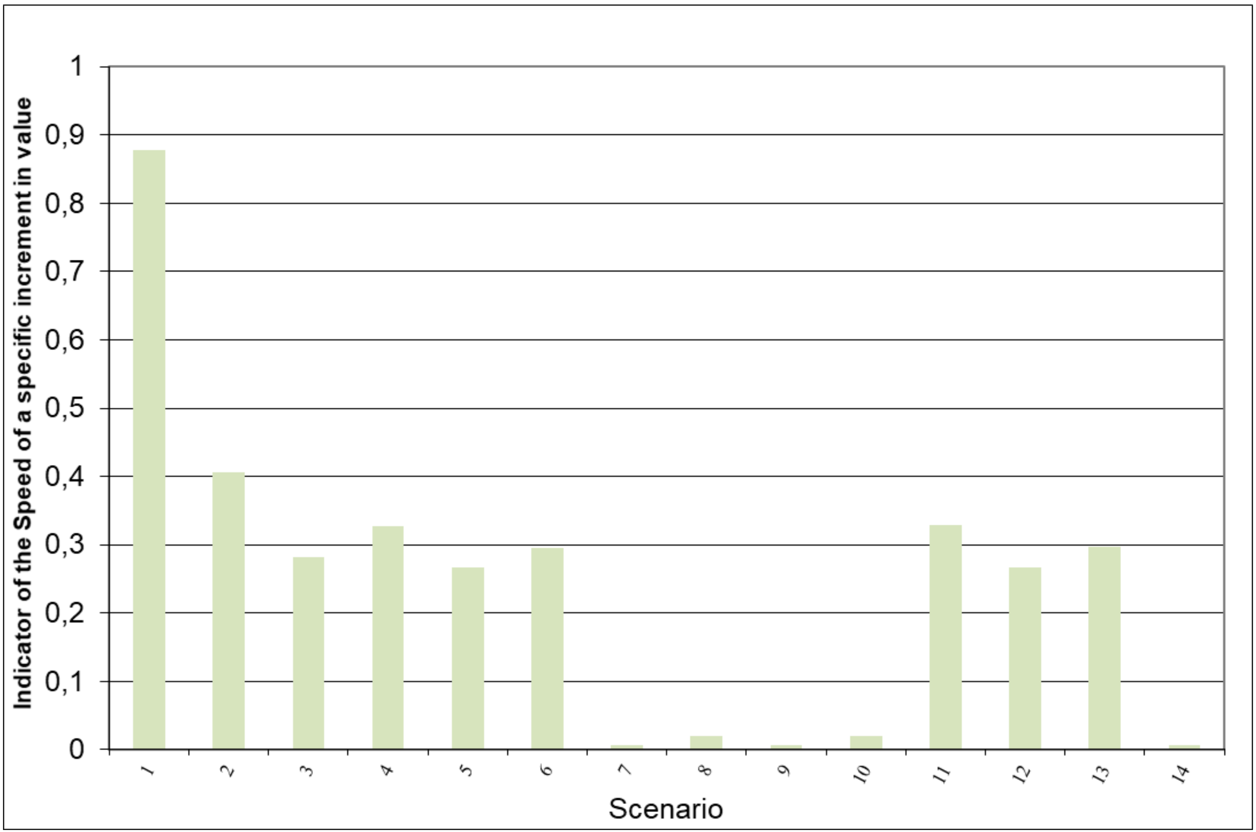
Figure 10: **Scenarios' CAPEX and expected income for the Urzhar–Chuguchak infrastructure corridor**



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy and ICT infrastructure; 3 – Separate construction of railway; 4 – Separate construction of railway and ICT infrastructure; 5 – Separate construction of railway and energy infrastructure; 6 – Separate construction of railway, energy and ICT infrastructure; 7 – Reconstruction of road; 8 – Separate construction of road and ICT infrastructure; 9 – Separate construction of road and energy infrastructure; 10 – Reconstruction of road and separate construction of energy and ICT infrastructure; 11 – Co-deployment of railway and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure, and separate construction of railway; 13 – Co-deployment of railway and ICT infrastructure, and separate construction of energy infrastructure; 14 – Co-deployment of energy and ICT infrastructure, and separate construction of road.

These findings confirm previous conclusions about the optimal scenario of co-deploying the ICT infrastructure with the railway infrastructure along the Urzhar–Chuguchak infrastructure corridor. Although findings show that the most attractive scenario is the separate deployment of the energy or ICT infrastructure, these scenarios, on their own, are not able to provide an increase in revenue as they are dependent on the increase in demand for other flows (Figure 11).

