EFFICIENCY ANALYSIS ON SOCIOECONOMIC DEVELOPMENT LEVELS AMONG LEADING TRADE PARTNERS OF UZBEKISTAN

Rakhimova Margarita Sergeevna,
Researcher of "System analysis and mathematical modeling" department,
Alimova Sofiya Rozumbaevna
Researcher of "System analysis and mathematical modeling" department

Abstract

Purpose *–Data envelopment analysis (DEA), a non-parametric mathematical programming methodology, was used to measure efficiency in the study. DEA, described as a linear programming model, aims to measure the relative performances of decision-making entities when it is difficult to evaluate because of multiple inputs and outputs. There are two different types of DEA, one input-oriented and one output oriented. Since the main objective of the present study is to maximize the turnover of the Republic of Uzbekistan with other countries, the output-oriented DEA model was preferred. Such socio-economic indicators as GDP, FDI, labor costs, overall turnover, and the number of foreign companies were used as the inputs. As a result of the analysis, the socioeconomic efficiency levels of the countries allowed dividing the countries into groups to realize whose potential is used thoroughly and at the same time to understand which countries can be considered prospective trade partners in the future. So, in addition to individual assessments of the nations, countries with similar national incomes were categorized under certain efficiency groups. Finally, similarities and differences between the countries were identified.*

Design/methodology/approach *– This paper includes research about the procedures to determine the ways of maximizing the turnover of the Republic of Uzbekistan with other countries in the DEA context. The contributions are classified with respect to the methodology and the procedure's main aim.*

Originality/value *– The present study aimed to measure the degree to which countries utilize their socioeconomic development inputs in terms of turnover and assess the findings comparatively. The paper would be useful for both theoretical and practical future research on the topic.*

Keywords - *Socioeconomic development, efficiency, data envelopment analysis, top ten countries with the largest foreign trade turnover with Uzbekistan.*

Paper type *Research paper*

Introduction

It is observed that countries do not demonstrate the same level of development and that these spatial developmental differences constantly escalate socioeconomic problems. Irrespective of the reasons for the differences in

development and the tools used to eliminate them, one of the most important points is whether the resources are used effectively. To this end, countries determine their regional policies in line with their national requirements to adapt to the global economic and social transformations, avoid adverse effects, take advantage of available opportunities, and construct the development of the region.

In particular, in countries, various policies have been adopted in order to overcome developmental differences among countries as required by the advances in the global economy.

To this end, the main regional objectives and policies could be summarized as social, economic, and spatial integration, conservation of the environment, strengthening the local governments, the establishment of an integrated socio-economic and geographical information system, creation of development axes that would strengthen the functional ties in the countries and a focus on their problems and potentials. For the selected countries, the goals and policies are to ensure efficient institutionalization, strengthen the public-private sector collaboration, ensure sustainable land use, support local entrepreneurship, and provide social equality.

In addition to policy-making efforts to reduce developmental disparities, it is also crucial to conduct research and assessments on the extent to which the countries utilize their existing resources efficiently and which countries perform better in utilizing their resources efficiently, thus which countries are more successful than others in productivity. So, efficient use of limited resources is very significant in achieving developmental and growth objectives, as well as ensuring the sustainability of these objectives. In the pre-1970 era, only the GDP was used as a developmental criterion, however, the number and quality of socio-economic criteria utilized as developmental criteria have increased since then.

In this context, the present study aimed to measure and comparatively assesses the socioeconomic development indicators in the selected countries to maximize the turnover between the Republic of Uzbekistan and selected countries. For this purpose, Data Envelopment Analysis (DEA), which is an efficiency measurement methodology based on linear programming, was used in the present study.

1. Literature review

1.1 Efficiency Analysis: Data Envelopment Analysis[1]

Performance measurement models include ratio analysis which is limited by a conventional input-output structure, parametric econometric models, and non-parametric modern techniques that are considered in the new approaches' category. The most known non -parametric method is the Data Envelopment Analysis (DEA). This approach assesses the efficiency of homogeneous units that produce the same output with the same input and compares each unit with the most efficient unit or units. Thus, it is considered that the use of DEA, which is a homogeneous cluster approach in the measurement of efficiency, is more adequate when compared to other approaches.[2]