Figure 11: **Scenarios' ratio of expected profitability to costs for the Urzhar–Chuguchak infrastructure corridor**



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy and ICT infrastructure; 3 – Separate construction of railway; 4 – Separate construction of railway and ICT infrastructure; 5 – Separate construction of railway and energy infrastructure; 6 – Separate construction of railway, energy and ICT infrastructure; 7 – Reconstruction of road; 8 – Separate construction of road and ICT infrastructure; 9 – Separate construction of road and energy infrastructure; 10 – Reconstruction of road and separate construction of energy and ICT infrastructure; 11 – Co-deployment of railway and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure, and separate construction of railway; 13 – Co-deployment of railway and ICT infrastructure, and separate construction of energy infrastructure; 14 – Co-deployment of energy and ICT infrastructure, and separate construction of road.

Based on the modelling and the results of an in-depth analysis of the socioeconomic and geopolitical state of the region along the Urzhar–Chuguchak infrastructure corridor, the optimal scenario is the co-deployment of the energy and ICT infrastructures with the railway infrastructure. Even though this scenario's ratio of expected profitability to costs is not the highest, its priority is due to the following factors:

- Absence of a railway route along the Urzhar–Chuguchak infrastructure corridor. The nearest railway is 75 km away, which passes through the Dzungar Gate and is part of the Viet Nam–China–Kazakhstan–Europe transit and transport corridor, therefore it is not intended for the transportation of goods over short distances;
- Growing demand for transport and logistics services and, as a result, for energy and ICT infrastructure services associated with both the growth of the region's population, especially from China, and the activation of meso- and macro-economic trade relations;
- Growing demand for accelerating the movement of passengers (personal, tourist and business) through border checkpoints, where due to the low throughput of the Bakhty checkpoint, road transport delays occur;
- Constant shortage of electricity and the export dependence of China's energy

sector, which make co-deployment of the energy infrastructure relevant, and will allow the diversification of electricity exports in the region if tariffs for electricity from Kazakhstan are comparable to those of the Russian Federation and other suppliers. This is consistent with the agreement between Kazakhstan and China on the strategic cooperation between Samruk-Kazyna JSC and the State Grid Corporation of China in creating electrical connections between China and Kazakhstan,[138] constructing the power grid infrastructure, and exploring and developing new energy resources; and

- Differences in the level of ICT infrastructure development in the border areas of Kazakhstan and China, which provide opportunities to improve and even out broadband Internet access in both countries.

3.2 Identification of the Optimal Form of Partnership for Scenario Implementation

Potential partners for the optimal scenario include local businesses, primarily agricultural enterprises and light industry enterprises that export their products (mostly from China).

Operators of hotel and restaurant businesses specializing in tourism at Alakol in Kazakhstan are directly interested in the development of this infrastructure corridor. Thus, the most appropriate form of partnership may be a holding structure or an alliance of interested businesses. At the same time, finances from non-residents (e.g., ethnic Chinese who are actively investing in the development of the country or regions) can act as an investment component for the holding structure or alliance.

Public-private partnership or other forms of partnership is not advisable for the Urzhar–Chuguchak infrastructure corridor given the significant differences in public administration of the participating countries. Nevertheless, China and Kazakhstan need to address the bottleneck at the Bakhty checkpoint, improve upon the visa-free regime, and accelerate passenger and freight flow.

The matrix of possible forms of partnership for the development of the Urzhar–Chuguchak infrastructure corridor is shown in Table 16.

[138] Казахстан планирует поставлять электроэнергию в Китай. Available at https://online.zakon.kz/Document/?doc_id=31640372#pos=3;-80.

Table 16: **Matrix of potential forms of partnership for development of the Urzhar–Chuguchak infrastructure corridor**

Kazakhstan / China	Macro level	Meso level	Micro level	Individuals (hired workers and small business owners)
Macro level	Financial and industrial group with the participation of interested investors from other countries	Holding or consortium of logistics, agricultural and light industry enterprises	Network structure, franchising	Employment contract
Meso level	Holding or consortium of logistics, agricultural and light industry enterprises	Alliance of local businesses (light industry, food, tourism, logistics)	Network structure, franchising (logistics, trade, service, small wholesale)	Labour contract for small wholesale supplies and services
Micro level	Network structure, and hotel, restaurant and logistics franchising	Network structure, franchising (trade, logistics, medicine)	Alliance and/or direct contractual relation between enterprises of light industry, tourism and logistics	Labour contract and contract for small wholesale deliveries
Individuals (hired workers and small business owners)	–	Labour contract and contract for small wholesale supplies and services	Labour contract and contract for small wholesale deliveries	Direct contractual relationship