Data Envelopment Analysis is a method that uses linear programming to measure the relative efficiencies of decision units that transform input into output. It was initially developed by Charnes, Cooper, and Rhodes in order to measure and evaluate the technical efficiencies of public institutions. DEA has several advantages over other alternative efficiency measurement methods. The most important of these advantages is the multivariate structure of the DEA. Because real-life problems have complex structures that require the concurrent assessment of several factors. Contrary to the parametric methods that utilize the regression line for the optimization of the decision-making units (DMU) included in the analysis, the DEA evaluates each DMU based on its position against the Pareto efficiency boundary. In parametric methods, each DMU is represented by a simple regression equation and evaluated with respect to a mean value, while DEA evaluates each observation based on other observations. The parametric approach requires a precondition on the distribution of the error term, while the DEA requires no prerequisites. The effectiveness assessment with DEA, which evaluates all DMUs separately based on their position above or below the efficiency boundary, includes a three-stage process: [3]

- Definition and selection of decision-making units that would be included in the analysis,

[1] EFFICIENCY ANALYSIS BASED ON THE CORRELATION BETWEEN NATIONAL INCOME AND SOCIO-ECONOMIC DEVELOPMENT LEVEL IN OECD COUNTRIES presented by the authors in the EYI18 Econometrics, Operations Research and Statistical Symposium

[2] Golany, B. & Roll, Y. (1989). An Application Procedure For Dea, Omega, 17 (3), p. 237.

[3] Golany, B. and Thore, S. (1997). The Economic And Social Performance of Nations: Efficiency and Returns to Scale, Socio-Economic Planning Sciences, 31(3), 191-204

- Determination of appropriate input and output variables for the assessment of the relative activities of selected DMUs,
- Application of DEA models and analysis of the findings.[4]

The basic efficiency score in DEA is calculated by dividing the weighted sums of the outputs by the weighted sums of the inputs. This score is calculated as given in Formula 1

$$e_k = \frac{\sum_{i=1}^{n} u_i Y_i}{\sum_{j=1}^{m} v_j X_j}, \qquad k = 1,2, \dots K$$

- u_i = weight assigned to output i,
- Y_i = quantity of output i,
- v_j = weight assigned to input j
- X_j = quantity of input j;

In DEA, the efficiency of decision-making unit k is measured either by maximizing the outputs for a given input level or by minimizing the inputs for a given output level and the resulting value is between 0 and 1. If the efficiency of a decision-making unit is less than one, it is assumed that the efficiency of this unit is relatively lower when compared to other units. Units with an efficiency score of 1 are considered the most efficient units among all decision-making units.

DEA models are divided into two main groups as input oriented and output-oriented models. In the input-oriented model, the aim is to minimize the input quantity to obtain a fixed output quantity. It is possible to control the input in this model, while the output that would be produced is controlled in the output-oriented model. In the output-oriented model, the aim is to produce the maximum amount of output with the constant input at hand, which can be achieved by minimizing the ratio of the weighted sum of inputs to the weighted sum of outputs. [5]In addition to these two main types of the model, a third type is called the basic oriented DEA model.

Here, the model aims to optimize a mixture of inputs and outputs of the decision-making unit. [6]DEA can also be made under fixed or variable return

[4] Charnes, A., Cooper, W., Lewin, A.Y. & Seiford, L.M. (Eds.) (1994). Data Envelopment Analysis : Theory, Methodology And Application. Boston, Mass.: Kluwer.
[5] Charnes, A., Cooper, W., Lewin, A.Y. & Seiford, L.M. (Eds.) (1994). Data Envelopment Analysis : Theory, Methodology And Application. Boston, Mass.: Kluwer.
[6] Charnes, A., Cooper, W. and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units, European Journal of Operations Research, 2, 429-444.

assumptions depending on the purpose of the study. Under the assumption of constant return to scale, an increase in the amount of input is assumed to lead to an increase in the amount of output in the same way. On the contrary, assuming a variable return to scale, it is accepted that the rate of change in output may be lower or higher than the rate of change in inputs. In this study, since the variable return to scale approach would not allow adequate interpretations of the objectives of the present study the constant return to scale approach was preferred, and the output-oriented DEA model by Charnes, Cooper, and Rhodes (CCR) was utilized. For example, it could be recommended that the units (countries) that exhibit decreasing return to scale should lower their scale. However, in the present study, it would be unrealistic to expect any country to reduce their socioeconomic indicators since they are considered to be a factor that determines the scale. Also, to propose countries that exhibit increasing returns to scale to raise their scale would not enrich the interpretation. For all these reasons, constant return to scale approach is preferred in the study. In fact, the supplementary methods implemented in addition to the CCR exceed the informativeness of the variable return to scale analysis The mathematical expression of the output-oriented CCR model is as follows:[7]

$$\max Z_0 = \emptyset$$

$$\emptyset Y_{r0} - \sum_{i=1}^{n} \lambda_j Y_{rj} + S_r^+ = 0 \quad r = 1, \dots, s$$