4. Calculation Results for Determining the Most Promising Scenario for Development of the Semey–Rubtsovsk Infrastructure Corridor

4.1 Determination of the Economic Efficiency of Scenario Implementation

For the Semey–Rubtsovsk infrastructure corridor, the simulation of flows indicates that the optimal scenario is the deployment of the energy infrastructure, and the co-deployment of energy and ICT infrastructures (Table 17 and Figure 12). These scenarios provide the maximum return at relative low costs, and a payback period of up to 2 years.

Reconstruction of the road requires the largest CAPEX at about USD464 million, while its expected profitability per year amounts to about USD2 million, which corresponds to a payback period of over 100 years provided that the existing flows and infrastructure are maintained.

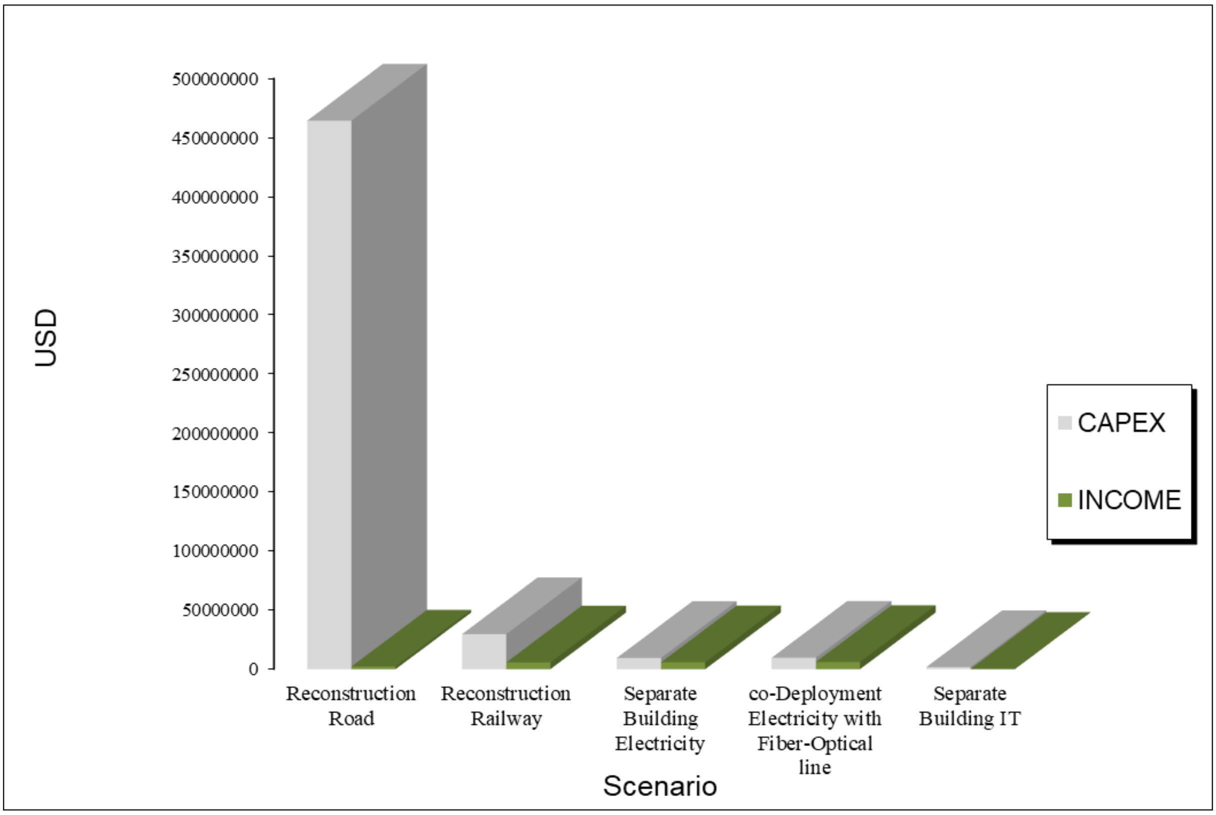
Table 17: **Financial indicators by type of infrastructure along the Semey–Rubtsovsk infrastructure corridor**

Type of infrastructure	CAPEX, USD	OPEX, USD per year	Income, USD per year
Road (reconstruction)	464,316,463.39	39,820,750.00	2,196,000.00
Railway (reconstruction)	29,628,787.92	17,554,908.00	5,707,000.00
Power line (construction)	9,519,750.89	1,834,863.00	5,800,000.00
Fibre-optic communications line (construction)	1,776,143.08	32,529.00	250,000.00

Reconstruction of the railway line also requires significant CAPEX (USD29.6 million), and with the expected profitability of USD5.7 million per year, the payment period of 5-6 years is considered acceptable for this type of project.

The construction of the ICT infrastructure is the least costly, but the estimated payback period is longer at 7-8 years, but still acceptable for this type of project.

Figure 12: **Profitability of actions by scenario**



Considering the scenarios' expected profitability and costs (Table 18 and Figure 13), the following conclusions can be drawn:

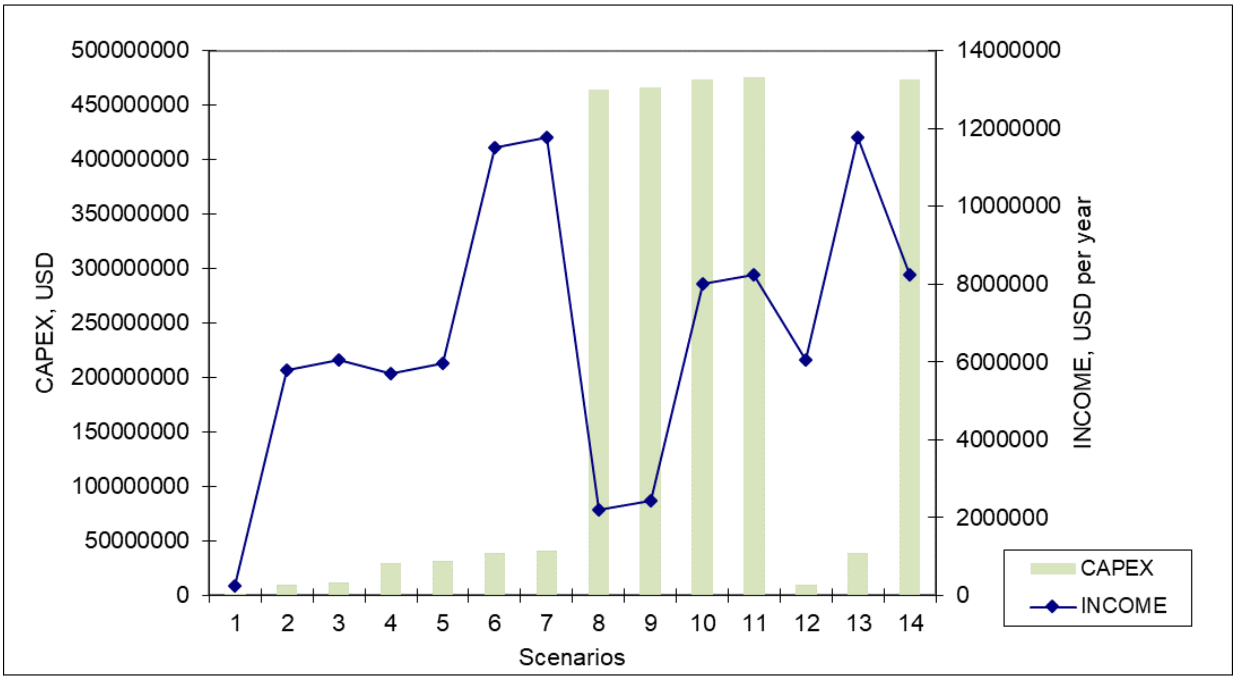
- The scenarios requiring the highest CAPEX are road reconstruction with separate or co-deployment of the energy and/or ICT infrastructures. However, their profitability are not the highest;
- The scenario with the highest expected profitability is the separate or co-deployment of the energy and ICT infrastructures with the reconstruction of the railway; and
- The scenario with the lowest expected profitability is the construction of the ICT infrastructure. This is because the ICT infrastructure on its own not generate significant demand. Potential growth in demand and, as a consequence, income, may arise with an increase in the traffic of other flows (e.g., freight, passenger, etc.) and the simultaneous increase in roadside services, population and businesses in the regions along the infrastructure corridor, which can generate new jobs and business processes.