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^- = X_{i0} \quad i = 1, \dots, m$$

$$\lambda, S_+, S_- \geq 0$$

In Equation (2), s depicts the output count, m depicts the input count and n is the decision unit count. The S and S are dummy variables useful in the analysis of inefficient decision-making units.

If any S value of a decision-making unit is different from 0, it can be argued that the decision-making unit could achieve the efficiency limit by increasing the related output and similarly if the S value of a decision-making unit is different

[7] Cooper, W.W., Seiford, L.M. & Zhu, J. (Eds.) (2004). Handbook On Data Envelopment Analysis. Boston: Kluwer Academic.

from 0, it can be argued that the decision-making unit could achieve the efficiency limit by decreasing the corresponding input.[8]

The concept of the CCR model was modified by the introduction of the BCC model. The model is named after its developers Banker, Charnes and Cooper who replaced constant returns-to-scale (CRS) by variable returns-to scale (VRS). The DMU operates under VRS if the input increase does not result in proportional changes of the output. The BCC model is formulated as[9]:

$$Max_{u_j v_i} E_k = \frac{\sum_{j=1}^{q} uY_{kj} - u_0}{\sum_{i=1}^{p} vX_{ki}}$$

Basically, in the BCC model, the formula calculates the efficiency of DMUs and the most efficient DMUs that lie on the convex line creating an efficient frontier after passing through the area of DMUs (production possibility set).

The theoretical characteristics of the FDH model shall be briefly presented as this model was also applied in the analysis of trade efficiency in the selected countries and Uzbekistan. The non-parametric FDH model formulated by Deprins, Simar, and Tulkens (1984) does not include the conditions of local convexity. This means that only the real existing observations (nonlinear combination of observations) are used while comparing efficiency. The model includes only the assumption of free access to resources and consequently fewer limitations than other models[10].

The idea of FDH is to ensure that efficiency measurements are the results of actually observed performances. The basic FDH model is an easy method to use, in fact, it can be extended from the CCR or BCC model with an additional constraint[11].

1.2 Extensions to the DEA model

By making the DEA model a small more complicated, the extent of subjects it can investigate is expanded. Especially curiously is the decay of the specialized

[8] Charnes, A., Cooper, W. W., Lewin, A. Y. and Seiford, L. M. (1994), Data Envelopment Analysis: Theory, Methodology, and Applications, Kluwer Academic Publishers, USA

9 Banker R.D., Charnes A., Cooper W.W. (1984), Some models for estimating technical and scale inefficiencies in data envelopment analysis, „Management Science", vol. 30 no. 9.

[10] Panayides, P.M., Maxoulis, C.N., Wang, T., Ng. K.Y.A. (2009). A critical analysis of DEA applications to seaport economic efficiency measurement. Transport Reviews, 29(2), pp. 183-206.

11 R. Green and W. D. Cook, "A free disposal hull approach to efficiency measurement," Journal of the Operational Research Society, vol. 55, pp. 1059–1063, 2004.

effectiveness score into components coming about from the scale of operations; overflow inputs that cannot be arranged; and a leftover or ‘pure’ technical effectiveness. A further expansion that is frequently critical is to permit for contrasts in working situations; this includes attempting to adjust for factors that may well be past managers’ control, and which hence conceivably grant a few associations an artificial advantage or disadvantage.