Table 3: Financial indicators of development scenarios for the Semey–Rubtsovsk infrastructure corridor

Road	Railway	Power line	Fibre-optic communications line	CAPEX, USD	OPEX, USD per year	Income, USD per year	Income / (CAPEX + OPEX)
S0	S0	S0	Sn	1,776,143.08	32,529.00	250,000.00	0.6447
S0	S0	Sn	S0	9,519,750.89	1,834,863.00	5,800,000.00	1.5512
S0	S0	Sn	Sn	11,295,893.97	1,867,392.00	6,050,000.00	1.4661
S0	Sr	S0	S0	29,628,787.92	17,554,908.00	5,707,000.00	0.2430
S0	Sr	S0	Sn	31,404,931.00	17,587,437.00	5,957,000.00	0.2495
S0	Sr	Sn	S0	39,148,538.81	19,389,771.00	11,507,000.00	0.4227
S0	Sr	Sn	Sn	40,924,681.89	19,422,300.00	11,757,000.00	0.4258
Sr	S0	S0	S0	464,316,463.39	39,820,750.00	2,196,000.00	0.0165
Sr	S0	S0	Sn	466,092,606.47	39,853,279.00	2,446,000.00	0.0183
Sr	S0	Sn	S0	473,836,214.28	41,655,613.00	7,996,000.00	0.0586
Sr	S0	Sn	Sn	475,612,357.36	41,688,142.00	8,246,000.00	0.0602
S0	S0	Scd+it	S0	9,654,880.30	1,858,000.00	6,050,000.00	1.5967
S0	**Sr**	**Scd+it**	**S0**	**39,283,668.22**	**19,412,908.00**	**11,757,000.00**	**0.4311**
Sr	S0	Scd+it	S0	473,971,343.69	41,678,750.00	8,246,000.00	0.0604

Notes: Sn – Construction of new infrastructure; S0 – No action taken; Scd+it – Co-deployment of infrastructure with ICT infrastructure (for more information see Part 2 of this series).

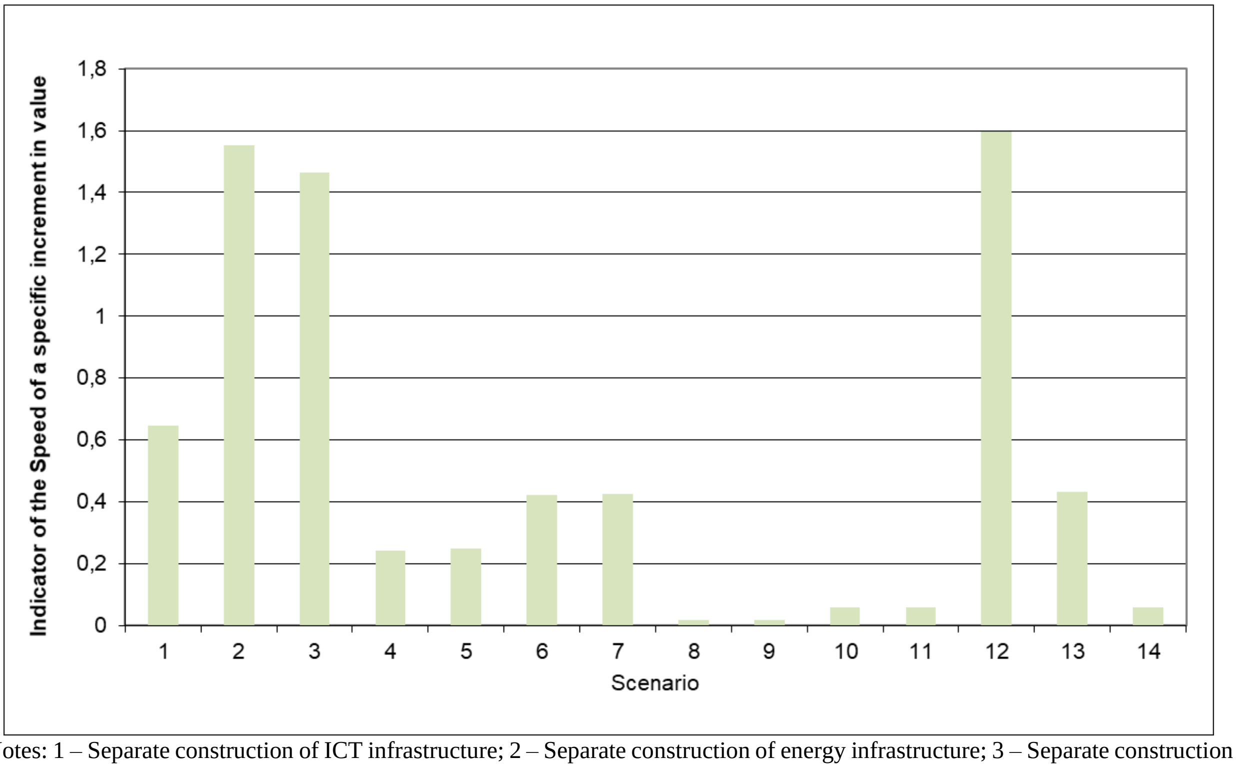
Figure 13: Scenarios' CAPEX and expected income for the Semey–Rubtsovsk infrastructure corridor



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy infrastructure; 3 – Separate construction of energy and ICT infrastructure; 4 – Reconstruction of railway; 5 – Separate reconstruction of railway and ICT infrastructure; 6 –

Separate reconstruction of railway and energy infrastructure; 7 – Reconstruction of railway and separate construction of energy and ICT infrastructure; 8 – Reconstruction of road; 9 – Separate reconstruction of road and ICT infrastructure; 10 – Separate reconstruction of road and energy infrastructure; 11 – Reconstruction of road and separate construction of energy and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure; 13 – Co-deployment of energy and ICT infrastructure, and reconstruction of railway; 14 – Co-deployment of energy and ICT infrastructure, and reconstruction of road.

Figure 14: **Scenarios' ratio of expected profitability to costs for the Semey–Rubtsovsk infrastructure corridor**



Notes: 1 – Separate construction of ICT infrastructure; 2 – Separate construction of energy infrastructure; 3 – Separate construction of energy and ICT infrastructure; 4 – Reconstruction of railway; 5 – Separate reconstruction of railway and ICT infrastructure; 6 – Separate reconstruction of railway and energy infrastructure; 7 – Reconstruction of railway and separate construction of energy and ICT infrastructure; 8 – Reconstruction of road; 9 – Separate reconstruction of road and ICT infrastructure; 10 – Separate reconstruction of road and energy infrastructure; 11 – Reconstruction of road and separate construction of energy and ICT infrastructure; 12 – Co-deployment of energy and ICT infrastructure; 13 – Co-deployment of energy and ICT infrastructure, and reconstruction of railway; 14 – Co-deployment of energy and ICT infrastructure, and reconstruction of road.

From the standpoint of economic efficiency and expected profitability, the most attractive scenarios are the separate construction of the energy and ICT infrastructures, as well as their co-deployment (Figure 14).

However, based on both the modelling and the results of an in-depth analysis of the socioeconomic and geopolitical state of the region along the infrastructure corridor presented in Part 1 of this series, the optimal scenario is the co-deployment of the energy and ICT infrastructures with the reconstruction of the railway.

This conclusion is based on the fact that rail passenger transportation is a priority in this region, and although freight transportation is largely by road, there is potential for cooperation between the Russian Federation and Kazakhstan in transit traffic through the Northern Corridor of the Trans-Asian Railway. This can result in the accelerated development of railway communications, but the growth of rail freight and passenger traffic will require additional traffic from the energy and ICT infrastructures.

4.2 Identification of the Optimal Form of Partnership for Scenario Implementation

Results from the in-depth analysis of the socioeconomic and geopolitical state of the region along the Semey–Rubtsovsk infrastructure corridor show that public-private partnership is the optimal form of partnership with the involvement of local businesses that are interested in building a major logistics corridor as partners of the state. These local businesses can be legal entities carrying out economic activities related to cross-border cooperation within the framework of the Eurasian transit corridor. These include transport enterprises, trade enterprises of import-export orientation and tourist operators.

Other potential forms of partnership include holding, and financial and industrial group. Potential partners include:

- Local industrial, mining and ore processing enterprises;
  - Food processing enterprises using the infrastructure corridor both for import and for supplying to the regions;
  - Producers and distributors of heat, electricity, gas and water for organizations and the population in the regions; and
  - Hotel and restaurant businesses that benefits from increased freight, passenger and tourist flows.

The matrix of possible forms of partnership for the development of the Semey–Rubtsovsk infrastructure corridor is shown in Table 19.