The main advantages of DEA are:

• You can easily include multiple inputs and outputs and only need information on production and input quantities (without prices) to calculate technical efficiency. This makes it particularly useful for analyzing the efficiency of government service providers, especially those who provide human services where it is difficult or impossible to price many of the services;

• Possible sources of inefficiency and degrees of efficiency can be determined. It offers a means of "decomposing" economic inefficiencies into allocation and technical inefficiencies. Furthermore, it also allows breaking down technical inefficiency into economies of scale, the effects of unwanted inputs that the agency cannot get rid of, and a residual component;

• By identifying the "peers" of organizations that are not considered efficient, it offers a number of possible role models that an organization can use primarily to improve its operations. This makes the DEA a potentially useful tool for benchmarking and change implementation programs. This functionality is enhanced by the DEA's ability to account for differences in operating environments beyond management's control and compare them to similar.

However, like any empirical technique, the DEA relies on a number of simplifying assumptions that must be considered when interpreting the results of DEA studies. The main limitations of DEA include the following.

• DEA is more of a deterministic than a statistical method and provides results that are particularly sensitive to measurement errors. If an organization's inputs are underestimated or its outputs overvalued, that organization can become an outlier, significantly distorting the shape of the boundary and lowering the efficiency scores of neighboring organizations. In regression-based studies, the presence of error terms in the estimate tends to exclude the effects of outliers, but in DEA they are weighted in the same way as all other organizations. It is important to check for possible outliers when compiling the data. A useful check is to examine those organizations whose output-input ratio is more than about two

and a half standard deviations from the sample mean. This approach is used in some of the case studies presented later in the report.

• The DEA only measures efficiency relative to best practices within the given sample. Therefore, there is no point in comparing the results between two different studies, as the differences in best practices between the samples are unknown. Similarly, a DEA study that contains only observations within the state or nation cannot tell us how those observations compare to national or international best practice.

• DEA scores depend on input and output specifications and sample size. Increasing the sample size tends to lower the average efficiency score, as including more organizations gives the DEA more freedom to find similar comparison partners. On the contrary, the participation of very few organizations in relation to the number of outputs and inputs can artificially increase efficiency values. Increasing the number of products and inputs included without increasing the number of organizations will increase efficiency scores on average. This is because the number of dimensions in which a given organization can be relatively unique (and therefore has no similar comparison partners) increases. The DEA gives organizations that do not have similar peer organizations the upper hand when in doubt so that they are considered efficient by default. There are different rules regarding the minimum number of organizations in the sample; A rule of thumb is that the number of organizations in the sample must be at least three times the sum of the outputs and inputs included in the specification. Despite these limitations, data turnover analysis is a useful tool for examining the efficiency of government service providers. Just as these limitations need to be recognized, the potential benefits of using DEA (in conjunction with other interventions) need to be explored to improve our understanding of public sector performance and possible ways of improving it.

2. The correlation between turnover and socioeconomic development indicators

In the present study, 1 output and 5 inputs variables were determined for the analysis based on available data. As seen in Table 1, the turnover of Uzbekistan with selected countries is the sole output variable. For the purpose of researching the abovementioned issue, applying respective methodology empirical data were collected from www.ilostat.ilo.org – labor cost,

www.worldbank.org – GDP, https://tradingeconomics.com\ https://trendeconomy.com – turnover, www.invest.gov.uz, www.stat.uz www.nordeatratde.com – FDI, https://trendeconomy.com - the number of foreign companies in 2019.

Table 1

Socioeconomic Variables Used in the DEA Analysis

Names	GDP (I)	Labour (I)	FDI (I)	Turnover (I)	Foreign (I)	Turnover Uzb (O)
China	14342903	5,51	1514000	4632980,00	1306	7791
Russia	1699877	15,93	479700	672000,00	1864	5969
Kazakhstan	180162	8,94	156200	96079,00	766	3365
South Korea	1642383	7,23	193000	1045430,00	824	2692
Turkey	754412	14,13	143700	391182,00	1690	2376
Germany	3845630	42	1455000	2733338	160	900
Kyrgyzistan	8455	0,94	5860	6869,00	115	893
USA	21427700	20,38	4084000	4750130,00	241	619
Afghanistan	19101	5,86	1595	7640,00	144	532
Turkmenistan	40761	6,23	3061	12608,00	11	514

According to the correlation matrix in Figure 1, the relationship between the FDI and the GDP (0.9) is significant. But the relationships between the other variables are not significant in Figure 1. If the model can be explained with only one variable, it is meaningless adding other variables to the model. In regression analysis, there should be a significant linear correlation between the dependent and independent variables. In the theory of linear regression, variables that have got insignificant correlations should not be included in the model. So, the data set cannot be trusted. Although this is a hypothetical data set, it must fit roughly with production theory and regression theory. The relations between the input and output variables of the data set are meaningless. So, there are low and reverse correlations between the input and output variables. The classical DEA evaluates