Table 4: **Matrix of potential forms of partnership for development of the Semey–Rubtsovsk infrastructure corridor**

Kazakhstan / Russian Federation	Macro level	Meso level	Micro level	Individuals (hired workers and small business owners)
Macro level	Holding, and financial and industrial group with the participation of interested investors from other countries	Holding and consortium (industry, transport)	Network structure and franchising	–
Meso level	Holding, consortium	Alliance of local industrial mining and ore processing enterprises	Network structure and franchising (logistics, service)	Labour contract and contract for small wholesale deliveries
Micro level	Network structure and franchising	Network structure and franchising (food industry, logistics, service)	Alliance and/or direct contractual relation between enterprises of light industry, tourism and logistics	Labour contract and contract for small wholesale deliveries
Individuals (hired workers and small business owners)	–	Labour contract and contract for small wholesale deliveries	Labour contract and contract for small wholesale deliveries	Direct contractual relationship

5. Conclusion

The main factors driving co-deployment and infrastructure sharing are economic benefits and the efficient use of limited resources. It is generally accepted that the criteria of efficiency are indicators of net cash flow and an index of the rate of specific growth in value.

The data and indicators used for simulation modelling to determine the most promising model for infrastructure corridor development can be divided into three groups:

1. The technologies for construction, upgrade or reconstruction, and maintenance of various types of infrastructure;
2. Primary information on the socioeconomic aspects of the infrastructure corridors; and
3. Secondary information on the socioeconomic aspects of the infrastructure corridors.

The data sources for the first group were technological standards, labour standards for performing technological operations, and the knowledge and experience of experts in the relevant subject areas. The data sources for the second and third groups were official statistical data on the socioeconomic aspects of the regions along the infrastructure corridors, and other information available in the public domain.

An algorithm to determine the most promising model for infrastructure corridor development was developed based on the availability of data. If all the necessary reliable statistical data was available, a direct calculation method was proposed. In the absence or lack of data, an indirect method was proposed by extrapolating existing flows in a given direction or by separating the flow share at the infrastructure corridor from flows existing in a region or country, and a reverse assessment method was applied to determine the expected profitability.
For the design of infrastructure facilities, results of engineering surveys, which include geological and geodetic surveys, and aerial photography are normally used. However, due to their high cost and narrow range, Google Earth was used as a source of data for this study in the formation of routes for existing and potential infrastructures. In addition, the complexity coefficients were introduced for each section of the infrastructure, taking into account the relief features. Following route construction using Google Earth and the calculation of the complexity coefficients for each of the scalable and non-trivial segments, configuration files of the corresponding infrastructure facilities were generated, which were used for further calculations in the simulation model.

To perform the calculations, six databases were created, based on the consolidated standards for construction prices. The main data sources were: documents of the series ФЕР 81-02-XX-2001 (federal unit rates for construction work) and ФСЭМ 81-01-2001 (prices for the operation of construction machines and vehicles); and statistical data on the average wages and working hours in the regions along the infrastructure corridors.

Calculation Results for Determining the Most Promising Model for Development of the Almaty–Cholpon-Ata Infrastructure Corridor

The results of calculations for the Almaty (Kazakhstan) – Cholpon-Ata (Kyrgyzstan) infrastructure corridor show that the optimal development scenario is the co-deployment of the ICT infrastructure with road or railway infrastructure, and a separate deployment of the energy infrastructure using the created tunnel. These are optimal scenarios because the road infrastructure carries 99.8 per cent of passenger traffic and the railway infrastructure carries 94.6 per cent of freight traffic, and they are priority infrastructures in this region. The co-deployment of the ICT infrastructure with road infrastructure, and a separate deployment of the energy infrastructure using the created tunnel, however, is the most optimal given the tourism potential of this infrastructure corridor.

However, the significantly high CAPEX for the deployment of the road infrastructure exceeding USD13 billion results in an unacceptably long payback period of more than 90 years. As a result, the following options are proposed:

- Reject the development scenario;
- Find ways to generate the necessary flows to ensure an acceptable payback period;
- Deploy the project initially as a social intervention; or
- Continue to find a less expensive solution from a technical perspective while simultaneously searching for interested partners.

If a decision is made to develop this infrastructure corridor, a public-private partnership model is recommended, where representatives of large multinational corporations in both the participating countries and other interested countries will act as private partners. This type of partnership can provide the necessary financial and regulatory support for the Almaty–Cholpon-Ata infrastructure corridor.

Another potential partnership model is the unification of all interested business units into an alliance or trust to finance and develop the infrastructure corridor. This form of partnership will be able to provide an acceptable payback period by intensifying the use of the infrastructure through the diversification of traffic and attraction of new users and partners.

Calculation Results for Determining the Most Promising Model for Development of the Urzhar–Chuguchak Infrastructure Corridor

The results of calculations for the Urzhar (Kazakhstan) – Chuguchak (China) infrastructure corridor show that the optimal development scenario is co-deployment of the ICT infrastructure with the new railway. This scenario provides the maximum return with a payback period of about 4.5 years.

However, based on both the modelling and the results of an in-depth analysis of the socioeconomic and geopolitical state of the region presented in Part 1 of this series, the optimal development scenario is the co-deployment of the energy and ICT infrastructures with the railway infrastructure. Even though this scenario's ratio of expected profitability to costs is not the highest, its priority is due to the following factors:

- Absence of a railway route along the Urzhar–Chuguchak infrastructure corridor;
- Growing demand for transport and logistics services and, as a result, for energy and ICT infrastructure services associated with both the growth of the region's population, especially from China, and the activation of meso- and macro-economic trade relations;
- Growing demand for accelerating the movement of passengers (personal, tourist and business) through border checkpoints, where due to the low throughput of the Bakhty checkpoint, road transport delays occur;
- Constant shortage of electricity and the export dependence of China's energy sector, which make co-deployment of the energy infrastructure relevant and will allow the diversification of electricity exports in the region; and
- Differences in the level of ICT infrastructure development in the border areas of Kazakhstan and China, which provide opportunities to improve and even out broadband Internet access in both countries.

Road reconstruction activities are the least attractive from the point of view of economic efficiency, since they have disparate indicators of costs and expected revenues.

Based on the ratio of expected profitability to costs, the most attractive scenario is the separate deployment of the energy or ICT infrastructure. However, these scenarios, on their own, are not able to provide an increase in revenue as they are dependent on the increase in demand for other flows.

Potential partners for the optimal scenario include local businesses, primarily agricultural enterprises and light industry enterprises that export their products (mostly from China). Operators of hotel and restaurant businesses specializing in tourism at Alakol in Kazakhstan are directly interested in the development of this infrastructure corridor.

Thus, the most appropriate form of partnership may be a holding structure or an alliance of interested businesses. At the same time, finances from non-residents (e.g., ethnic Chinese who are actively investing in the development of the country or regions) can act as an investment component for the holding structure or alliance.

Public-private partnership or other forms of partnership is not advisable for the Urzhar–Chuguchak infrastructure corridor given the significant differences in public administration of the participating countries. Nevertheless, China and Kazakhstan need to address the bottleneck at the Bakhty checkpoint, improve upon the visa-free regime, and accelerate passenger and freight flow.

Calculation Results for Determining the Most Promising Model for Development of the Semey–Rubtsovsk Infrastructure Corridor

The results of calculations for the Semey (Kazakhstan) – Rubtsovsk (Russia) infrastructure corridor show that the optimal scenario is the deployment of the energy infrastructure, and the co-deployment of the energy and ICT infrastructures. These scenarios provide the maximum return at relative low costs, and a payback period of up to 2 years.

However, based on both the modelling and the results of an in-depth analysis of the socioeconomic and geopolitical state of the region along the infrastructure corridor, the optimal scenario is the co-deployment of the energy and ICT infrastructures with the reconstruction of the railway infrastructure, since railway passenger traffic is a priority in this region.

The scenario with the highest expected profitability is the separate or co-deployment of the energy and ICT infrastructures with the reconstruction of the railway. The scenario with the lowest expected profitability is the construction of the ICT infrastructure. This is because the ICT infrastructure on its own does not generate significant demand. Modelling also shows the inefficiency of scenarios involving road reconstruction, since it requires the highest CAPEX and only average expected profitability.

The optimal form of partnership for the Semey–Rubtsovsk infrastructure corridor is public-private partnership with the involvement of local businesses that are interested in building a major logistics corridor as partners of the state. These local businesses can be legal entities carrying out economic activities related to cross-border cooperation within the framework of the Eurasian transit corridor. These include transport enterprises, trade enterprises of import-export orientation and tourist operators.

Other potential forms of partnership include holding, and financial and industrial group. Potential partners include:

- Local industrial, mining and ore processing enterprises;
- Food processing enterprises using the infrastructure corridor both for import and for supplying to the regions;
- Producers and distributors of heat, electricity, gas and water for organizations and the population in the regions; and
- Hotel and restaurant businesses that benefit from increased freight, passenger and tourist flows.