DMUs without taking into account the relative importance of inputs and outputs to each other. [12]

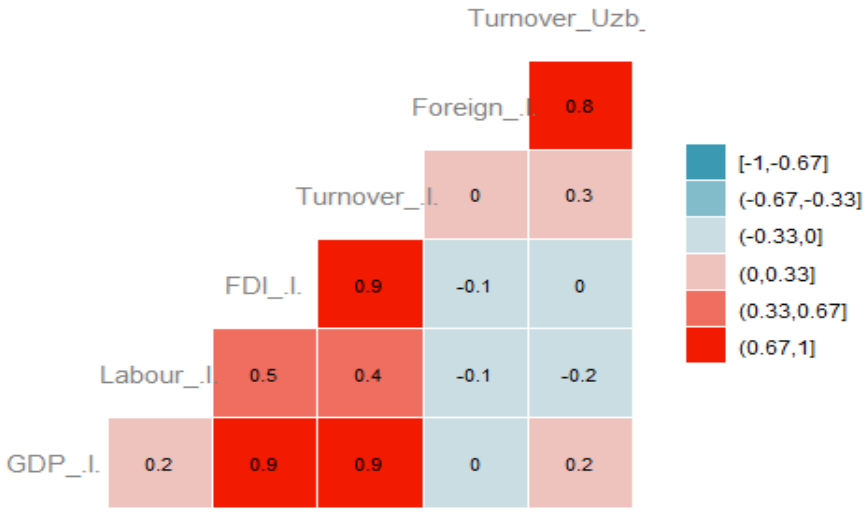

Figure .1 Correlation matrix of the set[13]

Created scatter plot matrix in Figure 2 is shown by groups. The plot contains following information:

- Scatter plot and the correlation coefficient, between each pair of variables, by groups
- Density distribution of each continuous variable, by groups

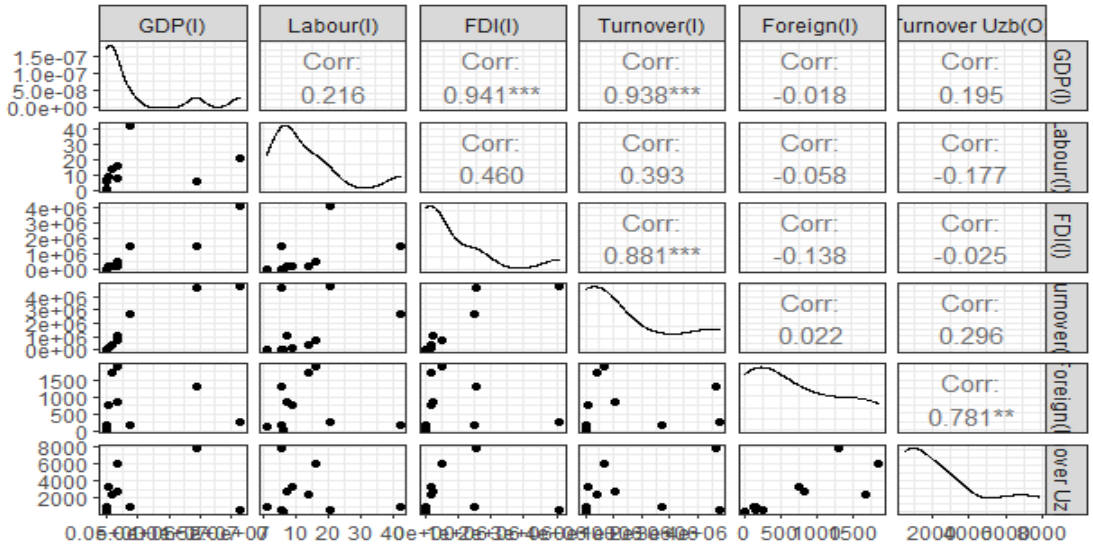

Figure 2. Bivariate analysis for the given set[14]

[12] Thanassoulis, E. A comparison of regression analysis and data envelopment analysis as alternative methods for performance assessments, Journal of the Operational Research Society 44, 1129–1144, 1993

[13] Done by the author in RStudio

[14] Done by the author in RStudio

From Figure 2 we can see a density plot which is a representation of the distribution of a numeric variable. It uses a kernel density estimate to show the probability density function of the variable. It is a smoothed version of the histogram and is used in the same concept. Checking this distribution also helps you discovering mistakes in the data. [15]In the Figure 2 none of the plots show normal distribution. Also, you can make a brief summary on correlation between variables according to this picture. Moreover, correlation between FDI and Turnover with Uzbekistan is negative as well as there are other 4points where the correlation is negative.

Efficiency scores of 10 selected countries that were obtained with the output-oriented CCR model are presented in Table 2, under the title of Phase 1. Classical DEA results demonstrated that China, Kyrgyzstan, Afghanistan and Turkmenistan were efficient among 10 selected countries in the first phase.

Table 2

Efficiency Scores for turnover on Socioeconomic Development indicators in selected countries

		Efficiency score		
	Country	Stage 1	Stage 2	Stage 3
1	China	**1**		
2	Russia	0.411	0.995	**1**
3	Kazakhstan	0.548	**1**	
4	South Korea	0.418	0.989	**1**
5	Turkey	0.181	0.768	**1**
6	Germany	0.479	**1**	
7	Kyrgyzstan	**1**		
8	USA	0.196	0.541	0.786
9	Afghanistan	**1**		
10	Turkmenistan	**1**		

Source: Done by the author in http://www.soft.onlineoutput.com/dea

Here, countries that were found to be efficient at every stage of the analysis were separated from other countries and DEA was repeated with the remaining non-efficient countries and the process was repeated until only a single country (USA) remained.

[15] https://www.data-to-viz.com/graph/density.html

In the study, the groups of countries that are evaluated separately may be called "co-efficiency levels," as well as "socio-economic development groups with respect to turnover". The groups formed thusly are presented in Table 3.

Table 3

Socio-Economic Development Groups based on turnover

Groups	Co-efficiency Groups
1	**China, Kyrgyzstan, Afghanistan, Turkmenistan**
2	**Kazakhstan, Germany**
3	**Russia, South Korea, Turkey**
4	**USA**

Source: Done by the author

Conclusion

As a result of the analysis, the turnover efficiencies of the scrutinized selected countries were determined. Based on the findings, the following conclusions could be formulated:

In the present study, DEA was initially applied to the whole sample, then to different groups of countries successively. This method is preferred because countries within a group have similar input-output combinations and it is more realistic to value each country within its own group.

According to the **Economic** and **Trade** Agreement (1992), a Most Favored Nation Treatment was established between Uzbekistan and China. **China** is one of its leading **trade** partners for **Uzbekistan**. Being neighbor countries, Kyrgyzstan, Afghanistan, and Turkmenistan continue to develop cross-border trade and connectivity. It can be concluded that Uzbekistan has fully utilized the capabilities of these countries.

The second stage includes Kazakhstan and Germany. So, we can summarize that trade relations between Uzbekistan and Kazakhstan, and Uzbekistan and Germany can be improved. Thus, there is significant unclaimed potential for further development of bilateral trade between the two countries. Also, many experts unanimously indicate that there is a significant potential for expanding trade and economic relations between Uzbekistan and Germany. In this regard, a very solid package of agreements reached at the Uzbek-German business forum held on January 14 in Berlin is clear evidence. According to its results, the

sides signed more than ten protocols of intent and investment contracts totaling over 4 billion euros[16].

The third stage includes Russia, South Korea, and Turkey. Although they are considered to be one of the main Uzbek trade partners, there is a great opportunity to continue developing mutual trade relations and full cooperation in the spirit of strategic partnership and alliance. It is noted the dynamic development and continually strengthening relations between the abovementioned countries and Uzbekistan in many areas, including in the trade-economic sphere while socioeconomic indicators show that the potential of the countries is not fully used.

The last stage is represented by the USA. Uzbekistan hasn't used great America's potential because of some reasons which include the long distance between the two countries, the superiority of political factors over economic ones and the priorities of the countries. There's an opportunity to rebalance U.S. relations with Uzbekistan, which have been relatively dysfunctional for some time. The commitment to reinvigorate the strategic partnership between the United States and Uzbekistan demonstrates the normalization of a relationship that has swung wildly over the years and at the same time makes Uzbekistan a more attractive investment destination.[17]

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